UNIVERSITI TEKNIKAL MALAYSIA MELAKA

# THERMAL COMFORT EVALUATION AT THREE NON AIR CONDITIONED PRE SCHOOL IN MELAKA USING CBE TOOL

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (AIR CONDITIONING AND REFRIGERATION SYSTEMS) WITH HONOURS

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**NUR NABILAH BINTI MOHD ISHAK**

**A thesis submitted**
**in fulfillment of the requirements for the degree of**
**Bachelor of Mechanical Engineering Technology (Air Conditioning And Refrigeration Systems) with Honours**



**Faculty of Mechanical and Manufacturing Engineering Technology**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2022**

**DECLARATION**

I declare that this Choose an item. entitled " Thermal Comfort Evaluation At Three Non Air Conditioned Pre School In Melaka Using CBE Tool " is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : Nur Nabilah Binti Mohd Ishak

Date : 28/01/2022

**APPROVAL**

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Air Conditioning And Refrigeration System) with Honours.

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Date : 28/01/2022

**DEDICATION**

To my beloved parents Mohd Ishak Bin Mohd Yunus and Kalsom Binti Badrus.Thank you for helping me to shape my life with positivity and passion. Without you, I'd never been the person I am today. Thank you for always supporting me in all the good and bad times. When the world closed its doors on me, you both opened your arms for me. When people shut their ears for me, you both opened your hearts for me. Thanks for always being there for me and making me believe that i can do everything and anything in life. In addition, I would like to express my heartfelt gratitude to my supervisor, Ts. Dr. Amir Abdullah Bin Muhamad Damanhuri, and my friends for being a part of this journey, and I wish everyone the best of luck in their future endeavours.

## ABSTRACT

Thermal comfort is a study of indoor comfort level experienced by the occupants in a room. This study involved 47 total students from different preschools. A study of thermal comfort towards preschools students were conducted in three different locations in Malacca. The purpose of this study is to determine the suitable condition for the students to feel comfortable during learning process. This research is focused on the evaluation and monitoring the thermal comfort level in three different preschools in Malacca which are Tadika Kemas Rumah Pangsa Kampung Padang, Tadika Kemas Kampung Padang A and Tadika Kemas Kampung Padang B. The factors that contributed thermal comfort towards the students were identified first. The monitoring and evaluation of thermal comfort parameters was done by using TSI VelociCalc and data obtained will be analyzed by using CBE Thermal Comfort Tool.The finding of this study reveals that the factors of thermal comfort towards occupants consists of two factor which are environmental factor and personal factor. It has been found that the value of PMV and PPD of these preschools does not comply that standard and above the acceptable range recommended by ASHRAE 55 - 2010 as well as Industry Code of Practice Indoor Air Quality, DOSH Malaysia (2010). Besides that, it has been found that the value of air temperature is increase as the time increases while the amount dust particles is irregular but it is increasing over time. The value of clothing insulation and metabolic rate effect the thermal comfort towards the students. It reveals that the lower the value of clothing insulation and metabolic rates, the more comfortable the students will be. The range of clothing insulation should be between 0.5 and 1.0, while the value of metabolic rates should be determined by the activities that they involved in. Ventilation of is important to improve the indoor air quality and productivity of the students during leaning process. Meanwhile, the data obtained from the survey shown most of students felt comfortable during learning process in the preschools. The result obtained prove that the feedback that the students gave is not significance with the ASHRAE standard.

## *ABSTRAK*

*Keselesaan terma ialah kajian tahap keselesaan dalaman yang dialami oleh penghuni di dalam sesebuah bilik. Kajian ini melibatkan 47 orang murid daripada prasekolah yang berbeza. Kajian keselesaan terma terhadap murid prasekolah telah dijalankan di tiga lokasi berbeza di Melaka. Kajian ini bertujuan untuk menentukan keadaan yang sesuai untuk pelajar berasa selesa semasa proses pembelajaran. Penyelidikan ini tertumpu kepada penilaian dan pemantauan tahap keselesaan terma di tiga prasekolah yang berbeza di Melaka iaitu Tadika Kemas Rumah Pangsa Kampung Padang, Tadika Kemas Kampung Padang A and Tadika Kemas Kampung Padang B. Faktor-faktor yang menyumbang keselesaan terma terhadap pelajar dikenal pasti terlebih dahulu. Pemantauan dan penilaian parameter keselesaan terma dilakukan dengan menggunakan TSI VelociCalc dan data yang diperolehi akan dianalisis menggunakan CBE Thermal Comfort Tool. Dapatan kajian ini mendedahkan bahawa faktor keselesaan terma terhadap penghuni terdiri daripada dua faktor iaitu faktor persekitaran dan faktor peribadi. Didapati nilai PMV dan PPD prasekolah ini tidak mematuhi piawaian tersebut dan melebihi julat yang boleh diterima yang disyorkan oleh ASHRAE 55 -2010 serta Kod Amalan Industri Kualiti Udara Dalaman, DOSH Malaysia (2010). Selain itu, didapati bahawa nilai suhu udara meningkat apabila masa meningkat manakala jumlah zarah habuk adalah tidak teratur tetapi ia meningkat dari semasa ke semasa. Nilai penebat pakaian dan kadar metabolisme mempengaruhi keselesaan terma terhadap pelajar. Ia mendedahkan bahawa semakin rendah nilai penebat pakaian dan kadar metabolisme, semakin selesa pelajar. Julat penebat pakaian hendaklah antara 0.5 dan 1.0, manakala nilai kadar metabolisme hendaklah ditentukan oleh aktiviti yang mereka terlibat. Pengudaraan adalah penting untuk meningkatkan kualiti udara dalaman dan produktiviti pelajar semasa proses bersandar. Sementara itu, data yang diperoleh daripada tinjauan menunjukkan kebanyakan pelajar berasa selesa semasa proses pembelajaran di prasekolah. Keputusan yang diperolehi membuktikan bahawa maklum balas yang diberikan oleh pelajar adalah tidak signifikan dengan piawaian ASHRAE.*

## ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

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## LIST OF SYMBOLS AND ABBREVIATIONS

| | | |
|---|---|---|
| ASHRAE | - | American Society of Heating, Refrigeration and Air- Conditioning Engineers |
| PMV | - | Predicted Mean Vote |
| PPD | - | Predicted of Percentage Dissatisfied |
| Ta | - | Air temperature (℃) |
| V | - | Air velocity (m/s) |
| RH | - | Relative humidity (%) |
| Tmrt | - | Mean Radiant Temperature (℃) |
| DOSH | - | Department of Occupational Safety and Health |
| MOE | - | Ministry of Education |
| IAQ | - | Indoor Air Quality |
| SET | - | Standard Effective Temperature (℃) |
| CBE | - | Centre For The Built Environment |
| clo | - | Unit of clothing insulation ($m^2$.K/W) |
| SPSS | - | Statistical Package for the Social Sciences |
| ICOP | - | Industry Code of Practice |

## LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Educational is an important thing in our life. It is because it is the process of learning to get the knowledge, skills or habits. Formal education in Malaysia can be divided into stages such as kindergarten, primary school, secondary school, college and university. There are many educational institutions that students can choose from whether in private or government institution.

School is a place for educational building for student to get knowledges, hubs of social activities and gains the interaction between students towards the surroundings. It is important for students to get a very good environment such as comfortability. Students around the age of 2 – 26 years old spend a lot of their waking hours in a classroom (considered age for kindergarten to university) according to (De Dear et al., 2015). The minimum hours for students to stay at their school is 7 hours. Which is from 7:30 a.m. to 2:30 p.m. and it is mostly followed by compulsory co – curricular activities or extra class. Each school has their own schedule that need to be followed by the students.

Malacca is located in south region of Malaysia. The tropical climate in Malaysia is hot and humid at all year. Due to some reason, the climate has change and the effects of it is continuous rising temperature, extreme weather events and public health in Malaysia is decreasing (Tang, 2019). This problem occurs due to activities that causing the global warming and green house effects which are burning fossil fuels, cutting down farming and

farming livestock. In addition, a curriculum is designed based on local climate condition according to (Perkins et al., 2018). In a classroom, the performance of the students such as attention, concentration and learning affected by the surrounding environment. It does not matter whether in primary or secondary school or even universities.

In Malaysia, educational institution need to meet the basic requirements of satisfaction comfort level such as good environment to improve the student performance (Mazlan et al., 2020). The comfort level can be improved between the performance and environment conditions. A strategic position to build up a school building is also a major factor where students can learn comfortably and focus when the teaching and learning process is being carried out. This is because the surrounding environment can influence students' behaviors and their mood to act. When students feel comfortable, they will stay focused and the motivation to study and it will help them to absorb more information. In addition, a school environment that is calm, clean and attractive can attract students to study well.



According to Ministry of Education (MOE), the total numbers of schools in Malaysia are 10,225 includes the preschools, primary schools and secondary schools. The total students throughout the year are 4,795,600 and the teachers are 413,022. As stated in the Figure 1.1, Figure 1.2, Table 1.1 and Table 1.2 below shows the basic educational information in Malaysia and basic preschool information in Malaysia.

Table 1.1 Basic educational information in Malaysia and Malacca (MOE,2021)

| | No. of school | No. Of teacher | No. of student | No. of classroom |
|---|---|---|---|---|
| Malaysia | 10,225 | 413,022 | 4,795,600 | 185,986 |
| Malacca | 315 | 137,767 | 149,915 | 6231 |

Table 1.2 Basic Preschool information in Malaysia and Malacca (MOE,2021)

| | No. of school | No. of teacher | No. of student | No. of classroom |
|---|---|---|---|---|
| Malaysia | 6,214 | 9,294 | 207,828 | 9,677 |
| Malacca | 170 | 246 | 5,621 | 246 |

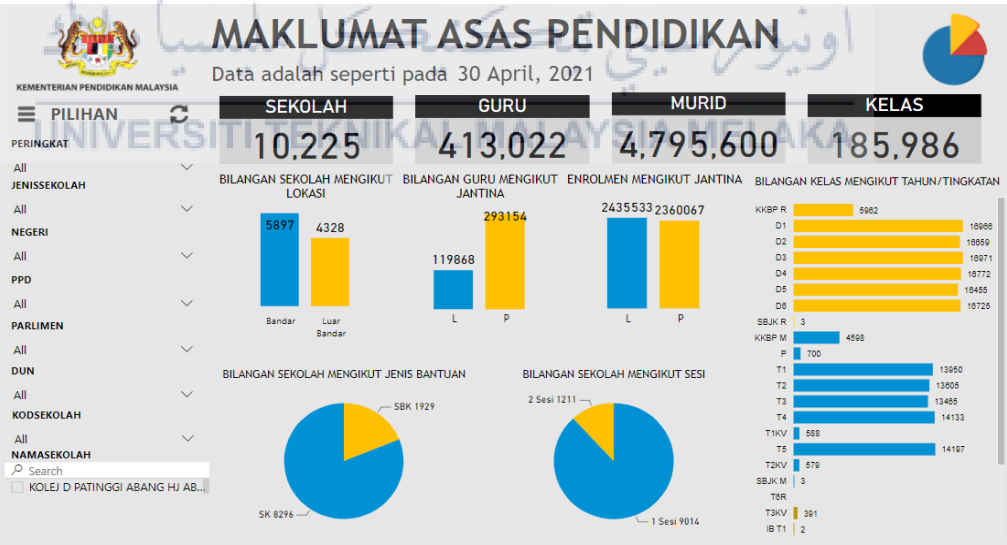


Figure 1.1 Basic educational information in Malaysia (Sources:

https://www.moe.gov.my/)

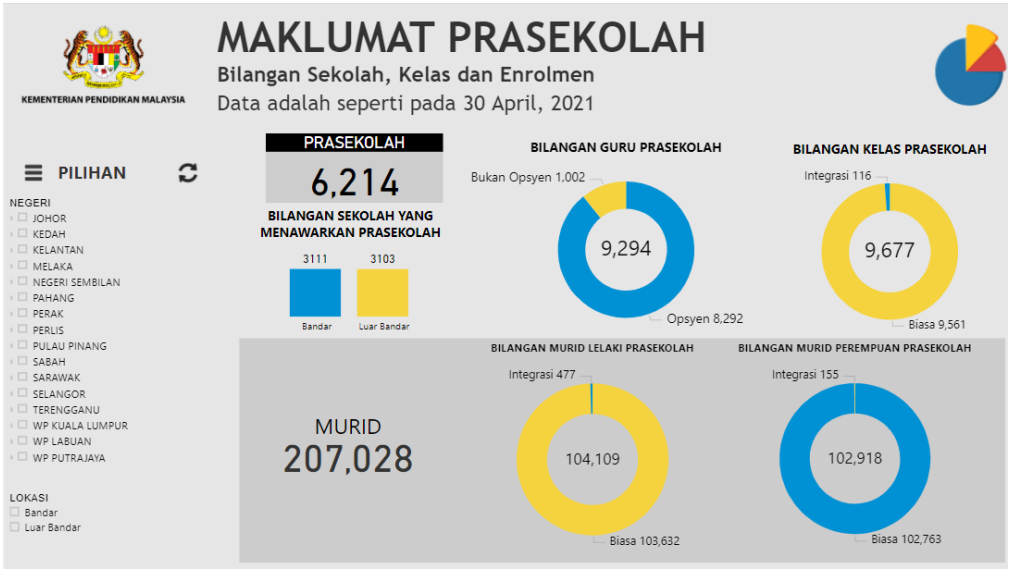


Figure 1.2 Basic educational information in Malacca (Sources: https://www.moe.gov.my/ )

## 1.2 Problem Statement

Classroom are designed for students where they spend most of their time during their teaching and learning process in school. Usually, teachers will apply all the theories and the applications between students in the classroom. During studies, students need comfortable surroundings to maximize their learning productivity performance in their school. Thermal comfort of the surrounding is very important because if there is lack of comfort it can cause an 'environmental stress' and it will produce a negative trend (Nico et al., 2015). To avoid that problem, we need to have an indoor comfort towards the school buildings especially the classroom.

Research has been reported that the indoor environment quality often inadequate in primary school. The temperature in classroom has a strong impact in learning according to (Wargocki et al., 2020). Moreover, the air quality of classroom may affect the cognitive skills as the student cannot concentrated and distracted with the work they were supposed to

do. Student's performance can be reduced because the teachers could not teach effectively as they need comfortable surroundings. The changes of climate and weather causing thermal comfort is hard to be achieved. The tropical climate in Malaysia is hot and humid so the temperature that were accepted for the comfort towards humans is between 27.1℃ and 29.3℃.

## 1.3 Research Objective

In this study, there are a few targets to be given fully attention to achieve these objectives.

a) To investigate selected parameter of indoor thermal data at three preschools in Malacca.

b) To determine indoor thermal comfort PMV and PPD level using CBE Tool.

## 1.4 Scope of Research

The scope of this research is to analyze on how the thermal comfort correlated with the occupants in non air conditioned classroom at different preschools and it will be held in Malacca. In this study, three different locations of preschools will be selected which are Tabika Kemas Rumah Pangsa Kampung Padang, Tadika Kemas Kampung Padang A and Tabika Kemas Kampung Padang B. The classroom will be occupied with the students and other occupants during the discussion or learning process. Furthermore, in this study the total students that will be involved in a classroom are about 15 to 20 students in each preschool and the mechanism that were used is fan. The parameter that will be used in this study based on thermal comfort are air temperature (Ta), mean radiant temperature (Tmrt), air velocity (V) and relative humidity (Rh). In addition, the predicted mean vote (PMV) index and

predicted percentage dissatisfied (PPD) index will be calculated by using CBE thermal comfort tools. The software that will be used is the latest edition which is version: 2.3.2.

## 1.5 Significance of Study

Nowadays, thermal comfort is important to enhance the quality of life and health towards everyone especially students. This element is needed for better surroundings during the process of teaching and learning. The results of this study are expected to provide ideas for stakeholders to improve the infrastructure of the kindergarten in the future. The data shows that high ambient temperature in the classroom will cause students to loss focus while learning. It can cause their academic achievement will be affected. In conclusion, the significance of this study will lead to increased student productivity in the learning process in the classroom.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Thermal comfort and Indoor Air Quality (IAQ) is a remarkable issue that were frequently arise related to comfortability (Merabtine et al., 2018). Comfort is the most important aspect for the environment and occupants. It is very crucial because people need comfort in doing an activity no matter where they are, whether indoor or outdoor. For example, students at school, employees working in the office or a rider. They need suitable attire to make them feel comfortable. The building where the occupants stay in is very important to have a good environment. For example, suitable temperature is needed for them to be comfortable in the building area. In this chapter it will cover the summarized of previous research and information about thermal comfort and Fanger model.



## 2.2 Preschools in Malacca

In Malaysia, the total of preschools in this country are 6,214 while in Malacca 170 and it include in urban and rural area according to Ministry of Education, 2021. The purpose of the preschool is to provide the learning experience towards the students to develop their basic skills such as in learning and exploring before entering primary school. The age of administration for the student to enter the preschools are starting from four years old to six years old based on Ministry of Education,2021. This type of institution basically based on two sectors which are government institution and private institution. Figure 2.1 below show the percentage of children (under age 18 years), by state in Malaysia.


Figure 2.1 Percentage of children (under age 18 years), by state, Malaysia, 2020

(Department of Statistics Malaysia,2020)

The location of the preschools usually located on the roadside, residential area or even in school area. Basically, the students will be sent to the preschools by their parents on their way to their workplace and they will pick up their children in the evening. Most parents will send their children in a private institution rather than in government institution. This is because they want their children feel more comfortable during the learning process. For instance, in private kindergarten they will include an air conditioning system in the class so they can do any activities in comfort rather than in government institution which they only using fans.

For an educational purpose, the environment and comfortability towards a classroom is very important for teaching and learning process. Basically, if the kindergarten were surrounded with high level of noise pollution it can affect the concentration of the children's (Series & Science, 2017). Figure 2.2 below illustrate the number of registered childcare center in Malaysia in 2018 and 2019.

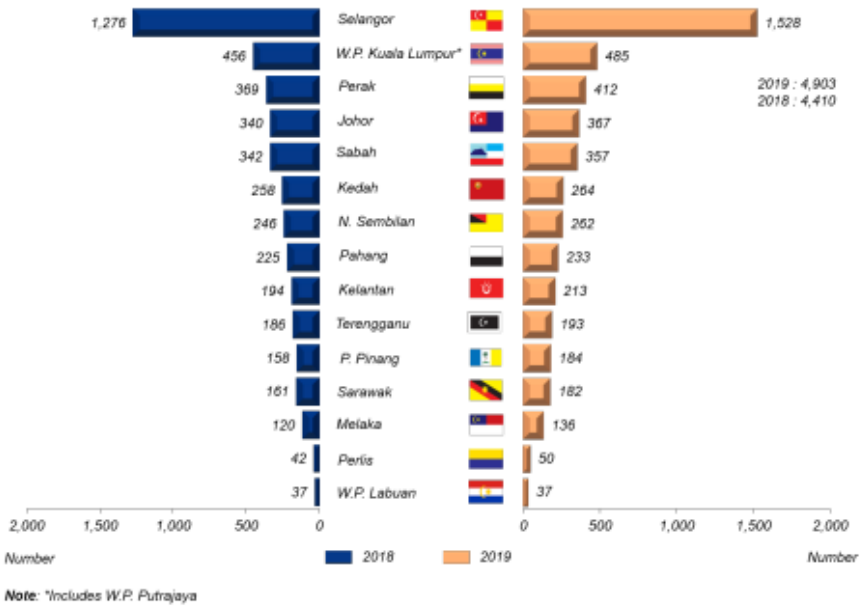


Figure 2.2 Number of registered childcare center by state, Malaysia, 2018 and 2019 (Department of Statistics Malaysia, 2020)

## 2.3 Description of Thermal Comfort

The American Society of Heating, Refrigeration and Air - conditioning Engineers, (ASHRAE, 2010) stated that thermal comfort is a condition of mind that express satisfaction with thermal environment and it is assessed by subjective evaluation. Thermal comfort is a very important in all aspects and it is related to productivity and health. Generally, poor thermal comfort usually will lead towards less productivity, health problem and little thermal satisfaction of the occupant The average of human temperature is about 37℃ as human is a constant temperature species. An individual usually will feel better when surrounding temperature between 23℃ to 26℃ while the relative humidity is 40% to 70% according to (DOSH, 2010).

Thermal comfort in a classroom is important to an academic performance (de Abreu-Harbich et al., 2018). Thermal comfort affects children health and comfort. Setting the temperature to meet the children needs. Because they prefer a lower temperature. They are more sensitive to higher temperature than adult. The students spend most of their time in the classroom. According to (Jiang et al., 2018) discomfortness correlated with surrounding temperature which is hot or cold so it will give a negative effect on the well - being of occupants. It also will be noticeable when the environments are colder.

In a tropical climate region such as Malaysia, an intensive cooling capacity is needed to make the occupants feel comfortable in a building since the climate in Malaysia is hot and humid at the same time. Each person had a different thermal comfort which it is very difficult to satisfy everyone's needs because of their preferences. Discomfort will happen towards peoples where there is a circumstance such as the surrounding conditions is too cold or too hot. As a student, a suitable thermal environment for a classroom in educational building will affect the thermal comfort. Student spends most of their time in the class to studies and it is reveal that the student achievement correlated with thermal comfort (Jing et al., 2019)



Moreover, ventilation improves the thermal comfort level of occupied area by providing a heat transport mechanism and decreasing the air temperature (Mohamed Kamar et al., 2019). There are several type of ventilation method to control the air distribution towards the building to give a satisfactory level of thermal comfort which are natural, mechanical and hybrid (Buonocore et al., 2020). In Malaysia, most of the buildings using a natural ventilation and mechanical fans to deliver fresh air and removing the air to increase the thermal comfort.

Furthermore, the clothing that the students wear also can cause a discomfort when it is too thick or thin. So, they need to wear a comfortable cloth based on the surroundings condition to avoid any inconvenience. In Malaysia, the clothes worn by the students have been set by Ministry of Education according to the comfortability on the tropical climate which is hot and humid weather in the country. This is because the clothes that were worn will affect the learning process, ability and motivation in participating academic in school. In addition, a comfortable cloth can give better environment towards students during studies. Thus, their performance during exam will increase as they can get good attention and concentration during learning.

## 2.4 Factors that affect the thermal comfort

According to (Schaudienst & Vogdt, 2017) in thermal comfort, there are six main parameter that gives dimensions to any unique thermal condition. It can be classified into environmental factor and personal factor. The properties for environmental factor are air velocity (V), relative humidity (RH), air temperature (Ta) and mean radiant temperature (Tmrt). While for personal factor the condition are clothing insulation and metabolic rate. These factors may be independent to each other, but it will contribute towards the occupant's thermal comfort. To achieve optimum thermal comfort for occupants in a building, the aspects will be discussed below.

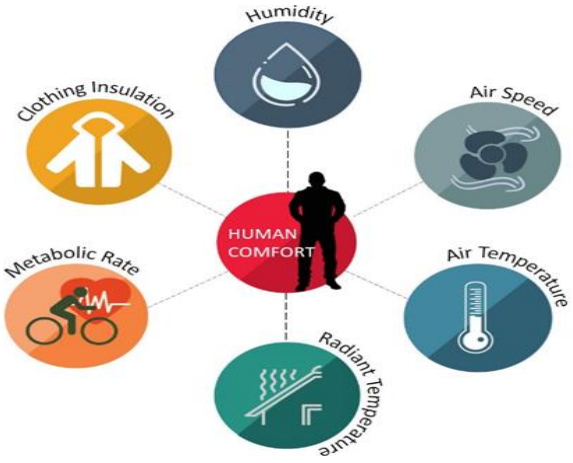


Figure 2.3 Factors that influence thermal comfort (Sources: https://www.linkedin.com/pulse/role-cfd-evaluating-occupant-thermal-comfort-sandip-jadhav/)

Air velocity is the main factor of thermal comfort because humans are sensitive towards air velocity. Air velocity is defined as the rate of air movement at appoint, without regard to direction. Furthermore, air velocity makes a big impact on comfort level towards the occupants. Based on (ASHRAE, 2010) it is the average speed of the air to which the body is exposed, with respect to distance and time. High speed of air moving will cause the occupants feel cool because the faster the air moves, the greater the heat exchange based on (Priya & Kaja, 2016). Moreover, activity that can increased the air movement is physical activities such as walking, cycling, dancing or swimming.

Second parameter is relative humidity (RH). Based on (Senin & Mydin, 2013) the definition of relative humidity can be defined as the quantity of moisture that carried in the air will affect the amount of certain temperature. In addition, if the relative humidity value is lower than 25%, the surrounding air will be dry and uncomfortable while if the humidity above 60 % it will feel uncomfortably humid. According to (Wolkoff & Kjærgaard, 2007) it

is suggested that the level of indoor humidity range is between 30% to 60% in air-conditioned buildings. In adaptive model, it will accept lower and higher humidity depend on other factor which involve in thermal comfort. As a result, when the relative humidity is high it can prevent the evaporation of sweat from the skin. It is because of increment of vapor in the air releasing of sweat is the main cause of heat reduction.

Third parameter in environmental factor for thermal comfort is air temperature (Ta). Air temperature is defined as changes of temperature towards human body through surrounding of air. The temperature that will be used usually in degree Celsius (℃) and it will be different for individuals, but it needs to be maintained at 37℃. Optimum for average indoor temperature needs to be around 23℃ to 26℃ (Jamaludin et al., 2015). Human is more affected to the variations of temperature compared to relative humidity and it has a significant effect on its occupancy (Mazlan et al., 2020). However, it should be taken into consideration for other factors too.

Mean radiant temperature has a greater influence than air temperature based on how the heat gain or lose towards the environment. Based on (ASHRAE standard 55-1992), mean radiant temperature is a constant temperature of an imaginary room at which the radiant heat transfer from a human body will be balanced by surrounding. For example, in an occupied space temperature of floor and walls will be close to the air temperature. As stated before, radiant temperature of surrounding nearly equal in all direction and same as the air temperature.

Clothing insulation is important towards an individual. It is to keep an individual warm or overheating which they need to wear layers of clothing to prevent heat loss. If the garments do not have enough insulation, the wearer can get an injuries like frostbite or

hypothermia. Outdoor temperature has been seen as the most critical factors that affect people's clothing insulation according to (W. Zhao et al., 2019). The relationship between activity and the clothing insulation can affect the thermal comfort of an individual. A numerical representation of clothing is known as "clo" and it acts the same as thermal resistance: 1 clo = 0.155 $m^2K/W$. Based on the Figure 2.4 below show the insulation of clothing in clo units according to type of garments while Table 2.1 and 2.2 is the checklist for clothing garment and undergarments in clo units.


Figure 2.4 Insulation of clothing in clo units

(Sources: https://edplondon.weebly.com/activity/human-comfort )



Table 2.1 Undergarments in clo values (ASHRAE Standard 55 - 2010)

| Clothing | Clo |
|---|---|
| Bra | 0.01 |
| Panties | 0.03 |
| Men's briefs | 0.04 |

Table 2.2 Garments checklist and insulation (clo) values (ASHRAE Standard 55 - 2010)

| Clothing | Light weight | Medium weight | Heavy weight | Description from ASHRAE Standard 55 - 2010 |
|---|---|---|---|---|
| Dress | 0.33 | 04 | 0.47 | Long – sleeve shirtdress (thin and thick) |
| Skirt | 0.14 | 0.19 | 0.23 | Skirt (thin and thick) |
| Long sleeve sweater | 0.25 | 0.3 | 0.36 | Long – sleeve (thin and thick) |
| Short sleeve shirt | 0.19 | 0.24 | 0.28 | Short sleeve dress shirt |
| Long sleeve shirt | 0.25 | 0.3 | 0.34 | Long - sleeve dress shirt and Long - sleeve flannel shirt |
| Pants | 0.15 | 0.2 | 0.24 | Straight trousers (thin and thick); 3 for jeans |
| Sleeveless sweater / vest /waistcoat | 0.13 | 0.18 | 0.22 | Sleeveless vest (thin and thick) |
| Jacket | 0.36 | 0.4 | 0.44 | Single - breasted (thin and thick) |
| Shawl | 0.27 | 0.3 | 0.35 | |
| Shorts | 0.08 | 0.13 | 0.17 | Walking shorts |
| Socks | 0.03 | 0.05 | 0.06 | Calf- length socks, Knee socks (thick) |
| Shoes | 0.02 | 0.06 | 0.1 | Shoes and Boots |
| Stockings | 0.02 | 0.04 | 0.06 | Pantyhose/stockings |
| Tie | 0.01 | 0.03 | 0.05 | |
| Scarves | 0.06 | 0.1 | 0.15 | |

Metabolic rates defines as the level of transformation of chemical energy into heat and mechanical work according to (ASHRAE, 2010). When an individual did some activities, it does not matter whether the activities produce sweat or just sitting and doing nothing we can measure the activity level by metabolic rate. Metabolic rate is measured as 1 met = 60 w/m² or 18.4 Btu/hr-ft². Toftum, 2005 stated that metabolic rates of an individual

rate are different based on the activities level or environmental condition. For example, individual that does not do any activity will feel cold cause they consume less energy rather than a person who moves all day doing some activities. Figure 2.5 represent typical metabolic rates for specific activities.


Figure 2.5 Typical metabolic rates for activity (Source: https://www.simscale.com/blog/2019/08/what-is-ashrae-55-thermal-comfort/ )



## 2.5 Indoor Air Quality (IAQ)

Both thermal comfort and air quality can have an important impact on productivity of an individual (Daghigh, 2015). In general, IAQ has a significance impact on health and quality of life that could affect an individual. A clean and clear air quality is needed as 80% to 90% populations. Better indoor air quality could protect the health of occupants in the building and contributes to their comfort. Poor air quality can affect a person comfort and performance towards working environment especially school. For the IAQ analysis, relative humidity usually measured since it's also important because it affects perceived comfort of the

IAQ, cause of symptoms like eye irritation and airway discomfort can give an effect in work performance in terms of physical and emotional (Wolkoff, 2018).

Based on Department of Occupational Safety and Health (DOSH), a poor condition can affect the occupant health such as headache, nausea, sore throat, eyes and skin irritation. Furthermore, according to (Wang et al., 2015) a comfort indoor environment can affected the learning process and motivation toward the students. It will cause the students to experience the difficulty to concentrate, memorize and think due to this health issues. Table 2.3 below shows the acceptable range for specific physical parameter according to Department of Occupational Safety and Health.

Table 2.3 Acceptable range for specific physical parameters (DOSH,2010)

| Parameter | Acceptable range |
|---|---|
| Air temperature | 23℃ – 26 ℃ |
| Relative humidity | 40 m/s – 70 m/s |
| Air movement | 0.15 m/s – 0.50 m/s |



## 2.6 Effects of thermal comforts towards the occupants

### 2.6.1 Decreased productivity

Thermal comfort has a strong influence on occupant productivity. Based on the paper stated by (Kaushik et al., 2020) the surrounding temperature influenced the occupant productivity. The optimum temperature comfort range for an occupant in a building are between 21℃ to 25℃. If the temperature increases above the 25℃ the productivity of the occupants will drop. According to (Lipczynska et al., 2018) there is a complaint from the occupant about thermal discomfort due to the low productivity in the building.

According to (Rosenlund, 2000) the productivity of a building can be increased by 5% - 10% just by enhancing the indoor air quality. Key for successful building performance depends on building productivity. Fanger (2005) reported residents spend more time in buildings with better thermal comfort and indoor air quality. Nowadays, cafeteria has been one of the attractive spots for student to study compared to library. This is because they provide better facilities to settle down such as better Wi - Fi connection, air conditioning, table and chair while having a meal at the same time at one place.

### 2.6.2 Poor performance and health psychology

If there is an increment of individual that will be occupy into the same building space, the performances of the building will be progressively reduced without specific method to regulating the temperature. Student that was seating or have a great access through the windows area or daylight will acquire 7% to 18% higher scores that other students according to (Heschong,2002). Thus, the students that having a discussion or studying at the cafeteria will have more comfortable situation by having a good ventilation and open space at the outdoor of the cafeteria while the daylight can be penetrate through the cafeteria. This is because, if an individual staying for a longer time without proper ventilation indoor it can cause health problems. According to (Senin & Mydin, 2013) it is reported that indoor environment naturally influenced human health such as allergy, asthma, headaches, respiratory illness and productivity.



Furthermore, an indoor environment was able to do satisfactory thermal comfort through natural ventilation. The strategies that can be used to achieve thermal comfort towards indoor environment is by having better wind speed (more than 1 m/s) and using having good designs, material and shading devices according to (Senin & Mydin, 2013). High wind speed will provide good ventilation towards an individual. For the design stage,

we must make sure that the design and materials used is good and the ventilation must have a great air flow pattern. By using this solution, the temperature can be decreased by 2℃ - 3℃.

## 2.7 Thermal comfort model

The study of thermal comfort had been continuously performed since 1960 to 1970 by Fanger and have been changed from qualitative to quantitative research (Q. Zhao et al., 2021). There are two different model that can be used which are the Fanger model (PMV/PPD) and the adaptive model. This model provide better thermal comfort and has been used by different type of working space (Mohamed Kamar et al., 2019).

### 2.7.1 Fanger model

The man who created Fanger model was Povl Ole Fanger. According to Fanger, human comfort was measured by individual skin temperature and their sweat production. By having these factor, it would make them feel comfortable because our body can modify the temperature through spontaneous responses. For example, someone who is shivering due to cold temperature or sweating during hot conditions can be modified by body core temperature and avoid local discomfort.



Fanger model is the most important variable which affecting the thermal sensation. This models were suggested by Fanger is useful for measuring thermal comfort in close environments according to (Koelblen et al., 2018). For instance, when the occupants are having long working or academic schedules, we can plan for an alternative improvement. This model is producing a very close result to the real ones if the values is not varying. The value that can be produce based on this model are Preventive Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD).

Predictive Mean Value is a proposed by Fanger and it is a mathematical model or an equation which correspond the thermal comfort with surrounding environment. From the equation, the comfort zone factors can influence the value of the thermal sensation include clothing insulation, metabolic rate, air velocity and mean radian temperature while PMV equal to zero show thermal neutrality. In addition, the value for PMV recommended limit is -0.5 < PMV < +0.5 according to (Hasan et al., 2016). The PMV is defined as an index to predict the mean value of a larger group of persons on the seven points of thermal sensation scale (Mohamed Kamar et al., 2019). It can be measured based on the seven – point thermal sensation scale from -3 (cold) to +3 (hot) as shown in Table 2.4 below:

Table 2.4 ASHRAE seven - point thermal sensation scale

| Thermal sensation | Description |
|---|---|
| +3 | Hot |
| +2 | Warm |
| +1 | Slightly warm |
| 0 | Neutral |
| -1 | Slightly cool |
| -2 | Cool |
| -3 | Cold |



Equations that were developed following the correlation between PMV and thermal load shown below:

$$PMV = (0.303\exp{-0.0336M} + 0.028) \times \{(M - W) - 3.5 \times 10{-3}\,[5733 - 6.99\,(M - W) - pa] - 0.42(M - 58.5) - 1.7 \times 10{-5} \times M\,(5867 - pa) - 0.0014M\,(34 - ta) - 3.96 \times 10{-8}\, fcl\,[(tcl + 273)4 - (tr + 273)4] - fcl \times hc\,(tcl - ta)] \quad (1)$$

Where:

M: is the metabolic rate, in Watts per square meter of the body surface area

W: is the effective mechanical power, inWatts per square meter, equal to zero for most activities

fcl: is the ratio of surface area of the body with clothes to the surface area of the body without clothes

ta: is the air temperature, in degree Celsius

tr: is the mean radiant temperature, in degree Celsius

Pa: is the water vapor partial pressure, in Pascal

hc: is the convective heat transfer coefficient, in Watts per square meter degree Celsius

tcl: is the clothing surface temperature, in degree Celsius

L = Thermal load (the difference between the internal heat production and the heat loss to the actual environment - for a person at comfort skin temperature and evaporative heat loss by sweating at the actual activity level.



Based on PMV we can predict the thermal sensation of a population, but it does not paint the whole picture. It is because we need to consider the level of satisfaction of occupants in an area and how thermal comfort could be achieved. To relate the Predictive Mean Vote (PMV) with Predicted Percentage of Dissatisfied (PPD), Fanger is developing another equation. It is to indicate the percentage of people who is uncomfortable towards the surrounding environment based on (Ekici, 2013). PPD is a quantitative prediction which apply towards the occupants who feel too cold or too warm which causing discomfort or dissatisfied (Fang et al., 2018). That is specifically what the PPD index is planned for. The PPD is found as a function of the PMV from the equation below:

$$PPD = 100 - 95\ X\ e^{(-0.3353\ x\ PMV^4 - 0.2179\ x\ PMV^2)} \quad (2)$$

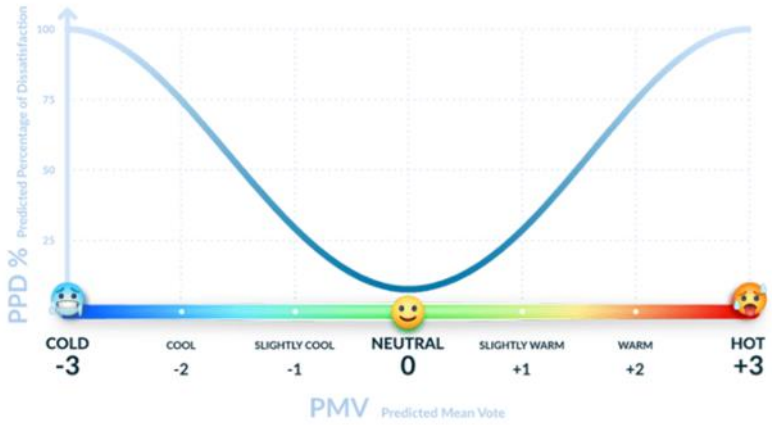


Figure 2.6 PPD as a function of PMV (Source: https://www.simscale.com/blog/2019/09/what-is-pmv-ppd/ )

Based on Figure 2.6 above, it shows an empirical relationship between the percentage of people dissatisfied (PPD) with thermal environment as function of the PMV. The PPD can be range between 5% to 100%, depend on the calculation of PMV. This value can be change depending on where and when the occupant is in the building. At least approximately 5% of people in a group will be dissatisfied with the thermal climate even with PMV = 0 based on (Kralikova et al., 2014) . If the PPD index fall below 5% it will be not accepted as part of PMV. This is because the difference in thermal sensation and thermal neutrality between individuals is different and not identical.

## 2.8 CBE Thermal Comfort Tool

CBE Thermal Comfort Tool is a free online tool that can be used to perform thermal comfort calculations and visualizations that complies with the ASHRAE 55 -2017, ISO 7730:2005 and EN 16798 -1:2019 Standards (Tartarini et al., 2020). This web application is created with JavaScript, HTML and CSS (Schiavon et al., 2014). Moreover, this web application is freely available via following URL: https://comfort.cbe.berkeley.edu/. This is

a latest version of CBE Thermal Comfort Tool which is version: 2.3.2. In this software, it can be used to calculate various type of thermal comfort model such as Predicted Mean Vote (PMV), adaptive comfort model, Standard Effective Temperature (SET), discomfort model and many more.

By choosing the PMV method there are six inputs that need to be key in based on thermal comfort factors which are environmental factors and personal factors. Based on this tool it is divided to three main parts which are User interface, Outputs and Chart. Figure 2.7 represent CBE Thermal Comfort Tool home page. This tool can be used to predict the occupant comfort and to verify the compliance with the standards and comfort requirements.

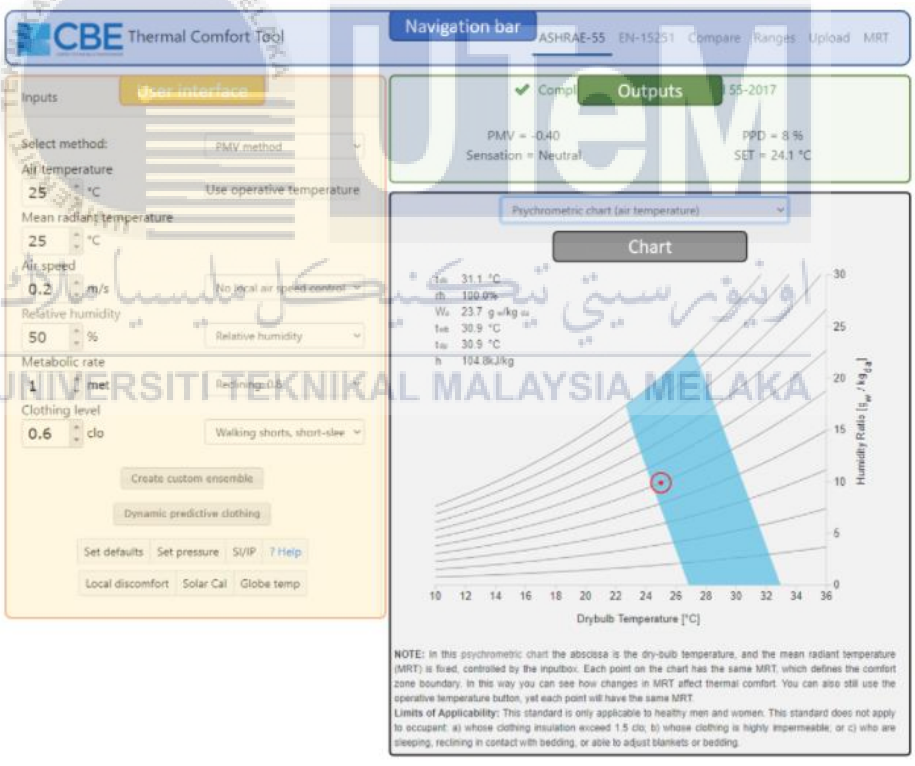


Figure 2.7 CBE Thermal Comfort Tool home page

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

In this chapter, the proposed methodology is to represent the method that will be applied to achieve its purpose of this study. The analysis of the thermal comfort based on the selection of parameters and the result will be analyzed by CBE Thermal Comfort Tool. A research flowchart is developed to make the flow of the analysis moves smoothly and efficient to perform the research in Figure 3.1.

## 3.2 Research design

An experimental study and observational study were conducted in order to evaluate the thermal comforts towards preschool students. The experimental study was conducted by comparing different location of preschool in Malacca. This evaluation was carried out by different parameters to determine the indoor thermal data and monitor the amount of dust particle. The data was monitored using TSI Velocicalc and TSI Dust Trax.

Meanwhile, observational study was conducted by walkthrough observation to observe the indoor comfort among the preschool's students during their learning process and to determine the existence of ventilation. Besides, the questionnaire will be asked orally to evaluate their thermal discomfort during their learning process.

## 3.3 Research Flow

This study was started with the site selection, where three different location of preschools was chosen to evaluate the thermal comfort among the students during teaching and learning process. After that, walkthrough observation was carried out to achieve the first objective, which is to investigate selected parameter of indoor thermal data at three preschools in Malacca.

Then, two types of method were used which are questionnaire entitled "Level of thermal comfort" adapted from ASHRAE Standard (2010) "Thermal Environment Conditions for Human Occupancy" (Refer Appendix C). Next, area monitoring and personal monitoring were conducted to achieve the first and second objective which is to determine indoor thermal comfort PMV and PPD level using CBE Tool.

After obtaining all the data and information required for this study, all the data were analyzed using Statistical Package for the Social Sciences, SPSS software. The data that has been analyze then being interpreted to achieve the level of thermal comfort of the preschools. Lastly, the results from the analysis of data were documented.

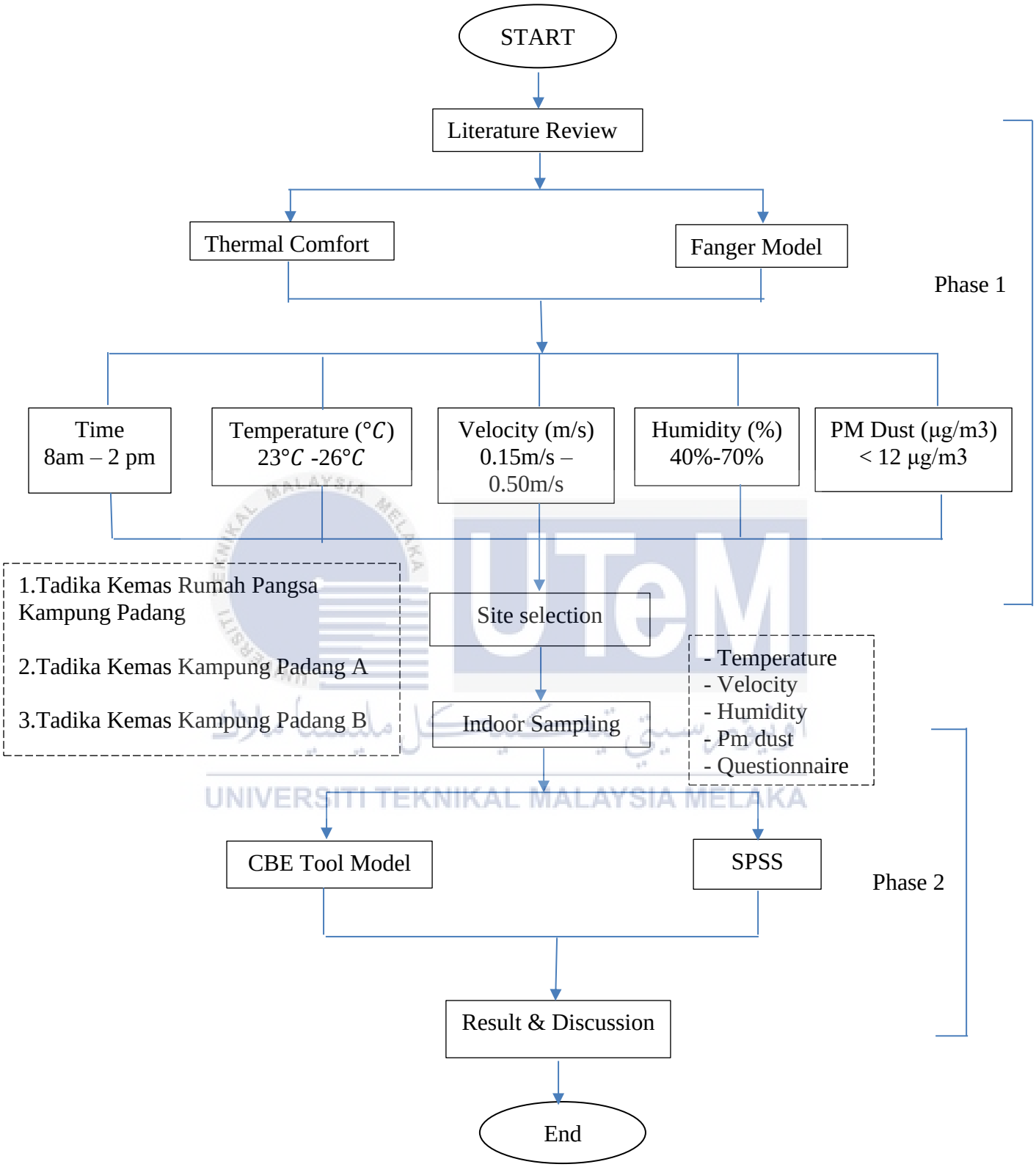


Figure 3.1 Research Flow Chart

## 3.4 Site visit selection.

This study was focused on preschools located at Kampung Padang, Malacca. The locations of the preschools will be at three different locations. These preschools tend to expose to the sources of heat during their learning process. Moreover, the air and noise pollution will be transmitted towards students. These kinds of pollutions might cause the students to suffer fatigue and thermal discomfort. Figures 3.2, Figure 3.4 and Figure 3.6 below illustrates the layout while Figure 3.3, Figure 3.5 and Figure 3.7 shows the locations of the preschools in different location for this research.

a. Tabika Kemas Rumah Pangsa Kampung Padang.

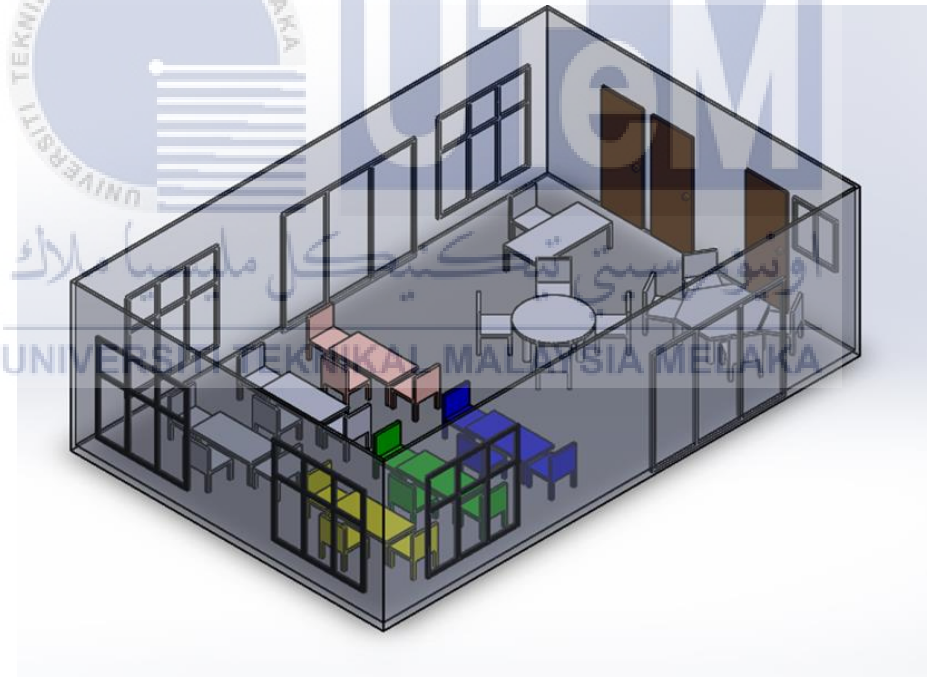

Figure 3.2 Layout building for Tabika Kemas Rumah Pangsa Kampung Padang, Malacca.


Figure 3.3 Location of Tabika Kemas Rumah Pangsa Kampung Padang

Table 3.1 Specifications of layout building of Tadika Rumah Pangsa Kampung Padang

| No | Part | Quantity | Dimension |
|---|---|---|---|
| 1 | Operation hours (7.30 am – 14.30 pm) | - | - |
| 2 | Popoulation | 16 | - |
| 3 | Area | - | W= 6.24 m, L = 9.57 m<br>Area = 59.71 $m^2$ |
| 4 | Ceiling height | - | H = 287 cm |
| 5 | Sliding door<br>1 Door : 90 cm x 208 cm | 2 | W = 270 cm, H = 208 cm |
| 6 | Wooden door | 3 | W = 83 cm, H = 210 cm |
| 7 | Window A (2 door)<br>1 Door : 44 cm x 90 cm | 1 | W = 88 cm, H = 90 cm |
| 8 | Window B (3 door)<br>1 Door : 62 cm x 178 cm | 5 | W = 186 cm, H = 178 cm |
| 9 | Chair | 27 | H = 50 cm |
| 10 | Hexagon desk | 1 | D = 122 cm |
| 11 | Circle desk | 1 | D = 120 cm |
| 12 | Rectangular desk | 6 | W = 60 cm, L = 121 cm |
| 13 | Teacher's desk | 1 | W = 70 cm,L =150 cm |

b. Tabika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka, 75250.

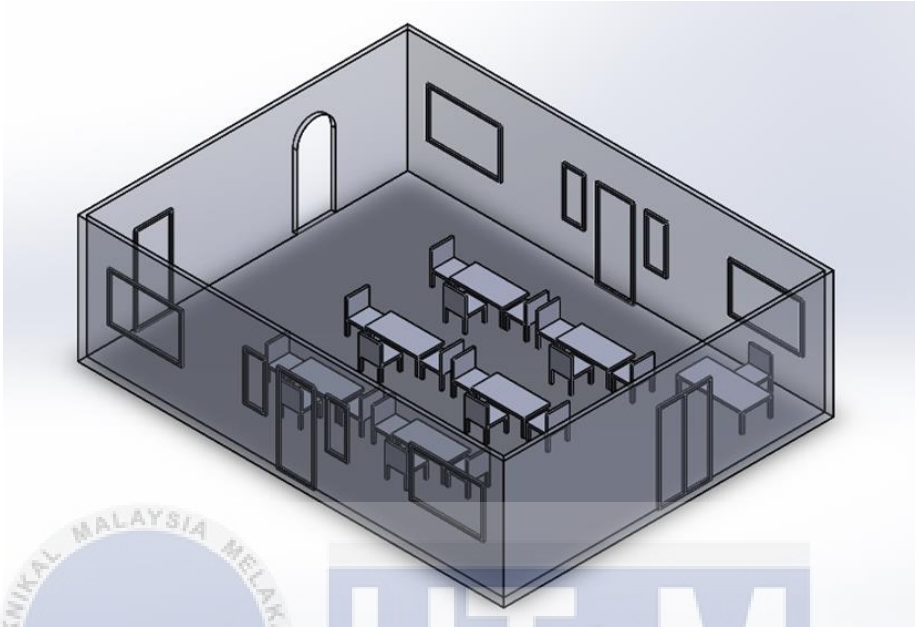

Figure 3.4 Layout building for Tabika Kemas Kampung Padang A


Figure 3.5 Location of Tabika Kemas Kampung Padang A

Table 3.2 Sepecifications of layout building of Tadika Kampung Padang A, Malacca

| No | Part | Quantity | Dimension |
|---|---|---|---|
| 1 | Operation hours (7.30 am – 14.30 pm) | - | - |
| 2 | Population | 15 | - |
| 3 | Area | - | W = 9.65 m, H = 7.45 m<br>Area = 71.89 $m^2$ |
| 4 | Ceiling height | - | H = 290 cm |
| 5 | Window A | 4 | W = 170 cm, H = 112 cm |
| 6 | Window B | 4 | W = 50 cm, H = 112 cm |
| 7 | Door A | 1 | W = 86 cm, H= 203 cm |
| 8 | Door B (2 door)<br>1 Door : 61 cm x 203 cm | 1 | W = 122 cm, H = 203 cm |
| 9 | Door C | 1 | W = 80 cm, H = 203 cm |
| 10 | Chair | 19 | H = 50 cm |
| 11 | Student's desk | 6 | W = 60 cm, L = 121 cm |
| 12 | Teacher's desk | 1 | W = 70 cm , L = 170 cm |

c. Tabika Kemas Kampung Padang B, Batu 3 ½, Kampung Padang, Melaka, 75250.

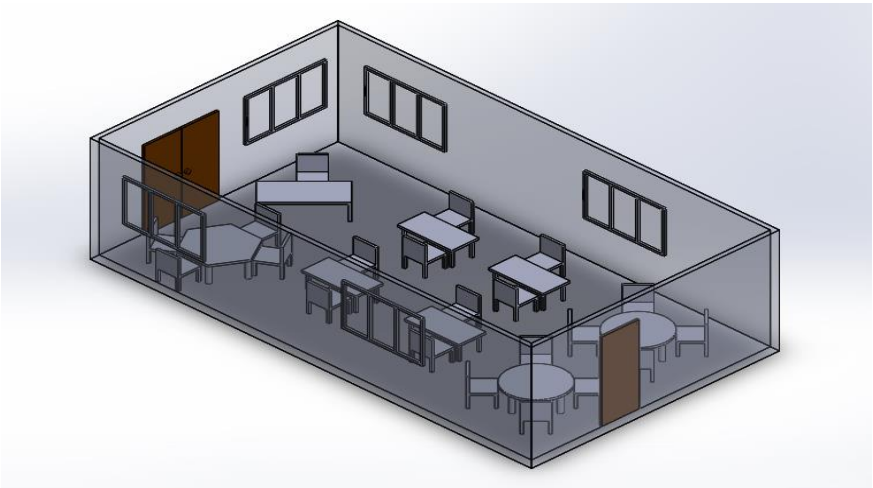

Figure 3.6 Layout building for Tabika Kemas Kampung Padang B


Figure 3.7 Location of Tabika Kemas Kampung Padang B

Table 3.3 Specifications of layout building of Tadika Kampung Padang B, Malacca

| No | Part | Quantity | Dimension |
|---|---|---|---|
| 1 | Operation hour (7.30 am – 14.30 pm) | - | - |
| 2 | Population | 16 | - |
| 3 | Area | - | W = 9.73 m, H = 5.42 m<br>Area = 52.73 $m^2$ |
| 4 | Ceiling height | - | H = 284 cm |
| 5 | Window A (3 door)<br>1 door : 60 cm x 120 cm | 2 | W = 180 cm, H = 120 cm |
| 6 | Window B (3 door)<br>1 door : 60 cm x 112 cm | 3 | W = 180 cm, H =112 cm |
| 7 | Door A (1 door) | 1 | W = 88 cm, H = 120 cm |
| 8 | Door B (2 door)<br>1 Door : 60 cm x 120 cm | 1 | W = 120 cm, H = 120 cm |
| 9 | Chair | 20 | H = 50 cm |
| 10 | Circle desk | 2 | D = 120 cm |
| 11 | Hexagon desk | 1 | D = 122 cm |
| 12 | Rectangular desk | 4 | W = 60 cm, L = 121 cm |
| 13 | Teacher's desk | 1 | W = 70 cm, L = 150 cm |

### 3.5 Indoor sampling

All the students will be participated as a respondent in this research. They are around 15 – 20 students for each preschool and the total respondents will be 45 – 60 respondents. According to (DOSH, 2010) it is stated that the measurement of the parameter should be made on 8-hour basis excepted otherwise specified. Although the operating hours at preschool is running for four hours with the students are from 8 am to 12 pm, the data that will be collected from the preschools are around 8 am to 2 pm.

In this research, data sampling of the parameter will be monitored by using TSI Velocicalc and TSI Dust Trax. The reading of the parameters will be taken for six hours then the data will be generated out. From the collected data, the reading of four parameter will be generated out and the data will be analyzed in CBE Thermal Comfort Tool and SPSS. As for the questionnaire, the question will be asked verbally at 9.30 a.m. simultaneously in three different preschools. It is to ensure that the data will be uniform and consistent.



The selection of parameter for this study will be essential element in IAQ standard. First, the air velocity (V) was used to ensure that the humidity within the classroom does not exceed the requirements of any machine or device to operate within the confine space. Second, it would be the mean radiant temperature (Tmrt). It is to measure the average temperature of the surface. Next parameter is air temperature (Ta). The air temperature is very important in this research because it can influence the thermal comfort of the student in the classroom whether it is cold or hot condition. Relative humidity (Rh) was used to control the moisture to maintain a comfortable environment in the building.

All the findings through this studies will be referring to the recommended from (DOSH, 2010). Based on Table 3.1 it is stated that the recommended minimum number required for sampling points for indoor air quality assessment towards a building. However, the recommended number of sampling points depends on the type and nature of the buildings and addition sample should be taken if necessary.

Table 3.4 Recommended minimum number of sampling for indoor air quality

| Total floor area (served by MVAC systems) ($m^2$) | Minimum number of sampling |
|---|---|
| <3,000 | 1 per 500$m^2$ |
| 3,000 < 5,000 | 8 |
| 5,000 < 10,000 | 12 |
| 10,000 < 15,000 | 15 |
| 15,000 < 20,000 | 18 |
| 20,000 < 30,000 | 21 |
| ≥ 30,000 | 1 per 1,200$m^2$ |



## 3.6 Software (CBE Thermal Comfort Tool)

In this study, the data will be collected at different time between 8.00 am to 2.00pm where it is the interaction hours for teaching and learning process at the preschool. The data collection was provided (Refer APPENDIX C, APPENDIX E and APPENDIX G) based on different parameters by using TSI Velocicalc.

After all the data were taken using TSI Velocicalc, then the values of PMV and PPD will be analyzed for thermal comfort by using CBE Thermal Comfort Tool. Based on the CBE tools, the inputs that need to be filled in are the thermal comfort factors, such as Ta, Tmrt, V, RH, metabolic rate, and clothing level. After the data have been filled in inputs section, the data of PMV, PPD, SET and sensation level will be shown whether it is complies with ASHRAE Standard.

Based on Figure 3.8 below shows the example of the result when the data were analyzed by CBE Thermal Comfort Tool. In addition, by using this software, it can ease the users in term of saving time and simplicity. It is because we just need to key in the data at the parameters provided without using the formula and calculate manually as the thermal comfort results will be shown at the output and psychometric chart section.

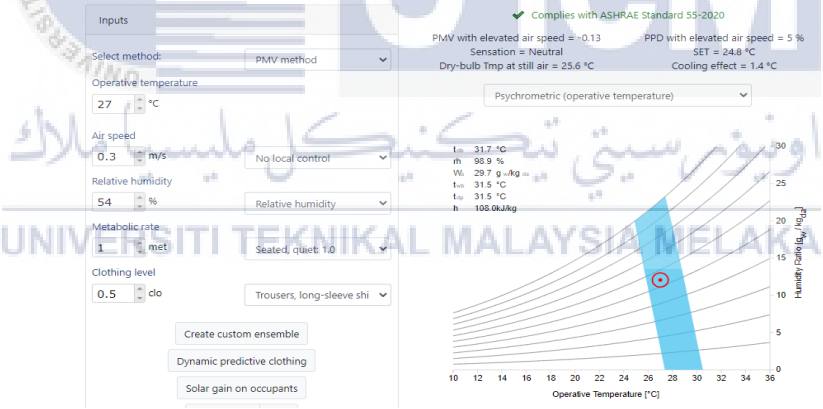


Figure 3.8 PMV method selection

## 3.7 Instrumentation

For area monitoring, the environmental parameters which are air temperature, humidity, air speed and radiant temperature were measured by using TSI Velocicalc. In the other hand, a dust monitor TSI Dust Trax were used to measures both mass and size fraction of dust particle. Both of this instrumentation will be running from 8 a.m to 2 p.m. Meanwhile, thermal comfort towards preschools students which is their comfortness and their feeling was determine using the questionnaire "Evaluation of thermal comfort towards students in their preschool" based on ASHRAE standard.

Table 3.5 Measuring instruments

| **Type of Parameter** | **Name Of Parameter** | **Instruments** |
|---|---|---|
| Environmental parameters | Relative humidity | TSI Velocicalc |
| | Air temperature | |
| | Air velocity | |
| | Mean radiant temperature | |
| | Dust particle | TSI Dust Trax |
| Student's General Information | | Questionnaire Form |



## 3.8 Data Collection Technique

Data collection was collected in November 2021 by conducting pilot study, distributed questionnaires and area monitoring.

### 3.8.1 Pilot Study

Before getting the responds from the students, a pilot study was carried out first. This pilot of study enables to estimate the suitability and feasibility of the actual study. In the beginning of the pilot study, face to face interview was conducted with the respondents. The purpose of this study is to explain the purpose of conducting the question to make sure that they understand about this study. Moreover, any errors that might influence the results obtained during pilot study can be used for the improvement during conducting the actual study so that actual study can be conducted smoothly and accurately.

### 3.8.2 Questionnaire

The questionnaires used in this study consist of ten (10) questions adapted from ASHRAE Standard (2010) which is thermal environment conditions for human occupancy. Level of Thermal Comfort Questionnaire (Refer Appendix I) will be divided into two section which are the section 1 consists of general information such as name, age and gender. Meanwhile, section 2 will be determined the thermal comfort of the students in the classroom. As for the weight and height, the information has been given by the teacher who was in charge at the preschool. A person's comfort level can be considered as affected by fatigue, excessive sweating, tiredness or headache. The results obtained from the questionnaire were used to determine the whether the condition in the preschool building were comfortable for teaching and learning or not.

### 3.8.3 Area Monitoring

For area monitoring, TSI Velocicalc was used to determine the environmental parameter while TSI Dust Trax was used to measure the dust particles in the classroom. During conducted area monitoring, the instruments were place at the height of 0.5 meter on

the table at the center of the class. Each probe was mounted at 1 meter height at the tripod to avoid anything that can block the airflow. Figure 3.6 and Figure 3.7 shows TSI Velocicalc and TSI Dust Trax.

During the class session, the activities that were done by the students are reading, writing, eating and drinking. The students were also provided with 2 times of short break, about 15 minutes at 8.15 a.m and 10.15 a.m. Therefore, the students have adequate rest time during their school's session.

The type of clothing worn by the students was evaluated during the course of these studies. It was found that, the students in the preschools wore cloths in short sleeves and long sleeves according to their gender. Short sleeves for males' students while long sleeves for females and they will be wearing a long pants. Other than that, some of the students were wearing a socks, scarves and skirts. The type of clothing or clothing insulation (clo) worn during learning process is very crucial as it can affect the comfortness of the students.



Figure 3.9 TSI Velocicalc

Figure 3.10 TSI Dust Trax

### 3.8.4 Background Information of Respondents

Table shows the background information of respondent in this research. The total respondents from three different preschools consist of 47 students. The ages of these students are from 4 to 6 years old and there are 22 males' students whereas 25 students are females. There were about 8.5 % of respondents is 4 years old, as for 5 years old students is 40.4% and the majority of respondent 6 years old which is 51.1%. While for the Body Mass Index (BMI) of the respondent, 76.6% have an underweight BMI, 17% have a normal BMI while only 6.4% of the respondents were overweight.

Table 3.6 Background information of respondents

| Variables | Frequency | Percentage (%) |
|---|---|---|
| Age (years) | | |
| 4 | 4 | 8.5 |
| 5 | 19 | 40.4 |
| 6 | 24 | 51.1 |
| Gender | | |
| Male | 22 | 46.8 |
| Female | 25 | 53.2 |
| Body Mass Index (BMI) | | |
| < 18.5 (underweight) | 36 | 76.6 |
| 18.5 - 24.9 (normal) | 8 | 17 |
| 25 – 29.9 (overweight) | 3 | 6.4 |

N = 47

## 3.9 Data Analysis

Statistical Package for Social Sciences (SPSS) as known as IBM SPSS Statistics, is a software for analyzing a statistical data. This software is very popular in other fields such as health sciences, marketing, organization customer databases, Google Analytic and scientific research results but it is commonly used in education research. SPSS is well documented with many textbooks available (Frey, 2017). By using SPSS software, the data that were collected during distributing questionnaire will be analyzed in a short time and easy to handle. It is very convenient for anyone who would want to use this software in their field. It is because it can support both analysis and modifications of any data in almost all formats of structured data. All the data obtained from the instruments were analyzed by using SPSS to find the correlation that were obtained from the questionnaire.

Descriptive analysis was used in this study to give a summary information about the respondents. For example, the respondent's demographic data such as body mass index (BMI), gender, age were represented by using mean, percentage (%), frequency (n), minimum and maximum value. All the data were shown in form of histogram, graph and data distribution which is normal distribution.



## 3.10 Calibration and Quality Control

Before conducting any data monitoring by using instrument such as TSI Velocicalc and Dust Trax need to undergo a calibration. It is to make sure that the data collection or readings is consistent to avoid systematic error as well as to ensure the accuracy of the readings. Furthermore, before distributing the questionnaire towards the respondents, an explanation will be given to them about the purpose of this study.

## 3.11 Study Ethics

During conducting this study, a few study ethics needed to be considered. The information of student and collection of data during this study should be only for academic and study purpose. Therefore, the preschools and respondent's information must be kept as privacy and confidential in order to protect their human right and sensitivity.

# CHAPTER 4

# RESULT AND DISCUSSION

## 4.1 Introduction

Based on this study, all necessary data will be collected using two instruments, TSI Velocicalc and TSI Dust Trax. Then it will analyzed by using CBE Thermal Comfort tool Version 2.3.2 and Statistical Package for the Social Sciences (SPSS) Version 26. The topic that will be discussed in this chapter is the walkthrough observation and the analysis of thermal comfort at different locations. In this study, the data will be collected at various locations to determine which location provides the best indoor thermal comfort to students. The result obtained will be based on ASHRAE 55-2010 standard and Industry Code of Practice for Indoor Air Quality (ICOP IAQ), DOSH Malaysia (2010).



## 4.2 Walkthrough Observation

From the walkthrough observation of the preschools, the sources of the ventilation used in the building was a natural and mechanical ventilation system. The ventilation that circulated the fresh air and heat from inside and outside of the building are from doors and windows. There are also a few fans provided in the buildings to minimize the flow of the heat during teaching and learning process. Figure 4.1 shows the position of the Dust Trax and Velocicalc that were placed at the center of the class at three different preschools at Kampung Padang, Malacca. The name of the preschools can be identified as A for Tabika Kemas Rumah Pangsa Kampung Padang, B for Tabika Kemas Kampung Padang A and C for Tadika Kemas Kampung Padang B.

Figure 4.1 Location of the Dust Trax and Velocicalc during collection of data

## 4.3 Air Temperature, Relative Humidity and Air Velocity

### 4.3.1 Air Temperature (˚C)

Figure 4.2 shows the air temperature at three different locations of preschools. Overall, the air temperature of these preschools is above the acceptable range which are between 27 ˚C to 35.5 ˚C. From the result obtained in ICOP Indoor Air Quality DOSH Malaysia (2010) point of view, the environment is not comfortable for students because it exceeded the acceptable range.

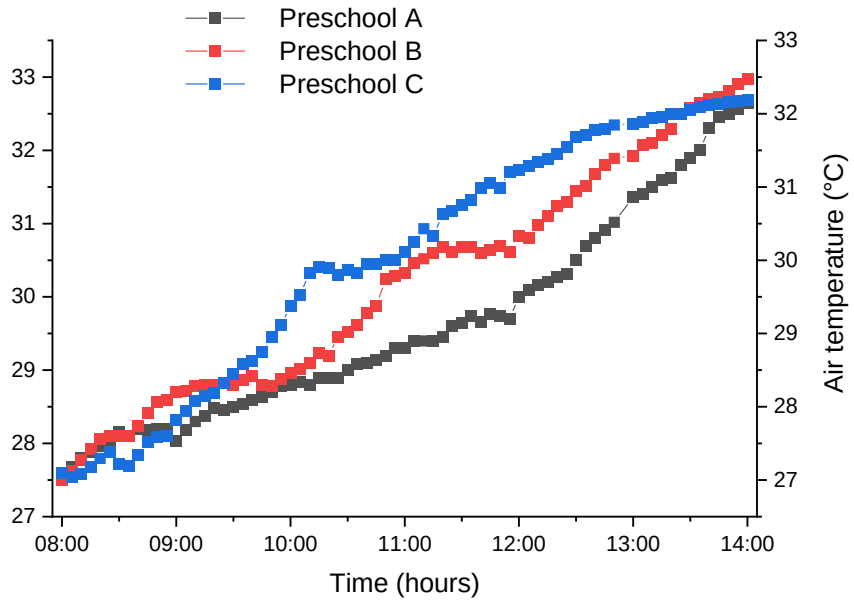


Figure 4.2 Air temperature value at different preschools

### 4.3.2 Relative Humidity (%)

Figure 4.3 shows the relative humidity at three different preschools. The average relative humidity obtained are between 75% to 81%, and it was above the acceptable range recommended by (ICOP IAQ) DOSH Malaysia, 2010 which is between 40% to 70%. However, if the relative humidity is lower than 40%, the higher the environmental temperature. As a result, it may have an impact on the students' productivity. Moreover, the conditions of weather can affect the relative humidity.

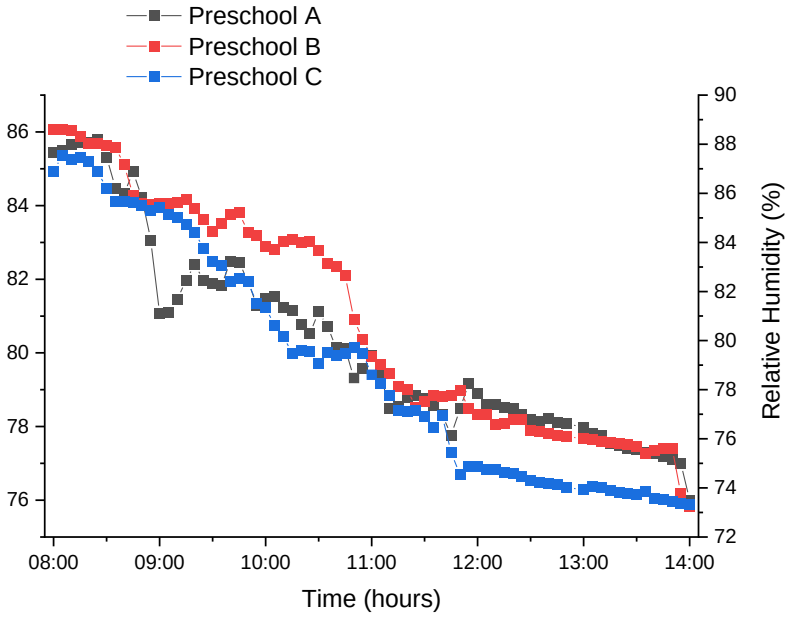


Figure 4.3 Relative humidity value at three different preschools

### 4.3.3 Air Velocity (m/s)

Figure 4.4 shows the air velocity at different preschools. The ventilation of the buildig influenced air movement in the building, as fresh air from outside the building flowed into the preschools and circulated the air. The average air velocity obtained in this study was 0.3 m/s and it exceeded the acceptable range recommended of 0.15 – 0.50 m/s by ICOP DOSH Malaysia (2010). In the other hand, the lowest value was 0.113 m/s and it is not exceeding the acceptable range.

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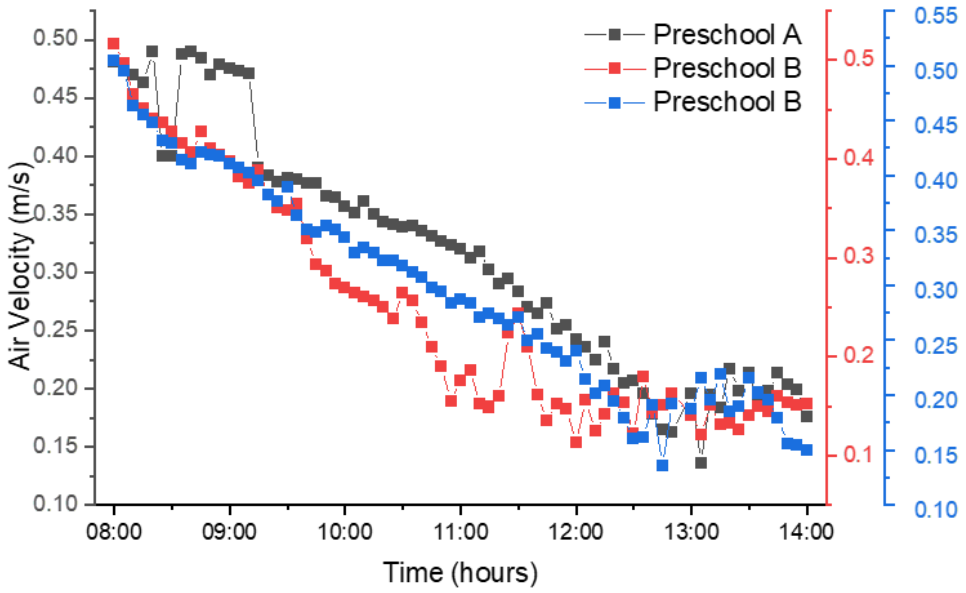


Figure 4.4 Air velocity value for different value of different preschools

## 4.4 Relationship between PMV and PPD using CBE Tool

Based on ASHRAE 55 standard, it is stated that thermal comfort can be achieved based on 80% occupant satisfaction rate or more and 10 % of occupant will experienced dissatisfaction based on whole body discomfort and remaining percentage will be based on partially body discomfort. Fanger model is the most important variable which affecting the thermal sensation which can be assessed based on Predicted Mean Vote (PMV) and Predicted Percentage Dissatisfied (PPD) value.

To define the comfort, the value of PMV need to be calculate first then it will be used to determine the range within the PPD index according to this standard. Moreover, it is used to discover an acceptable range of thermal conditions for human occupancy. The thermal limit on the 7-point scale of PMV must be between -0.5 and 0.5 to comply with ASHRAE 55-2010 standard while PPD value need to be between 5% and 100%, depending on the estimated PMV. These comfort levels will vary depending on where the occupant is in the given space.

Tropical climatic region has a high humidity level due to which trend is on positive side of thermal sensation scale and it is explained the trend towards 1,2 and 3 sensations of vote due to high temperature conditions. As mentioned before, the PMV value indices is difficult to be in the range of - 0.5 and 0.5 due to the circumstances. To analyze the thermal comfort value of PMV and PPD, CBE Thermal Comfort Tool was used. The value that was entered into the inputs were collected using TSI Velocicalc based on thermal comfort factors which are environmental and personal factors.

Figure 4.5 shown the value of PMV and PPD for Tadika Kemas Rumah Pangsa Kampung Padang. Based on the results obtained, it can conclude that the thermal sensation of the preschool does not comply ASHRAE 55-2010 standard. This is because the PMV result showed was not within the range that it was supposed to be. Data below represents two input values which are input 1 shown the data taken in the morning while input 2 shown the data in the afternoon. It is stated that the PMV value during morning is 0.90 and during afternoon is 2.72 and thermal sensation for both values are slightly warm and hot.



The PPD value for both temperatures represent the total percentage of dissatisfied occupants inside the building. It means that 31% of class occupants were dissatisfied with the indoor environment, whereas in the afternoon, the total percentage of dissatisfied was 94%. Furthermore, Figure 4.6 present the PMV and PPD value laying on the PPD curve. The dotted lines mean the value of PMV which are black for morning session and the blue line for afternoon session. Moreover, Table 4.1 shown the data of environmental parameters, PMV and PPD for every 1 hour starting from 8 am to 2 pm at preschool A.

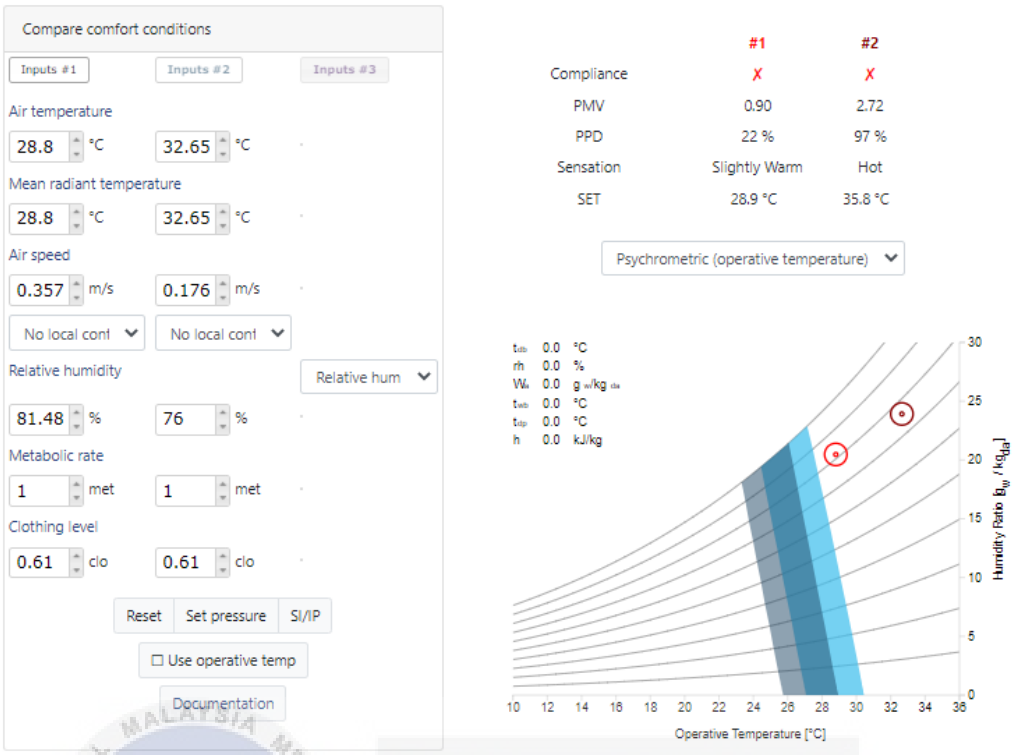


Figure 4.5 Result when the data analyzed using CBE Thermal Comfort Tool

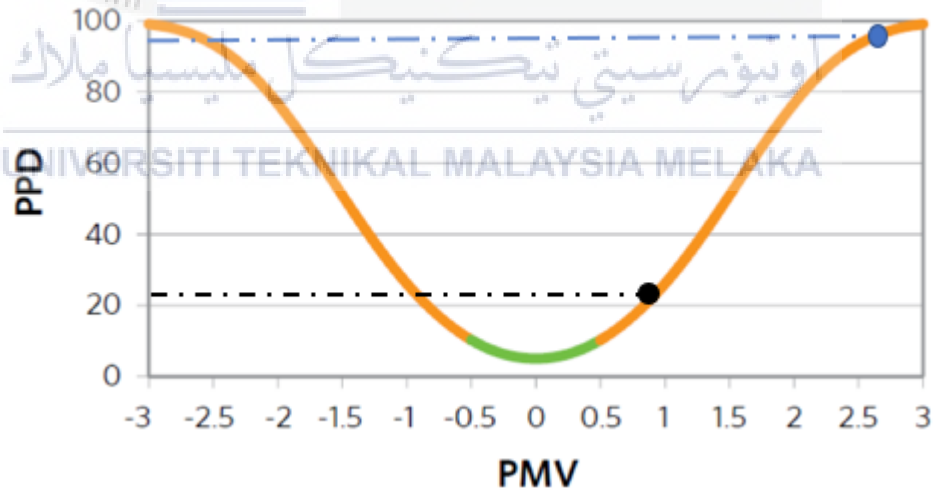


Figure 4.6 PMV and PPD value on PPD curve for Preschool A

Table 4.1 Result of PMV and PPD for every 1 hour at preschool A

| Time | Air temperature ($°C$) | Air speed (m/s) | Relative humidity (%) | Metabolic rate (met) | Clothing insulation (clo) | PMV | PPD (%) |
|---|---|---|---|---|---|---|---|
| 8:00 | 27.54 | 0.481 | 85.44 | 1 | 0.61 | 0.32 | 7 |
| 9:00 | 28.04 | 0.475 | 81.06 | 1 | 0.61 | 0.46 | 9 |
| 10:00 | 28.8 | 0.357 | 81.48 | 1 | 0.61 | 0.90 | 22 |
| 11:00 | 29.3 | 0.320 | 79.94 | 1 | 0.61 | 1.13 | 32 |
| 12:00 | 30.0 | 0.242 | 78.79 | 1 | 0.61 | 1.54 | 53 |
| 13:00 | 21.36 | 0.196 | 77.98 | 1 | 0.61 | 2.18 | 84 |
| 14:00 | 32.65 | 0.176 | 76.0 | 1 | 0.61 | 2.72 | 97 |

Result in Figure 4.7 below represent thermal sensation for Tadika Kemas Kampung Padang A. The value of PMV and PPD is determined by the environmental factor which are air temperature, relative humidity and air speed as well as the personal factor which are the metabolic rate and clothing insulation. These values are inserted in the inputs and the results will be generated. From the result, the value for both PMV and PPD is not compliance with thermal comfort standard and the sensation level for both conditions are slightly warm and hot. Figure 4.8 displayed the PMV and PPD values on the PPD curve based on the dotted line. The value of PMV and PPD during morning is 0.67 and 14% while in the afternoon the value increased to 2.71 and 97%. Moreover, Table 4.2 present the value of PMV and PPD for every 1 hour. As the time passes, both PMV and PPD values increase.

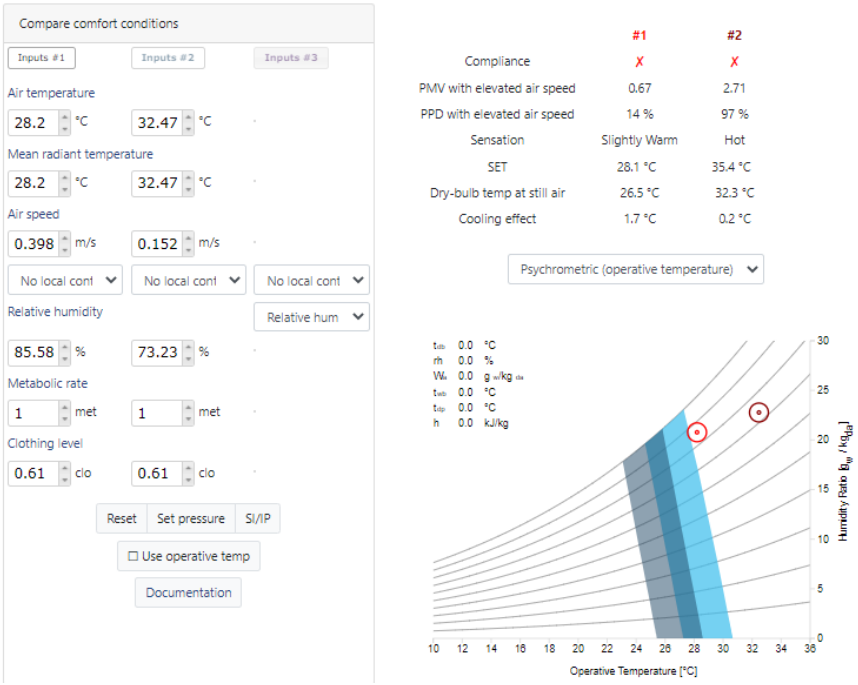


Figure 4.7 Result when the data analyzed using CBE Thermal Comfort Tool

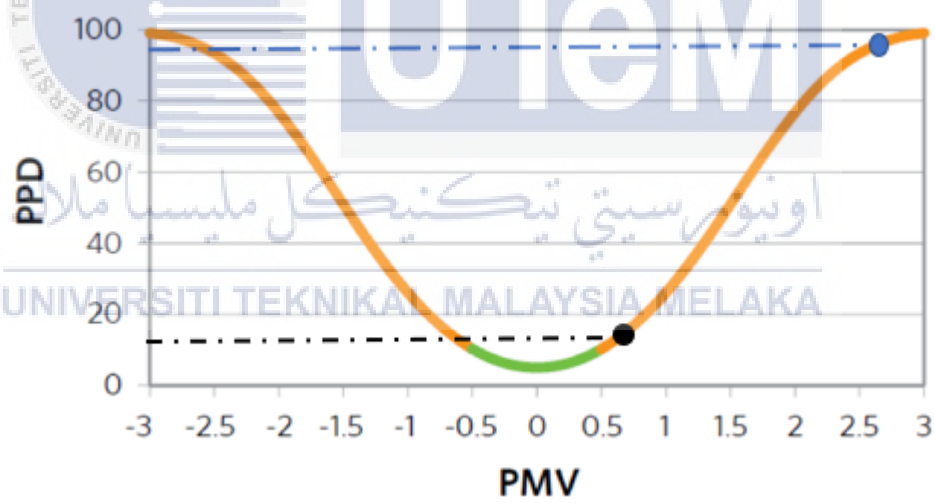


Figure 4.8 PMV and PPD value on PPD curve for Preschool B

Table 4.2 Result of PMV and PPD for every 1 hour at preschool B

| Time | Air temperature ($°C$) | Air speed (m/s) | Relative humidity (%) | Metabolic rate (met) | Clothing insulation (clo) | PMV | PPD (%) |
|---|---|---|---|---|---|---|---|
| 8:00 | 27.0 | 0.516 | 88.6 | 1 | 0.61 | 0.12 | 5 |
| 9:00 | 28.2 | 0.398 | 85.58 | 1 | 0.61 | 0.67 | 14 |
| 10:00 | 28.46 | 0.270 | 88.84 | 1 | 0.61 | 0.96 | 25 |
| 11:00 | 29.82 | 0.176 | 79.34 | 1 | 0.61 | 1.70 | 62 |
| 12:00 | 30.33 | 0.113 | 77.01 | 1 | 0.61 | 2.02 | 77 |
| 13:00 | 31.43 | 0.141 | 76.01 | 1 | 0.61 | 2.40 | 91 |
| 14:00 | 32.47 | 0.152 | 73.23 | 1 | 0.61 | 2.71 | 97 |

Malaysia is a country that is hot and humid throughout the year. As a result, achieving satisfaction with thermal comfort for thermal sensation is difficult. Figure 4.9 illustrated the thermal comfort satisfaction rate by using CBE Tool software. As the PMV and PPD value based on the surrounding conditions, it shown that 99% of the occupant felt discomfort during afternoon. This is because the value of air temperature inside the building is 33.5 $°C$. Furthermore, the value of PMV that were analyzed by CBE Tool for total of 6 hours durations are between 0.62 and 3.02 while PPD value was 13% and 99%. Based on the result, it can conclude that this preschool has the highest temperature and the hottest weather among three preschools.



Figure 4.10 shown the dotted lines that was plotted with the value of PMV and PPD at 9am and 2 pm. The result shown that the value of PMV for this preschool is not following the standard. This is because the value that were needs to be was between -0.5 and 0.5 in order to achieve the comfortable surroundings. Table 4.3 displays the results for the PMV and PPD values issued for every hour at preschool C.

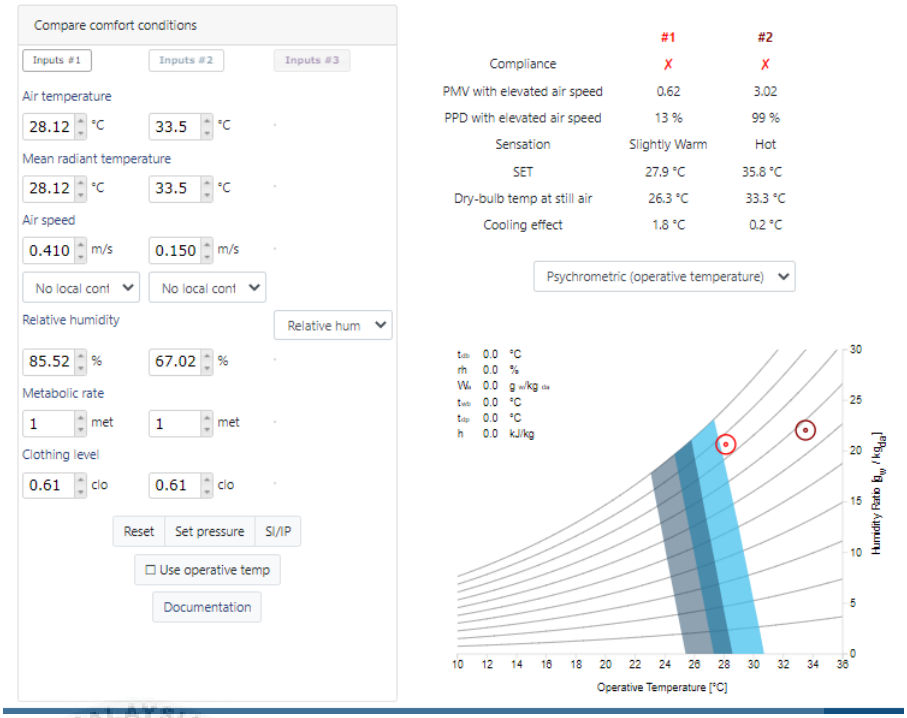


Figure 4.9 Result when the data analyzed using CBE Thermal Comfort Tool

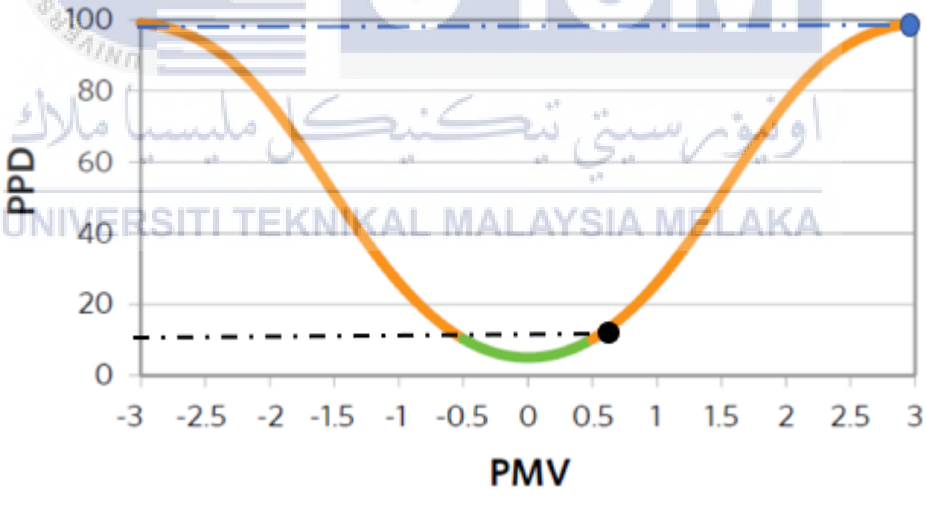


Figure 4.10 PMV and PPD value on PPD curve for Preschool C

Table 4.3 Result of PMV and PPD for every 1 hour at preschool C

| Time | Air temperature ($°C$) | Air speed (m/s) | Relative humidity (%) | Metabolic rate (met) | Clothing insulation (clo) | PMV | PPD (%) |
|---|---|---|---|---|---|---|---|
| 8:00 | 27.24 | 0.504 | 87.78 | 1 | 0.61 | 0.21 | 6 |
| 9:00 | 28.12 | 0.410 | 85.52 | 1 | 0.61 | 0.62 | 13 |
| 10:00 | 29.86 | 0.343 | 79.28 | 1 | 0.61 | 1.36 | 43 |
| 11:00 | 30.94 | 0.271 | 75.1 | 1 | 0.61 | 1.76 | 65 |
| 12:00 | 32.33 | 0.240 | 69.37 | 1 | 0.61 | 2.30 | 88 |
| 13:00 | 33.1 | 0.187 | 67.93 | 1 | 0.61 | 2.73 | 97 |
| 14:00 | 33.5 | 0.150 | 97.02 | 1 | 0.61 | 3.02 | 99 |

### 4.4.1 Correlation between CBE Tool and Questionnaire

Based on the result obtained by using CBE Tool, these three preschools did not comply and achieved the thermal comfort satisfactory based on ASHRAE 55-2010 standard. However, when the survey was given verbally in the class, the result obtained from the students was different. The questionnaire was distributed to all three preschools at 9.30 a.m. It means that all of the data will be synchronized.

According to the questionnaire results, all students from three different preschools said that they felt comfortable in the class based on seven - point thermal sensation. Out of 16 students in preschool A, 3 students declare that they experience neutral condition and the gender of these students are male. They declared that they don't feel cold or hot, it just neutral. The neutral value is 0, so the value is between the range of -0.5 to 0.5. While the remaining students said they felt cold.

While for students at preschool B, the total students are 15. It said the majority of student experienced neutral condition which are 11 students out of 15 and the remaining students said they felt cold. From the result that was obtained, 4 students that experienced cold sensation the gender of the students is fair which are both male and female has the same value which is 2 students. For preschools C, only 1 student experienced a neutral condition and remaining students said they felt cold. According to ASHRAE 55 -2010 standard, the thermal sensation value for cold is -2.

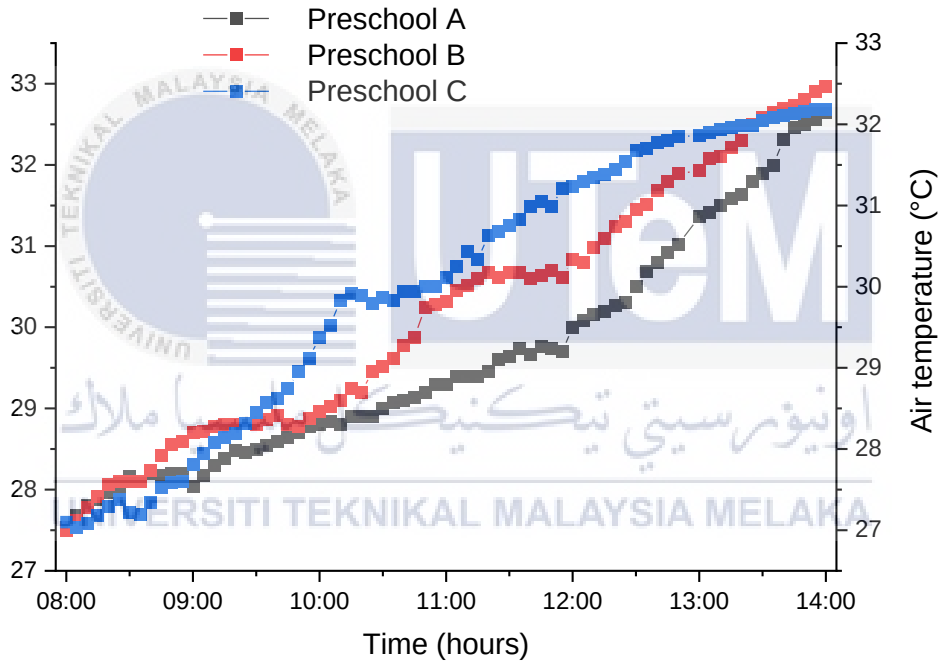


Figure 4.11 Air temperature value at different preschools

Based on the result of PMV and PPD shown above in Figure 4.11, it shown the differences value of air temperature for three different preschools. As the temperature is increasing, time also increase. According to the findings, the rise in temperature creates an uncomfortable environment for students in the building during their educational sessions. It is because based on ASHRAE standard the accceptable range for comfortable temperature

is between 19.4°$C$ to 27.8°$C$ but the result state that the thermal sensation for those three preschools are between slightly hot to hot. The result of thermal comfort by using CBE Thermal Comfort Tool and the survey distributed has a difference answer. If the surrounding temperature said to be slighly hot to hot, the students said that they felt neutral or cold. As the temperature is increasing, time also increase. Therefore, the feedback that the students gave is not significance with the ASHRAE standard.

## 4.5 Environmental Factor Monitoring

Environmental factor is important to determine the thermal comfort of the students during their teaching and learning process. The parameter of air temperature (°$C$), relative humidity (%), air velocity (m/s) and mean radiant temperature (°$C$) were monitored using TSI Velocicalc as well as TSI Dust Trax to determine the amount of dust particles. This assessment was conducted for 6 hours during their operation hours. After the result was obtained, it was compared with the standards to determine whether the environment temperature in the preschools is acceptable for thermal comfort.



### 4.5.1 Correlation between Air Temperature (°C) and Relative Humidity (%)

Figure 4.1 shown the location of Velocicalc during collection of data of air temperature and relative humidity in the classroom. Based on the Figures 4.8, 4.9 and 4.10 it can be seen the correlation between air temperature and relative humidity readings for preschools. The value of air temperature appears to increase as the time increases while the value of relative humidity is decreasing over time and it applied to all of the preschools. This is because relative humidity is affecting the air temperature. When the relative humidity is decrease, the air temperature will be increase.

Based on the result obtained in Table 4.4, it can be found that the average value of air temperature for preschool A is 29.60°$C$. While the minimum air temperature is 27.54°$C$ and the maximum indoor air temperature was 32.65°$C$. The value of highest air temperature can be seen in the evening which is 2 p.m. However, during that time the students had returned to their respective house and that's mean the temperature does not impact the thermal comfort of students. As for the value of minimum relative humidity is 76% and the average value is 80.31%. While the maximum value of humidity occurs in the morning at 8.00 am with a value of 85.50%.

Table 4.4 The minimum, maximum and average of air temperature and relative humidity at preschool A.

| **Environmental Parameter** | **Minimum** | **Maximum** | **Average** | **Acceptable Range (ICOP IAQ) DOSH Malaysia 2010** |
|---|---|---|---|---|
| Air temperature (°$C$) | 27.54 | 32.65 | 29.60 | 23°$C$ – 26 °$C$ |
| Relative humidity (%) | 76.00 | 85.80 | 80.31 | 40% -70% |



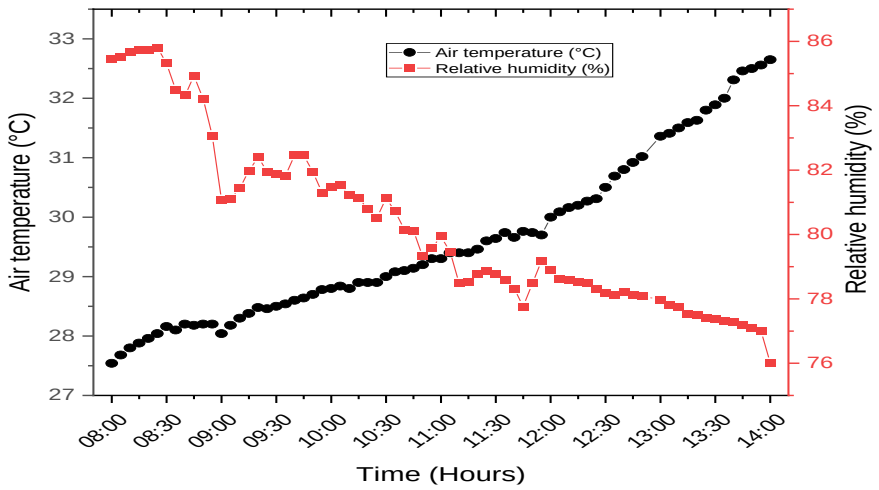


Figure 4.12 Correlation between air temperature and relative humidity in preschool A

Table 4.5 shows the Minimum, Maximum and Average of air temperature and relative humidity at preschool B. The average value of air temperature for preschool B is 29.65°$C$. The minimum air temperature is 27.00 °$C$ while the maximum indoor air temperature was 32.47°$C$. The value of lowest air temperature can be seen at 8 a.m. Moreover, the average relative humidity obtained in preschool B is 80.93%, was above the acceptable range of 40 – 70% recommended by ICOP DOSH Malaysia (2010). While the highest value of relative humidity recorded was 88.60% and the lowest value was 73.23%.

Table 4.5 The minimum, maximum and average of air temperature and relative humidity at preschool B

| **Environmental Parameter** | **Minimum** | **Maximum** | **Average** | **Acceptable Range (ICOP) IAQ DOSH Malaysia 2010** |
|---|---|---|---|---|
| Air temperature (°$C$) | 27.00 | 32.47 | 29.65 | 23°$C$ – 26 °$C$ |
| Relative humidity (%) | 73.23 | 88.60 | 80.93 | 40% -70% |



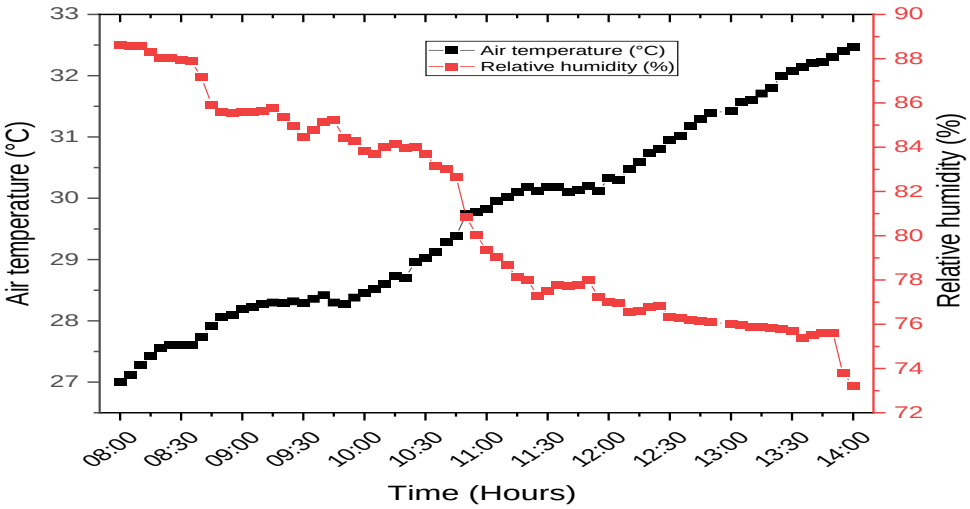


Figure 4.13 Correlation between air temperature and relative humidity in preschool B

Based on the result obtained in Figure 4.14, it can be found that the value of air temperature is increase as the time increases while the value of relative humidity is decreasing over time. The average value of air temperature for preschool C is 30.78 °C as shown in Table 4.6. While the minimum air temperature is 27.16°C and the maximum indoor air temperature was 33.50°C. As for the value of minimum relative humidity is 67.02% and the average value is 75.89%. Whereas the maximum value of humidity occurs in the morning at 8.00 am with a value of 88.74%. According to ICOP Indoor Air Quality DOSH Malaysia (2010), these three preschools air temperature is uncomfortable for students since the air temperature reading is exceeded the acceptable range which is $23°C - 26°C$.

Table 4.6 The minimum, maximum and average of air temperature and relative humidity at preschool C

| **Environmental Parameter** | **Minimum** | **Maximum** | **Average** | **Acceptable Range (ICOP IAQ) DOSH Malaysia 2010** |
|---|---|---|---|---|
| Air temperature ($°C$) | 27.16 | 33.50 | 30.78 | 23 $°C$ – 26 $°C$ |
| Relative humidity (%) | 67.02 | 88.74 | 75.89 | 40% - 70% |

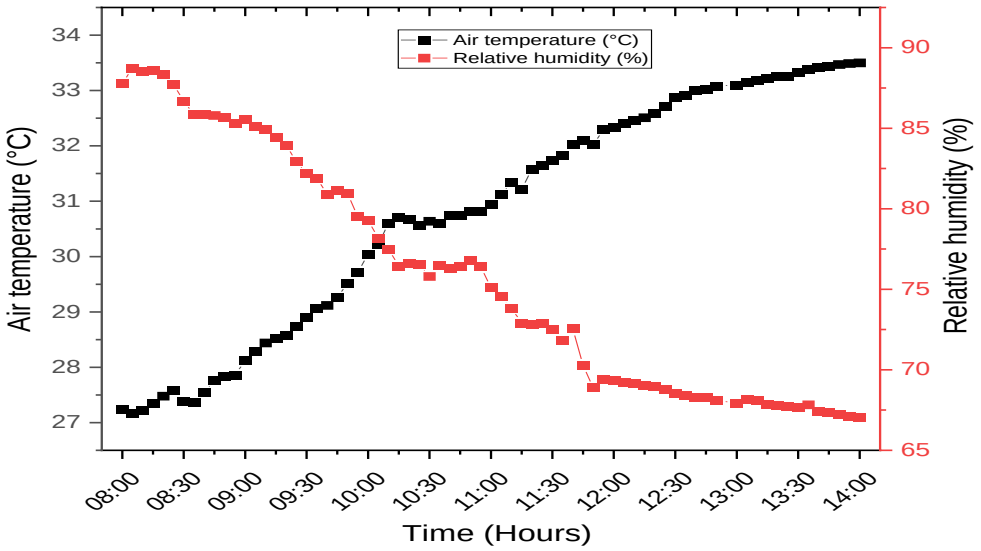


Figure 4.14 Correlation between air temperature and relative humidity in preschool C

### 4.5.2 Correlation between Air Velocity (m/s) and Amount of Dust Particles (PM)

Based on the Figures 4.15, 4.16 and 4.17, it shown a graph between two parameter which are air velocity and amount of dust particles for different preschools. The value of air velocity appears to increase as the time increase while amount of dust particles value is irregular and it is applied to those three preschools. If the air velocity value is increasing it can help to cool down the environment because the air moving across the surrounding area. According to US Environmental Protection Agency's national ambient air quality guidelines consider exposure to very small particulate matter known as PM2.5 to be safe as long as a person breath in an average of 12 micrograms per cubic meter of air ($\mu g/m^3$). It is because if the amount of the dust particle is above 12 micrograms, it can cause respiratory problem and irritating the eyes of the occupants.

Table 4.7 shows the Minimum, Maximum and Average of air velocity and amount of dust particles at preschool A. The average value of air velocity for preschool A is 0.315 m/s. The minimum air velocity is 0.136 m/s while the maximum indoor air velocity was 0.490 m/s. The value of lowest air velocity can be seen at 1.05 pm. Moreover, the average amount of dust particles obtained in preschool B is 0.253 μg/m$^3$. While the highest value of dust particles recorded was 0.3272 μg/m$^3$ and the lowest value was 0.0897 μg/m$^3$.

Table 4.7 The minimum, maximum and average of air velocity and amount of dust particles in preschool A

| **Environmental Parameter** | **Minimum** | **Maximum** | **Average** | **Acceptable Range (ICOP IAQ) DOSH Malaysia 2010** |
|---|---|---|---|---|
| Air velocity (m/s) | 0.136 | 0.490 | 0.315 | 0.15 m/s – 0.50 m/s |
| Amount of dust particles (μg/m$^3$) | 0.0897 | 0.3272 | 0.253 | - |

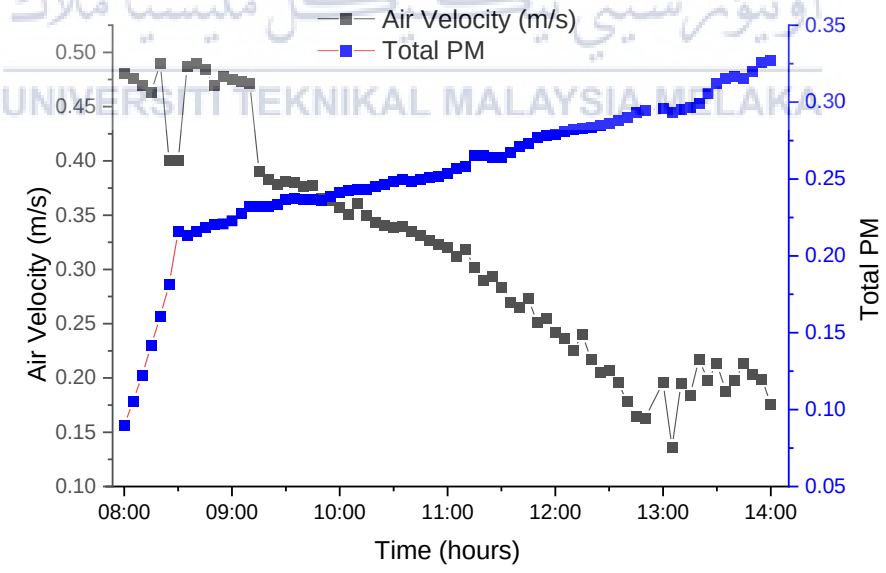


Figure 4.15 Correlation between air velocity and amount of dust particles in preschool A

Based on the result obtained in Table 4.8, it shown the average value of air velocity for preschool B which is 0.247 m/s. While the minimum air velocity is 0.113 m/s and the maximum indoor air velocity was 0.516 m/s. The value of highest air velocity can be seen in the morning which is 8 a.m. It shown that the surrounding velocity in the preschools is in comfortable state. As for the value of minimum amount of dust is 0.118 μg/$m^3$ and the average value is 0.249 μg/$m^3$. While the maximum amount of dust occurs in the morning at with a value of 0.304 μg/$m^3$. Moreover, the air movement also influenced by the mechanical fans that were placed inside the classroom.

Table 4.8 The minimum, maximum and average of air velocity and amount of dust particles in preschool B

| **Environmental Parameter** | **Minimum** | **Maximum** | **Average** | **Acceptable Range (ICOP IAQ) DOSH Malaysia 2010** |
|---|---|---|---|---|
| Air velocity (m/s) | 0.113 | 0.516 | 0.247 | 0.15 m/s – 0.50 m/s |
| Amount of dust particles (μg/$m^3$) | 0.118 | 0.304 | 0.249 | - |

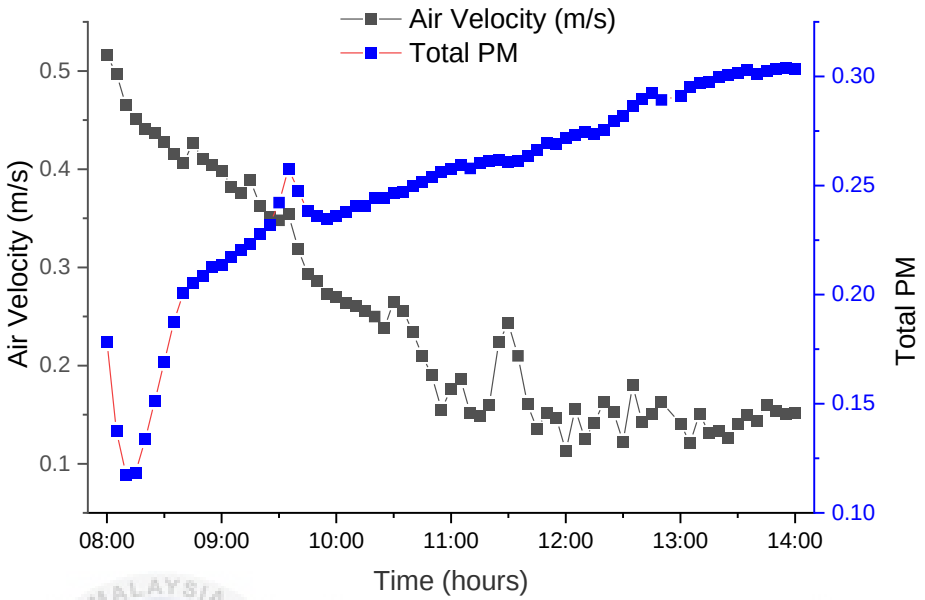


Figure 4.16 Correlation between air velocity and amount of dust particles in preschool B

Based on the result illustrated in Figure 4.17, it can be found that the value of air velocity is irregular while the amount of dust particle is decreasing over time. The average value of air velocity for preschool C is 0.295 m/s as shown in Table 4.9. While the minimum air velocity is 0.136 m/s and the maximum indoor air velocity was 0.504 m/s. According to ICOP Indoor Air Quality DOSH Malaysia (2010), the value of the air velocity is acceptable for average and maximum value because the range recommended is 0.15 – 0.50 m/s. while for minimum value, it is below the acceptable range. The results for minimum dust particle are 0.073 μg/m$^3$ and the average value is 0.253 μg/m$^3$. Whereas the maximum amount of dust particle occurs in the morning at 8.25 am with a value of 0.333 μg/m$^3$.

Table 4.9 The minimum, maximum and average of air velocity and amount of dust particles in preschool C

| **Environmental Parameter** | **Minimum** | **Maximum** | **Average** | **Acceptable Range (ICOP IAQ) DOSH Malaysia 2010** |
|---|---|---|---|---|
| Air velocity (m/s) | 0.136 | 0.504 | 0.295 | 0.15 m/s – 0.50 m/s |
| Amount of dust particles ($\mu g/m^3$) | 0.073 | 0.333 | 0.253 | - |

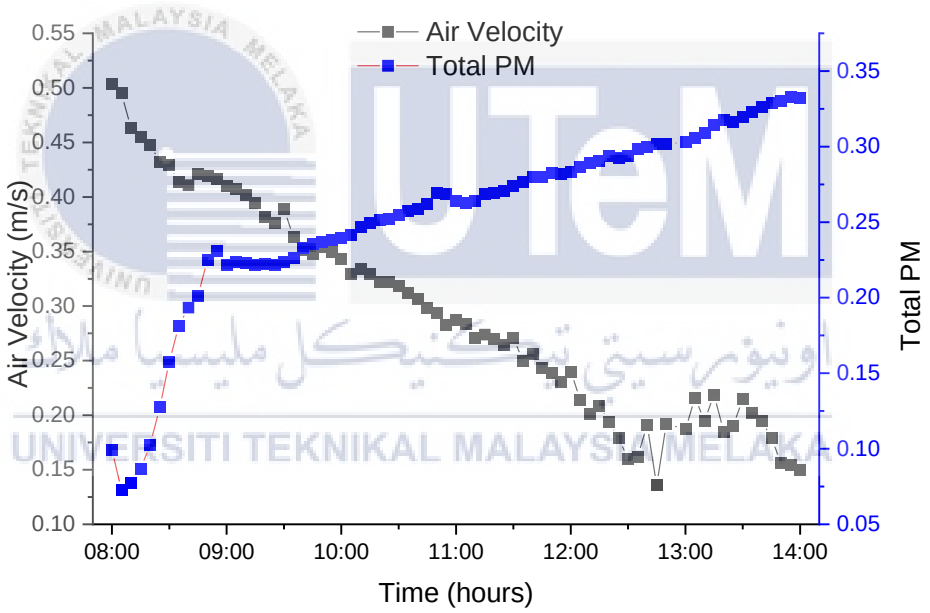


Figure 4.17 Correlation between air velocity and amount of dust particles in preschool C

## 4.6 Personal Factor Monitoring

Surrounding conditions becomes one of the factors to ensure occupants feels comfortable inside a building. This is because changes of environmental conditions especially the air temperature, relative humidity and velocity can affect their body temperature. Besides, personal factors such as clothing insulation (clo), metabolic rate can influence the physiological responses towards thermal comfort. Type or material of clothing can contribute to discomfort and reduce the student's productivity during learning process. In order to determine the level of thermal comfort towards the students, a few questions have been asked during the survey.

### 4.6.1 Characteristic of Clothing Insulation

Based on the questionnaire survey, different preschools wear different characteristics of clothing to schools. From the illustrate graph in Figure 4.18, they are some students wear long sleeves or short sleeves, socks and scarves at once. It shown that, the clothing insulation for a person will be difference with each other. According to ASHRAE standard 55-2010 in Table 2.1 and 2.2, it is stated the value of each garment of clothing insulation. From this survey, it can determine whether the student's clothing insulation is suitable with their condition in the class or vice versa. Since the metabolic rate also affect the thermal comforts, the activity performed by student should also be observed. This is because different type of activities has a difference value of met as mentioned in Figure 2.5.

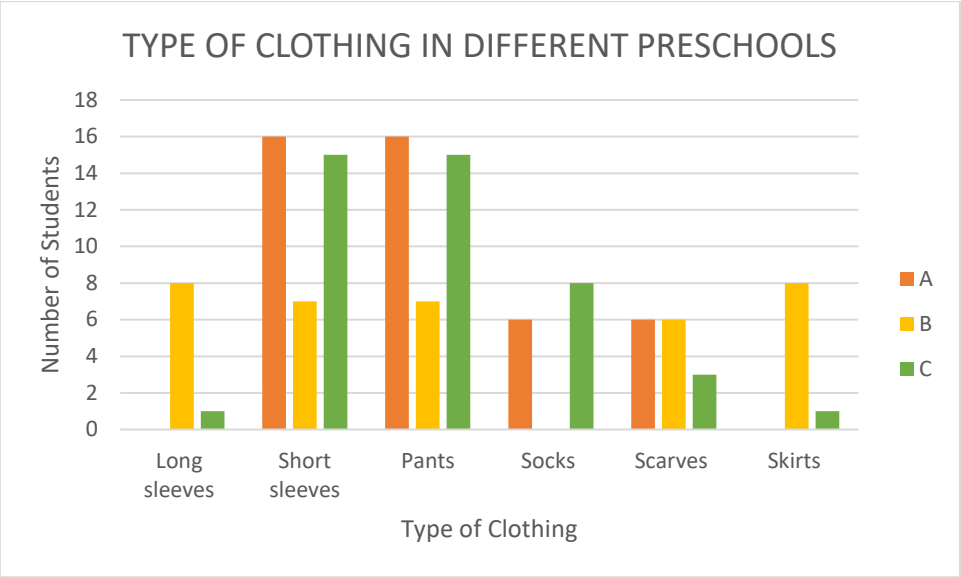


Figure 4.18 Type of clothing at different preschools

Based on the result obtained, the total student in preschool A is 16 students and 10 out of the students are males and the rest are females. All the students are wearing short sleeves t-shirts and the trousers which are the sports attire. Besides, all of the female's students are wearing the scarves and out of all the students 6 of them are wearing sock. As mentioned in Table 2.1, if the student is wearing a short sleeves t-shirt, trousers, scarves and undergarments, the total value of her clo is 0.61. Based on the survey, the met value obtained from student activities during learning process is 1 met. This is because the activities they have done during the survey was sat while doing the work assigned to them by the teacher.

For preschool B, they are wearing variety type of clothing. They are wearing official uniform for Tadika Kemas that were set from the government. The characteristics of the uniform are baju kurung which consist of long sleeves and skirts, short sleeves and pants and it is optional to wear socks and scarves. Figure 4.14 shown that the clothes worn by students according to their gender. All the female students wore baju kurung and some of them wore scarves while the male students wore a typical uniform of shirts and pants. In this preschool

no one wears socks maybe because of discomforts as well as the clothing insulation can be reduced. During the learning process which held in the preschool, most of the activities that been carried out are reading and writing while sitting at their own places. The value of met during these activities are 1 met it is equivalent with 60 W/m$^2$.

In preschool C, some students wore formal attire and the rest wore sports attire. Out of 16 students, 15 students wore sport attire while only one student wore a baju kurung. The total student in preschool C is 16 students and 11 out of the students are females and the rest are males. Based on the results obtained, out of 10 female's students only 3 students wore the scarves and 8 students wore the socks. The metabolic rate is important to make sure that the occupants feel comfortable during the activities that been done. Even though they are variety of activities during learning process, as long as it is in sitting condition the value of met will be the same which is 1 met.

### 4.6.2 Relationship between temperature, clothing insulation and metabolic rate

The questionnaire is being distributed towards the students at 9.30 am and the temperature during that time around 28 $°C$ – 29 $°C$. Although the acceptable range of ICOP IAQ, DOSH Malaysia 2010 is around 23°C - 26°C, the surrounding conditions such as windows, fans, and doors known as ventilation in a building play an important role. Figures 3.3, Figure 3.4 and Figure 3.5 shown the layout of the building for different location of preschools. The ventilation in the building is enough to make sure that students is comfortable in the classes during their learning session. This is because the size of the building and the number of students in a class is sufficient with the facilities available there. According on the data that been collected through the survey shown in Figure 4.19, all of these students said that they are very comfortable with the surroundings conditions.

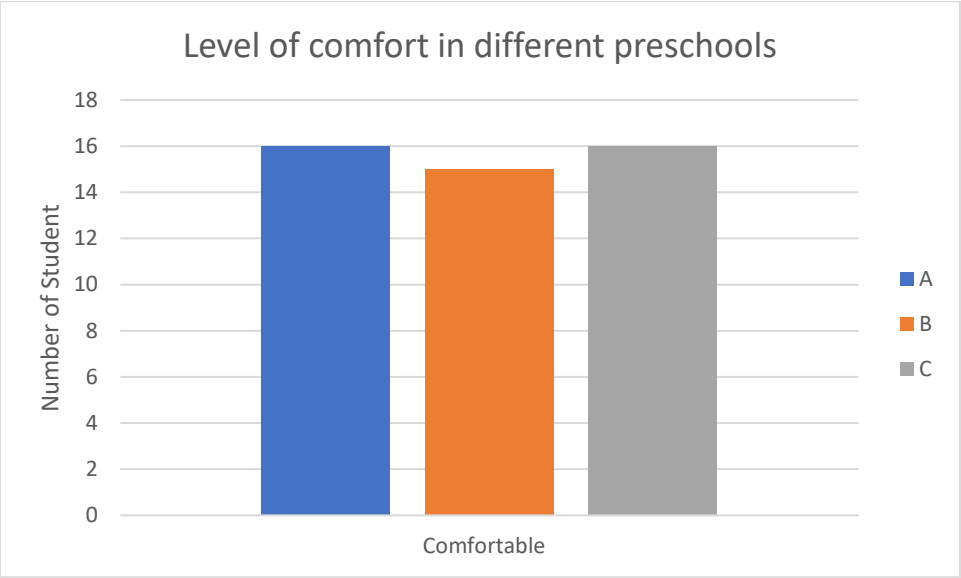


Figure 4.19 Level of comfort at different preschools

The students are wearing comfortable clothes during their lesson in their classes. Although there are different type of clothing and it has different value of clo such as cotton type or jersey type, it can be accepted. This is because the range of the clothing insulation needed between 0.5 clo and 1.0 clo and it is the most standard value. Moreover, the metabolic rate also apart of personal factor in thermal comfort. Metabolic rates of an individual are different based on the activities that been done. Based on the activities that have been done by the students in the classroom are seating while reading, writing, eating and drinking. The met value for these activities counted as 1 met. Therefore, the students felt very comfortable with the temperature and clothing insulation during their learning process.

## 4.7 Evaluation of the Psychological Effects for Thermal Comfort Among Preschools Students

Usually, students tend to feel tired and sleepy right after doing some activities no matter where they are neither in the house or at the school. They were also unable to concentrate on a single task. Therefore, they experience fatigue, especially when exposed to heat, which causes discomfort. During the survey, a question was asked about how they felt right now during learning process? Table 4.10, Table 4.11 and Table 4.12 shown the results of respondents among the preschools students about the condition they felt during learning process. Based on the Table 4.10 and Table 4.11, it can be clearly seen that majority of students felt not comfortable which are 10 students out of total students for both preschools. This means that the students are uncomfortable with their surroundings because the rising temperature has made them feel uneasy in the building. Although they felt that way, but they still manage to perform their learning process in the uncomfortable environment.

Table 4.10 Students condition during learning process in Preschool A

| Condition | Frequency | Percentage (%) |
|---|---|---|
| Dizzy | 0 | 0 |
| Short of breath | 0 | 0 |
| Not comfortable | 5 | 31.25 |
| Sleepy | 3 | 18.75 |
| Tired | 4 | 25 |
| Hungry | 4 | 25 |

N= 16

Table 4.11 Students condition during learning process in Preschool B

| Condition | Frequency | Percentage (%) |
|---|---|---|
| Dizzy | 0 | 0 |
| Short of breath | 0 | 0 |
| Not comfortable | 5 | 33.33 |
| Sleepy | 4 | 26.67 |
| Tired | 4 | 26.67 |
| Hungry | 2 | 13.33 |

N =15

Result obtained in Table 4.12 shown the student condition during learning process in preschool C. They condition consist of not comfortable, sleepy, tired and hungry. According to preschool C, the most common condition they felt, was hunger. The result shown in a selection of half of the class, or 50% and the least selection for this condition is sleepy condition. As for other condition such as not comfortable and tired, both of it has the same percentage value which are 18.75% equilvalent to 3 students each.



Table 4.12 Students condition during learning process in Preschool C

| Condition | Frequency | Percentage (%) |
|---|---|---|
| Dizzy | 0 | 0 |
| Short of breath | 0 | 0 |
| Not comfortable | 3 | 18.75 |
| Sleepy | 2 | 12.5 |
| Tired | 3 | 18.75 |
| Hungry | 8 | 50.0 |

N= 16

During the indoor sampling observation, preschool B was the only one of the three preschools that did not open the windows during the learning process. The ventilation of the air flows did occurs but it is less than it supposed to be. It can be seen from Table 4.11, there are variation of condition felt by students such as uncomfortable, sleepy and tired. From the result, the frequency of students experiencing these issues is quite high. More than half of all students are dissatisfied in such situations, causing them to feel tired and drowsy.

## 4.8 Summary

The findings from this study are to determine which preschools provide a high level of comfort for these students during the learning process and during their stay. By using the CBE Thermal Comfort Tool, it is easy to summarize the data conducted in this research. It is because it can determine whether the parameters inserted in the inputs is complies with ASHRAE 55 Standard or not. Analysis of Predictive Mean Vote (PMV) and predicted percentage of dissatisfied (PPD) was done to define the comfort level of occupansts in the buildings. The results shown that the thermal comfort throughout three different preschool does not achieved or comply the ASHRAE 55 - 2010 standard. High temperature of surrounding environment is the main factor of discomfort towards the preschool's students during learning process. Moreover, the purpose of this study is to determine the significance of the relationship between data collected using the CBE Thermal Comfort Tool and the answers provided by students via the questionnaire.



In addition, the clothing insulation and metabolic rate is affecting the thermal comfortness during learning process. This shown that, lower value of clo was a good choice for students aged 4 to 6 years old. Despite the fact that there are various types of clothing with varying clo, the students wore comfortable clothes during their lesson at the class. This is because the range of the clothing insulation needed was between 0.5 clo and 1.0 clo.

According to metabolic rates, the more movement made by an occupants, the higher the met value. Based on the result, the activities that been done by the students is equal to 1 met. It shown that, not much movements occurs besides the lower the met value, the higher the comfort level.

Based on the data that were collected before, the surrounding environment and design of a building also are important towards comfortness. This is because environment factor such as building area and ventilation will influence the student's indoor conditions. The larger the area of a building, the higher the probability of comfortness towards the occupants. Furthermore, the dimensions and unit of windows or doors play a role because ventilation affects the temperature of the surrounding area. Even if a building's layout is larger and the number of students is small, not opening the windows and doors for ventilation will have an impact on the students' learning process. Table 3.1, Tables 3.2 and Tables 3.3 shown the area of each preschool along with total number of students for different preschools.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

Based on this study all the parameters of thermal comfort are affecting the indoor thermal comfort towards the occupants in the building. According to the results, the air velocity and temperature were both above the acceptable range recommended by (ICOP IAQ) DOSH Malaysia, 2010, while the average value of air velocity was acceptable because it was between the range. This study also found that air temperature affects the value of relative humidity. This is because when the air is increase, the relative humidity will be decrease. However, these three preschools air temperature were uncomfortable towards the students since the air temperature reading is exceeded the acceptable range which is $23°C - 26°C$. This clearly shows that the temperature in the classroom is high and not comforting.

By using CBE Comfort Thermal Tool, the value of PMV and PPD for three different locations of the preschools did not complies with ASHRAE 55-2010 standard. This is because the PMV value for these three locations was greater than the expected range between - 0.5 and 0.5. The value of PPD was not achieved either for all three preschools because the value of PPD is above than it should be which is above 20%. It is indicates the percentage of people who feel uncomfortable or dissatified with the environment while in the building. Moreover, this study is interpreted by using thermal sensation analysis from ASHRAE 55 - 2010 standard.

According to the questionnaire results, all students from various preschools stated that they are comfortable with the surrounding temperature. However, from result analyzed by CBE Thermal Comfort Tool, the indoor air temperature is between slightly warm and hot. It shows that the result obtained it not significance between data collected using the CBE Thermal Comfort Tool and the answers provided by students via the questionnaire. In this case, the result that should be accepted was using the CBE Tool rather than the feedback from the students. This is because the instruments used were already defined to meet the ASHRAE 55-2010 standard. Furthermore, the feedback from the student is not authentic enough because it might be because they followed what does they friends said. Although, they said that the situation in the class is comfortable, this does not imply that it is comfortable by any means.

Lastly, ventilation is very important to improve the indoor air quality and it is essential process to replaced the stale air with fresh air. It is to avoid the students felt drowsy and not comfortable during their studies as it can reduced the students productivity. In order to avoid the air flow from lingering inside the building, teachers should open the windows or doors to allow fresh air inside the buildings.

## 5.2 Recommendations

There are few recommendations that can be proposed in this study for education system and future study. It is to improve the findings and increase validity of the results. Below are the recommendations that can be apply:

i) Ventilation system for education system can be improvised by adding more mechanical fans such as exhaust fans.

ii) Choose different site location and environment. Different locations and surroundings can produce better results to determine which location has a higher level of thermal comfort.

iii) Increased the number of sample data to acquired more valid and significant data. For example, take the data for three days in a row for each preschool.

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# APPENDICES

APPENDIX A Gantt Chart Final Year Project 1

| Week / Task | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PSM 1 briefing & meeting with Supervisor | | | | | | | | | | | | | | | | |
| Study research | | | | | | | | | | | | | | | | |
| Literature review | | | | | | | | | | | | | | | | |
| Methodology | | | | | | | | | | | | | | | | |
| Expected result | | | | | | | | | | | | | | | | |
| Writing the proposal | | | | | | | | | | | | | | | | |
| Proposal draft submission | | | | | | | | | | | | | | | | |
| Proposal report submission | | | | | | | | | | | | | | | | |
| Presentation of the proposal | | | | | | | | | | | | | | | | |

APPENDIX BGantt Chart Final Year Project 2

| Week / Task | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PSM 2 briefing & meeting with Supervisor | | | | | | | | | | | | | | | | |
| Update the methodology | | | | | | | | | | | | | | | | |
| Research regarding questionnaire and software | | | | | | | | | | | | | | | | |
| Apply permission to collect the data | | | | | | | | | | | | | | | | |
| Collect data from 3 different preschools | | | | | | | | | | | | | | | | |
| Update report, tabulating and analyzing the data obtained | | | | | | | | | | | | | | | | |
| Overall report, conclusion and recommendation | | | | | | | | | | | | | | | | |
| Proposal report submission & presentation | | | | | | | | | | | | | | | | |

APPENDIX CData collection based on different parameters using TSI Velocicalc for preschool A

| Parameters / Data every 5 minutes | Air temperature ($°C$) | Air velocity (m/s) | Relative humidity (%) | Co2 (ppm) |
|---|---|---|---|---|
| 8:00 | 27.54 | 0.481 | 85.44 | 549.6 |
| 8:05 | 27.68 | 0.476 | 85.5 | 574.2 |
| 8:10 | 27.8 | 0.470 | 85.66 | 593.2 |
| 8:15 | 27.88 | 0.463 | 85.72 | 595.8 |
| 8:20 | 27.96 | 0.490 | 85.72 | 620.6 |
| 8:25 | 28.04 | 0.400 | 85.8 | 639.2 |
| 8:30 | 28.16 | 0.400 | 85.32 | 651.6 |
| 8:35 | 28.1 | 0.487 | 84.48 | 617.6 |
| 8:40 | 28.2 | 0.490 | 84.32 | 621.6 |
| 8:45 | 28.18 | 0.484 | 84.92 | 618.4 |
| 8:50 | 28.2 | 0.470 | 84.22 | 597.2 |
| 8:55 | 28.2 | 0.478 | 83.06 | 572 |
| 9:00 | 28.04 | 0.475 | 81.06 | 502 |
| 9:05 | 28.18 | 0.473 | 81.1 | 514.4 |
| 9:10 | 28.3 | 0.471 | 81.44 | 536.4 |
| 9:15 | 28.38 | 0.390 | 81.98 | 552.2 |
| 9:20 | 28.48 | 0.383 | 82.4 | 579 |
| 9:25 | 28.46 | 0.378 | 81.96 | 561.4 |
| 9:30 | 28.5 | 0.381 | 81.88 | 559.6 |
| 9:35 | 28.54 | 0.380 | 81.82 | 563.8 |
| 9:40 | 28.6 | 0.376 | 82.48 | 571.2 |
| 9:45 | 28.64 | 0.377 | 82.46 | 572.6 |
| 9:50 | 28.7 | 0.365 | 81.94 | 574 |
| 9:55 | 28.78 | 0.364 | 81.3 | 548.4 |
| 10:00 | 28.8 | 0.357 | 81.48 | 543.2 |
| 10:05 | 28.84 | 0.351 | 81.54 | 540 |
| 10:10 | 28.8 | 0.361 | 81.22 | 522.4 |
| 10:15 | 28.9 | 0.350 | 81.14 | 536.2 |
| 10:20 | 28.9 | 0.343 | 80.78 | 529.6 |
| 10:25 | 28.9 | 0.341 | 80.52 | 529.2 |
| 10:30 | 29 | 0.339 | 81.12 | 548.6 |
| 10:35 | 29.08 | 0.340 | 80.72 | 547 |
| 10:40 | 29.1 | 0.335 | 80.14 | 530.4 |
| 10:45 | 29.14 | 0.331 | 80.12 | 517.4 |
| 10:50 | 29.2 | 0.327 | 79.32 | 515.8 |
| 10:55 | 29.3 | 0.323 | 79.58 | 525.6 |
| 11:00 | 29.3 | 0.320 | 79.94 | 530.4 |
| 11:05 | 29.4 | 0.312 | 79.46 | 525.2 |
| 11:10 | 29.4 | 0.318 | 78.48 | 520.8 |

APPENDIX C (Cont.) Data collection based on different parameters using TSI VelociCalc for preschool A

| | | | | |
|---|---|---|---|---|
| 11:15 | 29.4 | 0.302 | 78.54 | 533.2 |
| 11:20 | 29.46 | 0.290 | 78.78 | 540 |
| 11:25 | 29.6 | 0.294 | 78.86 | 559.6 |
| 11:30 | 29.64 | 0.283 | 78.76 | 548 |
| 11:35 | 29.74 | 0.270 | 78.58 | 539.8 |
| 11:40 | 29.66 | 0.265 | 78.32 | 495.8 |
| 11:45 | 29.76 | 0.273 | 77.76 | 458.6 |
| 11:50 | 29.74 | 0.251 | 78.48 | 454.4 |
| 11:55 | 29.7 | 0.255 | 79.18 | 453.4 |
| 12:00 | 30.0 | 0.242 | 78.89 | 457.6 |
| 12:05 | 30.09 | 0.236 | 78.61 | 461.3 |
| 12:10 | 30.16 | 0.225 | 78.59 | 464.5 |
| 12:15 | 30.2 | 0.240 | 78.51 | 463.7 |
| 12:20 | 30.27 | 0.217 | 78.48 | 463.4 |
| 12:25 | 30.31 | 0.205 | 78.32 | 462.9 |
| 12:30 | 30.5 | 0.207 | 78.2 | 462.5 |
| 12:35 | 30.69 | 0.196 | 78.13 | 461.8 |
| 12:40 | 30.8 | 0.178 | 78.23 | 461.3 |
| 12:45 | 30.92 | 0.165 | 78.11 | 460.9 |
| 12:50 | 31.02 | 0.163 | 78.08 | 459.1 |
| 13:00 | 31.36 | 0.196 | 77.98 | 459.5 |
| 13:05 | 31.41 | 0.136 | 77.81 | 458.6 |
| 13:10 | 31.5 | 0.195 | 77.76 | 458.1 |
| 13:15 | 31.59 | 0.184 | 77.53 | 457.9 |
| 13:20 | 31.63 | 0.217 | 77.49 | 456.4 |
| 13:25 | 31.8 | 0.198 | 77.41 | 456.1 |
| 13:30 | 31.89 | 0.213 | 77.39 | 455.7 |
| 13:35 | 32.0 | 0.188 | 77.31 | 455.1 |
| 13:40 | 32.31 | 0.198 | 77.28 | 452.7 |
| 13:45 | 32.46 | 0.213 | 77.18 | 452.1 |
| 13:50 | 32.5 | 0.203 | 77.10 | 448.6 |
| 13:55 | 32.56 | 0.199 | 77.01 | 443.8 |
| 14:00 | 32.65 | 0.176 | 76.0 | 441 |

APPENDIX D Data collection of amount of dust particles using TSI Dust Trax for preschool A

| Data Every 5 minutes | TOTAL PM |
|---|---|
| 8:00 | 0.0897 |
| 8:05 | 0.1056 |
| 8:10 | 0.1224 |
| 8:15 | 0.1415 |
| 8:20 | 0.1606 |
| 8:25 | 0.1816 |
| 8:30 | 0.216 |
| 8:35 | 0.2134 |
| 8:40 | 0.2159 |
| 8:45 | 0.2184 |
| 8:50 | 0.2203 |
| 8:55 | 0.2208 |
| 9:00 | 0.2229 |
| 9:05 | 0.2277 |
| 9:10 | 0.2321 |
| 9:15 | 0.2324 |
| 9:20 | 0.2322 |
| 9:25 | 0.2338 |
| 9:30 | 0.2367 |
| 9:35 | 0.2371 |
| 9:40 | 0.2365 |
| 9:45 | 0.237 |
| 9:50 | 0.2359 |
| 9:55 | 0.2385 |
| 10:00 | 0.241 |
| 10:05 | 0.2428 |
| 10:10 | 0.2432 |
| 10:15 | 0.2433 |
| 10:20 | 0.2452 |
| 10:25 | 0.2466 |
| 10:30 | 0.2482 |
| 10:35 | 0.2499 |
| 10:40 | 0.2487 |
| 10:45 | 0.2498 |
| 10:50 | 0.2509 |
| 10:55 | 0.2516 |
| 11:00 | 0.2537 |
| 11:05 | 0.257 |
| 11:10 | 0.2582 |
| 11:15 | 0.2654 |
| 11:20 | 0.2654 |
| 11:25 | 0.2639 |

APPENDIX D (Cont.) Data collection of amount of dust particles using TSI Dust Trax for preschool A

| | |
|---|---|
| 11:30 | 0.2641 |
| 11:35 | 0.2673 |
| 11:40 | 0.2714 |
| 11:45 | 0.2732 |
| 11:50 | 0.2769 |
| 11:55 | 0.2784 |
| 12:00 | 0.2790 |
| 12:05 | 0.2810 |
| 12:10 | 0.2823 |
| 12:15 | 0.2828 |
| 12:20 | 0.2836 |
| 12:25 | 0.2849 |
| 12:30 | 0.2861 |
| 12:35 | 0.2878 |
| 12:40 | 0.2901 |
| 12:45 | 0.2934 |
| 12:50 | 0.2945 |
| 13:00 | 0.2959 |
| 13:05 | 0.2931 |
| 13:10 | 0.2954 |
| 13:15 | 0.2963 |
| 13:20 | 0.2989 |
| 13:25 | 0.3056 |
| 13:30 | 0.3124 |
| 13:35 | 0.3155 |
| 13:40 | 0.3169 |
| 13:45 | 0.3153 |
| 13:50 | 0.3201 |
| 13:55 | 0.3256 |
| 14:00 | 0.3272 |

APPENDIX E Data collection based on different parameters using TSI VelociCalc for preschool B

| Parameters / Data every 5 minutes | Air temperature ($°C$) | Air velocity (m/s) | Relative humidity (%) | Co2 (ppm) |
|---|---|---|---|---|
| 8:00 | 27 | 0.516 | 88.6 | 603.6 |
| 8:05 | 27.12 | 0.497 | 88.58 | 590 |
| 8:10 | 27.28 | 0.465 | 88.56 | 593.8 |
| 8:15 | 27.42 | 0.451 | 88.3 | 594.4 |
| 8:20 | 27.56 | 0.441 | 88.04 | 600.4 |
| 8:25 | 27.6 | 0.437 | 88.04 | 604.2 |
| 8:30 | 27.6 | 0.428 | 87.94 | 589.6 |
| 8:35 | 27.6 | 0.416 | 87.88 | 585.2 |
| 8:40 | 27.74 | 0.406 | 87.16 | 583.4 |
| 8:45 | 27.92 | 0.427 | 85.92 | 591.2 |
| 8:50 | 28.06 | 0.410 | 85.6 | 637.8 |
| 8:55 | 28.1 | 0.404 | 85.56 | 667 |
| 9:00 | 28.2 | 0.398 | 85.58 | 678 |
| 9:05 | 28.22 | 0.382 | 85.6 | 679.6 |
| 9:10 | 28.28 | 0.376 | 85.62 | 688 |
| 9:15 | 28.3 | 0.389 | 85.76 | 697.4 |
| 9:20 | 28.3 | 0.363 | 85.38 | 656.8 |
| 9:25 | 28.32 | 0.351 | 84.94 | 642.8 |
| 9:30 | 28.3 | 0.348 | 84.46 | 625 |
| 9:35 | 28.36 | 0.354 | 84.78 | 621.4 |
| 9:40 | 28.42 | 0.319 | 85.16 | 630.6 |
| 9:45 | 28.3 | 0.293 | 85.22 | 610.4 |
| 9:50 | 28.28 | 0.286 | 84.42 | 591.4 |
| 9:55 | 28.38 | 0.273 | 84.3 | 566.8 |
| 10:00 | 28.46 | 0.270 | 83.84 | 547 |
| 10:05 | 28.52 | 0.264 | 83.7 | 539.2 |
| 10:10 | 28.6 | 0.261 | 84.02 | 548.6 |
| 10:15 | 28.74 | 0.256 | 84.14 | 546.8 |
| 10:20 | 28.7 | 0.250 | 83.98 | 533.2 |
| 10:25 | 28.96 | 0.238 | 84.02 | 564.6 |
| 10:30 | 29.02 | 0.265 | 83.68 | 546.2 |
| 10:35 | 29.12 | 0.256 | 83.14 | 528.4 |
| 10:40 | 29.28 | 0.234 | 83.04 | 531.2 |
| 10:45 | 29.38 | 0.210 | 82.66 | 542 |
| 10:50 | 29.74 | 0.190 | 80.86 | 562.4 |
| 10:55 | 29.78 | 0.155 | 80.04 | 540.8 |
| 11:00 | 29.82 | 0.176 | 79.34 | 539 |
| 11:05 | 29.96 | 0.186 | 79.04 | 559.4 |
| 11:10 | 30.02 | 0.152 | 78.66 | 559.8 |

APPENDIX E (Cont.) Data collection based on different parameters using TSI VelociCalc for preschool B

| | | | | |
|---|---|---|---|---|
| 11:15 | 30.1 | 0.149 | 78.12 | 574.8 |
| 11:20 | 30.18 | 0.160 | 78.02 | 589 |
| 11:25 | 30.12 | 0.224 | 77.3 | 571.8 |
| 11:30 | 30.18 | 0.243 | 77.52 | 565 |
| 11:35 | 30.18 | 0.210 | 77.78 | 561.6 |
| 11:40 | 30.1 | 0.161 | 77.72 | 533.6 |
| 11:45 | 30.14 | 0.135 | 77.78 | 515.2 |
| 11:50 | 30.2 | 0.152 | 77.98 | 533.2 |
| 11:55 | 30.12 | 0.147 | 77.22 | 529.8 |
| 12:00 | 30.33 | 0.113 | 77.01 | 523.8 |
| 12:05 | 30.3 | 0.156 | 76.98 | 521.7 |
| 12:10 | 30.48 | 0.125 | 76.57 | 522.4 |
| 12:15 | 30.6 | 0.142 | 76.61 | 521.3 |
| 12:20 | 30.74 | 0.163 | 76.79 | 520.1 |
| 12:25 | 30.8 | 0.153 | 76.81 | 516.4 |
| 12:30 | 30.95 | 0.122 | 76.34 | 511.4 |
| 12:35 | 31.01 | 0.180 | 76.28 | 510.1 |
| 12:40 | 31.18 | 0.143 | 76.21 | 500.8 |
| 12:45 | 31.3 | 0.151 | 76.14 | 496.3 |
| 12:50 | 31.39 | 0.163 | 76.09 | 482.6 |
| 13:00 | 31.43 | 0.141 | 76.01 | 486.8 |
| 13:05 | 31.58 | 0.121 | 75.96 | 482.8 |
| 13:10 | 31.6 | 0.151 | 75.9 | 480.5 |
| 13:15 | 31.71 | 0.131 | 75.87 | 479.5 |
| 13:20 | 31.8 | 0.133 | 75.81 | 465.5 |
| 13:25 | 32.0 | 0.126 | 75.77 | 465.9 |
| 13:30 | 32.08 | 0.141 | 75.71 | 451.8 |
| 13:35 | 32.14 | 0.150 | 75.4 | 450.6 |
| 13:40 | 32.20 | 0.144 | 75.51 | 449.4 |
| 13:45 | 32.23 | 0.160 | 75.59 | 447.8 |
| 13:50 | 32.31 | 0.154 | 75.63 | 444.5 |
| 13:55 | 32.4 | 0.151 | 73.78 | 442.5 |
| 14:00 | 32.47 | 0.152 | 73.23 | 440.3 |

APPENDIX F Data collection of amount of dust particles using TSI Dust Trax for preschool B

| Data Every 5 minutes | TOTAL PM |
|---|---|
| 8:00 | 0.1783 |
| 8:05 | 0.1375 |
| 8:10 | 0.1176 |
| 8:15 | 0.1184 |
| 8:20 | 0.1337 |
| 8:25 | 0.1513 |
| 8:30 | 0.1692 |
| 8:35 | 0.1876 |
| 8:40 | 0.2009 |
| 8:45 | 0.2054 |
| 8:50 | 0.2086 |
| 8:55 | 0.2128 |
| 9:00 | 0.2137 |
| 9:05 | 0.2171 |
| 9:10 | 0.2207 |
| 9:15 | 0.2231 |
| 9:20 | 0.2278 |
| 9:25 | 0.232 |
| 9:30 | 0.2422 |
| 9:35 | 0.2578 |
| 9:40 | 0.2477 |
| 9:45 | 0.2383 |
| 9:50 | 0.2362 |
| 9:55 | 0.2347 |
| 10:00 | 0.2361 |
| 10:05 | 0.238 |
| 10:10 | 0.2407 |
| 10:15 | 0.2405 |
| 10:20 | 0.2445 |
| 10:25 | 0.2443 |
| 10:30 | 0.2467 |
| 10:35 | 0.2472 |
| 10:40 | 0.2499 |
| 10:45 | 0.2516 |
| 10:50 | 0.2541 |
| 10:55 | 0.2564 |
| 11:00 | 0.2576 |
| 11:05 | 0.2595 |
| 11:10 | 0.2579 |
| 11:15 | 0.2605 |
| 11:20 | 0.2612 |
| 11:25 | 0.2617 |

APPENDIX F (Cont.) Data collection of amount of dust particles using TSI Dust Trax for preschool B

| | |
|---|---|
| 11:30 | 0.2607 |
| 11:35 | 0.2613 |
| 11:40 | 0.2635 |
| 11:45 | 0.2664 |
| 11:50 | 0.2694 |
| 11:55 | 0.2692 |
| 12:00 | 0.2720 |
| 12:05 | 0.2731 |
| 12:10 | 0.2748 |
| 12:15 | 0.2736 |
| 12:20 | 0.2757 |
| 12:25 | 0.2797 |
| 12:30 | 0.2821 |
| 12:35 | 0.2863 |
| 12:40 | 0.2895 |
| 12:45 | 0.2924 |
| 12:50 | 0.2893 |
| 13:00 | 0.2910 |
| 13:05 | 0.2951 |
| 13:10 | 0.2968 |
| 13:15 | 0.2976 |
| 13:20 | 0.2998 |
| 13:25 | 0.3009 |
| 13:30 | 0.3016 |
| 13:35 | 0.3028 |
| 13:40 | 0.3011 |
| 13:45 | 0.3025 |
| 13:50 | 0.3034 |
| 13:55 | 0.3041 |
| 14:00 | 0.3033 |

APPENDIX G Data collection based on different parameters using TSI VelociCalc for preschool C

| Parameters / Data every 5 minutes | Air temperature ($°C$) | Air velocity (m/s) | Relative humidity (%) | Co2 (ppm) |
|---|---|---|---|---|
| 8:00 | 27.24 | 0.504 | 87.78 | 558.8 |
| 8:05 | 27.16 | 0.495 | 88.74 | 553.6 |
| 8:10 | 27.22 | 0.463 | 88.52 | 565 |
| 8:15 | 27.34 | 0.455 | 88.62 | 566.2 |
| 8:20 | 27.48 | 0.448 | 88.34 | 572.2 |
| 8:25 | 27.58 | 0.432 | 87.74 | 564.4 |
| 8:30 | 27.38 | 0.429 | 86.68 | 532.8 |
| 8:35 | 27.36 | 0.414 | 85.86 | 527 |
| 8:40 | 27.54 | 0.411 | 85.88 | 538.2 |
| 8:45 | 27.76 | 0.421 | 85.8 | 543.6 |
| 8:50 | 27.84 | 0.419 | 85.64 | 544.4 |
| 8:55 | 27.86 | 0.417 | 85.3 | 558.8 |
| 9:00 | 28.12 | 0.410 | 85.52 | 567.6 |
| 9:05 | 28.28 | 0.407 | 85.08 | 574.8 |
| 9:10 | 28.44 | 0.402 | 84.92 | 583.2 |
| 9:15 | 28.52 | 0.395 | 84.42 | 560.4 |
| 9:20 | 28.58 | 0.382 | 83.94 | 546.2 |
| 9:25 | 28.74 | 0.376 | 82.94 | 535.6 |
| 9:30 | 28.9 | 0.389 | 82.18 | 534 |
| 9:35 | 29.06 | 0.363 | 81.9 | 527.4 |
| 9:40 | 29.12 | 0.351 | 80.9 | 530.6 |
| 9:45 | 29.26 | 0.348 | 81.12 | 515.2 |
| 9:50 | 29.52 | 0.354 | 80.92 | 520.2 |
| 9:55 | 29.72 | 0.350 | 79.52 | 524.2 |
| 10:00 | 30.04 | 0.343 | 79.28 | 524 |
| 10:05 | 30.22 | 0.329 | 78.18 | 505.2 |
| 10:10 | 30.6 | 0.334 | 77.5 | 515.2 |
| 10:15 | 30.7 | 0.329 | 76.44 | 505.8 |
| 10:20 | 30.68 | 0.322 | 76.62 | 504.8 |
| 10:25 | 30.56 | 0.322 | 76.54 | 507 |
| 10:30 | 30.64 | 0.318 | 75.8 | 515 |
| 10:35 | 30.6 | 0.312 | 76.5 | 506 |
| 10:40 | 30.74 | 0.307 | 76.32 | 510.2 |
| 10:45 | 30.74 | 0.298 | 76.42 | 511 |
| 10:50 | 30.82 | 0.294 | 76.8 | 513 |
| 10:55 | 30.82 | 0.283 | 76.4 | 504 |
| 11:00 | 30.94 | 0.287 | 75.1 | 505.4 |
| 11:05 | 31.12 | 0.284 | 74.56 | 508.8 |
| 11:10 | 31.34 | 0.271 | 73.84 | 487.2 |

APPENDIX G (Cont.) Data collection based on different parameters using TSI VelociCalc for preschool C

| | | | | |
|---|---|---|---|---|
| 11:15 | 31.22 | 0.274 | 72.9 | 452 |
| 11:20 | 31.58 | 0.270 | 72.8 | 495.8 |
| 11:25 | 31.64 | 0.264 | 72.9 | 507.2 |
| 11:30 | 31.74 | 0.271 | 72.52 | 491.2 |
| 11:35 | 31.82 | 0.250 | 71.84 | 474.6 |
| 11:40 | 32.02 | 0.256 | 72.54 | 485.6 |
| 11:45 | 32.1 | 0.243 | 70.26 | 482.2 |
| 11:50 | 32.02 | 0.239 | 68.88 | 462.4 |
| 11:55 | 32.3 | 0.231 | 69.4 | 450.6 |
| 12:00 | 32.33 | 0.240 | 69.37 | 463.5 |
| 12:05 | 32.4 | 0.214 | 69.21 | 471.4 |
| 12:10 | 32.46 | 0.201 | 69.18 | 461.6 |
| 12:15 | 32.51 | 0.209 | 69.05 | 460.5 |
| 12:20 | 32.59 | 0.194 | 68.98 | 459.4 |
| 12:25 | 32.71 | 0.179 | 68.76 | 458.5 |
| 12:30 | 32.88 | 0.160 | 68.54 | 457.3 |
| 12:35 | 32.91 | 0.162 | 68.39 | 455.8 |
| 12:40 | 33.0 | 0.191 | 68.31 | 453.5 |
| 12:45 | 33.02 | 0.136 | 68.29 | 451.7 |
| 12:50 | 33.08 | 0.192 | 68.1 | 449.8 |
| 13:00 | 33.1 | 0.187 | 67.93 | 448.1 |
| 13:05 | 33.14 | 0.216 | 68.14 | 451.5 |
| 13:10 | 33.19 | 0.195 | 68.10 | 447.5 |
| 13:15 | 33.22 | 0.219 | 67.87 | 442.4 |
| 13:20 | 33.26 | 0.185 | 67.79 | 440.8 |
| 13:25 | 33.26 | 0.190 | 67.7 | 439.1 |
| 13:30 | 33.33 | 0.215 | 67.65 | 437.4 |
| 13:35 | 33.38 | 0.202 | 67.83 | 435.6 |
| 13:40 | 33.41 | 0.195 | 67.41 | 434.2 |
| 13:45 | 33.44 | 0.179 | 67.34 | 432.9 |
| 13:50 | 33.47 | 0.156 | 67.21 | 431.1 |
| 13:55 | 33.49 | 0.154 | 67.1 | 430.8 |
| 14:00 | 33.5 | 0.150 | 67.02 | 430.1 |

APPENDIX H Data collection of amount of dust particles using TSI Dust Trax for preschool C

| Data Every 5 minutes | TOTAL PM |
|---|---|
| 8:00 | 0.0995 |
| 8:05 | 0.0725 |
| 8:10 | 0.0777 |
| 8:15 | 0.0865 |
| 8:20 | 0.1028 |
| 8:25 | 0.1274 |
| 8:30 | 0.1577 |
| 8:35 | 0.1815 |
| 8:40 | 0.1935 |
| 8:45 | 0.2013 |
| 8:50 | 0.2252 |
| 8:55 | 0.2307 |
| 9:00 | 0.2216 |
| 9:05 | 0.2238 |
| 9:10 | 0.2229 |
| 9:15 | 0.2214 |
| 9:20 | 0.2224 |
| 9:25 | 0.2214 |
| 9:30 | 0.2238 |
| 9:35 | 0.2266 |
| 9:40 | 0.2329 |
| 9:45 | 0.2354 |
| 9:50 | 0.2369 |
| 9:55 | 0.238 |
| 10:00 | 0.2396 |
| 10:05 | 0.2418 |
| 10:10 | 0.2466 |
| 10:15 | 0.2497 |
| 10:20 | 0.2517 |
| 10:25 | 0.252 |
| 10:30 | 0.2549 |
| 10:35 | 0.2577 |
| 10:40 | 0.259 |
| 10:45 | 0.2622 |
| 10:50 | 0.2692 |
| 10:55 | 0.2684 |
| 11:00 | 0.2638 |
| 11:05 | 0.2626 |
| 11:10 | 0.2641 |
| 11:15 | 0.2684 |
| 11:20 | 0.2695 |
| 11:25 | 0.2709 |
| 11:30 | 0.2742 |

APPENDIX H (Cont.) Data collection of amount of dust particles using TSI Dust Trax for preschool C

| | |
|---|---|
| 11:35 | 0.2764 |
| 11:40 | 0.2799 |
| 11:45 | 0.2799 |
| 11:50 | 0.2828 |
| 11:55 | 0.282 |
| 12:00 | 0.2833 |
| 12:05 | 0.2869 |
| 12:10 | 0.2891 |
| 12:15 | 0.2905 |
| 12:20 | 0.2938 |
| 12:25 | 0.2924 |
| 12:30 | 0.2937 |
| 12:35 | 0.2982 |
| 12:40 | 0.2998 |
| 12:45 | 0.3021 |
| 12:50 | 0.3018 |
| 13:00 | 0.3029 |
| 13:05 | 0.3058 |
| 13:10 | 0.3088 |
| 13:15 | 0.3142 |
| 13:20 | 0.3179 |
| 13:25 | 0.3165 |
| 13:30 | 0.3198 |
| 13:35 | 0.3227 |
| 13:40 | 0.3264 |
| 13:45 | 0.3291 |
| 13:50 | 0.3301 |
| 13:55 | 0.3328 |
| 14:00 | 0.3321 |

APPENDIX I Questionnaire distribution towards students

Questionaire For Students Towards Thermal Comfort In Their Pre School

Nama: Umur:

Jantina: Tarikh:

1. Adakah anda berasa selesa pada hari ini?

   - Ya - Tidak

2. Nyatakan keadaan yang anda rasai sekarang ini?

   - Selesa - Sangat selesa
   - Tidak selesa - Sangat tidak selesa

3. Apakah yang anda rasa dengan suhu bilik pada masa ini?

   - Sangat panas - Panas - Sedikit panas
   - Natural - Sedikit sejuk - Sejuk
   - Sangat sejuk



4. Sekiranya anda diberi pilihan, keadaan bilik darjah yang mana anda inginkan?

   - Lebih sejuk - Sejuk - Tidak berubah
   - Panas - Lebih panas

5. Di manakah kedudukan anda semasa sesi pengajaran & pembelajaran dilaksanakan?

   - Tingkap - Di belakang kelas
   - Kipas - Di tengah kelas
   - Di Depan kelas

APPENDIX I (Cont.) Questionnaire distribution towards students

6. Apakah yang anda akan lakukan sekiranya anda berasa panas atau sejuk?

   - Membuka tingkap
   - Menutup tingkap
   - Membuka pintu
   - Menutup pintu
   - Bergerak ke arah kipas

7. Adakah anda berpuas hati dengan suhu persekitaran bilik darjah pada waktu ini?

   - Ya - Tidak

8. Nyatakan ciri – ciri pakaian yang anda pakai hari ini.

| | Ya | Tidak |
|---|---|---|
| Baju lengan Panjang | | |
| Baju lengan pendek | | |
| Seluar Panjang | | |
| Seluar pendek | | |
| Tudung | | |
| Stoking | | |
| Skirt | | |

9. Apakah aktiviti yang telah anda lakukan 10 minit yang lalu?

   Makan Minum Berlari
   Berjalan Membaca Menulis

10. Antara pilihan di bawah, gambarkan apa yang anda rasa ketika berada di dalam kelas sekarang?

    Pening Sesak nafas Tidak selesa
    Mengantuk Letih Lapar

APPENDIX J Photos taken during conducting the study at different preschools

Locations of different preschools to conduct the study



TSI Velocicalc and TSI Dust Trax were placed at the center of class

Briefing was given to the students before starting the data collection

APPENDIX J (Cont.) Photos taken during conducting this study at different preschools

Student raised up the paper if they agree with the questions

Q and A session based on questionnaire with the students




Taking photos with the students of each preschool

APPENDIX K Permission letter to conduct research at Tabika KEMAS

Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya,
76100 Durian Tunggal,
Melaka, Malaysia.

+606 270 1000
+606 270 1022
www.utem.edu.my

**FAKULTI TEKNOLOGI KEJURUTERAAN MEKANIKAL DAN PEMBUATAN**

Tel : +606 270 1184 | Faks : +606 270 1064

Rujukan Kami (Our Ref): UTeM.46.01/500-25/1
Rujukan Tuan (Your Ref):
Tarikh (Date): 17 Oktober 2021

Pengarah KEMAS Negeri Melaka,
Jabatan Kemajuan Masyarakat (KEMAS)
NEGERI MELAKA,
Tingkat 2, Menara Persekutuan
Jalan Persekutuan,Hang Tuah Jaya
75450 Ayer Keroh, Melaka

Tuan/Puan,

**PEMOHONAN KEBENARAN MENJALANKAN KAJIAN / PENYELIDIKAN PERGERAKAN ANGIN DAN KESELESAAN TERMA BAGI TABIKA KEMAS RUMAH PANGSA KG.PADANG, TABIKA KEMAS KG PADANG A DAN TABIKA KEMAS KG PADANG B**

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Merujuk kepada perkara diatas, saya Nur Nabilah Binti Mohd Ishak (B091810284) merupakan pelajar dari Fakuliti Teknologi Kejuruteraan Mekanikal dan Pembuatan (FTKMP) di Universiti Teknikal Malaysia Melaka ingin memohon kebenaran daripada pihak tuan/puan bagi menjalankan penyelidikan di peringkat sarjana muda mengenai "Thermal comfort evaluation at non- air conditioning pre school" di Tiga (3) buah Tabika Kemas sekitar Melaka iaitu di Tabika Kemas Rumah Pangsa Kg.Padang, Tabika Kemas Kg Padang A Dan Tabika Kemas Kg Padang B.

3. Untuk makluman pihak tuan/puan, saya akan meletakkan alat pengukuran dan instrumentasi di dalam kawasan tabika. Alatan tersebut tidak akan mengganggu proses pembelajaran di tabika.Saya juga akan meletakkan alat itu sebelum murid mula datang ke sekolah dan akan mengambil semula alatan ini setelah murid pulang. Segala pematuhan SOP akan saya jaga dengan teliti.

4. Selain itu, saya akan melakukan sesi soal jawab bersama dengan murid di Tabika Kemas Kg Padang B, Melaka mengenai tahap keselesaan murid "Thermal comfort". Bersama - sama surat ini saya sertakan lampiran soal selidik yang akan saya ajukan kepada murid ketika bertanyakan soalan kepada para murid. Dengan ini, saya sertakan tarikh dan masa bagi proses penyelidikan ini berjalan dengan lancar dan teratur.

Tarikh: 22.11.2021 sehingga 31.11.2021
Masa: 7:30 pagi sehingga 12:30 tengahari

5. Kerjasama daripada pihak tuan amat saya hargai. Semoga dengan kajian ini dapat meningkatkan keselesaan di kalangan murid pra sekolah. Saya boleh dihubungi di talian 013-3280864 atau Penyelia Projek Sarjana Muda, Ts. Dr. Amir Abdullah 016-6573835.

Sekian, terima kasih.

Yang benar,

.....
Nur Nabilah Binti Mohd Ishak
Fakulti Teknologi Kejuteraan Mekanikal dan Pembuatan(FTKMP),
Universiti Teknikal Malaysia Melaka.

APPENDIX L TURNITIN

THERMAL COMFORT EVALUATION AT THREE NON AIR CONDITIONED PRE SCHOOL IN MELAKA USING CBE TOOL

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TS. DR. AMIR ABDULLAH BIN MUHAMAD DAMANHURI
Pensyarah
Jabatan Teknologi Kejuruteraan Mekanikal
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **THERMAL COMFORT EVALUATION AT THREE NON AIR CONDITIONED PRE SCHOOL IN MELAKA USING CBE TOOL**

SESI PENGAJIAN: **2021/22 Semester 1**

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