IN-SITU EVALUATION OF INDOOR THERMAL COMFORT PARAMETERS IN AIR CONDITIONING PRESCHOOL CLASSROOMS IN MELAKA TENGAH DISTRICT

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ABSTRACT: *This study presents an in-situ assessment of indoor thermal comfort conditions in three air-conditioned preschools located in the Melaka Tengah District, namely Tadika Kemas Batu Berendam (A), Tadika Kemas Melaka Baru (B), and Tadika Kemas Seri Wangi (C). The study was conducted to evaluate the thermal environment experienced by preschool children in Malaysia's hot and humid climate, with particular emphasis on indoor air temperature, relative humidity, and air velocity. Measurements were carried out during normal classroom operating hours from 8:00 a.m. to 2:00 p.m. using a VelociCalc instrument in accordance with the Industry Code of Practice on Indoor Air Quality (ICOP IAQ) 2010. Data were collected at the children's breathing zone to represent actual occupant exposure conditions. The measured indoor air temperatures ranged from 22.7 °C to 28.5 °C, relative humidity ranged from 40% to 76%, and air velocity varied between 0.04 m/s and 0.37 m/s across the three preschools. The results indicate that Tadika Kemas Seri Wangi provided the most favorable thermal comfort conditions, characterized by relatively stable temperatures, moderate humidity levels, and more consistent air movement. In contrast, Tadika Kemas Melaka Baru exhibited less favorable conditions, with higher temperatures, elevated humidity, and lower air velocities. Tadika Kemas Batu Berendam demonstrated intermediate performance, achieving acceptable temperature control but showing localized areas of low air movement. Overall, the findings highlight the importance of maintaining balanced temperature, humidity, and airflow conditions in preschool classrooms to enhance thermal comfort and support a conducive learning environment for young children.*

KEYWORDS: *Thermal Comfort, Indoor Parameters, Preschool, Classroom*

1.0 INTRODUCTION

Preschool classroom required a high level of indoor thermal comfort due to the vulnerability and high activity levels of young children. In Malaysia's hot and humid tropical climate, air conditioning systems are widely used in preschool buildings to maintain acceptable range indoor conditions[1]. However, achieving thermal comfort is not solely dependent on temperature control, the effectiveness of airflow distribution within the occupies zone plays a crucial role[2]. Uneven airflow, stagnant air regions and excessive humidity may lead to thermal discomfort, reduced concentration and potential health issues among preschool children [3]. Despite the widespread use of air-conditioning systems in educational buildings, limited studies have focused on airflow behaviour and thermal conditions specifically within air-conditioned preschool classrooms.

Thermal comfort is defined as the condition of mind that express satisfaction with the thermal environment[4]. The environmental parameters include air temperature, relative humidity and air velocity related to human body while the personal parameters are clothing insulation and metabolic rate[5]. Criteria are outlined in standards like ASHRAE Standard 55 that have an important acceptance for assessing thermal comfort. These standards are, however, mainly based on adult occupants and do not reflect children thermal perception fully [6].

In hot-humid tropical zones, it is difficult to achieve acceptable indoor comfort conditions due to high outdoor temperatures and humidity[7], [8]. Due to the tropical climate, most Malaysia educational buildings are equipped with air-conditioning systems[9]. Studies indicate air-conditioned classrooms in tropical regions cool excessively, increasing humidity levels impractically and causing thermal discomfort and an array of ill health effects [10].

A well-known issue within preschool classroom is the poor distribution of conditioned air due to less-than-optimal layout of the air-conditioning system, diffusers and airflow patterns [11]. Many classrooms show non-uniform temperature profile, low air velocity in occupied zones and stagnant airflow zones even when air-conditioning systems are operated continuously [12]. The problems are especially important in preschool places. The children spend longer times indoors and can't easily adjust to thermal discomfort. Further, prior research mainly relies on point-based field measurement, which is inadequate in fully capturing the spatial variation of airflow, temperature and humidity in enclosed classroom space. Table 1 shows ICOP acceptable range for physical parameter.

Table 1: ICOP acceptable range for physical parameter.

Parameter	Acceptable Range
Temperature	23-26 °C
Relative humidity	40-70 %
Air movement	0.15-0.50 m/s

Although there is a growing body of research on indoor environmental quality in school, investigations focusing specially on air-conditioned preschool remain limited, particularly in semi-urban districts such as Melaka Tengah. Therefore, this study aims to evaluate indoor thermal comfort conditions in three air-conditioned preschools through in-situ measurements of air temperature, relative humidity, and air velocity. The study seeks to identify variations in thermal conditions among preschool classrooms and assess their compliance with the Industry Code of Practice on Indoor Air Quality (ICOP IAQ) 2010. The findings are expected to provide practical recommendations for improving indoor thermal comfort and air-conditioning system performance in preschool learning environments located in tropical climates.

2.0 METHODOLOGY

2.1 Study Location and Classroom Description

The field investigation was conducted in the Melaka Tengah District, Melaka, Malaysia. Three government-operated preschools were selected for this study, namely Tabika Kemas Batu

Berendam (Preschool A), Tabika Kemas Melaka Baru (Preschool B), and Tabika Kemas Seri Wangi (Preschool C). All preschools are located within approximately 10 km of Melaka City and are situated in residential areas adjacent to local roads. Figure 1 illustrates the three preschools included in this study, while Table 1 presents the building specifications of each classroom. Preschool A has a floor area of 64 m², whereas Preschools B and C each have a floor area of 72 m². All classrooms have a ceiling height of 3 m and are equipped with split-unit air-conditioning systems. The average number of occupants ranged from 22 to 27 preschool children during the monitoring period.

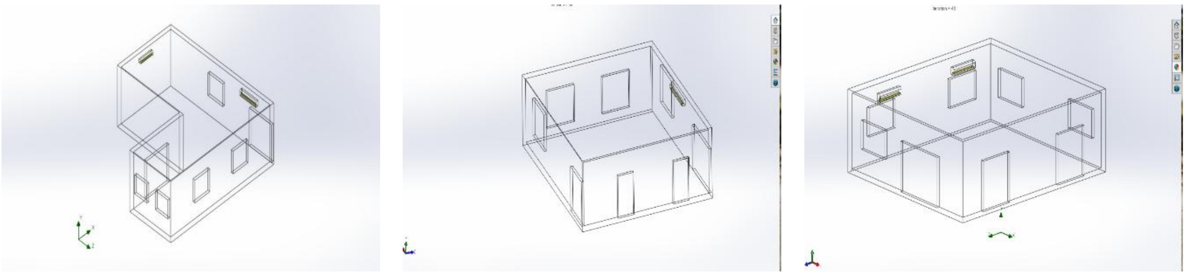

Figure 1: Preschool layout in data collection (a) Preschool A, (b) Preschool B and (c) Preschool C.

Table 1: Specification of Preschool A, B and C

Specifications	Preschool A	Preschool B	Preschool C
Population	27	27	22
Size (m²)	64	72	72
Ceiling height (m)	3	3	3

2.2 Indoor Thermal Comfort Measurements

The indoor environmental parameters evaluated in this study were air temperature (°C), relative humidity (%), and air velocity (m/s). These parameters were selected because they are the primary environmental factors influencing thermal comfort in air-conditioned classrooms[13].

Measurements were conducted using a TSI VelociCalc multifunction ventilation meter. Data collection was performed during normal preschool operating hours from 8:00 a.m. to 2:00 p.m., resulting in a total monitoring duration of six hours for each classroom. This monitoring period was selected to capture the thermal conditions experienced by occupants throughout a typical school day.

The measuring instrument was positioned at the centre of each classroom using a tripod. To represent the breathing zone of preschool children, the probe was placed at a height of 1.0 m above the floor level. The measurement location was selected to minimize airflow obstruction from furniture and occupants while providing representative environmental conditions within the occupied zone.

2.3 Sampling Procedure

The sampling procedure was conducted in accordance with the Industry Code of Practice on Indoor Air Quality (ICOP IAQ) 2010 issued by the Department of Occupational Safety and

Health (DOSH), Malaysia. Parameters such as sampling position, measurement height, monitoring duration, and data collection procedures followed the recommendations outlined in the guideline.

The indoor thermal comfort assessment was conducted through field measurements in the selected preschool classrooms. Air temperature (°C), relative humidity (%), and air velocity (m/s) were measured using a TSI VelociCalc multifunction ventilation meter. Measurements were performed during normal classroom operating hours from 8:00 a.m. to 2:00 p.m. to capture the thermal conditions experienced by occupants throughout a typical school day.

The instrument was mounted on a tripod and positioned at the centre of each classroom to obtain representative measurements within the occupied zone. The probe was placed at a height of 1.0 m above the floor level, corresponding to the breathing zone of preschool children. Care was taken to ensure that the instrument location was free from obstructions that could influence airflow patterns and measurement accuracy.

The measurement procedure, sampling duration, and monitoring location were established in accordance with the Industry Code of Practice on Indoor Air Quality (ICOP IAQ) 2010 issued by the Department of Occupational Safety and Health (DOSH), Malaysia. During the monitoring period, classroom activities were carried out as normal to ensure that the recorded environmental conditions reflected actual occupancy conditions.

The collected data were analysed to determine the variation of indoor thermal comfort parameters among the three preschools. The measured values were subsequently compared with the acceptable ranges specified in ICOP IAQ 2010, namely indoor air temperature of 23–26 °C, relative humidity of 40–70%, and air movement of 0.15–0.50 m/s[14]. The analysis was used to evaluate the thermal comfort performance of each classroom and identify potential areas requiring improvement in indoor environmental conditions.

2.4 Model and Data

Table 2 illustrates the average data collected in the preschool A, B and C. Data of temperature, air speed and relative humidity were compared to DOSH Malaysia requirement specification for acceptable range in indoor air quality inside the preschool classroom.

Table 2: Temperature, air speed and relative humidity collected at Preschool A, B and C.

	Preschool A			Preschool B			Preschool C		
Time	Temp (°C)	Air speed (m/s)	RH (%)	Temp (°C)	Air speed (m/s)	RH (%)	Temp (°C)	Air speed (m/s)	RH (%)
08:00	22.3	0.26	76.2	25.97	0.24	69.44	15.6	0.07	34.65
09:00	22.66	0.27	75.84	27.66	0.25	68.06	16.98	0.08	40.42
10:00	24.53	0.28	74.35	28.19	0.25	68.79	21.58	0.09	52.27
11:00	25.58	0.24	73.39	28.23	0.24	68.93	22.87	0.04	58.13
12:00	26.49	0.35	70.81	28.10	0.28	68.36	22.54	0.05	53.68
13:00	27.76	0.35	68.33	28.27	0.25	68.19	21.21	0.06	50.98
14:00	28.44	0.37	65.94	28.15	0.27	69.29	21.55	0.06	51.32

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3.0 RESULT AND DISCUSSION

Figure 2 illustrates the indoor air temperature measured in Preschools A, B, and C throughout the monitoring period. The results indicate that the indoor temperatures in all three preschools varied throughout the day, with several measurements falling outside the acceptable range recommended by the Industry Code of Practice on Indoor Air Quality (ICOP IAQ) 2010, which specifies an acceptable temperature range of 23°C to 26°C.

Preschool A recorded temperatures ranging from 23.12°C to 27.76°C. The indoor temperature remained within the acceptable range during most of the monitoring period but exceeded the upper limit at 1:00 p.m., reaching a maximum value of 27.76°C. Preschool B consistently recorded the highest temperatures among the three preschools, with values ranging between 27.50°C and 28.50°C from 9:00 a.m. to 2:00 p.m., indicating that the classroom environment was generally warmer than the recommended comfort range.

In contrast, Preschool C recorded the lowest temperatures, ranging from 15.60°C to 21.55°C, which were consistently below the recommended limit throughout the monitoring period. Such substantial deviations from the recommended thermal threshold suggest that the cooling capacity and distribution strategies in these facilities are inconsistent with the established standards for optimal education environment[15]. Although lower temperatures may provide a cooling effect, excessive cooling can contribute to thermal discomfort among preschool children. Overall, the findings indicate that none of the preschools consistently maintained indoor temperatures within the recommended ICOP IAQ 2010 comfort range.

Figure 3 presents the air velocity measurements obtained from Preschools A, B, and C. The measured values were evaluated against the acceptable air movement range of 0.15–0.50 m/s specified in ICOP IAQ 2010.

Preschool A consistently recorded air velocities between 0.26 m/s and 0.37 m/s throughout the monitoring period. All measured values were within the recommended range, indicating adequate and consistent air circulation within the classroom. Similarly, Preschool B maintained air velocities between 0.24 m/s and 0.27 m/s, which also complied with the recommended standard. Although the values were lower than those observed in Preschool A, the airflow remained sufficient to support occupant comfort.

In contrast, Preschool C exhibited significantly lower air velocities, ranging from only 0.04 m/s to 0.09 m/s. All measurements were below the minimum recommended value of 0.15 m/s, indicating insufficient air movement and the possible presence of stagnant air zones within the classroom. Poor air circulation may contribute to occupant discomfort and reduced indoor environmental quality. These findings suggest that while Preschools A and B provided acceptable airflow conditions, improvements to the ventilation and air distribution system may be required in Preschool C to enhance indoor comfort.

Figure 4 shows the relative humidity levels measured in the three preschools. The results were compared with the ICOP IAQ 2010 recommended relative humidity range of 40%–70%.

Preschool A recorded relative humidity values ranging from 65.94% to 76.20%. During the early monitoring period, the humidity levels exceeded the recommended upper limit before gradually decreasing and returning to the acceptable range after midday. This trend indicates that the classroom experienced excessive humidity during the morning hours but achieved more stable conditions later in the day.

Preschool B maintained relatively stable humidity levels between 68.06% and 69.44%, remaining within the acceptable range throughout the monitoring period. However, the values were consistently close to the upper limit, suggesting a tendency toward higher indoor humidity levels.

Preschool C recorded relative humidity values ranging from 34.65% to 58.13%. The classroom initially experienced humidity levels below the recommended minimum value during the morning period. However, the relative humidity increased gradually and remained within the acceptable range from 10:00 a.m. onwards. This finding suggests that the classroom environment was initially dry but improved as occupancy and operating conditions stabilized.

Overall, Preschools A and B generally satisfied the recommended relative humidity requirements, although Preschool A experienced periods of excessive humidity. Meanwhile, Preschool C demonstrated lower humidity levels during the early morning hours, indicating the need for closer monitoring to ensure consistent thermal comfort throughout the school day.

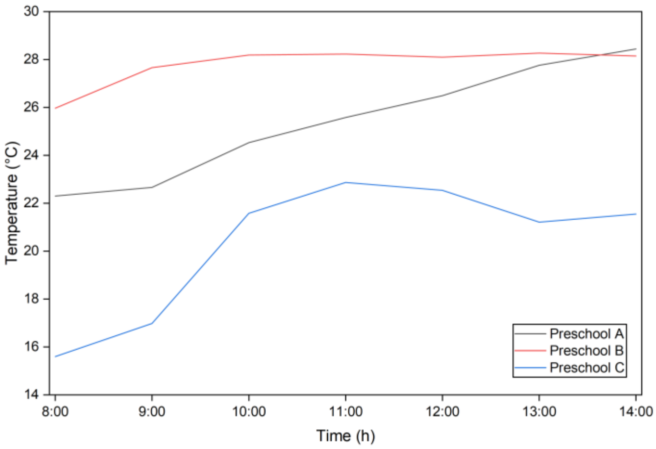

Figure 2: Temperature distribution for Preschool A, B and C

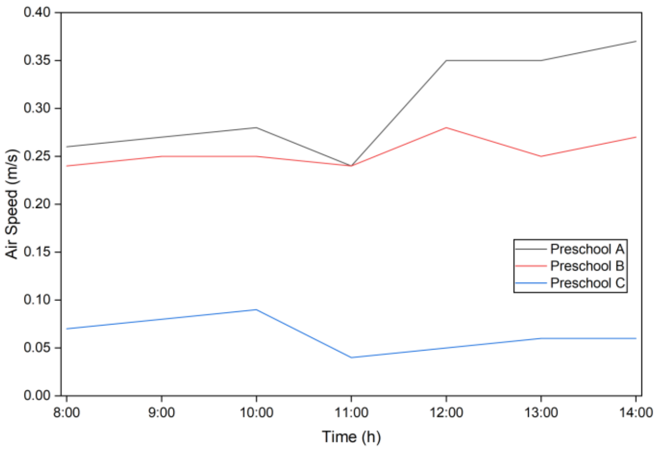

Figure 3: Air speed distribution for Preschool A, B and C.

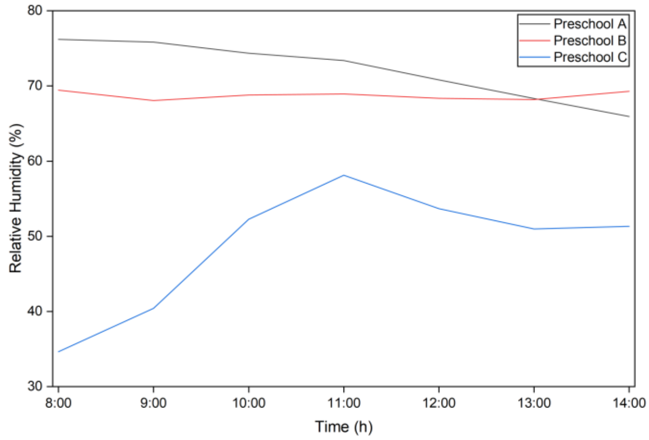

Figure 4: Relative humidity distribution for Preschool A, B and C.

4.0 CONCLUSION

This study evaluated indoor thermal comfort conditions in three air-conditioned preschool classrooms in the Melaka Tengah District through in-situ measurements of air temperature, relative humidity, and air velocity in accordance with the Industry Code of Practice on Indoor Air Quality (ICOP IAQ) 2010. The assessment was conducted during normal classroom operating hours to determine the thermal conditions experienced by preschool occupants.
The results revealed noticeable variations in thermal comfort performance among the three preschools. Preschool A exhibited moderate thermal conditions, with indoor temperatures ranging from 23.12°C to 27.76°C, relative humidity between 65.94% and 76.20%, and air velocities within the acceptable range of 0.26–0.37 m/s. Preschool B recorded the highest temperatures, ranging from 27.50°C to 28.50°C, while maintaining acceptable air velocity and relative humidity levels close to the upper recommended limit. Preschool C showed the lowest indoor temperatures, ranging from 15.60°C to 21.55°C, and inadequate air movement between 0.04 m/s and 0.09 m/s, although its relative humidity remained within the acceptable range for most of the monitoring period.

Comparison with the ICOP IAQ 2010 guidelines indicates that none of the preschools consistently maintained all thermal comfort parameters within the recommended ranges of 23–26°C for air temperature, 40–70% for relative humidity, and 0.15–0.50 m/s for air velocity. The findings demonstrate that achieving acceptable thermal comfort requires a balanced combination of temperature control, humidity management, and adequate air movement. Therefore, regular monitoring and proper operation of air-conditioning systems are essential to maintain a comfortable indoor environment for preschool children.

The study highlights the importance of optimizing indoor environmental conditions in preschool classrooms to support occupant comfort and well-being. Future studies should incorporate additional indoor environmental quality parameters, such as carbon dioxide concentration and particulate matter, as well as subjective thermal comfort assessments involving teachers and caregivers. Such an approach would provide a more comprehensive understanding of indoor environmental performance in early childhood education facilities.

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REFERENCES

[1] L. Faraj, M. F. Z. Bin Jaafar, and Z. Shari, "Evaluating Ventilation for Thermal Comfort in Two Classrooms Types in Malaysian Secondary Classrooms," *International Journal of Sustainable Development and Planning*, vol. 18, no. 7, pp. 2069–2078, Jul. 2023.

[2] M. N. H. Mat, A. A. Abd Manan, N. A. Rahmat, and M. Akrami, "Influence of Indoor Temperature Variation on Thermal Comfort in University Classrooms in a Tropical Malaysian Setting," *E3S Web of Conferences*, vol. 681, p. 05003, 2025.

[3] Z. S. Zomorodian, M. Tahsildoost, and M. Hafezi, "Thermal comfort in educational buildings: A review article," Jun. 01, 2016, *Elsevier Ltd*. doi: 10.1016/j.rser.2016.01.033.

[4] W. Chen *et al.*, "A field investigation on thermal comfort of kindergarten children in China's hot summer and cold winter zone during winter," *Indoor Environments*, vol. 1, no. 4, Dec. 2024.

[5] H. Djamila, C. M. Chu, and S. Kumaresan, "Field study of thermal comfort in residential buildings in the equatorial hot-humid climate of Malaysia," *Build. Environ.*, vol. 62, pp. 133–142, Apr. 2013.

[6] X. Yuan and Y. Ryu, "Evaluation of Children's Thermal Environment in Nursery School: Through the Questionnaire and Measurement of Wearable Sensors Approach," *Int. J. Environ. Res. Public Health*, vol. 19, no. 5, Mar. 2022, doi: 10.3390/ijerph19052866.

[7] G. Kiki, C. Kouchadé, A. Houngan, S. J. Zannou-Tchoko, and P. André, "Evaluation of thermal comfort in an office building in the humid tropical climate of Benin," *Build. Environ.*, vol. 185, Nov. 2020.

[8] M. Z. Allah, A. Hariri, and H. M. Kamar, "Comparison of Thermal Comfort Condition of Naturally Ventilated Courtyard, Semi-Outdoor and Indoor Air-Conditioned Spaces in Tropical Climate," *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, vol. 101, no. 1, pp. 45–58, 2023.

[9] D. A. Djabir, A. Hariri, M. N. H. Mat, and M. Hasanuzzaman, "Thermal Comfort of Indoor Open Spaces at University Library in Malaysia," *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, vol. 94, no. 2, pp. 142–165, 2022,

[10] G. Torriani, G. Lamberti, F. Fantozzi, and F. Babich, "Exploring the impact of perceived control on thermal comfort and indoor air quality perception in schools," *Journal of Building Engineering*, vol. 63, Jan. 2023.

[11] M. N. A. Nor Azli *et al.*, “Influence of Air Velocity on Thermal Comfort and Performance of Students in Naturally Ventilated Classrooms in Tropical Climate,” in *E3S Web of Conferences*, EDP Sciences, Jun.

[12] Z. Jastaneyah, H. M. Kamar, A. Hashmi, F. A. Ghaleb, and H. Al Garalleh, “The influence of zonal air supply on thermal comfort in a classroom located in a hot and humid environment: a case study from Jeddah—Saudi Arabia,” *Discover Sustainability*, vol. 5, no. 1, Dec. 2024.

[13]; F Megaron and G. Z. Gedik, “A field-based methodology for thermal comfort evaluation: A case study on university classrooms,” vol. 20, no. 4, pp. 540–556, 2025.

[14] J. Keselamatan Dan Kesihatan Pekerjaan, “Industry Code of Practice on Indoor Air Quality 2010 Department of Occupational Safety and Health Ministry of Human Rsources, Malaysia JKKP DP(S) 127/379/4-39 A.”

[15] A. Abdullah Muhamad Damanhuri *et al.*, “Journal of Design and Built Environment Evaluation Thermal Comfort based on PMV and PPD using CBE Tool for Three Non-Air-Conditioned Pre School: A Case Study in Melaka Tengah, Malaysia District Area”, [Online]. Available: https://ejournal.um.edu.my/index.php/jdbe