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Classroom Thermal Comfort and its Effect on Student Psychology in SMA Negeri 1 Obaa

Yisry Ary[1]
Student of Master of Architecture Program
Universitas Kristen Indonesia Jakarta, Indonesia

James ED Rilatupa[2]
Lecturer of Master of Architecture Program
Universitas Kristen Indonesia Jakarta, Indonesia

Aryantono Martowardjojo[3]
Lecturer of Master of Architecture Program
Universitas Kristen Indonesia Jakarta, Indonesia

Abstract:- Thermal comfort has an important role on student psychology because a comfortable environmental situation can improve psychological well-being and affect the creation of conducive and effective learning conditions. This study examines the thermal comfort of classrooms in SMA Negeri 1 Obaa, Mappi Regency, South Papua, and its impact on student psychology. The results showed that the thermal condition of the classroom reached a temperature of 32.4°C and humidity up to 86%, indicating discomfort for students, with an average PMV value of 2.35 (hot category) and PPD of 90%. Using descriptive quantitative methods, data was collected through measurements of air temperature, humidity, wind speed, as well as questionnaires on thermal comfort and student psychology. Results showed that 85% of students felt that thermal conditions had a significant effect on their psychology, affecting focus, concentration, stress, and emotional well-being. This study fills a gap in the literature by highlighting the importance of thermal comfort in hot climates, as well as providing empirical evidence on the psychological impact of thermal conditions in classrooms that has been underestimated.

Keywords:- *Thermal Comfort; Student Psychology*.

I. INTRODUCTION

Thermal comfort is one of the important factors that affect the teaching and learning process in classrooms [1]. A comfortable learning environment can improve concentration, learning effectiveness, reduce stress, and encourage better interaction between students and teachers [2]. In regions with hot climates, such as South Papua, high air temperatures are often a major challenge in creating optimal learning conditions [3]. The Center for Meteorology, Climatology, and Geophysics (BMKG) notes that temperatures in some areas of South Papua, including Mappi Regency, often reach 34°C or more, making it an area with an extreme climate [1].

Most previous research on thermal comfort in classrooms has focused on physical aspects, such as air temperature, humidity, and wind speed [4]. However, research exploring the psychological impact of thermal comfort on students, especially in areas with hot climates such as South Papua, is still very limited [5]. Much of the existing literature also comes from developed countries or regions with adequate facilities, such as air conditioning or mechanical ventilation, which are rarely found in remote areas such as Mappi Regency [6]. In fact, the condition of school facilities in the area is often far from ideal, and thermal comfort is a major challenge that can affect student well-being [7].

In addition, although there is a lot of literature discussing thermal comfort in the context of public buildings or offices, specific research highlighting the influence of classroom thermal comfort on student psychology-such as focus, concentration, stress, and emotional well-being-is still very few [8]. In fact, these psychological aspects have an important role in the success of the learning process [2].

Therefore, this study seeks to fill the gap in the literature by examining the thermal comfort of classrooms in SMA Negeri 1 Obaa, Mappi Regency, and analyzing its influence on student psychology. This research not only provides an overview of the thermal conditions of classrooms in areas with hot climates, but also provides empirical evidence of the impact of thermal comfort on the psychological aspects of students who have been less noticed.

II. LITERATURE REVIEW

A. *Thermal Comfort*

Thermal comfort refers to the condition in which a person feels comfortable with the air temperature, humidity, and airflow around them. In the context of classrooms, thermal comfort has a significant influence on concentration, motivation to learn, and the psychological well-being of students and teachers. Thermal comfort standards, as proposed by ASHRAE, require that at least 90% of respondents must be satisfied with thermal conditions to be categorized as a comfortable environment [9]. Factors such

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as air temperature, radiant temperature, air humidity, wind speed, clothing insulation, and physical activity are key elements in determining thermal comfort [10].

However, most of the previous studies focused on the physical parameters of thermal comfort, without exploring its impact on students' psychological aspects in depth. For example, Nugrahayu's (2020) study evaluated thermal comfort based on physical measurements without linking it to psychological impacts [11]. In addition, existing studies are mostly conducted in urban areas or developed countries, which have temperature control facilities such as air conditioning and mechanical ventilation [12].

B. PMV and PPD

PMV (Predicted Mean Vote) and PPD (Predicted Percentage Dissatisfied) indices are widely used to evaluate thermal comfort based on environmental parameters and human characteristics [13]. These indices provide a quantitative description of thermal perception and dissatisfaction with thermal conditions in a particular space. Although this tool has been widely used in various contexts, most studies stop at measuring thermal parameters, without linking it to subjective student perceptions and its effect on student psychology, especially in hot climate classrooms [14][15].

C. Student Psychology

Research on the relationship between learning environments and student psychology shows that inadequate thermal conditions can disrupt concentration, increase stress, and decrease motivation to learn [16]. Bai and Jin's study (2023) for example, showed that thermal comfort significantly affects psychological well-being, but this study was conducted in a region with a cold climate, so the context is not relevant for a hot region like South Papua [17]. In addition, research linking thermal conditions with psychological aspects of students in classrooms is still rare, especially in remote areas with minimal facilities such as Mappi Regency.

From the literature review above, several gaps in the literature can be identified:

- The lack of research on thermal comfort in hot climatic regions such as South Papua. Most studies are conducted in areas with different climatic conditions or better facilities.
- Lack of exploration of the psychological impact of thermal comfort on students. Previous research has focused more on the physical aspects and energy efficiency of buildings, while the impact on student psychology, such as focus, concentration, and stress, has not been widely discussed.
- Unrepresented local context. The reality of education facilities in remote areas such as Mappi district is rarely the focus of research, making the results of previous studies difficult to apply directly in the region.
- This study aims to fill the gap by analyzing the thermal condition of classrooms in SMA Negeri 1 Obaa and its effect on student psychology, providing empirical contributions that are relevant for hot climate areas with limited educational facilities.

III. REASEARCH METHODS

This research is categorized as descriptive quantitative research to collect systematic quantitative data about thermal conditions in the classroom and identify the thermal comfort conditions of classrooms in SMA Negeri 1 Obaa and its effect on student psychology. The research subjects in this study were classrooms and students of SMA Negeri 1 Obaa in class XII MIPA 2, XII IPS 2, XI B, XI F, X B, and X F, with 117 respondents. Measurement of environmental factors for thermal comfort in the classroom includes air temperature, air humidity, and wind speed will be measured using a thermometer and anemometer with a measurement technique of 5 points in one room.

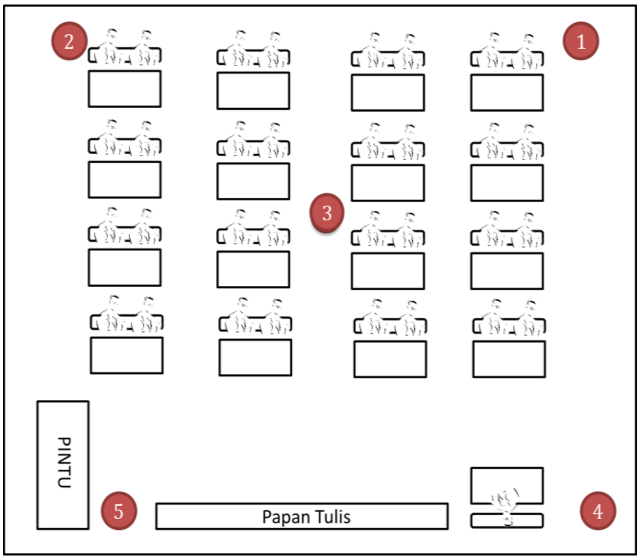

Fig.1: Data Collection Point

Measurements will be taken in two time zones, namely morning (07:30-10:00) and afternoon (11:00-14:00), over a period of five consecutive days. The anemometer will be used at a height of 1 meter above the floor surface. Clothing insulation is calculated based on the total Clo value for each type of clothing worn by students. Human activity, obtained from the calculation of MET average human activity in the classroom. The data will then be analyzed using PMV and PPD using CBE Thermal Comfort Tool (ASHRAE-55) to determine the level of thermal comfort of the classroom. The questionnaire to measure thermal comfort in the classroom uses five answer options: Somewhat Cold (AD), Neutral (N), Somewhat Hot (AP), Hot (P), and Very Hot (SP). While to collect data on the effect of thermal comfort of the classroom on student psychology, used a questionnaire with a Likert scale consisting of five answer options: Strongly Agree (SS), Agree (S), Undecided (RR), Disagree (TS) and Strongly Disagree (STS). This scale has a value of 5 to 1.

IV. RESULTS AND DISCUSSION

The results of sample measurement research for classroom thermal comfort conditions and their effect on student psychology can be described as follows:

A. Classroom Thermal Comfort Condition

- *Air temperature*

The results of temperature measurements on the research samples are presented in the following table:

Table.1: Air Temperature Measurement Results

Class	**Temperature**		**Min**	**Max**	**Average**
	Morning	**Afternoon**			
XII MIPA 2	29,5	32,3	29,5	32,5	30,9
XII IPS 2	30,0	32,4			31,2
XI B	29,7	32,4			31,1
XI F	29,9	32,4			31,2
X B	29,6	32,5			31,0
X F	29,5	32,4			31,0
Average	29,7	32,4			31,1

- *Radiant Temperature*

The results of radiant temperature measurements on the research samples are presented in the following table:

Table 2. Radiant Temperature Measurement Results

Class	**Radiant Temperature**		**Min**	**Max**	**Average**
	Morning	**Afternoon**			
XII MIPA 2	29,5	32,3	29,5	32,5	30,9
XII IPS 2	30,0	32,4			31,2
XI B	29,7	32,4			31,1
XI F	29,9	32,4			31,2
X B	29,6	32,5			31,0
X F	29,5	32,4			31,0
Average	29,7	32,4			31,1

- *Air Humidity*

The results of temperature measurements on the research samples are presented in the following table:

Table 3. Air Humidity Measurement Results

Class	**Humidity**		**Min**	**Max**	**Average**
	Morning	**Afternoon**			
XII MIPA 2	76,5	67,6	67	86,4	72
XII IPS 2	75,4	67,2			71,3
XI B	76,1	67			71,5
XI F	75,9	67,2			71,6
X B	76,8	67,6			72,2
X F	76,2	86,4			81,3

- *Wind Speed*

The results of wind speed measurements on the research samples are presented in the following table:

Table 4. Wind Speed Measurement Results

Class	Wind Speed		Min	Max	Average
	Morning	Afternoon			
XII MIPA 2	0,18	0,05	0	0,22	0,1
XII IPS 2	0,07	0			0
XI B	0	0			0
XI F	0	0,04			0
X B	0	0			0
X F	0,22	0			0,1

- *Clothing Insulation*

The results of the clothing insulation measurements on the research sample are presented in the following table:

Table 5. Student Clothing Insulation Value

Male	Clo	Female	Clo
Men's brief	0,04	Panties	0,03
T-shirt	0,08	Bra	0,01
Short-sleeve shirt dess (thin)	0,29	T-shirt	0,08
Straight trousers (thin)	0,15	Short-sleeve shirt dess (thin) / long-sleeve shirt dess (thin)	0,29
Calf-length socks	0,03	Skirts (thin)	0,14
Shoes	0,1	Calf-length socks	0,03
		Shoes	0,1
Clo	0,69	Clo	0,68

The clothing insulation value for male students is 0.69 clo and 0.68 clo for female students. Thus, the highest value for clothing insulation of 0.69 clo was taken.

- *Human Activity*

For the value of student metabolic rate in the classroom, it is assumed to be 55W/m^2 or equivalent to 1 MET in reading seated activity.

- *PMV and PPD*

Based on the data of environmental factors (air temperature, radiant temperature, relative humidity, wind speed) and human factors (clothing insulation and activity), the PMV and PPD values can be accumulated in the following table:

Table 6. Average PMV And PPD Of Classrooms

Class	Average PMV	Average PPD
XII MIPA 2	2,23	86%
XII IPS 2	2,39	91%
XI B	2,36	90%
XI F	2,4	91%
X B	2,33	89%
X F	2,37	90%
Average	2,35	90%

The measurement results show that the thermal condition of classrooms in SMA Negeri 1 Obaa is in the uncomfortable category based on the average PMV value of 2.35 (warm category) and the average PPD value of 90%, which means the majority of students feel thermally uncomfortable. These measurements were consistent across all classes, both in the morning and afternoon, with average temperatures reaching 30.9°C in the morning and 32.4°C in the afternoon. In addition, the air humidity ranged from 67% to 86%, the average wind speed was 0.1 m/s, and the insulation value of students' clothing was 0.69 Clo.

These thermal conditions are relevant to the gaps in the literature that show that most previous studies have not specifically examined regions with hot climates such as South Papua. This data provides an empirical contribution to understanding the thermal characteristics of classrooms in remote areas with extreme climates, which have been underrepresented in the literature.

B. Student Response to Thermal Comfort

Based on the results of filling out questionnaires by students regarding the thermal comfort felt in the classroom, the following data were obtained:

Table 7. Morning Questionnaire Results

Indicator	**Morning**				
	SD	D	N	P	SP
Temperature	2,6%	16,2%	69,2%	10,3%	1,7%
Humidity	1,7%	16,2%	35,0%	46,2%	0,9%
Wind Speed	3,4%	28,2%	60,7%	6,8%	0,9%
Clothing	1,7%	10,3%	70,1%	15,4%	2,6%
Activities	0%	7,7%	66,7%	17,9%	7,7%
Average	1,9%	15,7%	60,3%	19,3%	2,7%

Table 8. Daytime Questionnaire Results

Indicator	**Afternoon**				
	SD	**D**	**N**	**P**	**SP**
Temperature	0%	0,0%	5,1%	55,6%	39,3%
Humidity	6%	63,2%	12,8%	9,4%	8,5%
Wind Speed	0,9%	6,0%	21,4%	55,6%	16,2%
Clothing	0,9%	0%	1,7%	60,7%	36,8%
Activities	0%	0,9%	6%	60,7%	32,5%
Average	1,5%	14%	9,4%	48,4%	26,7%

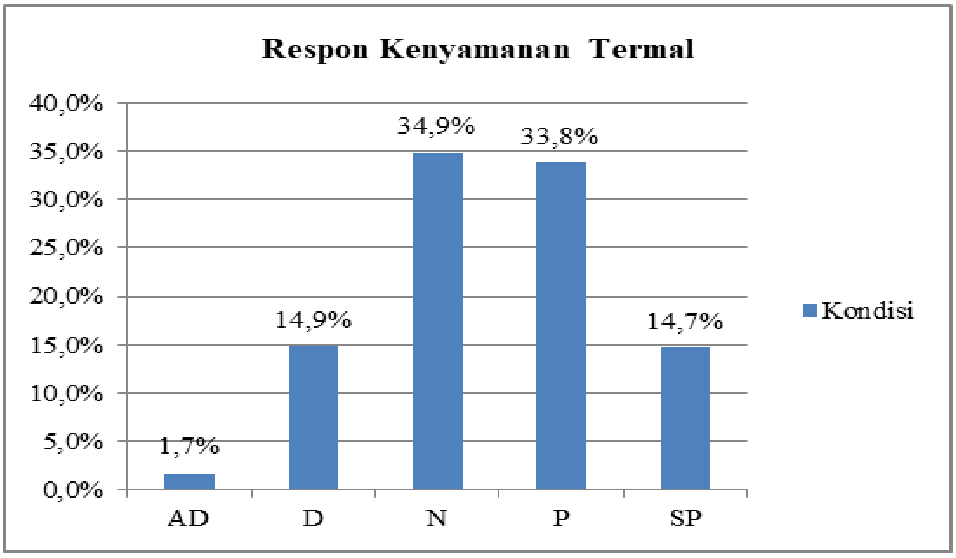

Fig.2: Thermal Comfort Response Recapitulation

The questionnaire results showed that: 60.3% of students felt neutral in the morning, but during the day the conditions changed drastically, with 48.4% feeling hot and 26.7% feeling very hot. Overall, only 34.9% of students felt neutral, while the rest felt uncomfortable (both hot and cold). This finding corroborates the literature gap that thermal parameters alone are not sufficient to evaluate classroom comfort, as students' subjective perception of thermal comfort varies greatly depending on time of day and room conditions.

C. *The Effect of Thermal Comfort on Student Psychology*

Thermal comfort conditions have an influence on student psychology, which can be represented from the results of filling out the questionnaire by students through the following table:

Table 9. Questionnaire on the Effect of Classroom Thermal Comfort on Student Psychology

Indicator	SS	S	RR	TS	STS
Physical Condition	79%	18%	2%	0%	2%
Focus	28%	50%	9%	9%	3%
Concentration	36%	44%	12%	5%	3%
Stress Level	48%	29%	10%	7%	6%
Emotions	38%	28%	15%	15%	4%
Serenity	73%	23%	2%	2%	1%
Learning Conditions	70%	26%	3%	0%	1%
Average	53%	31%	7%	5%	3%

Table 10. Recapitulation of the Influence of Classroom

Indicator	Percentage	Total
Physical Condition	94%	85%
Focus	78%	
Concentration	81%	
Stress Level	81%	
Emotions	76%	
Serenity	93%	
Learning Conditions	93%	

➢ *Thermal Comfort On Student Psychology*

A total of 85% of students agreed that the thermal conditions of the classroom had a significant effect on their psychology. From the questionnaire analysis, it was found that thermal comfort has an impact on:

- Physical well-being: 94% of students felt their physical condition was affected by thermal comfort.
- Focus and concentration: 78% of students reported impaired focus when thermal conditions were uncomfortable.
- Stress and emotions: 81% of students felt stress levels increased in hot conditions, while 76% reported changes in emotions.
- Tranquility and learning effectiveness: 93% of students reported that comfortable thermal conditions support calmness and learning effectiveness.

This result closes the gap in the literature regarding the lack of research linking thermal comfort with psychological aspects of students, especially in regions with extreme thermal conditions. This study shows that not only the physical condition, but also the mental and emotional well-being of students is greatly affected by thermal comfort.

➢ *Contribution to the Literature*

- *Contextualizing Research in Hot Climate Regions*

This study provides specific data from a hot climate region such as Mappi District, which is rarely represented in previous studies. The results reveal the thermal conditions in remote areas with limited educational facilities, which can inform the development of school facility policies in similar areas.

- *Relationship between Thermal Comfort and Student Psychology*

This study fills a gap in the literature by highlighting a direct link between classroom thermal conditions and their impact on student psychology, such as focus, concentration and stress levels. The findings are relevant for improving understanding of the importance of a comfortable learning environment in hot climates.

- *A Holistic Approach to Thermal Comfort*

The findings of this study suggest that thermal comfort evaluation should involve subjective aspects (student responses) in addition to physical parameters (PMV and PPD). This provides a new direction for future research and intervention.

V. CONCLUSION

This study examines the condition of thermal comfort of classrooms in SMA Negeri 1 Obaa, Mappi Regency, and its effect on student psychology. Based on the results of the analysis, the following conclusions were obtained:

A. *Thermal Comfort Conditions*

The thermal condition of classrooms in SMA Negeri 1 Obaa does not meet the thermal comfort standards according to ASHRAE. The measurement results show a PMV value of 2.35 (warm category) and PPD of 90%, indicating that the majority of students feel uncomfortable. This confirms the importance of evaluating thermal conditions in hot climates such as South Papua, which has rarely been the focus of research.

B. Effects on Student Psychology

A total of 85% of students stated that thermal conditions affected their psychology, including focus, concentration, stress levels and emotional well-being. This study extends the literature by showing that thermal comfort affects not only physical aspects, but also students' mental and emotional well-being, particularly in regions with extreme thermal conditions.

C. Contribution to the Literature

➢ *Filling the Contextual Gap:*

This research fills a literature gap related to the lack of research in hot climate regions such as South Papua, where school facilities are often inadequate to support thermal comfort. The empirical data obtained provides new insights that can be used for the planning and development of educational facilities in similar regions.

➢ *Holistic Approach:*

By combining the measurement of physical parameters (PMV and PPD) and the analysis of students' subjective perceptions, this study provides a holistic approach to thermal comfort evaluation, which previously focused more on physical aspects alone.

➢ *Relationship between Thermal Comfort and Psychology:*

This study strengthens the literature by highlighting the direct relationship between classroom thermal conditions and student psychology, which has been under-explored, especially in remote areas with hot climates.

This research confirms that thermal comfort is an important element that affects the success of the learning process, especially in regions with unique climate challenges. Therefore, strategic measures are needed to improve the thermal comfort of classrooms through building designs that are more adaptive to the local climate, effective use of natural ventilation, or provision of temperature control facilities.

RECOMMENDATIONS FOR FURTHER RESEARCH

This study opens up opportunities for further in-depth research, such as evaluating architectural design solutions that support thermal comfort, the development of local data-based thermal comfort prediction models, or cost-benefit analysis of interventions carried out to improve thermal comfort in schools with similar conditions.

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