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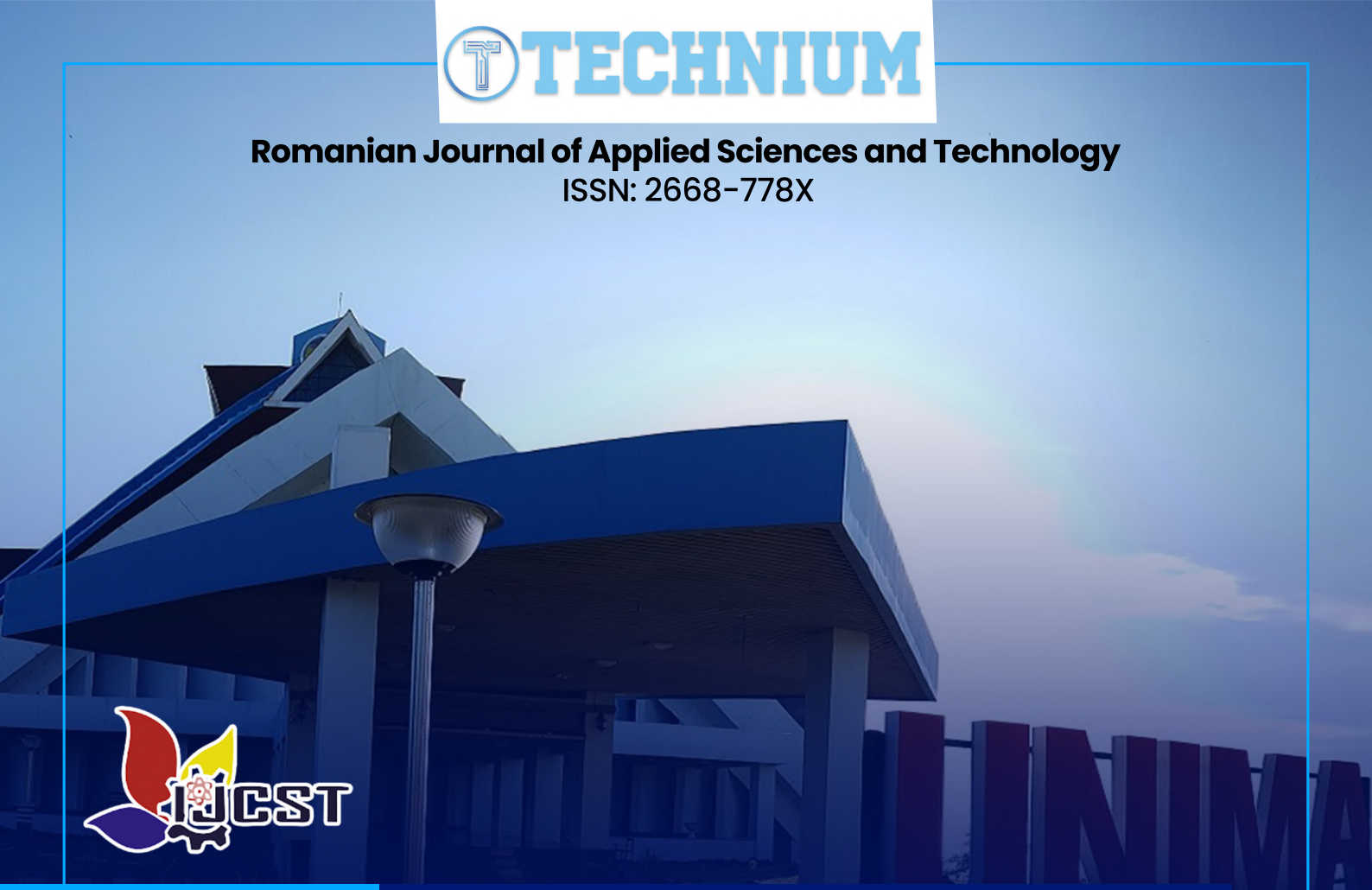

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The Influence of Latitude on the Climatic Characteristics of Classroom in Campus 1 and Campus 2 of Khairun University in Achieving Adaptive Thermal Comfort

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Abstract. Microclimate variables are important factors that affect adaptive thermal comfort. These factors include air temperature, solar radiation, air humidity, and wind speed. This study focuses on discussing microclimate variables, specifically air temperature and air humidity. This is based on previous research indicating that the most influential climate variables are air temperature, solar radiation, and air humidity. This study is a field research aimed at comparing air temperature and air humidity between campus 1 and campus 2 of Khairun University, due to differences in geographical elevation. Measurements were taken in March. The variables of air temperature and air humidity were measured inside the building. The research results show significant differences between campus 1 and campus 2. These differences can be associated with the perceived adaptive thermal comfort by the users. The thermal sensation results direct that the majority of users in campus 2 feel cool, while the majority of users in campus 1 feel comfortable or neutral. These findings provide a strong basis for improving adaptive thermal comfort in both campuses by considering optimal air temperature and air humidity settings.

Keyword: latitude, climatic characteristics, classroom, thermal comfort

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1 Introduction

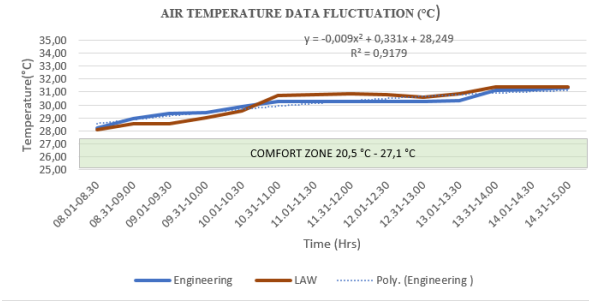
The variables that affect thermal comfort levels are known as thermal variables. These thermal variables have different values between one location and another and are often referred to as microclimate variables(1). The difference in elevation between locations will have an impact on these thermal variables, which ultimately affect the perceived thermal comfort level. In Indonesia, the variation in temperature is influenced by the elevation of the location from sea level, which can be divided into three different zones: highlands (mountains), lowlands, and coasts(2). According to Houbolt's altitude theory, there is a correlation between temperature and the location's altitude from sea level, where the maximum temperature in Indonesia decreases by around 0.57°C for every 100-meter increase in elevation below the 60°C latitude line(3). Some climate variables that can affect good thermal conditions are air temperature, air humidity, and air movement(4). However, Indonesia does not have reliable thermal comfort standards based on research studies(5,6).

Studies have shown that people tend to adapt to the ambient temperature around them, and the higher the ambient temperature, the higher the temperature that provides comfort for them(7). Predicting thermal comfort inside buildings or rooms also involves the application of adaptive thermal comfort theory. Several research studies have developed mathematical models that describe adaptive thermal comfort in various types of buildings. These models can be used to predict thermal comfort inside a building(8).

Based on the studies (9,10), the classroom has an area of 56 m² with an opening area of approximately 107.5 m². The average temperature in the classroom from eight o'clock in the morning until eleven o'clock is 29.88 °C. The opening area of approximately 107.5 m² in the classroom results in a temperature that falls outside the comfort standards for the classroom.

Indonesia's temperature and humidity are highly variable due to the diverse geographical locations across the country. The temperature and comfort thresholds in the eastern regions of Indonesia will differ significantly from the temperatures or standards established by both the Ministry of Manpower (MOM) and the Indonesian National Standard (SNI)(11)(12).

To achieve the desired thermal comfort, control and adaptive actions need to be taken by occupants, such as adjusting ventilation systems, regulating mechanical airflow, providing curtains for areas directly exposed to sunlight, and even designing sun shading devices to minimize radiant heat(13). Therefore, research on ventilation systems that can maximize natural ventilation for achieving thermal comfort is needed (14–16). Buildings in humid tropical regions face challenges in meeting the standards required according to the ASHRAE 55 comfort zone(15,16).



2 Research methods

Classrooms are specialized rooms used for learning activities in schools or universities, and they play a crucial role in creating à comfortable and productive learning environment for students. Campus 1 is located at latitude 32 meters above sea level (mdpl), while Campus 2 is located at latitude 65 mdpl. The research was conducted during clear weather conditions. Both quantitative and qualitative methods were employed in this study. The quantitative method involved measuring variables such as air temperature and humidity using Hobo data loggers. The measurements were taken twice, in the morning and afternoon, during the third week of March. The measurements were conducted for 7 hours, from 8:00 AM to 3:00 PM (WIB - Western Indonesia Time). Two different classrooms from different faculties were selected for the measurements. The qualitative method involved administering questionnaires to gather data on thermal sensation and usé activities.

Quantitative data analysis will involve using graphs to illustrate the differences in air temperature and humidity. The graph will also display the variations in air temperature and humidity during the last week of March. Qualitative data analysis will provide insights into the students' perception of thermal sensation at different campuses (Campus 1 and Campus 2) with varying latitudes and altitudes.

3 Results and Discussion

The research findings are presented in the form of graphs comparing the climate variables in four classrooms. Overall, it can be observed that both air temperature and humidity differ between the two campus locations, Campus 1 and Campus 2, due to the significant difference in elevation between 32 mdpl and 65 mdpl. In Campus 1, the air temperature ranges from 29-32°C, while in Campus 2, the air temperature ranges from 28-31°C. The humidity levels in Campus 1 range from 63-81%, while in Campus 2, they range from 61-76%.

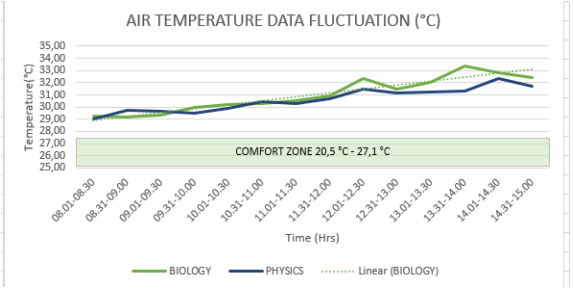


Fig. 1. Temperature Campus 1 biology and physics classrooms

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In Campus 1, the difference in air temperature between the biology and physics classrooms is not significant. The highest air temperature is observed in the biology classroom between 12:00-15:00 WITA (Western Indonesian Time), while the lowest air temperature occurs between 08:00-10:00. In the physics classroom, the lowest temperature is recorded between 08:00-10:30, and the highest temperature is observed between 12:01-15:00.

Fig. 2. Temperature Campus 2 Engineering and Law classrooms

Table 1. The biology classrooms air temperature

20-Mar-23	*AIR TEMPERATURE (° C)*				
TIME	*BIOLOGY*	*STDV*	*DATA*	*MAX*	*MIN*
08.01-08.30	29,26	0,19	30	29,91	29,10
08.31-09.00	29,18	0,05	30	29,26	29,12
09.01-09.30	29,33	0,13	30	29,35	29,22
09.31-10.00	29,99	0,18	30	30,15	29,74
10.01-10.30	30,20	0,08	30	30,30	30,00
10.31-11.00	30,28	0,24	30	30,80	30,00
11.01-11.30	30,56	0,26	30	30,90	30,00
11.31-12.00	30,96	0,39	30	31,80	30,00
12.01-12.30	32,31	0,53	30	32,90	31,43
12.31-13.00	31,45	0,26	30	31,93	30,96
13.01-13.30	32,02	0,89	30	33,45	31,00
13.31-14.00	33,41	0,79	30	34,25	31,72
14.01-14.30	32,84	0,34	30	33,43	31,85
14.31-15.00	32,43	0,25	30	32,98	32,00

In Campus 2, the difference in air temperature between the Engineering and Law classrooms is not significant. The highest air temperature is observed in the Engineering classroom between 13:31-15:00 WIT (East Indonesia Time), while the lowest air temperature occurs between 08:00-10:30. In the law classroom, the lowest temperature is recorded between 08:00-10:30, and the highest temperature is observed between 13:31-15:00.

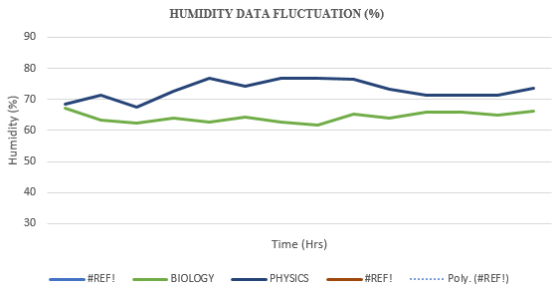

Fig. 3. Humidity Campus 2 Engineering and Law classrooms

The fluctuations in air humidity at Campus 1 are variable. At 08:00 WIT (Western Indonesian Time), the air humidity starts at 68.61% and begins to rise at 08:31 WIT. It then decreases again between 09:01-09:30, averaging at 67.39%. Subsequently, the humidity gradually increases throughout the day, reaching 73.56% in the afternoon. From 10:00 to 14:30, the humidity remains relatively stable around 71-76%.

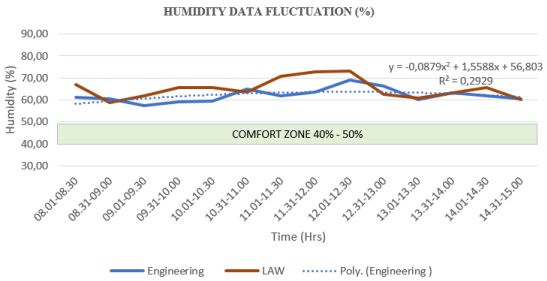

Fig. 4. Humidity Campus 2 Engineering and Law Classrooms

At Campus 2, the fluctuations in air humidity are relatively stable. At 08:00 WIT (Western Indonesian Time), the air humidity starts at 67.09% and continues to decrease until 11:00 WIT. It then increases between 11:01-12:30, reaching around 73%. From 12:32 onwards, it gradually decreases, reaching 60.32% towards the late afternoon.

Table 2. The Engineering classrooms humidity

20-Mar-23	*HUMIDITY (%)*				
TIME	*Engin.*	*STDV*	*DATA*	*MAX*	*MIN*
08.01-08.30	61,32	0,07	30	61,32	60,21
08.31-09.00	60,62	0,21	30	60,62	59,40
09.01-09.30	57,48	0,05	30	59,16	56,02
09.31-10.00	59,08	0,08	30	59,88	58,03
10.01-10.30	59,56	0,12	30	59,97	59,02
10.31-11.00	65,08	0,07	30	74,70	59,36
11.01-11.30	62,01	0,00	30	64,10	60,40
11.31-12.00	63,52	0,00	30	64,10	62,90
12.01-12.30	68,90	0,00	30	70,00	64,20
12.31-13.00	66,32	0,01	30	68,90	60,80
13.01-13.30	60,29	0,26	30	68,40	56,00
13.31-14.00	63,18	0,02	30	66,90	61,70
14.01-14.30	61,82	0,03	30	62,30	61,50
14.31-15.00	60,52	0,00	30	64,70	51,20

In the Faculty of Engineering, the fluctuation in air humidity occurs between 08:01-10:30, averaging around 61-52%. Then, between 12:01-13:00, the humidity rises to approximately 68.90%. After 13:01-15:00, the air humidity tends to decrease, averaging around 60.52%.

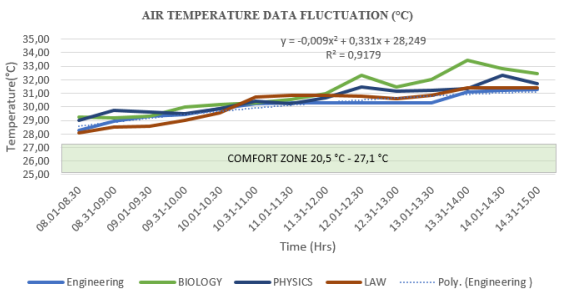

Fig. 5. Temperature Campus 1 and Campus 2 Classrooms

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The thermal variables are related to thermal comfort adaptability, which is expressed through thermal perception consisting of a 7-point scale measurement: -3 (very cold), -2 (cold), -1 (cool), 0 (neutral), +1 (warm), +2 (hot), +3 (very hot). The collection of thermal comfort variables is done by conducting direct interviews with students.

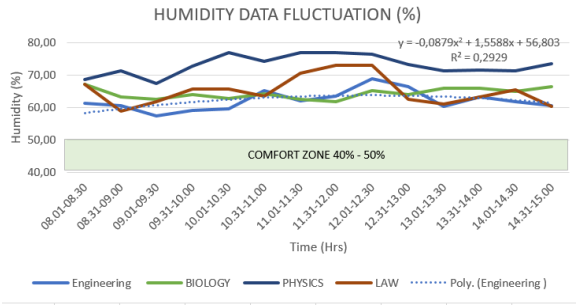

Fig. 6. Humidity Campus 1 and Campus 2 Classrooms

The largest percentage at Campus 1 is -1 thermal sensation, chosen by 67% of the respondents. On the other hand, at Campus 2, the largest thermal sensation is 0, chosen by 45% of the respondents. This indicates that most respondents feel cool at Campus 2 and comfortable at Campus 1. Overall, both at Campus 1 and Campus 2, respondents feel cool at a raté of 29.8%, which represents a comfortable or neutral sensation.

4 Conclusion

The thermal variables between Campus 1 and Campus 2, which are located at different geographical elevations, show a relatively small difference, considering that the elevations of the two locations are not significantly apart. The research findings state that Campus 1 is able to create a warmer indoor air temperature compared to the outdoor air temperature. The diagram also shows that Campus 1, which includes biology and physics classrooms, has similar temperature and humidity levels. At certain times, the window design and building orientation are effective in cooling the rooms, but at other times, there is a noticeable drastic increase in room temperature. The 30-meter difference in elevation does not have a significant impact on the thermal variables in user comfort activities. The adaptive thermal comfort, as seen from the thermal sensation, differs between Campus 1 and Campus 2. The thermal variables do not have a strong influence on adaptive thermal comfort in both campus locations due to the relatively small difference in elevation. The research results indicate that there is an influence of air temperature and humidity on thermal sensation in the two locations of Khairun University campuses.
Figures and tables, as originals of good quality and well contrasted, are to be in their final form, ready for reproduction, pasted in the appropriate place in the text. Try to ensure that the size of the text in your figures is approximately the same size as the main text (10 point). Try to ensure that lines are no thinner than 0.25 point.

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