CHAPTER II

LITERATURE REVIEW

2.1 Literature Review

Table 2.1 Literature review

NO	TITLE	OBJECTIVE	METHOD	RESULTS
1	Impact Of Classroom Environment, Teacher Competency, Information And Communication Technology Resources, And University Facilities On Student Engagement And Academic Performance [12].	Conducting learning and teaching, and university facilities on academic and student performance at Higher Education Institutions (HEI).	Distributing questionnaires to room users.	Supports a better teaching and learning process.
2	Assessment Of Daylight Performance Of Advance Daylighting Strategy In Large University Classrooms : Case Study Classrooms At JUST [13].	Daylight lighting applied to university buildings can reduce energy use, as well as provide thermal and visual comfort in classrooms.	This research was carried out by comparing direct measurements with simulations in IES-VE (Integrated Environmental Solutions-Virtual Environment) software.	Ensure that software technology and direct calculations meet established thermal and visual comfort level standards. Consumption reduces energy use in the classroom by 40-50% which is used for natural lighting.
3	Smart Classroom Learning Environment Preferences Of Higher Education	Creating a smart educational environment in higher	Distribute questionnaires to teachers and students, and take	Teachers and students like environmentally intelligent learning

	Teachers And Students In China : An Ecological Perspective [14].	education in China and implementing smart learning processes.	measurements directly.	processes and intelligent learning environment spaces. This is related to the room design that uses energy efficiently and applies thermal comfort standards.
4	Effect Of Acoustic And Thermal Comfort To Support Learning Process In A University [15].	Conduct research by knowing the acoustic level in the room to determine the thermal comfort in the classroom.	Carry out direct calculations and compare research data on classroom use.	The average comparison result in the two classrooms was 69 dBA and the results in the student questionnaire felt comfortable.
5	The Dilemma Of Variables Assumptions In Thermal Comfort Calculations For Educational Buildings: To Simplify Or Not? [16].	To radiate a research trend while overcoming the limitations of globe sensors in measuring average radiation temperature.	Perform direct calculations and perform Predicted Mean Vote (PMV) analysis for room users.	The resulting variable model is more likely to recommend thermal comfort.
6	The Architecture Design Checklist Of Classrooms For Children With Cochlear Implant In Rehabilitation Centers [17].	To address a gap in research on the needs of room users in terms of rehabilitation needs.	Carry out direct measurements of indoor conditions, such as: temperature, humidity, lighting and air circulation.	Create a healthy and conducive environment in the learning and teaching process.

7	Classroom-Comfort-Data: A Method To Collect Comprehensive Information On Thermal Comfort In School Classrooms [18].	Developing thermal comfort standards in educational environments and establishing comfort in classrooms.	Carry out direct measurements and distribute questionnaires, as well as make comparisons with standards that have been created.	Shaping research results in accordance with the standards that have been created.
8	Use Of Active Learning Classrooms In Health Professional Education: A Scoping Review [19].	Conduct research to create a study overview of the use of classrooms in professional health education.	Qualitative, quantitative methods by distributing questionnaires to room users and creating comfort standards that are in accordance with a healthy environment.	Make effective use of learning spaces and create professional education that complies with health standards.
9	Evaluation Of Thermal Comfort Conditions In A Classroom Equipped With Radiant Cooling Systems And Subjected To Uniform Convective Environment [20].	Carrying out numerical evaluations is carried out by determining the PMV index which is made using thermal comfort standards.	Using numerical calculation methods to determine the indoor PMV index.	The results of this research were that 24 students and 1 teacher in the class achieved comfort in the teaching and learning process.
10	How much is the indoor comfort of a residential building worth? A discrete choice experiment [21].	Knowing the amount of interest in indoor comfort during the COVID-19 pandemic.	Carry out direct calculations on the room to determine the thermal, visual and acoustic comfort in the room during	Thermal comfort in the room is 51%, visual comfort 22%, acoustic comfort 11%

			the COVID-19 pandemic	

Based on previous research in Table 2.1, evaluate the level of thermal comfort in classrooms, visual comfort, and air conditioning flow [12] [13] [15] [16] [18] [20] using the main calculations in the form of instrumental measurements in the classroom. Type of calculation that uses a questionnaire [12] [14] [18] [19], which uses the Predicted Mean Vote (PMV) calculation [16] [20], who uses software simulations to conduct research on thermal comfort in classrooms [13].

Monitoring thermal comfort levels in classrooms by calculating thermal comfort in accordance with established standards [12] [17] [18], research that calculates thermal comfort by knowing how comfortable people are in the room and the humidity in the room, where the calculation is by knowing the operational time in the room, the level of thermal comfort depends on the number of room user capacities and the building design [12] [14] [17] [18] [19].

2.2 Basic Theory

2.2.1 Thermal Comfort

Thermal comfort is where the human body can feel a certain temperature in the room psychologically, physiologically, and in a person's behavioral patterns, feeling comfortable in an environment. Where the human body attempts to adjust to environmental temperature [22].

Factors that can influence the occurrence of thermal comfort in classrooms are:

1) Temperature of the Air
   Humans and the environment they live in are certainly surrounded by air temperatures that can bring hot or cold air, so that air temperature becomes an important factor in thermal comfort which is used to determine room temperature [23].
2) Humidity of the Air
   The high humidity content of water vapor in an area is used as an indication that the air in that area contains a lot of water vapor or solid air [23].
3) The Speed of Wind
   A unit that can determine air speed from high pressure to low pressure. Wind speed is measured using an anemometer or grouped according to the resulting wind scale which can be used as a specific influence on wind speed [23].

2.2.2 Thermal Comfort Standard

2.2.3.1 American Society of Heating, Refrigerating, and Air Conditioning Engineer (ASHRAE)

Thermal comfort can be produced by having HVAC (Heating, Ventilation, and Air Conditioning) in the room. The main purpose of HVAC is to provide thermal comfort conditions for humans when indoors. Apart from body comfort which can fulfill thermal comfort, comfort in the mind reflects satisfaction with the thermal environment and has subjective value [24].

ASHRAE Standard 55. Mentions when open conditions are meant by the state of mind and satisfaction in humans, but correctly states an assessment that human thermal comfort is the process of adjusting environmental conditions to human thermal comfort which can involve many benefits [25].

Factors that can influence thermal comfort are physical, physiological, psychological, and others. This thermal comfort provides protection in the form of the basics of thermoregulation and human comfort in a room or environment. Apart from that, this discussion provides benefits to building owners or people who build it to always pay attention to operational systems and design the comfort and health of the occupants of the room or building [26].

Comfort occurs through behavior carried out consciously or unconsciously which can influence the process of thermal comfort and humidity to reduce discomfort in the room. Some examples that can reduce humidity and discomfort in the room include: changing clothes, reducing activity, changing location or posture, opening windows, and adjusting the air conditioning in the room. This illustration can be shown below [26].

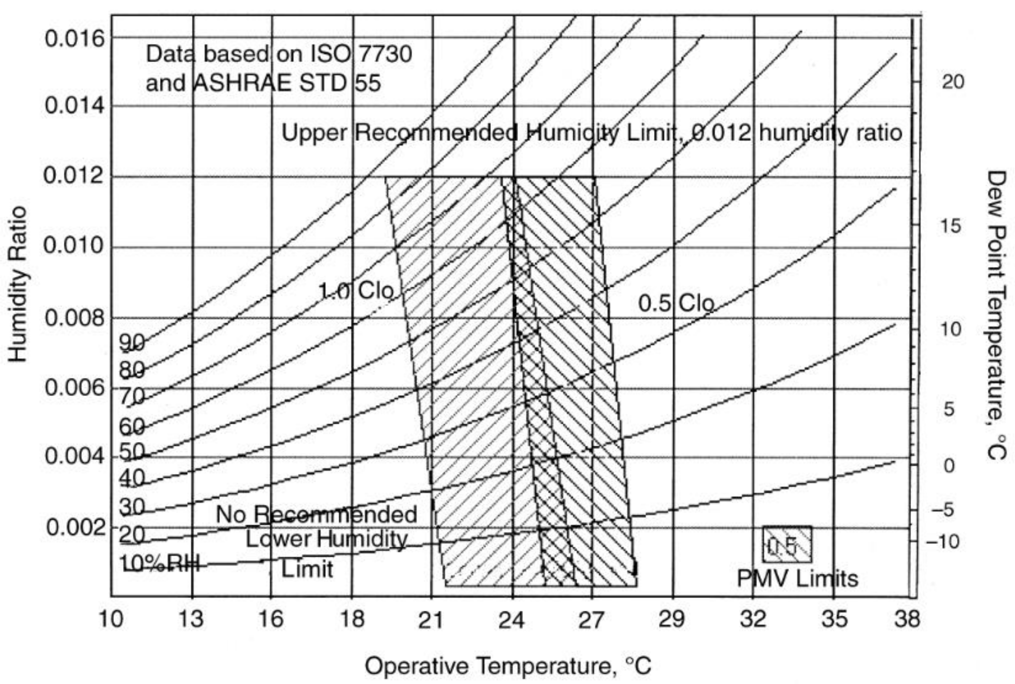

Figure 2.1 Acceptable operating temperature and humidity range for a room that meets the criteria in a room with 80% occupation and air speed not exceeding 0.2m/s [26].

2.2.3.2 Indonesian National Standards (SNI)

Factors that influence thermal comfort have been stated in the Indonesian National Standards (SNI) and influence each other. In this research, the standard will be used as a guide to combine these factors by determining whether the results that have been achieved are in accordance with the standard or not and using SNI 03-6572-2001 [27]. This table can be shown below.

Table 2.2 Acceptable Temperature And Relative Humidity Based On SNI 03-6572-2001 [27].

Category	Active Temperature (TE)	Air Humidity (RH)
Cool Comfortable Upper Threshold	20,5°C – 22,8°C 24°C	50 % 80 %
Comfortable Optimal Upper Threshold	22,8°C – 25,8°C 28°C	70 %
Warm Comfortable Optimal Upper Threshold	25,8°C – 27°C 31°C	60 %

Relative air humidity in a room is a comparison between the amount of water vapor content contained in the air compared to the amount of water vapor content in a saturated state at room air temperature. The relative humidity standard is 40% -50%. However, rooms with a dense number of occupants such as classrooms are allowed to reach 55% - 60%[7]. This illustration can be shown below.

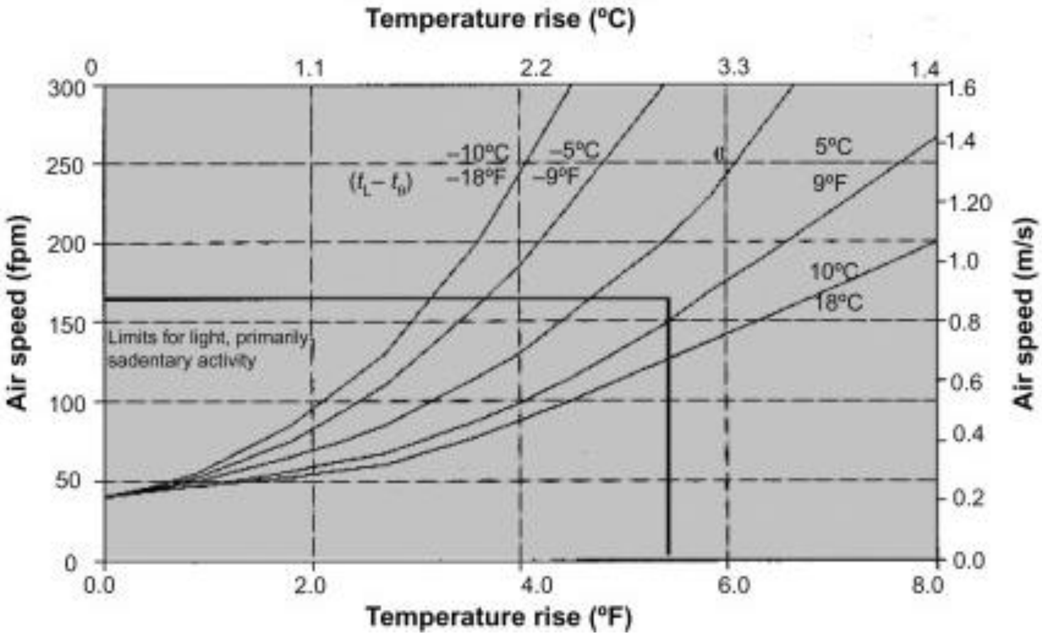

Figure 2.0.2. Image of the need to increase air velocity to compensate for the increase in dry temperature [7].

2.2.3 Predicted Mean Vote (PMV)

2.2.3.1 Introduction PMV

Thermal comfort study can employ PMV to quantify a room's total thermal comfort as it affects human body temperature [28].

The PMV calculation uses the ambient temperature to calculate how much heat the human body is able to balance. The physiological reaction of the thermoregulatory system, which is linked to statistical computations by voting on the gathered room occupants, is used to carry out PMV computations. Thermal comfort can be experienced as a consequence of the thermal comfort burden on the human thermoregulatory system, according to the PMV calculation itself [29].

2.2.3.2 PMV Scale

When the environment is comfortable, the human's thermoregulatory systems alter sweat production and skin temperature to maintain the heat balance of the human body. Apart from that, it can also determine the perceived thermal comfort. PMV can be used as a standard for measuring thermal comfort in the human body in terms of physiological levels of stress felt by the body. The PMV calculation carried out to measure the assessment of thermal comfort of pregnant rooms with body comfort in humans has 7 assessment categories. Below is the PMV Scale which includes physiological stress levels [30].

Table 2.3 Average Environmental Ergonomic Parameter Data [30]

PMV Scale	Thermal Sensation	Physiological Stress
+3	Hot	Strong Heat Stress
+2	Warm	Moderate Heat Stress
+1	Slightly Warm	Slight Heat Stress
0	Natural	No Thermal Stress
-1	Slightly Cool	Slight Cool Stress
-2	Cool	Moderate Cold Stress
-3	Cold	Strong Cold Stress

2.2.4 Adaptive Thermal Comfort

Adaptive thermal comfort is thermal comfort that can be assessed by users or occupants of rooms and buildings that have adapted to their environment. Adaptive thermal comfort itself can act as an environmental climate which can be called a microclimate. Adaptive thermal comfort theory itself can be used to reveal that the occupants of a room or building are the main factor in determining thermal comfort in a building [31].

Adaptive thermal comfort is becoming an important factor in rooms and buildings. Adaptive thermal comfort is a supporting factor in the smooth process of learning and teaching. Adaptive thermal comfort has several factors that can be researched, including: temperature in the room, humidity in the room, number of occupants in the room, building design in the building, interior used in the room, human activity in the room, climatic conditions in the area, and location building [32].

2.2.5 Sick Building Syndrome (SBS)

Sick Building Syndrome is a sign and symptom of a disease that arises as a result of unhealthy air conditions or air circulation in a room. Sick Building Syndrome has similarities with the duration of indoor stay and indoor air quality. The factors that cause Sick Building Syndrome include chemical factors, physical factors and biological factors. Chemical factors that can be associated with CO, CO_2, formaldehyde, and dust. Physical factors that can be related to temperature, humidity, wind speed, and lighting. Biological factors that can be associated with the presence of bacteria and fungi in the room [33].

Sick Building Syndrome can affect human productivity while indoors or in buildings. Symptoms that can influence the occurrence of Sick Building Syndrome include headaches, nausea, eye irritation, smell problems, sore throat, dry cough, dry skin, difficulty concentrating on activities, flu, and so on. These symptoms occur only in the room or building where they live, will disappear when the person leaves the room or building they live in [34].

It is necessary to maintain air quality in a room or building to reduce and prevent the occurrence of Sick Building Syndrome, such as: paying attention to temperature, humidity and lighting in the room appropriately by maintaining goods and building systems in accordance with thermal comfort standards [35].