

# OPTIMIZING AIR FLOW DISTRIBUTION OF THREE NON-AIR-CONDITIONED PRE-SCHOOL AT MELAKA



# BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (MAINTENANCE TECHNOLOGY) WITH HONOURS

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# Faculty of Mechanical and Manufacturing Engineering Technology



# MUHAMMAD LUQMAN HAZIQ BIN ZULKIFLEE

# Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours

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#### MUHAMMAD LUQMAN HAZIQ BIN ZULKIFLEE





Faculty of Mechanical and Manufacturing Engineering Technology

## UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

#### DECLARATION

I declare that this Choose an item. entitled "OPTIMIZING AIR FLOW DISTRIBUTION OF THREE NON-AIR-CONDITIONED PRE-SCHOOL AT MELAKA 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.



### 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 (Maintenance Technology) with Honours.

Signature	TS. DR. AMIR ABDULLAH BIN MUHAMAD DAMANHURI Pensyarah Jabatan Teknologi Kejuruteraan Mekanikal Sakulti Teknologi Kejuruteraan Mekanikal dan Pembuatar Universiti Teknikal Malaysia Melaka
Supervisor	Name Ts. Dr. Amir Abdullah Bin Muhamad Damanhuri
Date	: 19 January 2023
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#### DEDICATION

To my beloved parents. 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

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#### ABSTRACT

Air flow distribution refers to the air circulation in the classroom. Students unable to concentrate and feel distracted from the class activity due to their need comfortable surroundings. Lack of environmental parameter such as air velocity and air temperature cause of air distirbution in the classroom will result in environmental stress and negative trends toward occupants during teaching and learning session. This study is focused on the monitor and simulate the air flow distribution at 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 goal of this research is to discover the appropriate flow of air circulation that should be present throughout the learning process. It has been found that the value of environmental parameter of these preschools out of acceptable range value based on standard recommended by ASHRAE 55 - 2010 as well as Industry Code of Practice Indoor Air Quality, DOSH Malaysia (2010). Several data collection of environmental parameter more conducted air velocity and air temperature by using TSI VelociCalc instrument to improve air flow distribution in the classroom at three preschools. By using CFD simulation analysis tool method, an appropriate layout to improve air circulation are conduct. It will carry out four probability layouts of classroom for each three different preschools. From the simulation of all probability layouts, it carries of detailed map-out of air flow distribusion consist of air velocity and air temperature on the classroom of each three preschools. As a result of probability layouts, it can optimize which is the best layout of classroom that consists of great environmental parameter to be used as classroom layout for each preschool. The suitable layout to be use for preschool Tadika Kemas Rumah Pangsa Kampung Padang is the layout (b), preschool Tadika Kemas Kampung Padang A is layout (a), and preschool Tadika Kemas Kampung Padang B is layout (c). The best selected layout that suitable to be used to classroom at preschool is because consist the combination quality of air velocity and air temperature. By conclusion, the best selected layout of classroom for each three different preschool can solved the discomfortness of occupants in the classroom especially during teaching and learning session.

#### ABSTRAK

Pengagihan aliran udara merujuk kepada peredaran udara di dalam bilik darjah. Pelajar tidak dapat menumpukan perhatian dan berasa terganggu daripada aktiviti kelas kerana mereka memerlukan persekitaran yang selesa. Kekurangan parameter persekitaran seperti halaju udara dan suhu udara menyebabkan pengagihan udara di dalam bilik darjah akan mengakibatkan tekanan persekitaran dan trend negatif terhadap penghuni semasa sesi pengajaran dan pembelajaran. Kajian ini tertumpu kepada memantau dan mensimulasikan pengagihan aliran udara di tiga buah prasekolah yang berbeza di Melaka iaitu Tadika Kemas Rumah Pangsa Kampung Padang, Tadika Kemas Kampung Padang A dan Tadika Kemas Kampung Padang B. Matlamat penyelidikan ini adalah untuk mencari kesesuaian aliran peredaran udara yang perlu ada sepanjang proses pembelajaran. Telah didapati bahawa nilai parameter persekitaran prasekolah ini di luar nilai julat yang boleh diterima berdasarkan piawaian yang disyorkan oleh ASHRAE 55 - 2010 serta Kod Amalan Industri Kualiti Udara Dalaman, JKKP Malaysia (2010). Beberapa pengumpulan data parameter persekitaran lebih banyak menjalankan halaju udara dan suhu udara dengan menggunakan instrumen TSI VelociCalc untuk meningkatkan pengagihan aliran udara di dalam bilik darjah di tiga buah prasekolah. Dengan menggunakan kaedah alat analisis simulasi CFD, susun atur yang sesuai untuk meningkatkan peredaran udara dijalankan. Ia akan menjalankan empat susun atur kebarangkalian bilik darjah untuk setiap tiga prasekolah yang berbeza. Daripada simulasi semua susun atur kebarangkalian, ia membawa peta keluar terperinci pengagihan aliran udara yang terdiri daripada halaju udara dan suhu udara di bilik darjah setiap tiga prasekolah. Hasil daripada susun atur kebarangkalian, ia boleh mengoptimumkan susun atur bilik darjah yang terbaik yang terdiri daripada parameter persekitaran yang terbaik untuk digunakan sebagai susun atur bilik darjah bagi setiap prasekolah. Susun atur yang sesuai digunakan untuk prasekolah Tadika Kemas Rumah Pangsa Kampung Padang ialah susun atur (b), Tadika Kemas Kampung Padang A prasekolah ialah susun atur (a), dan Tadika Kemas Prasekolah Kampung Padang B ialah susun atur (c). Susun atur pilihan terbaik yang sesuai digunakan untuk bilik darjah di prasekolah adalah kerana terdiri daripada gabungan kualiti halaju udara dan suhu udara. Kesimpulannya, susun atur bilik darjah pilihan terbaik bagi setiap tiga prasekolah yang berbeza dapat menyelesaikan ketidakselesaan penghuni di dalam bilik darjah terutamanya semasa sesi pengajaran dan pembelajaran.

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## LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter	
Та	-	Air temperature (°C)	
V	-	Air velocity (m/s)	
MOE	-	Ministry od Education	
DOSH	-	Department of Occupational Safety and Health	
ASHRAE	-	American Society of Heating, Refrigeration and Air-Conditioning	
IAQ	-	Indoor Air Quality	
CFD	-	Computatitional Fluid Dynamic	
CV	-	Constant Volume	
VAV	-	Variable Air Volume	
VSD	- 10	Variable Speed Drive	
	A TEKUINAL		

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#### **CHAPTER 1**

#### **INTRODUCTION**

#### 1.1 Background

Education is very important in our lives. It is because learning is the process of gaining information, skills, or habits. Kindergarten, primary school, high school, college, and university are the stages of formal education in Malaysia. There are several educational institutions from which students can enrol, whether private or public.

School is an educational building where students may receive information, a hub for social events to gains the interaction between students towards the surroundings and a location where students can engage with their environment. It is critical that children have a pleasant atmosphere in which to learn. According to research, students aged 2 to 26 spend most of their waking hours in a classroom (from kindergarten to university) (de Dear et al., 2015). Students must attend school for a minimum of seven hours. It runs from 7:30 a.m. to 2:30 p.m. and is usually followed by compulsory co-curricular activities or extra classes. Each school has its own system of regulations that students must adhere to.

Malacca is located in Malaysia's southern region. Malaysia's tropical climate is hot humid all year. The climate has changed for unknown reasons, with the consequences of rising temperatures, severe weather events, and declining public health in Malaysia (Tang, 2019) This problem arises because of behaviours that contribute to global warming and greenhouse gas emissions, such as burning fossil fuels, chopping down trees, and raising animals. Furthermore, a curriculum is developed depending on local climate conditions, (Perkins et al., 2018). The surrounding environment influences students' performance in a classroom, such as attention, concentration, and learning. It makes no difference whether you are in elementary, secondary, or university.

In Malaysia, educational institutions must provide the basic criteria of satisfaction and comfort, such as a good environment, in order to improve student performance (Mazlan et al., 2020). The level of comfort between performance and environmental circumstances can be improved. A strategic place to develop a school building is also an important factor where children may study comfortably and focus while the teaching and learning process is carried out. This is because the surrounding environment could influence students' actions and desire to act. Students will be more focused and motivated to learn if they feel at ease. Furthermore, a pleasant, clean, and appealing school environment may encourage students to study well. Therefore, the preschool needs to prepare a good layout plan to get good air flow in the classroom. Window openers during teaching and learning session are very important to get good air flow to supply fresh air into the classroom.

#### 1.2 Problem Statement

# Classrooms are created for students to spend the most of their time in during the

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teaching and learning process at school. Teachers will typically apply all ideas and applications between students in the classroom. Students require pleasant environments throughout their studies to optimise their learning and performance at school. Thermal comfort of the surroundings is important because a lack of comfort might result in environmental stress and a negative trend (Nico et al., 2015).

Quality of the interior environment in elementary schools is frequently poor. According to (Wargocki et al., 2020), the temperature in the classroom has a significant influence on learning. Furthermore, the air quality in the classroom may influence cognitive skills since students are unable to concentrate and are distracted from the activity that they were intended to complete. Students' performance may feel the consequences of teachers' inability to teach effectively due to their need for comfortable surroundings. Thermal comfort is difficult to accomplish due to fluctuations in environment and weather. Because Malaysia's tropical climate is hot and humid, the temperature that has already been considered for human comfort is between 27.1°C and 29.3°C. To avoid this problem, we need to provide good air circulation to school buildings, especially classrooms.

#### 1.3 Research Objective

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

a) To monitor air temperature and air velocity of non air-conditioned for three different pre-school at Melaka.

b) To simulate air flow distribution based on environmental monitoring of three non-air-conditioned based on four probability layouts of pre-schools.

#### **1.4** Scope of Research

The aim of the research is to analyze whether or not the distribution of air flow in classrooms non air conditioning at a number of different preschools located in Malacca. In this research, three preschools will be chosen: Tadika Kemas Rumah Pangsa Kampung Padang, Tadika Kemas Kampung Padang A, and Tadika Kemas Kampung Padang B. The classroom will be occupied by students as well as other people at some point throughout the process of learning or having a discussion. In addition, the total number of pupils who will participate in this research will range from 15 to 20 in each preschool, and the mechanism that will be used will be a fan.

The air temperature (Ta), the air velocity (V) are going to be the parameters that are employed in this research that are dependent on the air distribution. A "thermometer enviroment indicator tool" will be used to measure the air temperature, a "air velocity meter tool" will be used to measure the air velocity, and a "Hygrometer tool" will be used to measure the relative humidity data (DOSH,2010). In addition, the data from the measurements will be taken using a "Hygrometer tool." Using design software, a visual layout of the classroom should be created after the necessary data has been collected. CATIA V5 2020 is going to be utilised for the structural analysis programme that will be used. After the structure has been created, the simulation can be simulated using the data that has been collected to run the simulation. This may be done depending on the data that has been taken. The software that will be used for the simulation is the most recent edition of Ansys Fluent, which is version 2022.

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#### **CHAPTER 2**

#### LITRERATURE REVIEW

#### 2.1 Introduction

In the context of comfortability, air distribution and indoor air quality IAQ are two key concerns that crop up on a regular basis (Merabtine et al., 2018) Comfort is of the utmost importance for both the environment and the individuals. People need to feel comfortable while they are engaging in an activity, regardless of whether it is taking place indoors or outside. For instance, students who are in class and workers who are working at their place of employment or even outdoors. In order for them to provide their best performance in the classroom, they need a sufficient supply of clean air. It is essential to make the space in which people live aesthetically pleasing, since this is where they will spend the majority of their time. It is necessary, for instance, that the temperature in the construction area be set appropriately in order for them to feel at ease there. In this chapter, a summary of the past study will be presented, as well as information on the distribution of air flow and the methods of simulation analysis.

#### 2.2 Preschools In Malacca

The Malaysian Ministry of Education claims that there are a total of 6,214 preschools throughout the country, including 170 in the city of Malacca alone. These preschools may be found in both urban and rural areas. Before starting elementary school, it is the goal of the preschool to provide youngsters with opportunity to develop core skills such as learning and exploration so that they are better prepared for those experiences. The minimum age that a student must be in order to be accepted into a preschool programme in accordance with the regulations established by the Ministry of Education varies from four to six years old. The majority of institutions of this kind are either privately owned or run by the government. Figure 2.1 shows the proportion of children in Malaysia who are under the age of 18 years old divided by state.



Figure 2.1 Percentage of children (under age 18 years), by state, Malaysia, 2021.

Preschools are often located by the side of the road, in residential neighbourhoods, or even on the grounds of nearby elementary schools. In most cases, parents will bring their children to preschool on their way to work, and they will pick them up again on their way home from work in the evening. The majority of parents choose to enrol their children in private schools as opposed to state institutions for education. They do this because they care about their students and want them to have a pleasurable interaction while they are learning. For instance, students at a private school would have access to an air conditioning system in the classroom, whereas at government schools, students would only make use of wind fans. This would allow students at private schools to participate in a wider variety of activities without feeling uncomfortable.

When it comes to the teaching and learning process in an academic setting, the environment of a classroom is just as important as how pleasant the seats are. In an essence, the children's ability to concentrate will be affected if the kindergarten is located in an area with a high level of pollution (Tong et al., 2017). The number of childcare centres that have been officially registered in Malaysia is shown in Figure 2.2 below for both 2018 and 2019.



#### 2.3 Description of Air Flow Distribution

Air distribution systems consist of air handlers, ductwork, and other components for heating, ventilating, and air-conditioning buildings. They provide fresh air to maintain indoor air quality and conditioned air to counteract heating and cooling demands. Their many components must act in concert in order to adequately sustain the appropriate conditions. Applying intelligent operating methods and appropriate maintenance procedures may greatly minimise their energy use. Constant-volume (CV) and variable-air-volume (VAV) airdistribution systems are the two most common types (VAV). The following descriptions give an overview of typical system types seen in bigger commercial and institutional structures. Constant-volume systems function with a constant airflow rate; only the temperature changes to maintain the area set temperature. Single-zone and multi-zone applications are both suitable for constant-volume units. The amount of supply air from a VAV air handler fluctuates in response to terminal units' supply air intake in order to maintain zone temperature setpoints. The supply-air fan is regulated in order to maintain a static pressure setpoint in the ductwork. In reaction to a static pressure sensor in the duct, supply-air volume is managed in one of three ways: 1) bypass dampers, 2) inlet vanes either upstream of or inside the supply fan casing, or 3) a variable-speed drive (VSD) on the fan motor controlling the fan speed.

According to the findings of the inquiry, a large number of studies have been conducted on the efficiency of ventilation, but only a small number of studies have been conducted on other elements of air distribution. The performance of each ventilation method varies from one case to another due to the various uses of the ventilation system in a room and the various assessment indices that are used. Among the various types of ventilation systems that are currently available, the performance of each ventilation method varies. This review demonstrates that the evaluation of the effectiveness or efficiency of ventilation should be carried out in accordance with each task that the ventilation system is responsible for, such as the removal of heat and pollutants, the provision of clean air to the breathing zone, and the prevention of the spread of infection from one occupant to another.

The enhancement of IAQ might lead to a reduction in student performance in the classroom, which in turn would increase intellectual ability. In addition, (Kabirikopaei et al., 2021) investigated the connection that exists between the variety of ventilation system,

the quantity of ventilation, the number of fine particles, the air temperature, the air velocity, and the relative humidity. They discovered a correlation between the reading scores of the subjects and the levels of PM2 in the air.

#### 2.4 Indoor Air Quality (IAQ)

Circulation of the air flow Productivity may be significantly influenced by the quality of the air a someone breathes (Daghigh, 2015) IAQ, in general, has the potential to have a major impact on both the health and quality of life of a person. Eighty to ninety percent of the population has a need for the cleanliness and purity of the air they breathe. A higher degree of comfort and protection for building inhabitants' health might be achieved by improving the building's indoor air quality. A person's ability to be comfortable and productive may be negatively impacted by poor air quality, especially in an educational setting. The assessment of indoor air quality (IAQ) often includes a measurement of relative humidity. This is because relative humidity is especially crucial since it influences how comfortable indoor air quality is considered to be. Eye irritation and pain in the airways are two symptoms that may have a detrimental influence on both the physical and emotional productivity of employees (Wolkoff, 2018).

The Department of Occupational Safety and Health (Keselamatan Dan Kesehatan Pekerjaan, n.d.-b) reports that occupants who are exposed to conditions that are in poor condition may have symptoms such as headaches, nausea, sore throat, irritated eyes, and skin irritation. It has been suggested by (Khairil et al., 2013) that an indoor environment that is conductive to pleasure may have an effect on the learning process as well as the motivation of students. The student's health issues will make it difficult for them to think clearly, memorise information, and concentrate on their studies. The acceptable range for a number

of different physical characteristics is outlined in Table 2.3 of the guidelines provided by the Department of Occupational Safety and Health (OSHA).

Parameter	Acceptable range
Air temperature	23°C – 26 °C
Relative humidity	$40\ m/s-70\ m/s$
Air movement	0.15  m/s - 0.50  m/s

Table 2.1 Acceptable range for specific physical parameters (DOSH,2010).

#### 2.5 Bad Air flow Distribution affact throught health problem

#### 2.5.1 Decreased productivity in classroom

The manner in which air flow is distributed has a significant impact on productivity. The study that was written by (Kaushik et al., 2020) said that the temperature of the environment had an effect on the productivity of the people who were living there. Between 21 and 25 degrees Celsius is the ideal temperature comfort range for occupants of a structure. If the temperature increases beyond 25 degrees Celsius, the productivity of the residents will begin to drop. According to research carried out by (Lipczynska et al., 2018), residents of a building report feeling uneasy due to the building's temperature, which in turn leads to decreased productivity.

According to study that Rosenlund conducted in the year 2000, just enhancing the quality of the air inside a building may lead to a five to ten percent boost in the overall productivity of the facility. The level of productivity achieved in a building is the single most critical aspect in determining its overall success. (Schaudienst & Vogdt, 2017) claims that residents remain in buildings for longer periods of time if the structures have better ratings

for air flow distribution and indoor air quality. In contrast to the library, the student cafeteria has in recent years become one of the most popular study locations in the school. This is owing to the fact that they provide more amenities to settle down such as enhanced Wi-Fi connection, air conditioning, table and chair while eating parallelly at one area.

#### 2.5.2 Performance and health psychology of occupant

The performance of the building will gradually decrease even if there is not a particular strategy for regulating the temperature if there is an increase in the number of people who will be occupying the same building area. This will occur if there is an increase in the number of people who will be occupying the same building area. According to the findings of the study, students who were able to sit close to windows or who had easy access to fresh air were able to get grades that were seven to eighteen percentage points higher than other students (Heschong, 2002). The fact that the cafeteria has adequate ventilation and open space on its exterior in addition to having daylight that can penetrate through the cafeteria will result in a situation that is more comfortable for the students who are having a conversation or studying in the cafeteria. This will be the case as a result of the cafeteria AYSIA MEL ατικάι μαι having daylight that can penetrate through the cafeteria. This is because it is possible for a person to develop a range of health problems if they remain indoors for a long amount of time without enough ventilation. This is the reason behind this. It has been hypothesised that several aspects of human health, including allergies and asthma, headaches, respiratory sickness, and productivity, are all naturally impacted by the interior environment (Senin & Mydin, 2013).

In addition, it was shown that the use of natural ventilation was capable of delivering a sufficient flow of pure, fresh air inside an indoor environment. Having a higher airflow (more than 1 m/s) is one of the methods that may be utilised to generate air distribution in an interior environment. Other methods, such as using having appropriate designs, material, and shading devices, can also be employed, according to (Senin & Mydin, 2013). Increasing the ventilation in an area will be beneficial to a person who is subjected to strong wind speeds. When it comes to the design process, we need to make sure that the layout, ventilation, and materials used all have a beneficial influence on the way air flows through the space. If we don't do this, we won't be able to create an environment where air can move freely. It is feasible to accomplish a temperature drop of between 1° C and 3°C by using this method.

#### 2.5.3 Air Flow Distributtion standard

The distribution of airflow places a greater emphasis on providing servers with the appropriate amount of volume air. Great number of research have focused on settings that did not have air conditioning. When comparing data sets with various geometries or ventilation systems, there may be significant changes in the distribution of airflow. There are several methods of airflow distribution that may, to varying degrees, satisfy the need for data centres to be reliable and efficient in their use of energy. However, there is no one geometry that can fulfil all of these prerequisites. To establish a balance between dependability and energy economy, the best airflow distribution should take into consideration all of the constraints that are being placed on the system.

The rate at which air from the outside replaces the air from the inside of a building is referred to as the air exchange rate. In its Standard 62.2-2016, titled "Ventilation and Acceptable Indoor Air Quality in Residential Buildings," ASHRAE (formerly known as the American Society of Heating, Refrigerating, and Air-Conditioning Engineers) recommends that homes receive 0.35 air changes per hour but not less than 15 cubic feet of air per minute (cfm) per person. as the minimal ventilation rates in residential structures in order to produce indoor air quality (IAQ) that is acceptable to human inhabitants and that minimises the risk of negative impacts on health. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recommends using intermittent exhaust capacity in kitchens and bathrooms to assist regulate the levels of moisture and pollutants in such spaces. In addition, ASHRAE points out that "dwellings with tight enclosures may need extra ventilation supply for fuel-burning equipment," such as fireplaces and appliances that are mechanically exhausted.

#### 2.6 Computational Fluid Dynamic (CFD)

Computational fluid dynamics (CFD), is a subfield of fluid mechanics that applies numerical analysis and data structures to the study of issues involving fluid flows in order to find solutions to such problems. Computers are utilised to execute the calculations necessary to simulate both the free-stream flow of the fluid and the interaction of the fluid (both liquids and gases) with surfaces that are specified by boundary conditions. These calculations are performed in order to model the flow of the fluid. Better methods are possible to get with high-speed supercomputers, and these types of computers are often needed to handle the biggest and most complicated issues. Ongoing research has resulted in the development of software that enhances the accuracy as well as the speed of simulations of complicated phenomena, such as transonic or turbulent flows. In most cases, the first validation of software of this kind is carried out with the use of experimental equipment such as wind tunnels. In addition, one may utilise for comparison the results of an analysis, either analytical or empirical, that was done on a given topic in the past. Full-scale testing is often used in the performance of a final validation. The prediction is centred on a group of fluid variables, such as temperature, pressure, and velocity, that are able to explain the flow of fluid and the transfer of heat within the system (Panduit, 2016).

#### 2.6.1 CFD Model

CFD model was built up, and all of its parameters, including those essential for evaluating thermal comfort in accordance with UNI 7730 and for verifying the model, were measured. To be more specific, the temperatures (Th) of the air both inside and outside, the relative humidity (Rh) of the air, the air velocity (v) inside, the temperature of the globe thermometer, and the air pressure, All of the CFD simulations were carried out with the help of a CFD solver system software ANSYS Fluent. This software makes it possible to analyse the thermal and flow fields based on continuity, momentum, and heat transfer equations that have previously been discussed in detail.

#### 2.6.2 CFD Simulation tool

For the real time simulations, the CFD programme Ansys Fluent version 2022 UNVERSITIEE ANALAYSIA MELAKA throughout the process. This is a tried-and-true method of modelling and evaluating fluid flow, air velocity, and temperature by quantitatively predicting the patterns of airflow (Chiang & Lai, 2009) are only a few of the studies that cite the usage of Ansys Fluent as a primary tool for analysing the airflow in classrooms ash show in Figure 2.3. The conservation equations for mass, momentum, and energy are solved using CFD software in order to provide predictions about the flow of air. In most cases, the airflow is a turbulent; hence, it is necessary to have a technique for modelling turbulence. For the purpose of accurately simulating buoyancy effects, this study made use of the standard k- turbulence model developed by Launder and Spalding (1974) in conjunction with the Boussinesq approximation. These models take into account the impacts of changes in density by including an extra source term into the momentum equation(Cook et al., 2016.); it has been extensively tested and is now the primary turbulence model for steady-state modelling of buoyancy-driven flows(Visagavel & Srinivasan, 2007)

When the spot values of each variable were consistent the simulations were deemed to have converged. In general, it was anticipated that all residuals would decrease by a factor of one hundred from their original sweeps (Walker, 2005). Before beginning the simulations for the specified ventilation scenarios, mesh sensitivity analysis were carried out in order to determine the optimal mesh density.



Figure 2.3 CFD Air Flow Distribution simulation tool

#### 2.7 Previous Study of Air Quality

Children spend a significant portion of their waking hours in classrooms where they acquire new knowledge and develop a variety of skills and abilities. It has been demonstrated in earlier research by (Wargocki et al., 2020). that classroom temperature has a significant effect on learning. Studies have shown that poor air quality in classrooms can impair students' cognitive skills and abilities because they find it difficult to focus or are easily distracted from their assigned work. Additionally, when there is poor air quality in the classroom, it affects the working environment for the teachers. As a result, teachers may be less able to effectively teach, which can lead to decreased learning performance. The determination of thermally comfortable temperatures in various settings, in climates ranging from temperate to tropical, has taken up a significant portion of thermal comfort studies conducted in recent decades (Wong & Khoo, 2018.).The equatorial comfort index's ideal corrected value for the ambient temperature was discovered to be 26.4 8C. According to (Park et al., 2022) One-way and four-way outlets were installed in the space, and it was found that the four-way outlet was more effective at doing this than the one-way outlet.

#### **CHAPTER 3**

#### METHODOLOGY

#### 3.1 Introduction

In this chapter, the methodology that has been provided is going to reflect the approach that is going to be used in order for this research to achieve its aim. CFD simulation Tool will do an analysis of the airflow distribution based on the parameters that are chosen and the results that are obtained from the simulation. To ensure that the flow of the simulation analysis is carried out in a way that is both smooth and effective for the purposes of carrying out the study shown in Figure 3.1, a research flowchart is designed

#### 3.2 Research design

In order to determine the airflow of distribution experienced by preschool students, both experimental research and an observational study were carried out. In the experimental study that was conducted in Malacca, the various locations of preschools were compared with one another. This evaluation was carried out using a variety of factors in order to identify the temperature data of the indoor environment. TSI Velocicalc were used in order to keep an eye on the data.

Throughout this phase, observational research was carried out in the form of a walkthrough observation to examine the level of interior airflow experienced by the preschool's pupils while they were engaged in the learning process and to establish whether a good ventilation was present. In addition, the data from the experiment will be taken to determine how the airflow circulate in the classroom while they were learning

#### 3.3 Research Flow

This investigation started with the process of site selection, during which three different preschools from all over the area were chosen for the purpose of analyzing the degree to which their students' airflow distribution impacted the teaching and learning process. The goal of this investigation was to find out how airflow distribution affected the teaching and learning process. After that, walkthrough observations were carried out in order to accomplish the first aim, which was to investigate a selected parameter of the indoor thermal airflow distribution data at three preschools in Malacca. This was done in order to achieve the second aim, which was to determine whether or not there was a significant difference between the two types of preschools.

Then, two different kinds of approaches were employed, the first of which was site data gathering. For this method, an adaption of the ASHRAE Standard (2010) named "Thermal Environment Conditions for Human Occupancy" was applied. After that, area monitoring and environmental monitoring were carried out in order to achieve the first and second objectives, which were, respectively, to determine the level of air temperature, air velocity, and relative humidity in order to simulate real time simulation by using CFD analysis. This was done in order to achieve the first objective.

After gathering all of the pertinent information and data required for this study, the Fluent Ansys software was used to do an analysis on each and every piece of data that was gathered. After doing the necessary analysis and interpretation of the data, the air flow distribution across the preschools will be mapped out. Figure 3.1 shows research flowchart of this study.



Figure 3.1 Research flowchart.
# 3.4 Site review.

This research focuses on preschools that are situated in the Kampung Padang of Malacca. The sites of the preschools will be spread out among three distinct areas. Children who attend these preschools are often exposed to sources of air circulation while they are engaged in the educational process. In addition, the students would be exposed to the unhealthy levels of air. The students may experience non-air-conditioned airflow distribution as well a direct result of these types of air flow circulation. Figures 3.2, 3.4, and 3.6 below depict the plan, while Figures 3.3, 3.5, and 3.7 indicate the placements of the preschools in various places for the purposes of this study. Therefore, table 3.1, 3.2, and 3.3 is the specification dimension of the pre-school classroom.



Figure 3.2 Layout building for Tadika Kemas Rumah Pangsa Kampung Padang, Melaka.



Figure 3.3 Location of Tadika Kemas Rumah Pangsa Kampung Padang, Melaka.

Table 3.1	Specifications of layout building of Tadika Rumah Pangsa Kampung Padang,
	Melaka.

No.	Part	Quantity	Dimension
1	Operation hours (7.30 am – 14.30 pm)		
2	Population	16	
3	Area		W= 6.24 m, L = 9.57 m Area = 59.71 m2
4	Ceiling height	Si,	H = 287 cm
5	Sliding door 1 Door : 90 cm x 208 cm	2	W = 270  cm, H = 208  cm
6	UNIVERSITI TEKNIKAL Wooden door	MALAYS	W = 83  cm, H = 210  cm
7	Window A (2 door) 1 Door : $44 \text{ cm x } 90 \text{ cm}$	1	W = 88 cm, H = 90 cm
8	Window B (3 door) 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



Figure 3.4 Layout building for Tadika Kemas Kampung Padang A, Batu 3 1/2, Kampung Padang, Melaka.



Figure 3.5 Location of Tadika Kemas Kampung Padang A, Batu 3 1/2, Kampung Padang, Melaka.

No.	Part	Quantity	Dimension
1	Operation hours (7.30 am – 14.30 pm)	-	-
2	Population	15	-
3	Area	-	W= 9.65 m, L = 7.45 m Area = 71 89 m2
4	Ceiling height	-	H = 290  cm
5	Window A	4	W = 170  cm, H = 112  cm
6	Wooden B	4	W = 50  cm, H = 112  cm
7	Door A	1	W = 86 cm, H = 203 cm
8	Door B (2 door) 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	- i.	W = 70 cm, L = 170 cm

Table 3.2 Specifications of Layout Building of Tadika Kampung Padang A, Batu 3 1/2,<br/>Kampung Padang, Melaka.

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Figure 3.6 Layout building for Tadika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka.



Figure 3.7 Location of Tadika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka.

No.	Part	Quantity	Dimension
1	Operation hours (7.30 am – 14.30 pm)	-	-
2	Population	16	-
3	Area	-	W = 9.73  m, L = 5.42  m Area = 52.73 m2
4	Ceiling height	-	H = 284  cm
5	Sliding door 1 Door : 90 cm x 208 cm	2	W = 180 cm, H = 120 cm
6	Wooden door	3	W = 180 cm, H = 112 cm
7	Window A (2 door)	1	W = 88 cm, H = 120 cm
8	Window B (3 door)	1	W = 120  cm, H = 120  cm
9	Chair	20	H = 50  cm
10	Hexagon desk	2	D = 120  cm
11	Circle 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
	UNIVERSITI TEKNIKAL	MALAYS	SIA MELAKA

Table 3.3 Specifications of layout building of Tadika Kemas Kampung Padang B, Batu 31/2, Kampung Padang, Melaka.

# 3.5 Monitoring

For monitoring in the classroom, TSI Velocicalc was used to determine the environmental parameter in the classroom. During conducted monitoring session, the instruments were place at the height of 0.5 meter (DOSH 2010.) on 37 the table at the center of the classroom. Each probe was mounted at 1 meter height at the tripod to avoid anything that can block the airflow during monitoring session. Figure 3.8 shows TSI Velocicalc. During the class session, the activities that were done by the students are reading, writing, and learning. The students were also provided with 2 times of short break, around 15 minutes

at 8.15 a.m and 10.15 a.m. Therefore, the students have adequate rest time during their school's session.

In the classroom, pre-school student are very active during class session. Were there a lot of movement between them. In this situation it will contribute of air fricton consist of air velocity and air temperature. The temperature and velocity will generately from their moving around the classroom. The monitoring instrument device are very sensetive through the change of temperature and velocity



## 3.6 Data Collection

In this study. There are around 15–20 children enrolled in each preschool. It is mentioned in (DOSH, 2010) that the measurement of the parameter should be done on an 8-hour basis unless in cases where it is differently indicated. In spite of the fact that students attend preschool for a whole day (eight hours) between the hours of eight in the morning and noon, data will be gathered from preschools between the hours of eight in the morning and two in the afternoon.

In the course of this study, the TSI Velocicalc will be used to keep track of the data samples collected from the parameter. Following the completion of the reading of the parameters, which will take place over the course of six hours, the data will be created. The readings of four parameters will be created out of the data that has been gathered, and the data will be evaluated using CFD to determine the distribution of air flow mapping. The monitoring session will verify that the data are consistent and uniform in their presentation at all times.

The choice of parameters for this research will play a significant role in the development of IAQ standards. First, the air velocity (V) was utilized to make certain that the humidity in the classroom does not exceed the standards for any equipment or device to work inside the confined area. This was done so that the classroom could continue to function normally. The air temperature (Ta) is the second variable to consider. The temperature of the air is highly significant in this investigation because it has the potential to have an impact on the thermal air flow of air circulation for the students in the classroom, regardless of whether the environment is cold or warm. In order to determine the interior temperature at a reasonable level and to regulate the amount of moisture present, relative humidity (Rh) was utilized.

All of these studies' results will be discussed in relation to the recommendations that were given (DOSH, 2010). That the suggested minimum number necessary for sample locations for assessing the quality of the indoor air inside a structure based on table 3.4. However, the number of sampling locations that are advised changes depending on the kind and character of the buildings. If further samples are required, they should be collected.

Total floor area (served by MVAC systems) (m <sup>2</sup> )	Minimum number of samplings
<3,000	1 per 500m <sup>2</sup>
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 1,200m <sup>2</sup>

Table 3.4 Recommended minimum number of sampling for indoor air quality

# 3.6.1 Instrumentation

Using a TSI Velocicalc, the environmental characteristics of the air, including air temperature, humidity, and air speed, were monitored for the purpose of monitoring the area. On the other hand, the instrumentation will be operational from 8:00 in the morning until 2:00 in the afternoon according to preschool operation time. In the meanwhile, data on the distribution of airflow towards preschool classrooms will be collected at precisely per gap and every metre of space area to ensure the accuracy of data sampling. Table 3.5 presents measuring instrument.

Type of Parameter	Name Of Parameter	Instruments
Enviromental parameters	Air temperature TSI VelociCalc	
	Air velocity	

## 3.6.2 Air Velocity (m/s)

During the data collection session, the layout plan of the preschool has its own door and window position compared to the three different preschools. therefore, It can be used as an air velocity variable in the class. in this case, each class from three different preschools should be predicted against the opening of doors and windows to get various plan probabilities in the classroom. In this methodology, the class layout must be predicted by redesigning with various new plans using design software such as Catia. The layout is taken from a real situation image in three different preschools in Melaka import to desgin software. Catia is the design software, it required a specific dimension to generate a real image of the classroom. This study case will generate 3D image of the classroom. These three different classroom has a different layout need to design in this session. After that, each classroom will provide 4 different layout of opening doors and windows. Below is shown figure of layout of three different pre-schools design.

A. Tadika Kemas Rumah Pangsa Kampung Padang, Melaka.



B. Tadika Kemas Kampung Padang A, Batu 3 1/2, kampung Padang, Melaka



C. Tadika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka



**<sup>3.6.3</sup>** Air Temperature (°C)

Air temperature is an important parameter in this study. in this methodology, the data that needs to be taken is using the same set up as the following air velocity data collection. Therefore, it uses the same instrument which is TSI VelociCalc. In this case, it will take time from 8.00 am to 2.00 pm which is the time of the learning session at the preschool. Using the instrument that has been set, it needs careful observation because the instrument is very sensitive to every change in the surrounding temperature. The instrument should be placed in the correct and precise place such as every one meter radius in each classroom based on

Figure 3.9. This search title are to monitor the air flow in the classroom and it is related to air temperature and air velocity. So any mechanical ventilation mechanism will turned off for a while during data colleted session to get an accurate numberical data. Figure 3.9 shown the setup of instrument located at site.



Figure 3.9 Location of the TSI VelociCalc during data collection session.

# 3.7 Software (CFD Analysis Tool)

The data for this research will be collected at a variety of times throughout the day, but mostly between hours of 8:00 am and 14:00 pm, which are the interaction hours for the teaching and learning process at the preschool. Using TSI VelociCalc tool, a collection of data was supplied. Following the collection of all the data with the help of TSI VelociCalc, the values of air temperature, air velocity, and relative humidity will be examined for airflow distribution with the use of CFD simulation analysis Tool. In order to use the CFD tools effectively, the environmental parameters, such as temperature, pressure, and relative humidity (RH), must be entered as inputs. After the inputs section has had its data filled in, the data of air temperature (Ta), and air velocity (v) as well as the airflow distribution mapping, will be shown to demonstrate whether it satisfies with the ASHRAE Standard. Figure 3.10 shows airflow parameter selection which is fluid flow setup on Fluent due to detailed due to layout outcome



Figure 3.10 Airflow parameter selection

## 3.8 CFD Design

The advancement of environmental conditions has been facilitated by computational fluid dynamics (CFD), among other factors. Fluid mechanics, computing techniques, visual effects, and a broad selection of other fields are all involved in the development of CFD technology. CFD simulations begin with the establishment of computer models based on the structural design scheme. Next, CFD software such as FLUENT ANSYS is used to simulate

the indoor airflow distribution of a constructed and occupied building. Finally, simulation diagrams of air temperature (Ta), air velocity (V) are drawn while the air in the classroom is not air conditioned.

The equations that will be used, will include those for the conservation of mass as well as those for the conservation of momentum, which are also known as the Navier-Stokes equations in certain instances. By solving these equations, it is possible to make predictions about the velocity and pressure across the flow field. If the flow is turbulent, then it is necessary to either utilize a "turbulence model," which requires the solution of additional equations, or make assumptions about the amount of the diffusion effects brought about by the turbulence (Jones & Whittler, 1992). For each newly introduced variable that has to be computed, it is necessary to find the answer to an extra equation. As an example, extra variables might very well be the airflow distribution printed out on the CFD simulation analysis monitoring.

In this CFD design, it consists of several setup which is geometry, meshing, setup, solution, and result refer to Figure 3.11. All setup is very important because it will produce an accurate map out of simulation result.



# 3.8.1 Geometry

The geometry of pre-school classroom are design from Catia v5 software. All **UNIVERSITITEKNIKAL MALAYSIA MELAKA** specific dimension of the classrooom are inserd in the Catia software as shown. There three different layout of pre-school are design by using this software and will import to the Ansys Fluent software for simulation purpose. The method of determine geometry is very important to determine the accuracy and effectiveness of the simulation to be carried out. Every geometry in this design needs to be made in more detail such as windows and doors in the class design as Figure 3.12. with that detailed design, it will produce the best results in the simulation



Figure 3.12 Geometry of classroom from Catia

# 3.8.2 Meshing

Even though the mesh types were different, the distributions of the mesh were the same. For instance, due to the presence of substantial gradients in the variables, the mesh was extremely small in the areas that were closest to the walls and air diffusers. On the other hand, large meshes were utilised in the region that was responsible for the primary flow (Duan et al.,2015). They has two type of grid: Cartesian and curvilinear so best for the classroom design grid is the cartesian. Displays the grid models for E type at grid resolutions 24 and the velocity distribution at the middle height in the model for grid resolution conditions of 4, 24, and 32 for E type. Both the best grid resolution of 24 and the finest grid resolution of 32 resulted in the generation of qualitatively equivalent velocity patterns (Camelli et al., 2014). Because of this, the air flow has the highest possible resolution, making it the ideal type of grid, it must be selected according to the appropriate grid as shown in Table 3.6. Based on this analysis, the global mesh dimension was determined to

be the large mesh dimension that was employed in the major flow region. The hybrid mesh was separated into three different flow regions, the region with regular geometry such as wall and floor, where hexahedral meshes were used, the region with irregular geometry such as the seats, and tables, where tetrahedral meshes were used and the transition regions. while Figure 3.13 displays the mesh of the tetrahedral and hybrid meshes. All setup on meshing procedure is for three different pre-school a shown in Table 3.6 to generate mesh layout of design.

Grid resolution	A type	B type	C type	D type	E type
32	-	-	-	-	-
28 MAI	1.00	0.99	0.97	0.97	0.99
24	1.00	0.98	0.99	0.99	0.98
20	1.00	5 0.97	0.97	0.95	0.98
16	0.99	0.98	0.96	0.95	0.97
12	0.99	0.97	0.95	0.93	0.96
8 8 AINT	0.99	0.97	0.96	0.92	0.95
4	0.98	0.97	0.93	0.93	0.66
ו מאניב	mulo,	سيحسر	بى بيھ	ريوم	91

Table 3.6 Type of grid based on grid resolution

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	Project Model (A3)						
Create name	Create name Select all selected window and door rename as inlet and outlet						
selection	selection						
	Detail of mesh						
Display	Display Display Style						
	Physics Preference	CFD					
Defults	Solver Preference	Fluent					
Defuits	Element Order	Linear					
	Export Preview Surface Mesh	Yes					
and the second se	Use adaptive sizing	Yes					
TEM	Resolution	2					
L'esta	Mesh Defeaturing	Yes					
shi	Deafeature Size	yes					
	U Transition	Slow					
UNIV	ERSITI TSpan Angle Center LAYSIA	IELAK/Fine					
Sizing	Initial Size Seed	Assembly					
	Smoothing	High					
	Mesh Metric	Orthogonal Quality					
	Inflation Option	Total Thickness					
	Number of layers	4					
	Growth Rate	1.2					
	Maximum thickness	0.002					

# Table 3.7 Procedure on meshing setup



Figure 3.13 Room desgin with a orthogonal mesh grid of resolution type E.

3.8.3 Setup

The most efficient way to carry out a computation is to begin by generating a relatively coarse grid in order to obtain a solution relatively quickly and create some level of confidence in the modelling assumptions and the approach that is being taken. The next step in the procedure is to refine the grid in order to improve resolution and accuracy. The grid will be refined in particular areas where large gradients of the solution variable air velocity (v), air temperature (Th) are evident. These areas include regions where airflow distribution is modelled, for example, and will be the focus of the work to be done on refining the grid. On the setup parts, there are several step to completed as shown in Table 3.8. Those steps are very important to generate the simulation map-out of the air flow distribution. On this setup part, all data collected at real site will be applied to the ansys software. Refer to Figure 3.14 is the result after applied data calculated by software coding to produce a simulation of pre-school classroom situation.

Setup					
	Mesh	Scale Mesh	Unit: cm		
			Surfaces		
		Mesh Display	Inlet		
General			Wall-bodypart		
	Solver	Pressure-Based	Absolute		
	Time	Steady			
	Gravity	Axis (X,Y,Z)	-9.81		
Models	Energy	Energy Equation	on		
materials	Fluid	Air			
1 TE.	Solid	Aluı	minium		
Cell Zone Condition	Fluid	Par	rtbody		
الأك	o hundo 10		a sid		
	Inlet	Velocity Magnitude [m/s]	Avarage calculated data		
UNI	/ERSITI TEK	Temperature [K] A	Avarage calculated data		
Boundary		Wall Motion	Stationary wall		
Conditiona	Wall	Shear Condition	No Slip		
		Wall Roughness	Standard		
	Outlet	Velocity Magnitude [m/s]	Avarage calculated data		
		Temperature [K]	Avarage calculated data		
Reference	Compute from	Interior	r-Partbody		
Values					

Table 3.8 Procedure on setup Ansys Fluent



Figure 3.14 Result on setup when all data applied

# 3.8.4 Solution

Solution setup require the a detaild settings in several section in the Ansys Fluent software for each parameter should be perfectly inside based on the calculated data. The procedure in this setup need to be included the specific method as shown in Table 3.9. Procedural conditions, reactions such pressure, distribution energy that will occur in the classroom layout. In addition, it determines the initialization that will occur between the fluid enegy which is an air and the layout of the classroom. After the procedure for this setup solution has been done, it will produce a graph regarding to the calculated data that has been inserted to determine the movement of energy refer to Figure 3.15 that will produced in the layout.

Solution					
Methods	Solution Methods	Pressure-Velocity Coupling			
			Spatial Discretization		
Controls	Solution Controls Pseudo Ti		me Explicit Relaxation Factors		
		Resi	dual		
Monitors		Repor	t Files		
	Report Plots				
	Convergence Conditions				
Initialization	Solutions Initial	lization	Hybrid Initialization		
	VEL P.K	Pseudo Ti	me Setting		
TEA	Fluid Time Scale		Time Step Method		
E Stanto			Time Scale Factor		
Run Calculation			Length Scale Method		
	یک میسی	······································	Verbosity		
UNIVE	RSITI TEKNIKAL MALAN		SIA Number of Iterations		
	Parameter	S	Profile Update Interval		
			Reporting Interval		

# Table 3.9 Procedure of the solution on the Ansys Fluent



Figure 3.15 Solution calculated graph for to result process.

# 3.8.5 Result

From this result of the simulation, it will carry our all map out result such as contour of air temperature, and air velocity. They have several step procedure on this result shown in Table 3.10 below. To carry out efficiency of map out it required a specific setup on this Ansys Fluent software.this will be the last procedure that use parameter on this software. Refer to Figure 3.16, all previous parameter will connected on this last step to generate a perfect result.

Reuslt					
			All Domains		
	Detail of Plane 1	Geometry	Method (Selected axis)		
			Unit (cm)		
		Geometry	All Domains		
	Detail of Contour 1	Location	Plane 1		
		Variable	Velocity		
Contour			Temperature		
E		Range	Global		
EKU		# of Contours	10-2500		
1 IL			Appearance		
-3	AINO	Presicion	2		
رك	Details Legend View 1	ىتى تتك	Fixed او بیو مربسہ		
LIM		Value Ticks			
UN UN		Color Mode	Default		

Table 3.10 Procedure on result setup process.



Figure 3.16 Final procedure setup of result on Ansys Fluent Software

# **3.9** Setting up layout for air flow velocity and temperature.

To simulate a several probabilities of layout for air flow velocity and temperature, it requires of different set up of layout at the classroom. The layout will consist of real situation of pre-school building dimension and the layout in the classroom. Besides, the setting up for air flow distribution of air velocity and air temperature in the classroom need to determine the direction of movement of air by setting up the inlet and the outlet. In this case, for each pre-school will be provide four probability of layout and each of it will be different set up of the inlet and outlet.

Layout probability that has been set to be used in the analysis simulation software. Each image of the layout has been specified in more detail as an indicator such as an inlet, outlet, window, sliding door, and door. The purpose of doing this probability layout is to get various results in the classroom. From the results obtained, it can be predicted which one of the best layouts can be used at the pre-school. It is because of the best layouts that obtain a good environmental parameter, and it can improve the level of the student performance during learning session in the classroom.

# 3.9.1 Probability layouts for preshool A





**(b)** 



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Symbol	Desciption
	Inlet
-	Outlet
W	Window
SD	Sliding Door

Figure 3.17 Probability layout for classroom of pre-school Tadika Kemas Rumah Pangsa, Kampung Padang, Melaka. Probability layout for pre-school Tadika Kemas Rumah Pangsa Kampung Padang, Melaka consist of four layouts as shown in Figure 3.17 is a detail layout of the classroom to continuous to the analysis simulation purposed. The layout is taken from the real image of the Tadika Kemas Rumah Pangsa Kampung Padang, Melaka. The dimension is based on the site review stated dimension.

The air flow distribution in the classroom in layout (a) will started from window and sliding door. As an inlet, it will be set up to three inlets from outside air flow will passing through the set of inlets. For the outlet in the layout (a) are set as two at the window.

There is a different setup on this layout (b). The inlet will be different position and location. There will be four inlets through the window. For the outlet, there will be three outlets though the sliding door and window. In this layout (b) will be predicted to be a complex air flow distribution in the classroom because of the abnormality of setting up in the classroom.

There will more inlet than outlet in layout (c). The inlet will be set up to five inlets through the window and sliding door. The air flow distribution will be entered opposed flow different wall of the classroom. It may contribute to a good ventilation of the air flow distribution in the classroom. For the outlet, it will be set up to two of outlets. The outlet will be at side of the wall inlet entered.

Last layout for this pre-school is layout (d). On this layout, all window and sliding door will be used in this layout. For inlets it will be designated up to four inlets consisting of windows surrounded the classroom. for outlets, set to three outlets. the outlet will be positioned opposite the wall to obtain a result that need to be achieved during the analysis simulation session.

# 3.9.2 Probability layouts for preshool B





**(b)** 



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Symbol	Desciption
	Inlet
-	Outlet
W	Window
SD	Sliding Door
D	Door

Figure 3.18 Probability layout for classroom of pre-school Tadika Kemas Kampung Padang A, Batu 3 1/2, Kampung Padang, Melaka.

Layout provided is the detail layout of the classroom as shown in the Figure 3.18 to continuous to the analysis simulation purposed. The layout is dimensioned from the real situation of the pre-school Tadika Kemas Kampung Padang A, Batu 3 1/2, Kampung Padang, Melaka.

There are three inlets that have been set on this layout (a). The inlet is located on the wall that has a sliding door wintdow. The wall has sliding doors and windows and it will produce a high intake of air distribution. For the outlet, there are four outlets that has been selected on this first layout of the classroom.the outlet location that has been set is opposite of the inlet.

The layout of (b) inlet will be the same as previous layout (a). It have no change on the inlet position and location. Therefore, the outlet will be set to two outlet and located at different places, namely the door on the opposite side of the classroom and the position of the two doors is on a different wall. One is blessed on the left and the other is blessed on the right.this layout will be expected with the presence of high air velocity due to the position of the inlet and outlet.

There will be different design layout of inleet and outlet in layout (c). The different is the inlet will be more set than the outlet. the inlet will be set to four and its location will be opposite from previous layout. For the outlet, it will be set to three channels only and it include window and sliding door. The change of the layout will produce a different mapout image on the analysis simulation from outher layouts.

Lastly, more of inlet will added at that classroom layout of (d). So it will total up to six inlet in the classroom layout. By added more inlet into the classroom it will predicted to be an ideal classroom layout because it containt high environmental paramter and the better air flow distribution in the classroom.







Figure 3.19 Probability layout for classroom of pre-school Tadika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka.

There are four probabilities of layouts for pre-school of adika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka shown in Figure 3.19. In that layout is a detail layout of the classroom to continuous to the analysis simulation purposed. The layout is set onto different layouts. The dimension is based on the site review stated dimension. In this layout, it consists of several windows, and door.

The inlet will be set of four inlets at the layout (a). The position and location of the inlet is at the front of the classroom, it will be passing through the window at the front of the classroom in this layout. For the outlet, it will set on the back or the classroom through windows and door.

The layout design (b) will different than previous layout. the number of inlets will be added to the total of four in this layout. For the outlet, it consists of two windows in front of the classroom. The position of the inlet in this layout is facing each wall in the classroom. Thus, the outlet is on the different wall than the inlet.

On this classroom layout (c) consists of three inlets will be set on the layout. The designated inlets will be placed on the windows at the side of the classroom and also the door at the back of the classroom. As for the outlet, it has been set to only two on this layout. outlet it is located on the side wall of the classroom.

For the last layout of the classroom (d), it will be used as an inlet 90% compared to the outlet. It means that the inlet has six channels that will be set on this layout. These six inlets include all the windows in the classroom. On the outlet side, it will be set to one channel only, which is the door at the back of the classroom. What is expected in this last layout is that the air velocity will be expected to be high what is expected in this last layout is that the air velocity will be expected to be high.

#### **CHAPTER 4**

#### **RESULT AND DISCUSSION**

# 4.1 Introduction

Based on this study, all necessary data will be collected by using specific instrument, which is TSI Velocicale. Then the data will be managed into data table for calculation purpose to applied into Computational Fluid Dynamic CFD. From the calculated numberical data, the progress of CFD will be perfom by using CFD sofware Ansys Flunt version 2022. The topic that will be discussed in this chapter is the walkthrough observation and the analysis of air flow distribution at different locations. In this study, the data will be collected at various locations to determine which layout of classroom provide the best indoor air flow disdribution to students for every each of classroom. 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 ventilation 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. In this observation method, the mechanical ventilation system will turned off to determine the accucary of air flow distribution by using natural ventilation system.

# 4.3 Data Collection

## 4.3.1 Air Velocity

The ventilation of the building 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 0.2 m/s and it exceeded the acceptable range recommended of 0.15 - 0.50 m/s by (DOSH 2010). In the other hand, the lowest value was 0.113 m/s and it is not exceeding the acceptable range. Based on real time situation data taken stated at Appendix A,B, and C. The result generated a graph on real time situation of air velocity in the classroom. The graph show in Figure 4.1 are comparison between three different preschool. The thing that can be described is the change between air velocity based on time. Based on pre-school A,B, and C, air velocity at 8.00 a.m is the peak value of air velocity. This is likely due to naatural environmental factor which outside air speed are high in the morning. This is because of possibility less air fraction at outside and it would insert thru pre-school directly. By passing the time, at 9.00 a.m air velocity value decrease. Opposite by that, pre-school A seem increaced drustictly compare to others pre-school. This is because of the location of the pre-school A was at open space. By 11.00 am, all three preschool value of air velocity dropped especially pre-school B. This situation happed because by the time on 11.00 out side air velocity was low due to air disturbance from outside as a air fraction. The lowest air velocity value at three different pre-school is at 14.00 p.m. The reason behind on this finding is because it the peak hour. At this peak hour time, the air velocity appears to have a low value because at this time the air velocity outside is disturbed by excessive air fractions and can be associated with an increase in temperature.



The air temperature of these preschools is above the acceptable range which are UNIVERSITITEKNIKAL MALAYSIA MELAKA

between 27 °C to 32 °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. Based on the obtained from the data collection stated at Appendix A,B, and C. From the data obtained, it can be used for comparison between air temperature at three different pre-school shown in Figure 4.2. As a result of that data, it can generate a graph to be used as a clear diagram of this comparison. The data was taken at 8.am, where it was seen that the air temperature was low among all the pre-schools. This is because in the morning, the air temperature is cooler due to the beginning of the appearance

of the sun. The increase in air temperature can be seen interestingly from time to time. At 10.00 a.m, the air temperature in the classroom of three different pre-school increased especially classroom at pre-school C. This is because the location of pre-school C is around an area dense with development. It can be related that the increase in air temperature will increase when the location of a building is in an area with dense development. The increaced in air temperature at three different pre-school along with time. This is due to the position of the sun are above the earth's horizon and that will affectd by the heating surface on earth. By 14.00 p.m, that is the maxzium value of air temperature has been taken. The temperature reach to 32 °C to 33 °C at all three different pre-school.



Figure 4.2 Air temperature value for three pre-schools.

## 4.4 CFD (Simulation Analysis Tool)

From the used of this CFD software, it can produce very helpful results in terms of air temperature and air velocity in the form of exit maps. Besides that, it is very detailed from the aspects that need to be explained in this section. Because of that, this software can produce a real-time simulation situation by obtaining the allocated data. With this simulation software, the search for air velocity and air temperature can be solved by means of a deep calculation of a design.

# 4.4.1 Result of Air Velocity (m/s) in the different classroom.

From this part, it is consisting of result on air velocity at the three different preschools. The result of air velocity map out is contributed to the four layout each pre-school. In this result session, there several probabilities of the air flow distribution setup that are been use in the simulation. Every pre-school is different layout of the classroom, and it will be a different resulted on the air flow distribution simulation. The air velocity that has been produced from the software shows various patterns about the air velocity in the classroom. this matter needs to be emphasized because air velocity is very important in an inhabited space.


Figure 4.3 Air velocity layout for pre-school Tadika Kemas Rumah Pangsa, Kampung Padang, Melaka.

What can be seen is the result of the analysis simulation that has been carried out refer to Figure 4.3. The purpose of this analysis simulation is to simulate and monitor air flow in the classroom at three preschools. It turns out that dilatation is the result issued by Ansys Fluent CFD software for pre-school Tadika Kemas Rumah Pangsa Kampung Padang, Melaka.

Image map-out of the results (a) of the classroom layout that has been carried out through simulation analysis. What can be seen is that the air velocity in the class is too narrow through the classroom. This is because the inlet entry has only two inlets and for the outlet it has only one. What can be seen, the whole class will not get equal air velocity in the class. In addition, the air velocity in this layout states around 2.29 m/s that crosses the classroom and it is very unsuitable for learning sessions in the classroom

The results obtained in this layout (b) case are quite good for class plan layout. This is because, it looks very ideal for the use of learning session space. This layout image looks suitable because the air velocity value is around 0.15 m/s - 0.21 m/s. The circle of values is suitable to be applied in the learning area especially in the classroom. In terms of air flow, it is quite systematic because it flows air to every part of the class.

Changed the inlet and outlet and improved a quantity of this inlet makes a significant difference at layout (c). The result obtained on this layout shows the air velocity circle in the range of 0.20 m/s - 0.30 m/s. but the air flow does not reach every room in the classroom.

Outlets have been increased to four outlets. seen there, the air flow is not very good and not very suitable for use in the layout (c) classroom. In addition, the air velocity value also shows a high value in the range of 0.24 m/s - 0.32 m/s. This air velocity value is not suitable for use in the learning space.



Figure 4.4 Best layout of air velocity in the classroom for Pre-school A

Compare with the several probability layouts at the preschool Tadika Kemas Rumah Pangsa, Kampung Padang, Melaka. Figure 4.4 shown is the layout of (b). What can be said is that this layout is the best layout is that it has a comprehensive air velocity pattern in the classroom. Therefore, it will result in improved student performance in the classroom if this layout is used as a layout plan in the preschool. range value of air velocity is 0.15 m/s - 0.21 m/s is the optimal air velocity that is suitable for the classroom. The air flow in this layout is the best because, with the velocity speed in a comfortable range and it will have a positive effect on the occupants in the classroom. Based on environmental factors, if the occupants get a sufficient level of environmental factors such as the effect of comfortable air velocity it will produce high rate of humankind effects such as cheerfulness, freshness, and a high level of focus during the learning session in the classroom.



Figure 4.5 Air velocity layout for pre-school Tadika Kemas Kampung Padang A, Batu 3 1/2, Kampung Padang, Melaka.

From the Figure 4.5 air velocity for preschool Tadika Kemas Kampung Padang A, Batu 3 1/2, Kampung Padang, Melaka. What can be seen is the result of the analysis simulation that has been carried out in this research. The purpose of this analysis simulation is to simulate and monitor air flow in the classroom at three preschools. It turns out that dilatation is the result issued by Ansys Fluent CFD software for this pre-school.

In the results obtained in this layout (a), the air flow distribution in the classroom can be seen that the air velocity entry at the entrance is relatively high which is 0.23 m/s. But due to the large outlet it can stabilize the air velocity in the class up to 0.15 m/s - 0.16 m/s. on the air flow structure, it looks good and is suitable for use in that classroom.

There are three inlet inlets and for the outlet it has two outlets that are at the door in layout. This layout (b) shows that if the inlet is more than the outlet, there will be a difference in the air velocity as an increase in the air velocity value from 0.18 m/s - 0.21 m/s and also the structure of the air flow will change. The change of the structure of the air flow is more likely to loss of velocity energy.

This results in an air velocity of 0.17 m/s - 0.25 m/s shown at layout (c). There are six designated inlets as opposed to three outlets. The air flow obtained in the class is good in the middle of the class. This is because of the air entering from the edge of the classroom. In the front of the class, air velocity cannot be seen because there is a curve of air flow distribution

The air flow distribution in the classroom layout (d) can be seen that the air velocity entry at the entrance is relatively high which is 0.23 m/s. But due to the large outlet it can stabilize the air velocity in the classroom up to 0.14 m/s - 0.16 m/s. On the air flow structure. If student seat beside the window, it will feel strong wind or air flow because there is the highest value of air velocity.



Figure 4.6 Best layout of air velocity in the classroom for Pre-school Tadika Kemas Kampung Padang A, Batu 3 1/2, Kampung Padang, Melaka.

Based on Figure 4.6 shown that the best layout of air velocity in the classroom compare with others probability layouts. The air velocity pattern on this layout is suitable for use in this preschool classroom because the space in the classroom is large and it needs a suitable layout to supply air flow to each space area in the classroom. The range value of the air velocity in the classroom is 0.18 m/s - 0.21 m/s according to the appropriate standard used in the classroom. When this layout is used as a class layout in preschool classroom, the preschool does not need to worry about the students level of satisfaction because environmental factors have helped to provide comfort in general with the help of setting the appropriate layout in the classroom.





Figure 4.7 Air velocity layout for pre-school Tadika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka.

The result of air velocity for preschool Tadika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka shown at Figure 4.7. What can be seen is the result of the analysis simulation that has been carried out in this research. The purpose of this analysis simulation is to simulate and monitor air flow in the classroom at three preschools. It turns out that dilatation is the result issued by Ansys Fluent CFD software.

The results of the simulation analysis show that the air flow in the classroom is comprehensive at the layout (a). This is because there are four inlets that have been set on this layout and three outlets to be used as an outlet for the airflow. In addition, the rate of air speed in the class that uses this design is in the range of 0.12 m/s - 0.24 m/s. This shows that the appropriate air velocity is applied in the class.

The layout has been changed to a different design, and the pattern for the air flow will change to that shown in the layout (b). What can be seen about the air flow pattern that the middle room of the class does not get a good air flow. This is because the design does not meet the standards for use in the classroom. The value rate for air velocity in the class is between 0.15 m/s - 0.27 m/s. It is in a good range for the class

The design for the third layout (c) looks more to straight forward. Means the result of the airflow path through the mesh of the right wall to the left wall. As a result, the airflow pattern in the classroom is not the best to use in the classroom. Because of that, the middle class does not get the airflow. The range value for air velocity is 0.17 m/s - 0.26 m/s.

For the result of air velocity at layout (d), layout design in this case by using all windows as inlets and only one door as outlet. This produces low air velocity in the classroom. the range value of air velocity is 0.10m/s - 0.90 m/s. The air flow distribution pattern in the classroom seems to fade because of loss of energy.



Figure 4.8 Best layout of air velocity in the classroom for Pre-school Tadika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka.

Based on Figure 4.8 shown that the best layout of air velocity in the classroom compare with others probability layouts. This layout consists of the best air flow distribution pattern compared to others layout. This is because this layout consists of the best airflow distribution pattern due to the settings that have been arranged to get the best layout that can be used in the this preschool classroom . The air velocity value on this layout is of 0.12 m/s - 0.24 m/s and it means that it is suitable for use in this classroom because it reaches the appropriate standard for learning sessions in the classroom.

### 4.4.2 Result of Air Temperature (°C) in the different classroom.

By using Ansys Fluent software, it carry out the temperature counter result for all layout of classroom. In this case, it will be different from the air velocity result because it is a air temperature that covers the entire classroom layout. In this result what can see is colour contrast that repesents the air temperature formed from the applied data in the simulation method. As a result shown, the unit for temperature are set from degrees celcius (°C) to the kelvin (K). The air temperature was measured at different heights depending of the classroom. Therefore, the difference from the designed temperature depended on the measurement location. In the classroom situation, the classroom temperature can be around 25 °C - 32 °C based on the data taken. Intake temperature was 0.7 °C higher than the air temperature in the occupied. Especially, the outlet temperature was 0.7 °C higher than the air temperature in the partial occupancy cooling case with the displacement.

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Figure 4.9 Air temperature layout for pre-school Tadika Kemas Rumah Pangsa, Kampung Padang, Melaka.

From the Figure 4.9 is the probability result of air temperature for preschool Tadika Kemas Rumah Pangsa, Kampung Padang, Melaka. What can be seen is the result of the analysis simulation that has been carried out in this research. The purpose of this analysis simulation is to simulate and monitor air flow in the classroom at three preschools. It turns out that dilatation is the result issued by Ansys Fluent CFD software.

The air temperature in this classroom layout (a) seems to be divided into two. The temperature on the right side is relatively low compared to the left side of the classroom. In the middle. looks like a comfortable temperature. The air temperature range in the classroom is 26.85  $^{\circ}$ C - 32.26  $^{\circ}$ C. there it is not suitable to be used as a design layout in the class.

On this design layout (b) it looks suitable to be used as a design layout for this preschool class. This is because the air temperature pattern on the result shows the overall stability of the air temperature in the class. The range value for the air temperature in the class is 26.93°C - 31.45°C and it is at a comfortable temperature. This layout is suitable for used in the classroom due to better air temperature pattern compare to others.

It shows that the air temperature in the classroom layout (c) result is between 28.93°C - 32.5°C. In terms of the air temperature pattern, it shows that the air temperature does not reach the entire classroom. Only at the front can be accessed by the air temperature. This situation can be related to the situation where the temperature is not comfortable to be used as a design layout in the preschool class

The result of air temperature pattern in the classroom layout (d) is somewhat less stable due to the inappropriate position of the inlet and outlet. The air temperature pattern shows that the center of the space is stable, and the sides will face high temperatures. Range value of air temperature is 28.97°C - 32.6°C. At the back of the class will feel the uncomfortable air temperature when students sit in that area.



Figure 4.10 Best layout of air temperature in the classroom for Pre-school Tadika Kemas Rumah Pangsa, Kampung Padang, Melaka.

Figure 4.10 shown the layout that is suitable to be applied in pre-school classroom layout. Because of that, the stability of the air temperature in the classroom can be that is the main factor to be used as the best layout. Can be seen in the layout above, the air temperature range is 26.85  $^{\circ}$ C - 32.26  $^{\circ}$ C and means it is a suitable temperature for the occupants in the class using natural ventilation. With the comfortable air temperature, students will feel comfortable sitting in the class during the learning session



Figure 4.11 Air temperature layout for pre-school Tadika Kemas Kampung Padang A, Batu 3 1/2, Kampung Padang, Melaka.

From the Figure 4.11 air temperature for preschool Tadika Kemas Rumah Pangsa, Kampung Padang, Melaka. What can be seen is the result of the analysis simulation that has been carried out in this research. The purpose of this analysis simulation is to simulate and monitor air flow in the classroom at three preschools. It turns out that dilatation is the result issued by Ansys Fluent CFD software for pre-school.

An overview of this layout (a) design shows that the entire classroom will have a comfortable and stable air temperature. This is because the entrance and exit channels are arranged very suitable for the class. The air temperature range value in this class is 26.85°C - 28.46°C. If this design layout is used in the classroom, it will be the best layout compare to others due to good air temperature.

The air temperature range value result in the class is 28.67°C - 29.88° C in layout (b). The inlet and outlet positions that have been set are not strategic for the class. This results in instability of the air temperature in the classroom. Besides that, the air temperature depicted is not stable because there are only two outlets and their positions are far from each other.

As a result of simulation analysis of layout (c), the layout illustrates the instability of the air temperature in the classroom. Lower temperatures are on the right and high temperatures are on the left. This situation is not stable to be applied in the classroom because it will cause discomfort for the students. The temperature value in the class is  $28.99^{\circ}$ C -  $32.04^{\circ}$ C.

This design layout (d) brings instability in the classroom. Range value for air temperature is 29.29°C - 32.34°C. The air temperature pattern can be seen that the area around the inlet is higher than the outlet. Therefore, the classroom does not get a stable air temperature



Figure 4.12 Best layout of air temperature in the classroom for Pre-school Tadika Kemas Kampung Padang A, Batu 3 1/2, Kampung Padang, Melaka.

Figure 4.12 shown the layout that was selected to be used as the design layout for preschool B, because this layout contains a consistent air temperature pattern that is comfortable, which is 26.85°C - 28.46°C. in addition, The air temperature pattern on this layout is produced comprehensively to every area in the class. with this best layout, the level of comfort and performance of students in the classroom will increase due to the perfect environmental factors that the classroom has obtained.



Figure 4.13 Air temperature layout for pre-school Tadika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka.

From the Figure 4.13 air temperature for preschool Tadika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka. What can be seen is the result of the analysis simulation that has been carried out in this research. The purpose of this simulation analysis is to simulate and monitor air flow in the classroom at three preschools. It turns out that dilatation is the result issued by Ansys Fluent CFD software for Tadika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka.

On the layout design (a), it is suitable to be used as a classroom layout in this pre school. This is because the air temperature pattern in the classroom is stable and each room gets an even air temperature. The air temperature range value is 28.17°C - 30.18°C. If this layout is applied in this preschool, the level of student performance will increase due to the good environmental factor.this will be the best layout design that can be used in the classroom of this preschool.

Design layout (b) is quite stable in terms of air temperature. This is because the position of the inlet and outlet has been set in the appropriate place. The air temperature pattern is seen evenly throughout the classroom. Range value of air temperature is 28.09°C - 30.79°C.

The result shows on layout (c) that the comfortable air temperature is concentrated in one part only. While the hot temperature is concentrated in one part only, which is in the corner of the classroom. This layout diagram turns out to contain air temperature instability. he range value in the classroom is  $27.76^{\circ}$ C -  $32.6^{\circ}$ C.

For the last layout design (d) is also suitable for use in this pre-school as well. This is because the resulting air temperature pattern is similar to the previous layout but the comfortable temperature level is less satisfactory at the back of the class. range value of air temperature is  $28.06^{\circ}$ C -  $30.33^{\circ}$ C.



Figure 4.14 Best layout of air temperature in the classroom for Pre-school Tadika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka.

Figure 4.14 Shown the layout listed for use as a layout design in preschool Tadika Kemas Kampung Padang B, Batu 3 1/2, Kampung Padang, Melaka. It is because the air temperature in the classroom shows a very good air temperature if it is used in a real-time situation. The resulting temperature from this layout is 28.17°C - 30.18°C and it is the ideal temperature for classrooms that do not use any cooling equipment system. Therefore, the level of comfort in the classroom will increase because the classroom contains environmental contributing factors.

#### **CHAPTER 5**

### CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion

Based on this study, all environmental parameters affect the air flow distribution in the different pre-school classroom. According to the results, air velocity and air temperature exceed the acceptable range recommended by (ICOP IAQ) DOSH Malaysia, 2010, while the average value of air velocity is 0.15 m/s - 0.50 m/s that mean acceptable because it is in between the range. This study also found that air temperature is important to gain the comfortness in the classroom during learning session. However, the air temperature of these three different preschools is in comfortable zone against students considering due to the non-air-conditioned equipment system to the classroom.

By using CFD Analysis Tool, the layout of the three different pre-schools are complies with the ASHRAE 55-2010 standard. This is because of the air velocity value for three different pre-school was ranged between 0.15 m/s – 0.30 m/s. Therefore, the value of air temperature reading range of  $25^{\circ}C$  -  $32^{\circ}C$  are average temperature in countries that are on the equator.

Lastly, natural ventilation is very important due to improve the air flow distribution in the classroom and it is essential process to replace the uncomforted environment air with better quality of air. It is to improve the performance of student during learning session and produce student productivity. The improvement of air flow distribution in the classroom, preschool authorities should provide the bet layout classroom for student due to improvement and productivity of student.

## 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:

- Ventilation system for the classroom can be improvised by open a more window due to get a better air flow distribution.
- ii) Choose a suitable inlet and outlet as a channel for air flow distribution to gaina better result of the comfortness in the classroom.
- iii) Increased the number of layout simulation to acquired more valid and significant data. For example, the data of air streamline. اونیون سینی تیکنیکا ملیسیا ملاک UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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## APPENDICES

Parameters Data Every 5 minutes	Air Temperature (°C)	Air Velocity (m/s)
8:00	27.54	0.481
8:05	27.68	0.476
8:10	27.8	0.470
8:15	27.88	0.463
8:20	27.96	0.490
8:25	28.04	0.400
8:30	AYS/4 28.16	0.400
8:35	28.1	0.487
8:40	28.2	0.490
8:45	28.18	0.484
8:50	28.2	0.470
8:55	28.2	0.478
9:00	28.04	0.475
9:05	28.18	0.473
9:10	28.3	0.475
9:15	28.38	0.473
9:20	28.48	0.471
9:25 E	RSITI TE 28.46 AL MALA	YSIA ME0.390A
9:30	28.5	0.383
9:35	28.54	0.378
9:40	28.6	0.381
9:45	28.64	0.380
9:50	28.7	0.376
9:55	28.78	0.377
10:00	28.8	0.365
10:05	28.84	0.364
10:10	28.8	0.357
10:15	28.9	0.351
10:20	28.9	0.361
10:25	28.9	0.350
10:30	28.9	0.343
10:35	29	0.341
10:40	29.08	0.339
10:45	29.1	0.340

## APPENDIX A Data collection baced on air temperature and air velocity using TSI Velocicalc for pre-school A

10:50	29.14	0.335
10:55	29.2	0.331
11:00	29.3	0.327
11:05	29.4	0.312
11:10	29.4	0.318
11:15	29.4	0.302
11:20	29.46	0.290
11:25	29.6	0.294
11:30	29.64	0.283
11:35	29.74	0.270
11:40	29.7	0.265
11:45	30.0	0.273
11:50	30.09	0.251
11:55	30.16	0.255
12:00	30.2	0.242
12:05	30.27	0.236
12:10	30.31	0.225
12:15	30.5	0.240
12:20	AY 30.69	0.217
12:25	30.8	0.205
12:30	30.92	0.207
12:35	\$31.02	0.196
12:40	31.36	0.178
12:45	31.41	0.165
12:50	31.5	0.163
12:55	31.59	0.196
13:00	31.63	0.184
13:05	31.8 June 1	0.217
13:10	32.0	0.198
13:15	DOITI TEL 32.31 AL MALA	VCIA ME 0.213 A
13:20	32.46	0.188
13:25	32.5	0.198
13:30	32.5	0.213
13:35	32.51	0.203
13:40	32.52	0.199
13:45	32.54	0.176
13:50	32.54	0.198
13:55	32.56	0.217
14:00	32.65	0.176

## APPENDIX B Data collection of air temperature and air velocity using TSI VelociCalc for pre-school B

Parameters Data Every 5 minutes	Air Temperature (°C)	Air Velocity (m/s)
8:00	27	0.516
8:05	27.12	0.497
8:10	27.28	0.465
8:15	27.42	0.451
8:20	27.56	0.441
8:25	27.6	0.437
8:30	27.6	0.428
8:35	27.74	0.416
8:40	27.92	0.406
8:45	28.06	0.427
8:50	28.1	0.410
8:55	28.2	0.404
9:00	28.22	0.398
9:05	28.28	0.382
9:10	28.3	0.376
9:15	28.3	0.389
9:20	28.32	0.363
9:25	28.3	0.351
9:30	28.36	0.348
9:35	28.42	0.354
9:40 VE	RSITI TEK28.3 AL MALA	WSIA ME $0.319$ A
9:45	28.36	0.293
9:50	28.42	0.286
9:55	28.3	0.273
10:00	28.28	0.270
10:05	28.46	0.264
10:10	28.52	0.261
10:15	28.6	0.256
10:20	28.74	0.250
10:25	28.7	0.238
10:30	28.96	0.265
10:35	29.02	0.256
10:40	29.12	0.234
10:45	29.28	0.210
10:50	29.38	0.190
10:55	29.73	0.155

11:00	29.82	0.176
11:05	29.96	0.186
11:10	30.02	0.152
11:15	30.1	0.149
11:20	30.18	0.160
11:25	30.12	0.224
11:30	30.18	0.243
11:35	30.18	0.210
11:40	30.1	0.161
11:45	30.14	0.135
11:50	30.2	0.152
11:55	30.12	0.147
12:00	30.33	0.113
12:05	30.3	0.156
12:10	30.48	0.125
12:15	30.6	0.142
12:20	30.74	0.163
12:25	30.8	0.153
12:30	AYS, 30.95	0.122
12:35	31.01	0.180
12:40	31.18	0.143
12:45	\$ 31.3	0.151
12:50	31.39	0.163
12:55	31.43	0.141
13:00	31.53	0.121
13:05	31.6	0.151
13:10	31.71	0.131
13:15	31.8	0.133
13:20	32.0	0.126
13:25		$V \leq 1 \wedge M \equiv 0.141 \wedge$
13:30	32.14	0.150
13:35	32.23	0.144
13:40	32.31	0.160
13:45	32.4	0.154
13:50	32.41	0.151
13:55	32.45	0.151
14:00	32.47	0.151

# APPENDIX C Data collection of air temperature and air velocity using TSI VelociCalc for pre-school C

Parameters		
Data	Air Temperature (°C)	Air Velocity (m/s)
Every	i ()	
5 minutes		
8:00	27.24	0.504
8:05	27.16	0.495
8:10	27.22	0.463
8:15	27.34	0.455
8:20	27.24	0.448
8:25	27.48	0.432
8:30	27.58	0.429
8:35	27.38	0.414
8:40	27.36	0.411
8:45	27.54	0.421
8:50	27.76	0.419
8:55	27.84	0.417
9:00	27.86	0.410
9:05	28.12	0.407
9:10	28.28	0.402
9:15	28.44	0.395
9:20	28.52	0.382
9:25	28.58	0.376
9:30	28.74	0.389
9:35	28.74 -	0.363
9:40	28.9	0.351
9:45	RSIII IEP29.06 AL MALA	M SIA ME $0.348$ A
9:50	29.12	0.354
9:55	29.26	0.350
10:00	29.52	0.343
10:05	29.72	0.329
10:10	30.04	0.334
10:15	30.22	0.329
10:20	30.6	0.322
10:25	30.7	0.322
10:30	30.68	0.318
10:35	30.56	0.312
10:40	30.64	0.307
10:45	30.6	0.298
10:50	30.74	0.294
10:55	30.74	0.283
11:00	30.82	0.287

11:05	30.82	0.284
11:10	30.94	0.271
11:15	31.12	0.274
11:20	31.34	0.270
11:25	31.22	0.264
11:30	31.58	0.271
11:35	31.64	0.250
11:40	31.74	0.256
11:45	31.82	0.243
11:50	32.02	0.239
11:55	32.1	0.231
12:00	32.02	0.240
12:05	32.3	0.214
12:10	32.33	0.201
12:15	32.4	0.209
12:20	32.46	0.194
12:25	32.51	0.179
12:30	32.59	0.160
12:35	AYS/ 32.71	0.160
12:40	32.88	0.162
12:45	32.91	0.191
12:50	\$ 33.0	0.136
12:55	33.02	0.192
13:00	33.08	0.187
13:05	33.1	0.216
13:10	33.14	0.195
13:15	33.19	0.219
13:20	33.22	0.185
13:25	33.26	0.190
13:30		$v \leq 1$ $M = 0.215$
13:35	33.33	0.202
13:40	33.38	0.195
13:45	33.41	0.179
13:50	33.44	0.156
13:55	33.47	0.154
14:00	33.5	0.150



 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

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Tuan

## PENGKELASAN TESIS SEBAGAI TERHAD BAGI TESIS PROJEK SARJANA MUDA

Dengan segala hormatnya merujuk kepada perkara di atas.

2. Dengan ini, dimaklumkan permohonan pengkelasan tesis yang dilampirkan sebagai TERHAD untuk tempoh LIMA tahun dari tarikh surat ini. Butiran lanjut laporan PSM tersebut adalah seperti berikut:

Nama pelajar: MUHAMMAD LUQMAN HAZIQ BIN ZULKIFLEE Tajuk Tesis: Optimizing Air Flow Distribution of Three Non-Air-Conditioned Pre-school at Melaka.

3. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA" "KOMPETENSI TERAS KEGEMILANGAN"

Saya yang menjalankan amanah,

NAMA Penyelia Utama/ Pensyarah Kanan Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan Universiti Teknikal Malaysia Melaka

