CHAPTER II

LITERATURE REVIEW

2.1 LITERATURE REVIEW

The Table 2.1 Literature Review contains the previous research about thermal comfort in an educational setting. The research was used to study and help with things that related to the study such as the method or the analysis of the research.

Table 2.1 Literature Review

No	Research Title	Research Objective	Research Method	Research Result
1	Study of occupant behaviour to improve thermal comfort conditions by arranging furniture in student hostel rooms [7]	Study the thermal comfort of the student dorm room as well as how the arrangement of the furniture can affect the student's thermal comfort in the dorm room	Monitoring weather data, measurement of thermal comfort parameters in the research area, as well as conducting questionnaire surveys on hostel students	There is a correlation between the arrangement of the furniture and the thermal comfort of the dormitory where, in order to obtain better thermal comfort, it is recommended that the bed or study table be placed in the middle of the room or under the ventilator installed.
2	Passive Cooling and Thermal Comfort Performance of Passive Downdraught Evaporative Cooling (PDEC) Towers in a Saudi Library: An On-site Study [8]	Passive Downdraught Evaporative Cooling (PDEC) tower performance evaluation to improve thermal comfort when compared to other conventional air conditioning.	Measuring and calculating the wind speed and cooling performance of the PDEC towers and collating them with the environmental conditions in the interior.	It was found that as the wind speed increases, the indoor temperature also decreases and can maintain cooling efficiency between 70 and 75%.

3	Analysis of determining factors in the thermal comfort of university students. A comparative study between Spain and Portugal [9]	Study and compare various factors of student thermal comfort on classroom buildings in Portugal and Spain	Measurement of parameters in the area as well as conducting questionnaire surveys to students and performing PMV-PPD applications	It was found that the ventilation system and the concentration of CO_2 in Spanish classrooms were more careful than in Portugal and also Portuguese students showed a preference for warmer temperatures (26.4°C) than Spanish students (24.7°C), and also the type of clothing, gender, and country were crucial factors.
4	Thermal comfort evaluation in campus classrooms during room temperature adjustment corresponding to demand response [10]	Study the level of thermal sensation, reception, as well as student preferences with an increased set point of cooling temperature on the occupied part of the building.	Conducting interviews and questionnaires to the student sample at the time of changing the cooling temperature set point on the occupied part of the building.	A decrease of 2 °C is known to be the limit of the reduction of the set point of cooling temperature without causing any occupant discomfort.
5	Experimental and Statistical Survey on Local Thermal Comfort Impact on Working Productivity Loss in University Classrooms [11]	Finding a relationship between thermal comfort and decreased productivity in the university classroom	Measuring the parameters of a classroom that will be divided into several sectors, then conducting a survey of the student questionnaires that are in the classroom which is divided in these sectors and performing a Novel test to measure student productivity.	It was found that thermal comfort as well as CO_2 content had a strong influence on productivity loss but this study did not factor circumstances or individual factors.
6	Experimental Study and Analysis of Thermal Comfort in a University Campus Building in Tropical Climate [12]	Evaluating student performance and acceptance in classrooms with mini-split cooling systems in tropical climates	Measuring temperature both inside and outside the classroom and asking students to complete a thermal comfort survey in the classrooms. From the survey will be obtained the Predicted Mean Vote (PMV), predicted percentage dissatisfied (PPD), thermal	It was found that the PMV result, although each person is different because it can be affected by each person's clothing, has no influence on the TMV value where there is a difference of 2°C to 3°C. In addition, the student's temperature

			sensation vote (TSV) and the Actual Percentage Dissatisfied (APD)	preference of 23°C and 24°C is obtained.
7	Thermal comfort and Indoor Air Quality assessment in university classrooms [13]	Conducting an evaluation of thermal comfort and indoor air quality at the University of Western Macedonia	Measurement of thermal comfort parameters and indoor air quality in the classrooms of the University of Western Macedonia in the winter and conducting surveys of students	Based on the results obtained thermal comfort is at a neutral level and for the air quality is good but in rooms with a lot of occupation there is a decrease in air quality
8	Field investigations on thermal comfort in university classrooms in New South Wales, Australia [14]	Analysis of student thermal comfort levels and temperature preferences at the University of New South Wales	Doing an ASHRAE questionnaire while studying and measuring indoor thermal conditions.	The results of the questionnaire showed the mean comfort votes were -1 slightly cold and 1 slightely warm.
9	Preliminary Study on Student's Performance and Thermal Comfort in Classroom [15]	Finding a relationship between thermal comfort and student performance in the classroom.	Measuring the comfort parameters of indoor and outdoor spaces, using questionnaires to students present in the classroom and performing the Neurobehavioral Core Test Battery. (NCTB)	The results show that if the speed of the fan is lowered, the more students choose a colder temperature and the faster the fan, the higher the student's concentration and the test scores.
10	Indoor Thermal Comfort in University Classroom: A Case of Universiti Teknologi Malaysia [16]	Find out the level of thermal comfort in the classroom at the University of Technology Malaysia	Taking data on thermal comfort parameters in the classroom and performing many observations of two sessions in the morning and afternoon	The results of this study indicate that 70% of the classrooms already meet the existing air temperature standards and 85% of the classes already meet existing humidity standards, but the entire classroom wind speed exceeds the current standard.

2.2 BASIC THEORY

2.2.1. Thermal Comfort

Thermal comfort refers to the subjective satisfaction or dissatisfaction of an individual with the thermal environment they are in. Each person has their own unique preferences and tolerances for thermal conditions around them. In recent years thermal comfort has been emphasized as one of the important factors when planning or maintaining a building. Especially in educational settings, providing optimal thermal comfort plays an important part in ensuring students' productivity and concentration [17].

There are a few factors that affect thermal comfort, that include air temperature, humidity, air velocity, and clothing [18]. These factors are in determining thermal comfort because it directly influences the heat exchange between the body and the surrounding environment [19]. Additionally other individual factors such as an individual's age, gender, body type, and health condition can be another factor that alter an individual's thermal comfort [20]. It is important to consider these factors when designing or regulating the thermal environment in order to ensure the comfort of the building's occupants.

The impact of thermal comfort can not be underestimated. It can affect various aspects such as productivity, concentration, and the well being of an individual. Previous research showed that when people are in a thermally comfortable environment, their performance, concentration, and productivity increase. The incapability to provide a thermally comfortable environment can lead to discomfort, reduced productivity, concentration, and performance, and also can cause health issues such as fatigue and stress [21].

2.2.2. Standard Thermal Comfort

2.2.2.1 SNI

The Standard National Indonesia (SNI) for thermal comfort is a set of guidelines and standards that define the optimal conditions for indoor thermal comfort in buildings. The standard that is used is SNI T 03-6572-2001, which provides guidelines on temperature, humidity, and air movement in various rooms such as classroom, office, and residential spaces. These guidelines are based on extensive research and studies and taking into account factors such as average outdoor temperature, humidity levels, and air quality in Indonesia. The thermal comfort level is divided into three categories: cool comfort, optimum comfort, and warm comfort [22]. Table 2.2 showed the thermal comfort level according to SNI T 03-6572-2001 showed the category of thermal comfort category and the standard of temperature and humidity on each category.

Table 2.2. Thermal Comfort Level According to SNI T 03-6572-2001

	Effective Temperature (TE)	Humidity (RH)
Cool Comfort Upper limit	20,5°C- 22,8°C 24°C	50% 80%
Optimum Comfort Upper limit	22,8°C - 25,8°C 28°C	70%
Warm Comfort Upper limit	25,8°C - 27,1°C 31°C	60%

2.2.2.2 ASHRAE

The American Society of Heating, Refrigerating, Air-Conditioning Engineers developed the standard for thermal environmental conditions, known as ASHRAE Standard 55. This standard establishes guidelines for indoor thermal comfort parameters, such as temperature, humidity, air speed, and other factors. ASHRAE also provided a psychrometric chart that can be used to analyze the relationships between various properties of air, including temperature, humidity, and enthalpy By utilizing the psychrometric chart and following the guidelines set by ASHRAE Standards 55 it can determine whether the thermal conditions in a room or building are within the acceptable comfort level [23]. Figure 2.1. showed the psychrometric chart used to analyze the thermal comfort in the room.

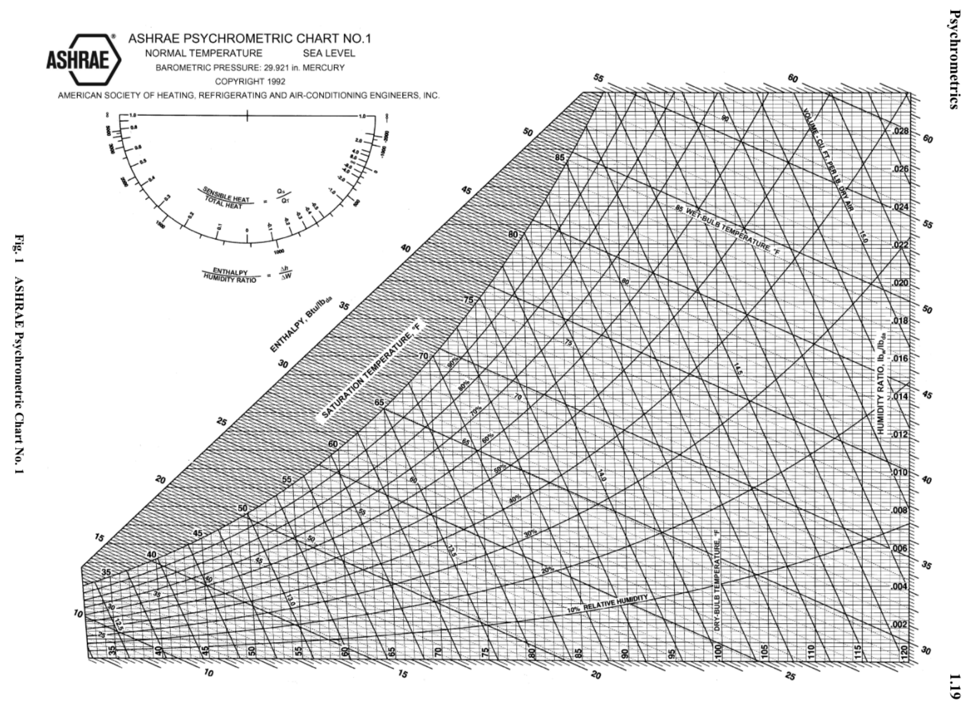

Figure 2.1. Psychrometric Chart 2021 ASHRAE Handbook [24]

2.2.3. PMV

Predicted Mean Value (PMV) Thermal Comfort Predicted Mean Value or known as PMV is a method used to calculate and assess the thermal comfort level experienced by occupants in a particular environment, such as inside a room or building [25]. PMV models take into account various factors including air temperature, relative humidity, air velocity, activity level, radiant temperature, clothing insulation, and personal presences. This index used a scale ranging from -3 to +3, where negative values indicate a feeling of cold and the positive value indicates a feeling of warmth a person felt. The PMV model can predict the average thermal sensation felt by a group of people and determine the Predicted Percentage of Dissatisfied (PPD). Predicted Percentage of Dissatisfied is prediction of the percentage of people who feel dissatisfied with the condition of the room [26].

2.2.4. Adaptive Thermal Comfort

Adaptive thermal comfort refers to the idea that individuals have the ability to adapt and adjust to their thermal environment in order to maintain comfort. This idea suggests that thermal comfort is not solely determined by objective factors such as air temperature, but also by individual factors including physiological responses, behavioral adjustments, and others. The cause of adaptive thermal comfort is the recognition that humans are active agents in their environment. Humans will try to adapt and make changes in their behavior to achieve the optimum thermal comfort. Research has shown that adaptive thermal comfort can vary greatly depending on factors such as clothing, metabolic rate, and even psychological factors. For example, individuals may choose to dress in layers or adjust their activity levels to better cope with different thermal conditions [27].