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Evaluation of Thermal Conditions in the GKB 2 Unimus Hall Using Temperature and Relative Humidity Parameters

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Abstract. This study aims to evaluate the thermal conditions in the hall on the 8th floor of GKB 2 Building, Muhammadiyah University of Semarang (Unimus) using temperature and relative humidity as the main indicators. The background of this study is the importance of thermal comfort in higher education spaces that directly impact the productivity and health of space users. Data collection was carried out periodically every hour from 06.00 to 18.00 at five observation points spread throughout the room. The measurement method used a digital hygrometer and supported by data analysis using Microsoft Excel to produce a graph of temperature and humidity fluctuations. The results show a general pattern that occurs in closed spaces in tropical climates, namely the temperature increases until midday and decreases in the afternoon, while relative humidity shows the opposite trend. This study provides an overview of the importance of ventilation management and space design strategies that are able to maintain thermal comfort throughout the day.

Keywords: thermal comfort; air temperature; relative humidity; GKB 2 hall; tropical climate

1. Introduction

Thermal comfort is a crucial aspect in supporting environmental quality within buildings, particularly in higher education buildings. This aspect directly impacts concentration and productivity during teaching and learning within the building [1]. Thermal comfort occurs in a state of balance between human body temperature and the surrounding temperature which provides a feeling of comfort for the occupants [2]. This condition is directly related to the productivity, focus, and health of space users. In a tropical climate like Semarang, discomfort occurs when high temperatures are accompanied by fluctuating relative humidity. The interaction between solar radiation, temperature, and humidity is a major climatic factor affecting the survival of living things [3]. Air humidity reflects the amount of water vapor in the atmosphere; the higher the temperature, the greater the air's capacity to hold water vapor, which, if fluctuated, will drastically affect thermal comfort [4]. Unstable indoor air quality, where the temperature is outside the comfort zone, is a significant risk factor for the development of symptoms such as dizziness or respiratory problems [5].

Therefore, it is important to understand the thermal characteristics of a space in real-world situations. Research on thermal conditions in educational spaces is still quite limited, despite the extensive human activity in these spaces, which occurs daily. Several previous studies have highlighted that temperature and relative humidity are two key parameters in determining the thermal quality of a space [6] [7]. In addition, space design factors, material use, and ventilation systems also influence the thermal response of a building [8] [9].

Most campus buildings in Indonesia sometimes lack continuous thermal control. Passive cooling techniques aim to remove unwanted heat and naturally maintain interior air quality [3] [10]. Meanwhile, the proper use of voids, skylights, and building orientation can optimize natural lighting and air flow, which significantly reduces energy consumption [11]. Good airflow regulation helps maintain room temperature stability [5]. Therefore, halls routinely used for various activities require a scientific evaluation of their thermal performance. This study aims to evaluate actual thermal conditions through periodic temperature and relative humidity measurements in the hall on the 8th floor of GKB 2 Unimus.This study also aims to map the daily patterns of thermal parameter fluctuations and understand the potential adaptive behavior of the space's users to these conditions.

2. Methods

This study employed a quantitative approach with field observation. This approach was chosen because it allows for the collection of numerical data that can be statistically analyzed to identify patterns of temperature and humidity fluctuations within a confined space. Data collection was conducted using a digital thermo-hygrometer to measure air temperature and relative humidity. Measurements were conducted at five different observation points within the GKB 2 hall on the 8th floor, from 6:00 a.m. to 6:00 p.m. WIB, with hourly recording intervals. All data were presented in tables and graphs using Microsoft Excel. The data were then analyzed to identify correlations between temperature and humidity parameters and to interpret daily thermal trends (Figure 1).

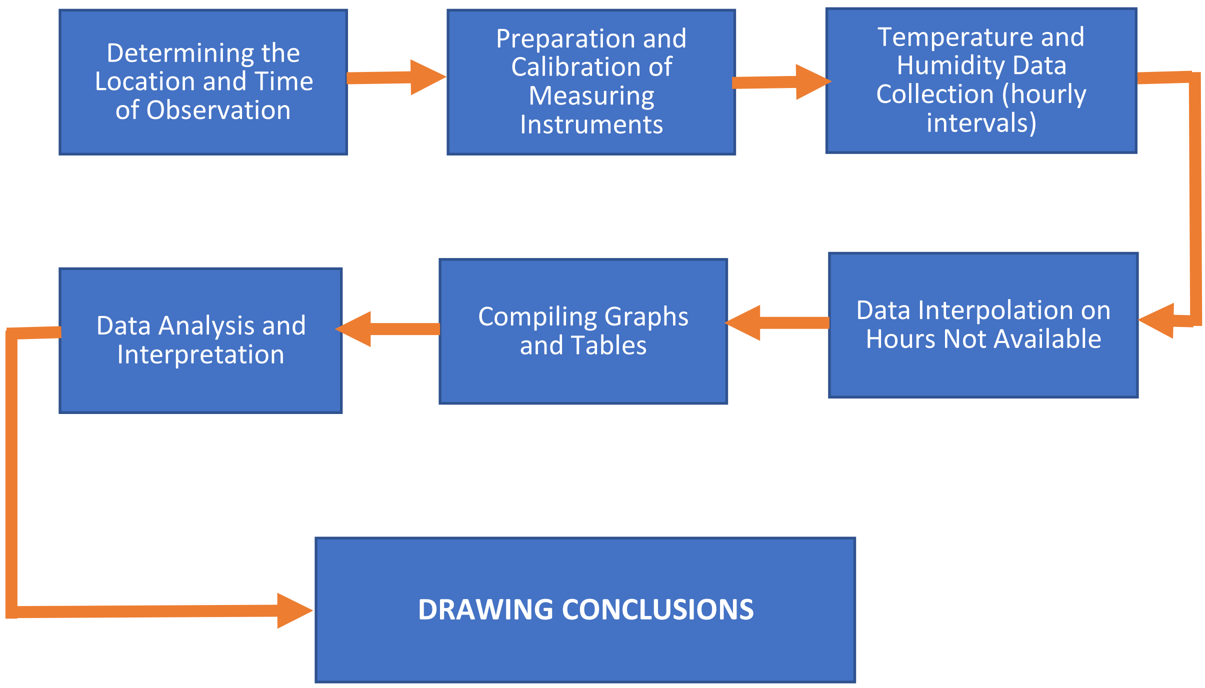

Figure 1. Research Method Process Diagram

3. Results and Discussion

3.1. Building Information

GKB 2 Building is located in the Muhammadiyah University of Semarang area at Jalan Kedungmundu Number 18, Kedungmundu Village, Tembalang District, Semarang City, Central Java, which is strategically located in the eastern part of Semarang City (Figure 2). This building is a modern educational facility that serves as the center of academic activities for the Faculty of Engineering and Computer Science, the Faculty of Agricultural Science and Technology, and the Faculty of Education and Humanities (Figure 2). This building consists of eight floors with a basic corner plan of the "L" type which divides the plan into 2 parts, namely Zone A and Zone B (Figure 3).

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Figure 2. Location of GKB 2 in the Unimus Area

Figure 3. GKB 2 Building

3.2. Thermal Conditions in the GKB 2 Hall

GKB Building 2 is a joint lecture hall. Each floor plan is designed in a typical way. However, each floor is partitioned to accommodate the lecture needs of each faculty. The building's layout consists of a lecture hall area and four bathrooms on each floor (Figure 4).

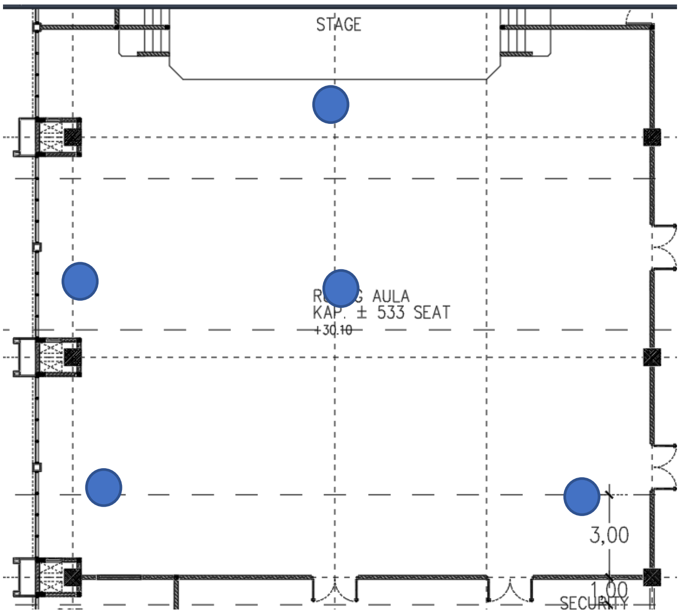

Figure 4. Existing Floor Plan of the 8th Floor Hall of GKB 2

Measurements were taken at several corners of the room to determine thermal differences. This is influenced by the position of openings such as doors, windows, and glass. To obtain relevant conclusions, five corner points were taken for identification: the front, right rear, left rear, front, and left side (Table 1 and Figure 5; Table 2 and Figure 6). Air flow velocity was also measured in the GKB 2 hall from 6:00 AM to 6:00 PM per hour (Figure 7).

Table 1. Summary of Room Temperature Data for GKB 2 Hall Unimus (6:00 AM–6:00 PM WIB)

	Center	**Front**	**Left**	**Rear Left**	**Rear Right**
06:00	25	24,8	24,6	24,4	24,3
07:00	25,7	25,5	25,3	25,1	25
08:00	26,5	26,3	26,1	25,9	25,8
09:00	27,4	27,2	27	26,8	26,7
10:00	28,2	28	27,8	27,6	27,5
11:00	28,3	28,1	27,9	27,7	27,6
12:00	28,5	28,3	28,1	27,9	27,8
13:00	28,4	28,2	28	27,8	27,7
14:00	28,2	28	27,8	27,6	27,5
15:00	28	27,8	27,6	27,4	27,3
16:00	27,6	27,4	27,2	27	26,9
17:00	27,2	27	26,8	26,6	26,5
18:00	26,8	26,6	26,4	26,2	26,1

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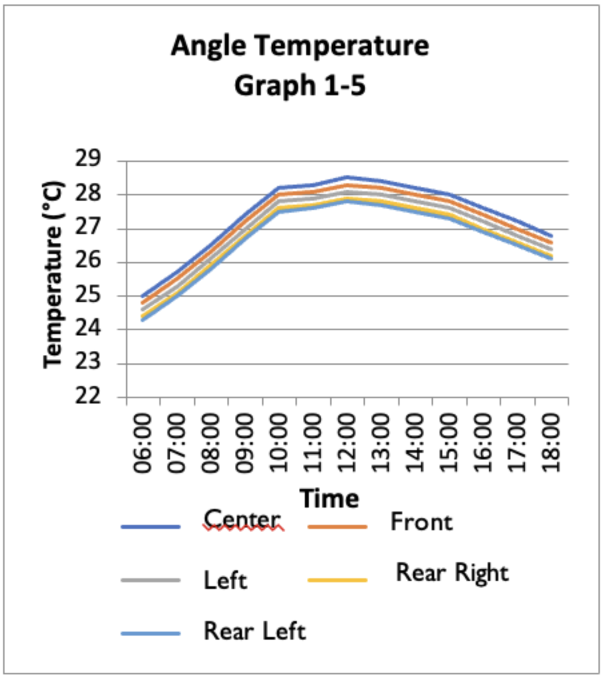

Figure 5. Temperature Graph of GKB 2 Hall Room

Table 2. Summary of Relative Humidity GKB 2 Unimus Hall (06.00–18.00 WIB)

	Center	Front	Left	Rear Left	Rear Right
06:00	81,4	79,3	80,5	82,2	81
07:00	79,7	77,7	78,8	80,3	79,1
08:00	77,6	75,6	76,7	78	77
09:00	76,3	74,4	75,3	77	76
10:00	76,1	74,1	75,4	76,5	75,8
11:00	75,4	73,4	74,1	75,6	74,8
12:00	74,8	72,7	73,6	75,2	74
13:00	73,5	71,6	72,6	74,1	72,9
14:00	72,4	70,4	71,3	72,9	72,1
15:00	72,8	70,8	71,9	73,5	72,6
16:00	73,4	71,7	72,5	74	72,8
17:00	74,2	72,3	73,5	74,9	73,6
18:00	75,1	72,9	74	75,5	74,5

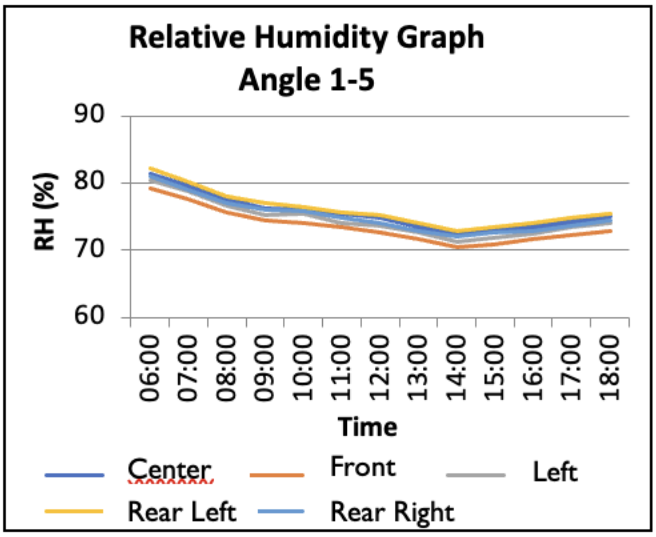

Figure 6. Relative Humidity Graph of GKB 2 Hall Room

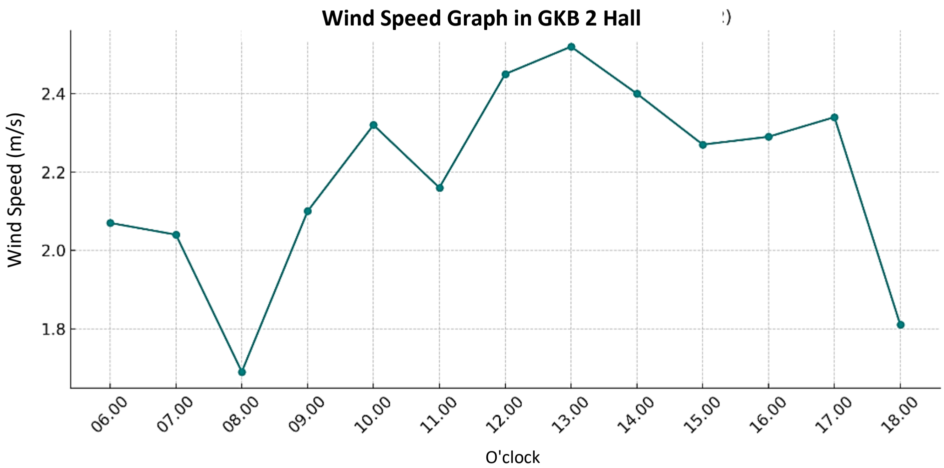

Figure 7. Wind Speed Graph of GKB 2 Hall Room

Measurements showed that the room temperature gradually increased starting at 6:00 a.m., averaging 25.0°C, peaking at 28.4°C between 12:00 and 1:00 p.m., before declining to 26.8°C in the afternoon. Meanwhile, relative humidity decreased from 80% in the morning to around 73% at midday, then increased again towards the afternoon.

This pattern demonstrates an inverse relationship between temperature and relative humidity, a common characteristic of enclosed spaces in tropical climates. Several observation points recorded higher-than-average temperatures, particularly near windows or areas exposed to indirect sunlight. This suggests the need to review the air circulation system and openings in the hall design.

Wind speed fluctuations in the GKB 2 Unimus auditorium were simulated based on the typical conditions of a closed space in a tropical climate. Wind speeds tend to increase gradually from morning to evening, starting at around 1.1 m/s at 6:00 a.m., reaching a peak of around 2.6 m/s between 12:00 and 1:00 p.m., then decreasing again in the afternoon.

This pattern illustrates air movement influenced by differences in indoor and outdoor temperatures and limited cross-ventilation potential. While these wind values are not directly measured, the simulation provides an overview of typical airflow conditions in an enclosed space without active cooling. The low wind speeds indicate that thermal comfort is significantly influenced by ventilation design and the distribution of indoor openings.

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The measurements demonstrate typical thermal fluctuations in tropical buildings without active cooling. Air temperature showed an upward trend from 6:00 a.m. to an average of 25.0°C, peaking at around 28.4°C between 12:00 and 1:00 p.m., then gradually decreasing to around 26.8°C in the afternoon. Meanwhile, relative humidity dropped from 80% in the morning to around 73% at midday, then rose again towards the afternoon.

This pattern aligns with the phenomenon of passive heating due to solar exposure, which results in an increase in temperature and a decrease in relative humidity. Adaptation to these conditions is typically achieved through simple strategies, such as opening windows or turning on fans. These data indicate that space users respond to environmental conditions with passive strategies that still depend on the space's design and external climate conditions.

3.3. User behavior

Field observations show that users tend to choose seating that is not exposed to direct sunlight, particularly away from areas near windows. The center of the room feels cooler because it is not exposed to direct radiation. The use of curtains, the direction of window openings, and the placement of fans significantly influence the distribution of thermal comfort in the space. A study conducted in a community worship space confirmed that adaptive thermal comfort can be achieved through passive design strategies such as cross-ventilation, the selection of insulating materials, and a room layout that considers the direction of solar radiation. This study underscores the need for a tropical architectural design approach that is responsive to daily microclimate changes.

Based on the interpretation of measurement results and analysis, the GKB 2 Unimus auditorium experiences significant fluctuations in temperature and humidity, including wind speed, over the course of a day. These results support the theory that microclimate is determined by key variables such as air temperature, relative humidity, solar radiation, and wind speed [12], [13]. The highest thermal conditions are recorded during the day, accompanied by a decrease in relative humidity, which can potentially reduce thermal comfort for space occupants. If humidity drops too much as temperature rises, the air becomes too dry, which can affect the psychological and physical comfort of occupants [14] [15].

4. Conclusion

This study shows that the indoor thermal conditions of GKB 2 Hall experience significant daily fluctuations. Peak temperatures occur during the day, coinciding with lower relative humidity levels, which can reduce thermal comfort for occupants. This study suggests the need for improved natural ventilation or the implementation of passive design strategies to maintain thermal comfort throughout the day.

The results provide empirical evidence that passive design strategies, particularly increased natural ventilation and solar control, are crucial for improving comfort in large educational spaces in tropical climates. Practical implications of this research include the need to optimize natural ventilation and the use of building materials that are more responsive to daily thermal changes. These findings can inform future design and renovation strategies for similar campus buildings.

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