JMU
Jurnal Medika Udayana

ISSN: 2597-8012 JURNAL MEDIKA UDAYANA, VOL. 15 NO.11, NOVEMBER, 2026

Received: 2026-01-03 Revision: 2026-08-04 Accepted: 01-11-2026

THERMAL COMFORT LEVELS AMONG STUDENTS DURING LEARNING ACTIVITIES IN LECTURE ROOM OF THE FACULTY OF MEDICINE UDAYANA UNIVERSITY 2025

I Gusti Agung Krisania Mahaputri[1]*, I Made Krisna Dinata[2], I Putu Gede Adiatmika[2], I Dewa Ayu Inten Dwi Primayanti[2]

Department of Physiology

[1.] Bachelor of Medicine, Faculty of Medicine, Udayana University

[2.] Department of Physiology, Faculty of Medicine, Udayana University

Corresponding Author

I Gusti Agung Krisania Mahaputri

[1.] Bachelor of Medicine, Faculty of Medicine, Udayana University

e-mail: mahaputri.2202511143@student.unud.ac.id

*e-mail: mahaputri.2202511143@student.unud.ac.id

ABSTRACT

Background: Thermal comfort in lecture rooms plays a crucial role in supporting learning process. Thermal conditions affect the body's thermoregulatory system, which influences alertness, concentration, and cognitive performance. However, determining the ideal thermal condition remains challenging due to the concept of comfort is a subjective individual response and difficult to define. This study aims to describe and analyze both objective and subjective thermal comfort levels during students' learning activities in lecture room of the Faculty of Medicine, Udayana University.

Method: This study, approved under Ethical Clearance No. 1298/UN14.2.2.VII.14/LT/2025, is descriptive quantitative research with an observational cross-sectional design. Thermal comfort levels were analyzed based on environmental measurements and subjective data by point in time survey questionnaire from 104 respondents. Respondents were selected using simple random sampling from students attending on May 26, 2025.

Results: The study results showed that in Lecture Room 4.01, the mean air humidity was 59.18%, air temperature 23,57 oC, and air velocity 0.9 m/s. Thermal comfort was reported by 82.7% respondents, representing 86.7% of room occupants, with an acceptance (72.2%). A total of 54.8% of respondents preferred a cooler temperature, while 51.9% preferred greater air movement. All respondents had an activity level of 1.1 met and clothing insulation between 0.5-1 clo, with the highest thermal comfort achieved among those with 0.5 clo.

conclusion: The mean air humidity and air temperature in Lecture Room 4.01 met the Indonesian National Standard for comfort. Subjectively, thermal comfort was achieved, with 82.7% thermal comfort reports as defined by the ANSI/ASHRAE thermal sensation scale standard.

Keywords : thermal comfort, thermal sensation, lecture room, relative air humidity, air temperature, air velocity.

INTRODUCTION

The rapid development of knowledge leads the world into the era of Industrial Revolution 4.0. Humans had to continuously develop and update their knowledge through learning. Learning was a process in which individuals sought to achieve changes in skills, knowledge, and attitudes through several stages.[1] The learning process took place at various places and levels of education, both from formal and non-formal institutions, one of which was in university. According to data from the Badan Pusat Statistik (BPS), Indonesia had over 7.8 million university students among its 22.4 million residents aged 20 to 24 years in 2022.[2]

The learning process required adequate cognitive ability. Effective learning was influenced by teachers, students, facilities, and the environment. The degree of comfort in a given environment played a crucial role in determining the productivity of activities performed within

that space.[3] A Study by Marisa found that among students who experienced learning difficulties, 68% had a high level of learning difficulties.[4] Students' learning difficulties were influenced by physical and environmental conditions.[4] An uncomfortable environment affects the cognitive function of medical students, the cognitive domains were impaired, especially working memory and selective attention.[5] This condition indicated that an ergonomic learning environment was needed to reduce physical and mental workload as well as to improve learning quality.

Spatial comfort was an individual response based on feelings of relief, tranquility, and the ability to cope with discomfort in the occupied environment.[6] Circulation space, visual, acoustic, and thermal aspects were the indicators that influence spatial comfort.[7] Artificial ventilation, such as air conditioner, was required to maintain thermal comfort during learning activities, indicating that the thermal indicator had a significant influence on spatial comfort.[3] Thermal comfort was a condition that described an individual's psychological, physical, and physiological satisfaction within a thermal environment. Individuals who experienced thermal comfort did not desire any change in thermal conditions, either cooler or warmer. Variations in thermal requirements existed among individuals to achieve a state of comfort. Thermal comfort was influenced by climatic and personal factors of the occupants. Climatic factors included air humidity, radiation temperature, air temperature, and air velocity, while individual factors consisted of clothing insulation (*clo*) and metabolic rate (*met*).[8]

A space was considered to be thermally comfortable condition when the Predicted Mean Vote (PMV) scale ranged between -0.5 and +0.5, assuming only 10% of Predicted Percentage of Dissatisfied (PPD). In addition, occupants' responses to the seven-point thermal sensation scale (TSENS), which could be measured through a point in time survey, were also used as a reference. Thermal comfort was achieved when the TSENS ranged between -1.5 and +1.5 for at least 80% of individuals occupying the space. This percentage was obtained from the accumulation of responses categorized as slightly cool (-1), neutral (0), and slightly warm (+1).[8] The Badan Standardisasi Nasional (BSN) also defined comfort limits of indoor environments, indicating that the relative humidity should range between 30% and 60%, air temperature between 20.5 and 27.1 ^{o}C, and air velocity between 0.15 and 0.25 m/s.[9]

The spatial thermal condition affected the body's thermoregulatory system and ultimately influenced an individual's body temperature. The thermoregulatory mechanism impacted thinking speed, sensitivity, alertness, and concentration. If the thermogenesis continued for an extended period, the body became fatigued and experienced stress. By contrast, when the body was exposed to excessively high room temperatures, individuals found it more difficult to concentrate due to the slowing of physiological functions. The body's ability to perceive gradients of thermal sensation was influenced by the relative stimulation of different types of nerve endings, spatial summation of the exposed body surface area, and core body temperature.[10]

Ilma et al.[11] reported that 92.9% students stated that temperature affected their learning quality. Therefore, a room with appropriate thermal comfort conditions was required to achieve an effective learning process. Based on several previous studies examining the relationship between thermal conditions and human physiological functions, the research findings remained varied.[12] This variation made it difficult to determine thermal conditions suitable for individual needs. Moreover, the concept of comfort was a responsive and subjective assessment, making it challenging to define. Therefore, this study was conducted to determine the level of thermal comfort both objectively, based on air humidity, air temperature, and air velocity, and subjectively in students' learning activities in the Lecture Rooms of the Faculty of Medicine, Udayana University. The results of this study were expected to provide additional references for identifying and determining room conditions with appropriate thermal comfort to support an effective learning process.

OBJECT AND METHOD

This study with ethical clearance No. 1298/UN14.2.2.VII.14/LT/2025, was observational non-experimental research with data collected through a cross-sectional approach. A quantitative descriptive design was used to describe the level of the thermal comfort during students' learning activities. The target population of this study consisted of all students engaged in learning activities in the lecture room of the Faculty of Medicine, Udayana University. The accessible population consisted of 121 students from the KUB 2022 cohort of the Undergraduate Medical Study Program who attended classes in lecture room 4.01.

The minimum sample size was determined using the Slovin formula with 5% margin of error, with an additional 10% added to anticipate possible errors in questionnaire completion, resulting in a total of 103 samples. Respondents were selected through simple random sampling based on inclusion criteria. The inclusion criteria were active students from the KUB 2022 cohort, participating in learning activities in the lecture room 4.01 of the Faculty of Medicine during the study period, physically and psychologically healthy, having a normal body temperature range, willing to participate in the study and provide informed consent, as well as being cooperative in providing data throughout the research process.

doi:10.24843.MU.2026.V15.i11.02

The study was conducted in Lecture Room 4.01 of the Faculty of Medicine, Udayana University, on Monday, 26th of May 2025 from 08.00 to 10.00 Central Indonesia Time (WITA). The variables examined included the objective thermal comfort level, based on air humidity, air temperature, and air velocity, as well as the subjective thermal comfort level. Body temperature was used as a control variable and measured using non-contact infrared forehead thermometer, while the mean radiant temperature played as a confounding variable. Environmental data for objective thermal conditions were measured using a thermometer hygrometer HTC-1 at three different points and an anemometer at one point every 15 minutes. Subjective data were obtained from a questionnaire containing questions on respondents' personal information and the ASHRAE (2023) point in time thermal sensation survey.

RESULT

The study was conducted in Lecture Room 4.01, West Building, Faculty of Medicine, Udayana University, on Monday, 26th of May 2025. The room measured 146.519 m^2 and was equipped with six air conditioners. Data collection took place under partly cloudy weather conditions, with the outdoor temperature was approximately 28 ^oC. Questionnaires were completed by 104 respondents who met the inclusion criteria, representing 86.7% of the total 120 occupants in the room. The respondents consisted of 70 females and 34 males. The complete distribution of respondents' age and body temperature is presented in **Table 1.**

Table 1. Characteristics of study participants

Characteristic	Mean	SD	Max.	Min.
Age (year)	20.68	0.68	23	19
Body temperature (^oC)	36.45	2.86	37	36.1

The environmental data measured were air humidity, air temperature, and air velocity in Lecture Room 4.01, with the results presented in **Table 2.**

Table 2. Results of environmental measurements

Category	Mean	Max.	Min.
Air humidity (%)	59.18	66	48
Air temperature (^oC)	23.57	26	20.8
Air velocity (m/s)	0.9	1.2	0.7

The results of point in time survey questionnaire obtained from 104 respondents included data on thermal sensation, thermal satisfaction level, preferences for changes in temperature and air movement, clothing insulation, and activity level. Responses falling within the thermal comfort range, based on the thermal sensation scale, which comprised the categories slightly cool, neutral, and slightly warm, accounted for 82.7% indicating that thermal comfort had been achieved. The findings also revealed that 72.2% of respondents perceived the thermal condition as acceptable or comfortable. The detailed results are presented in **Table 3.**

Table 3. Results of the ASHRAE Point-in-Time Thermal Sensation Survey

Questionnaire Category	Frequency	
	N	%
Seven Point Thermal Sensation Scale (TSENS)		
a. Cold (+3)	0	0
b. Cool (+2)	11	10.6
c. Slightly cool (+1)	29	27.9
d. Neutral (0)	41	39.4
e. Slightly warm (-1)	16	15.4

doi:10.24843.MU.2026.V15.i11.02

Questionnaire Category	Frequency	
	N	%
f. Warm (-2)	6	5.8
g. Hot (-3)	1	1
Thermal Satisfaction Scale		
a. Very Dissatisfied	2	1.9
b. Dissatisfied	8	7.7
c. Slightly Dissatisfied	19	18.3
d. Neutral	29	27.9
e. Slightly Satisfied	19	18.3
f. Satisfied	22	21.2
g. Very Satisfied	5	4.8
Temperature Preference Scale		
a. Cooler (-1)	57	54.8
b. Without Change (0)	41	39.4
c. Warmer (+1)	6	5.8
Air Movement Preference Scale		
a. Less air movement (-1)	7	6.7
b. Without change (0)	43	41.3
c. More air movement (+1)	54	51.9
Clothing Insulation Scale		
a. 0.2 *clo*	0	0
b. 0.4 *clo*	0	0
c. 0.5 *clo*	17	16.3
d. 0.6 *clo*	75	72.1
e. 1 *clo*	12	11.5
Activity Level Scale		
a. 0.8 *met*	0	0
b. 1.1 *met*	104	100
c. 1.2 *met*	0	0
d. 1.7 *met*	0	0
e. 3.8 *met*	0	0

Figure 1. and 2. show that the highest percentage of thermal sensation among female respondents was neutral at 45.7%, while among male respondents it was slightly cool at 29.4%. The percentage of thermal comfort was 88.5% for females and 70.6% for males .

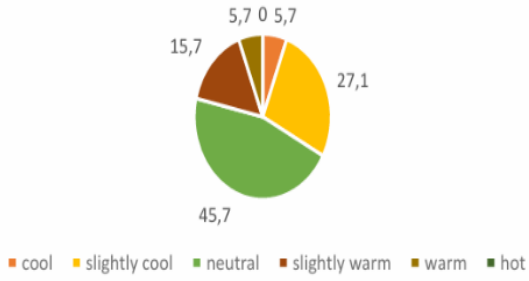


Figure 1. Percentage of thermal sensation among female respondents

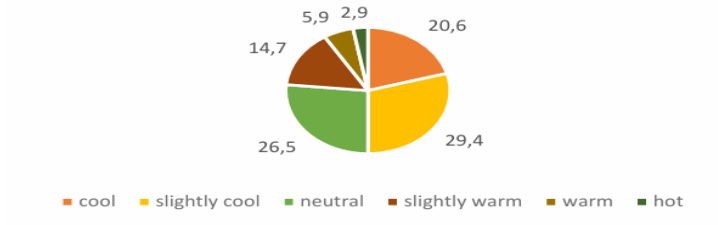


Figure 2. Percentage of thermal sensation among male respondents

The distribution of thermal sensation data perceived at each clothing insulation scale were analyzed to determine the percentage of thermal comfort based on the thermal sensations achieved at each insulation level, as shown in **Table 4.**

Table 4. Distribution of thermal comfort levels based on thermal sensation across different clothing insulation scales

Clothing Insulation Scale	Percentage of Thermal Comfort
0.5 *clo*	88.23%
0.6 *clo*	81.33%
1.0 *clo*	83.33%

DISCUSSION

The average relative humidity in the lecture room was within the thermal comfort standard. The mean relative humidity was 59.18% with a minimum value of 48% and a maximum of 66%. According to the BSN, a relative humidity level of 30-60% or 60%±5% is considered optimal for achieving thermal comfort.[9] The distribution of relative humidity was not uniform throughout the lecture room, as one measurement point (B) recorded a value exceeding the comfort limit, namely 66% as measured using the thermometer hygrometer HTC-1. This finding aligns with the recommendation to maintain indoor humidity levels around 55% during building design planning.[13] Furthermore, the optimal range of relative humidity is reported to be 40-60%.[14]

The average air temperature in the lecture room was within the thermal comfort range. The measured average temperature was 23.57 ºC, with a maximum of 26 ºC and a minimum of 20.8 ºC. According to the BSN, the recommended indoor air temperature for achieving thermal comfort is 24 to 27 ºC or 25.5 ºC ± 1.5 ºC.[9] The BSN also states that a temperature range of 22.8 to 25.8 ºC is considered as the optimal comfort temperature, while 24 ºC still falls within the cool range.[9] Furthermore, the acceptable indoor air temperature for good air quality is between 18 ºC and 30 ºC.[15] A study by Masruri and Patradhiani also found that optimal body function can be achieved at a temperature of ±24 ºC.[16]

Based on the questionnaire responses, 54.8% respondents expressed a desire for a cooler temperature, while 39.4% preferred no change. This finding contrasts with Rohman et al.[17], who reported that thermal comfort is achieved at temperature between 27 ºC and 29 ºC. Therefore, although the average room temperature met the thermal comfort standards and was suitable for learning activities, some occupants still preferred a cooler environment. This tendency might be due to uneven temperature distribution within the lecture room, as indicated by thermometer hygrometer HTC-1 measurement at point (A), which recorded 25.9 ºC to 26 ºC. These values fall within the comfortable warm range, 25.8 ºC to 27.1 ºC, resulting in occupants' tendency to prefer a cooler environment.[9]

In this study, the influence of outdoor air temperature on indoor temperature was weak. The average indoor air temperature in the lecture room was 23.57 ºC, while the outdoor air temperature during the study was 28 ºC. For every 1 ºC increase in outdoor temperature, the indoor temperature increased by approximately 0.4 ºC. A similar increase was observed in temporary prefabricated buildings lacking heating or cooling systems.[18] When air conditioner was not used, the indoor temperature rose in line with the outdoor temperature.[19] This corresponding increase required greater cooling energy consumption to maintain indoor thermal comfort levels.[20] The lecture room used six air conditioners to maintain thermal comfort for occupants. Therefore, the indoor temperature was primarily controlled by these cooling systems.

The measured air velocity in the lecture room exceeded the recommended range for thermal comfort. The average air velocity measured was 0.9 m/s, with a minimum value of 0.7 m/s and a maximum value of 1.2 m/s. Air

doi:10.24843.MU.2026.V15.i11.02

velocity was measured at a single point, point (B), located directly in line with the air conditioner unit. The air velocity that meets the thermal comfort standards ranges from 0.15 m/s to 0.25 m/s.[9,21,22]

The questionnaire results showed that 51.9% respondents desired an increase in air movement, while 41.3% preferred no change. During the study, the outdoor air temperature was approximately 28 ºC. According to Givoni, when the outdoor temperature ranged between 28 ºC and 32 ºC, thermal comfort is achieved at an air velocity of 1.5 m/s to 2.0 m/s.[23] This condition likely accounted for the tendency of some respondents to prefer increased air movement, which could also be attributed to the uneven distribution of air velocity within the lecture room.

The respondents' ages in this study did not differ significantly. Therefore, age differences were not expected to have meaningful effect on the thermal sensitivity experienced. This finding aligned with Mao et al.[24], who reported that sensitivity to thermal conditions decreases with age, as older adults exhibit lower sensitivity and a reduced desire for thermal changes. The respondents in this study consisted both male and female participants. The percentage of thermal sensation responses was dominated by comfortable sensations in both groups. This result was consistent with Greenfield et al.[25], who stated that the difference in thermal sensitivity between males and females under local cooling conditions was minimal. Differences in thermal sensation between male and female appeared primarily when local cooling was applied. Woman were more sensitive on the upper arm area, whereas men were more sensitive on the lower arm.[26] In this study, a general air conditioning system was used for all occupants rather than local cooling. Therefore, gender was not expected to have a significant effect on respondents' thermal sensation.

The average body temperature of the respondents was 36.45 ºC, which falls within the normal body temperature range of 36.1 ºC to 37.2 ºC, as measured using a non-contact infrared thermometer. Respondents with body temperatures outside this range were excluded from the study. Thermal sensation is influenced by body temperature, when skin temperature actively decreases, individuals tend to perceive a cooler thermal condition, and vice versa.[10] Fever can also affect thermal sensation, as the body simultaneously activates thermoregulatory mechanisms to increase temperature.[10]

Based on the respondents' thermal sensation, the lecture room met the thermal comfort standard. Subjective thermal comfort was assessed according to the occupants' perceptions during the study period. The results showed that 82.7% respondents reported feeling thermally comfortable. The respondents represented 86.7% of the total lecture room occupants. According to ANSI/ASHRAE criteria, thermal comfort is considered achieved when 80% or more of respondents, representing ≥35% total occupants, reported feeling comfortable.[8,27] Therefore, it can be concluded that the thermal conditions in the lecture room met the thermal comfort standard based on the seven-point thermal sensation scale analysis.

The assessment of thermal comfort based on the thermal satisfaction question showed that only 72.2% respondents considered the thermal conditions were acceptable. This percentage was below the ANSI/ASHRAE threshold of 80% which indicates that thermal conditions are accepted by the majority of occupants.[8] Therefore, based on the respondents' perception of thermal acceptability, the lecture room did not fully meet the ANSI/ASHRAE thermal comfort standard.[8] Crosby and Rysanek reported that under similar psychometric conditions, differences in non-thermal factors, such as CO_2 concentration and indoor noise level, may lead to variations in thermal satisfaction.[28] Hence, this finding likely indicates that non thermal environmental factors within the lecture room may have influenced the respondents' perception of thermal satisfaction, even though the physiological or thermal sensation were within the comfort range.

The majority of respondents wore clothing with an insulation value of 0.6 *clo*, which corresponds to the standard attire prescribed for medical students by the Faculty of Medicine, Udayana University. The questionnaire results on activity level indicated that all respondents were engaged in the same type of activity, which was light sedentary activities such as sitting, attending lectures, and writing, equivalent to 1.1 *met.*[29] An increase in activity intensity also leads to a higher *met* value. Although clothing insulation and air temperature affect the met value, this influence is not constant due to variations in the interaction among these variables, which depend on individual preferences and perceptions.[30] Therefore, the uniformity in activity levels suggests that variations in respondents' thermal comfort perceptions were not significantly affected by their *met* values.

Variations in respondents' clothing insulation levels resulted in different percentages of thermal comfort across each insulation scale. Thermal comfort was achieved by 88.23% of respondents wearing clothing with an insulation value of 0.5 *clo*, while those with 0.6 *clo* and 1.0 *clo* insulation achieved 81.33% and 83.33% comfort, respectively. This finding aligns with Luitel et al.[31], who stated that clothing contributes to major differences in human thermal comfort levels. Hence, differences in clothing insulations values may have contributed to the observed variation in respondents' thermal comfort level.

CONCLUSIONS AND SUGGESTIONS

The level of thermal comfort during students' learning activities in Lecture Room 4.01, Faculty of Medicine, Udayana University, was objectively within the comfort

doi:10.24843.MU.2026.V15.i11.02

range according to Indonesian thermal comfort standards, based on the average relative air humidity (59.18%) and air temperature (23.57 ºC). However, the room was thermally uncomfortable in terms of air velocity, as the average value (0.9 m/s) exceeded the Indonesian standard range. Subjectively, Lecture Room 4.01 achieved thermal comfort, with 82.7% out of 104 respondents reporting comfort based on the ANSI/ASHRAE thermal sensation scale.

Future research should incorporate mean radiant temperature measurements and a greater number of climatic measurement points to ensure a more representative and evenly distributed dataset. In addition, further research could be conducted to analyze the relationship between gender, clothing insulation, and thermal comfort.

REFERENCES

1. Muliani R, Arusman. Faktor-Faktor yang Mempengaruhi Minat Belajar Peserta Didik. J Ris dan Pengabdi Masy. 2022;2(2):133–9.
2. BPS. Hasil Proyeksi Penduduk Interim 2020–2023.
3. Sukmawan A, Karina L, Sekar, Muazir S. Persepsi Mahasiswa Mengenai Kenyamanan Ruang Belajar Selama Masa Perkuliahan. Semin Nas Penerapan Ilmu Pengetah dan Teknol 2021. 2021 Aug 24;97–102.
4. Amaliyah M, Suardana IN, Selamet K. Analisis Kesulitan Belajar dan Faktor-Faktor Penyebab Kesulitan Belajar IPA Siswa SMP Negeri 4 Singaraja. J Pendidik Dan Pembelajaran Sains. 2021 Apr;4(1):90–101.
5. Wiguna NKJ, Adiatmika IPG. Pengaruh Lingkungan Tidak Nyaman Terhadap Fungsi Kognitif Mahasiswa Fakultas Kedokteran Universitas Udayana. E-Jurnal Med. 2019;8(3).
6. Utami C. Integrasi Teori/Model Kenyamanan (Kolcaba) Pada Ruang Perawatan Risiko Tinggi. [Denpasar]: Universitas Udayana; 2016.
7. Aghniya A, Pandelaki E. Kajian Kenyamanan Pada Ruang Dalam Perkantoran. Imaji. 2020 Nov;9(5):601–10.
8. ANSI/ASHRAE. Standard 55-2023, Thermal Enviromental Conditions for Human Occupancy (ANSI Approved) [Internet]. 2023rd ed. ANSI; 2023. Available from: https://ashrae.iwrapper.com/ASHRAE_PREVIEW_ONLY_STANDARDS/STD_55_2023
9. Badan Standardisasi Nasional. Konservasi Energi Sistem Tata Udara Bangunan Gedung. In: SNI 6390:2011. 2011.
10. Hall J, Hall M. Guyton and Hall Textbook of Medical Physiology. 14th ed. Elsevier Health Sciences; 2020. 1–1150 p.
11. Nurfajriyani I, Intan, Fadilatussaniatun Q, Yusup I, Kurniati T. Pengaruh Suhu Ruangan Kelas Terhadap Konsentrasi Belajar Mahasiswa Pendidikan Biologi Semester VII (B). J Bio Educ. 2020 Apr;5(1):11–5.
12. Ball D. Contrasting effects of heat stress on neuromuscular performance. Exp Physiol. 2021 Dec 1;106(12):2328–34.
13. Badan Standardisasi Nasional. Konservasi Energi Sistem Tata Udaya Pada Bangunan Gedung. In: SNI 6390:2020. 2020.
14. Guarnieri G, Olivieri B, Senna G, Vianello A. Relative Humidity and Its Impact on the Immune System and Infections. Int J Mol Sci. 2023 May;24(11).
15. Kementrian Kesehatan. Peraturan Menteri Kesehatan Nomor 1077/menkes/per/v/2011 Tahun 2011 Tentang Pedoman Penyehatan Udara dalam Ruang Rumah. In: Pedoman Penyehatan Udara Dalam Ruang Rumah. 2011.
16. Masruri A, Patradhiani R. Faktor Ergonomi Terkait Kenyamanan Ruang Kelas Fakultas Teknik Universitas Muhammadiyah Palembang. Integr J Ilm Tek Ind. 2019;4(1):40–9.
17. Rohman A, Nurbaiti U, Fianti. Analisis Kenyamanan Suhu Ruang. EnviroScienteae. 2021 Apr;17(1):1–6.
18. Asumadu-Sakyi A., Barnett AG, Thai P, Jayaratne ER, Miller W, Thompson M., et al. The Relationship Between Indoor and Outdoor Temperature In Warm and Cool Seasons In Houses In Brisbane, Australia. Energy Build. 2019;191:127–42.
19. Lin Y, Huang T, Yang W, Hu X, Li C. A Review on The Impact of Outdoor Environment on Indoor Thermal Environment. Buildings. 2023;13(1600).
20. Ang BW, Wang H, Ma X. Climatic influence on electricity consumption: The case of Singapore and Hong Kong. Energy [Internet]. 2017;127:534–43. Available from: https://www.sciencedirect.com/science/article/pii/S0360544217305674
21. Badan Standard Nasional. SNI 6390:2011 Konservasi Energi Sistem Tata Udara Bangunan Gedung. 2011.
22. Menteri Kesehatan Republik Indonesia. Keputusan Menteri Kesehatan No. 261/MENKES/SK/II/1998 Tentang : Persyaratan Kesehatan Lingkungan Kerja. 1998.
23. Givoni B. Passive Low Energy Cooling of Buildings. John Wiley and Sons Inc; 1994.
24. Mao H, Yu H, Tang Y, Weng Q, Zhang K. Age differences in thermal comfort and sensitivity under contact local body cooling. Build Environ [Internet]. 2025;268:112355. Available from: https://www.sciencedirect.com/science/article/pii/S0360132324011971

doi:10.24843.MU.2026.V15.i11.02

25. Greenfield AM, Alba BK, Giersch GEW, Seeley AD. Sex differences in thermal sensitivity and perception: Implications for behavioral and autonomic thermoregulation. Physiol Behav. 2023 May;263:114126.
26. Zhao Q, Lyu J, Du H, Lian Z, Zhao Z. Gender differences in thermal sensation and skin temperature sensitivity under local cooling. J Therm Biol [Internet]. 2023;111:103401. Available from: https://www.sciencedirect.com/science/article/pii/S0306456522002157
27. ANSI/ASHRAE. Thermal Environmental Conditions for Human Occupancy. In: ANSI/ASHRAE Addendum h to ANSI/ASHRAE Standard 55-2020. 2022.
28. Crosby S, Rysanek A. Correlations between thermal satisfaction and non-thermal conditions of indoor environmental quality: Bayesian inference of a field study of offices. J Build Eng [Internet]. 2021;35:102051. Available from: https://www.sciencedirect.com/science/article/pii/S2352710220336834
29. International Organization for Standardization. Ergonomics of The Thermal Environment - Determination of Metabolic Rate. In: ISO 8996:2021. 2021.
30. Liu X, Liu S, Zhang H, Ye T, Na Y, Zheng W. An investigation of college students on metabolic rate considering activity intensity, ambient temperature and clothing insulation. Build Environ [Internet]. 2023;245:110865. Available from: https://www.sciencedirect.com/science/article/pii/S0360132323008922
31. Luitel K, Gurung DB, Khanal H, Uprety KN. Role of Clothing Insulation for Thermal Comfort: A Numerical Study using Bio-Heat Transfer Model. J Math Stat [Internet]. 2020;16(224.232). Available from: 10.3844/jmssp.2020.224.232

