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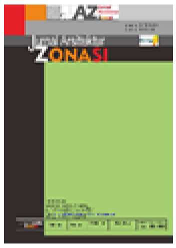

Analysis of Thermal Comfort Changes Before and After Becool Paint Application at the Nurul Iman Karangmulya Al-Quran Education Park

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ABSTRACT

This study investigates the impact of applying BeCool reflective paint on the thermal comfort of classrooms at TPA Nurul Iman, Karangmulya Village, Plumbon District, Cirebon. The research background is based on the hot and dry climatic conditions of the northern coast of Java, which significantly affect indoor thermal conditions, especially in educational buildings with limited design strategies for heat reduction. The study was conducted over six consecutive days in August 2025. Data collection employed the Elitech RC-4 device to measure roof surface temperature, indoor air temperature, and mean radiant temperature, while outdoor climatic parameters were recorded using a Weather Station. The data were processed and analyzed with Microsoft Excel and further evaluated using the CBE Thermal Comfort Tool to assess compliance with ASHRAE 55 standards. The results show that the application of BeCool reflective paint successfully reduced roof surface temperature by 10–12 °C, indoor air temperature by 9–11 °C, and mean radiant temperature by 2–3 °C. These improvements shifted classroom thermal conditions, which were initially outside the comfort zone, closer to the acceptable range of thermal comfort. The conclusion highlights that reflective paint is a simple, economical, and effective strategy for improving thermal quality in learning spaces, though complementary architectural improvements in ventilation, openings, and façade orientation remain necessary.

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1. INTRODUCTION

According to a report by the Intergovernmental Panel on Climate Change (IPCC), the global average temperature has increased by more than 1°C since the pre-industrial era, and this trend is projected to continue (Nunez et al., 2019). In the classroom, this increase in temperature has a direct impact on learning comfort, making it difficult for students to concentrate and causing educators to tire more quickly (Sekar Larasati & Faculty of Engineering Architecture Study, n.d.). Unfortunately, many school buildings do not yet have adequate designs to deal with these conditions.

This is also experienced by Karangmulya Village in Plumbon District, Cirebon Regency, which has a population of around 2,673 and is located in the lowlands of the north coast of Java. Its geographical conditions make this village vulnerable to rising temperatures and climate variability, with exposure to hot and dry air due to low humidity (Ramadani et al., 2022). In an effort to minimize these impacts, environmentally friendly building design has become one solution, although it is often constrained by cost (Ayu Ratna Winanda & Kartika, n.d.). A more affordable alternative is the use of reflective materials on building surfaces to reduce heat absorption. Studies show that roof surfaces coated with brightly colored solar reflective paint can lower and reduce heat in buildings (Damayanti et al., 2025).

To achieve an economical solution, the use of reflective paint is one of the most cost-effective technical methods. BeCool is claimed to effectively reduce the air temperature in a room by applying it to the roof surface (Puspitaningtyas et al., n.d.). The solution provided is to reduce the heat (hot air) from outside entering the room through the heat released from the walls and ceiling of the building.

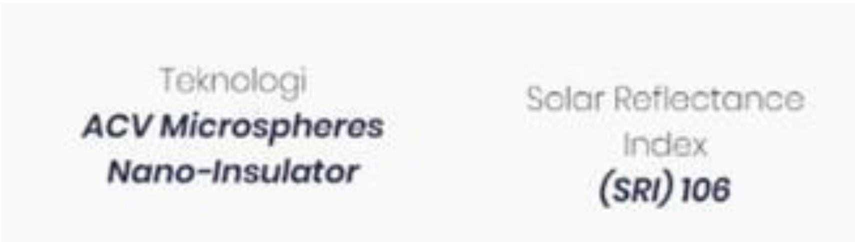

Figure 1. Description of SRI Reflective Paint Products
Source: Apa itu BeCool? Apa Pengaruhnya Terhadap Bangunan? | BeCool

This study aims to determine the effectiveness of using solar reflective paint on surface and indoor temperature changes in classrooms at the Nurul Iman landfill, Karangmulya Village, Plumbon, Cirebon Regency. Solar reflective paint is an alternative solution to reduce heat in rooms and an economical alternative solution to reduce global warming on a micro scale.

2. RESEARCH METHOD

The research was conducted at Nurul Iman Landfill, Karangmulya Village, for six days. The building was chosen because it has a tile roof and is highly active during the day, requiring comfort factors considering that the building is a learning space. The building area is approximately 180 m2, and measurements were taken in August.

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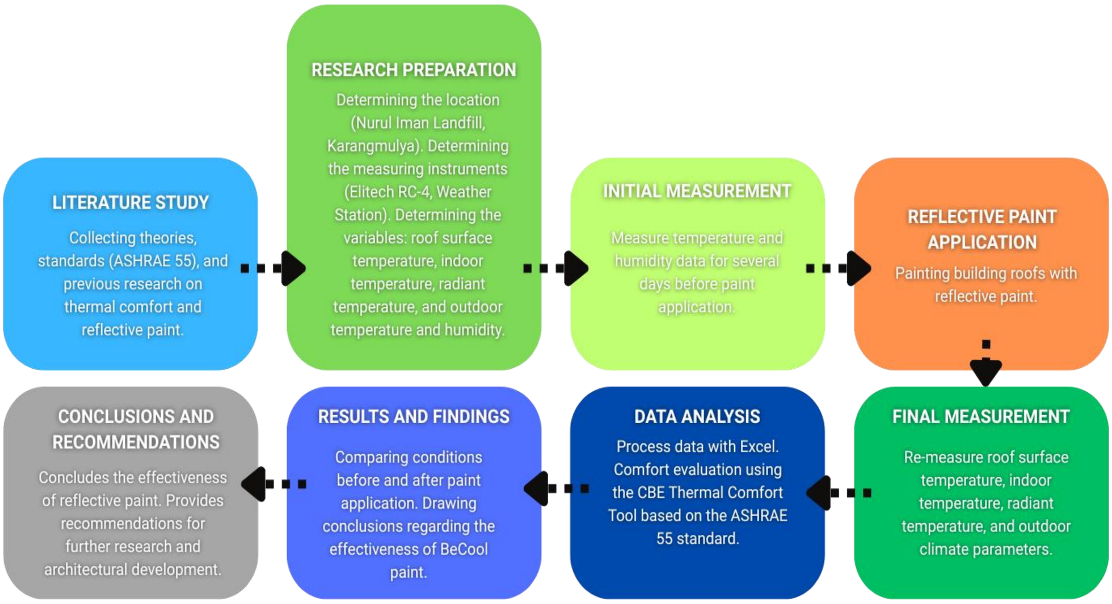
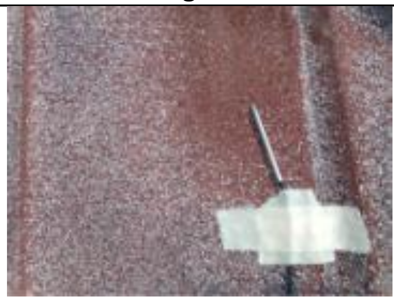


Figure 2. Research Methods and Stages Chart
Source: Author

Table 1. Research Instruments and Measurement Locations

Tools	**Figure**
Elitech RC 4 (surface) • On the roof surface of the house	
Elitech RC 4 (Indoor) • On the ceiling of the house	
Elitech RC 4 (Radiant) • In the middle of the room	

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Tools	Figure
Weather Station ● At the top of the roof	

Description: Sensors are placed in accordance with thermal comfort measurement standards to obtain data on surface temperature, indoor air temperature, radiation, and outdoor climate conditions

Source: Researcher Documentation, 2025

Reflective paint was applied to areas of the roof that were exposed to direct sunlight. Data collection was carried out by measuring surface temperature, indoor temperature, and radiant heat using Elitech RC-4 on the roof surface. To obtain information on outdoor temperature, humidity, and wind speed, a weather station was installed outdoors.

The data obtained will be analyzed to determine the differences before and after in the room. Data analysis uses Excel and CBE Thermal Comfort software and is presented in graphs to obtain the desired calculations

3. RESULTS AND DISCUSSION

3.1. Measurement Data before painting (Surface Temperature)

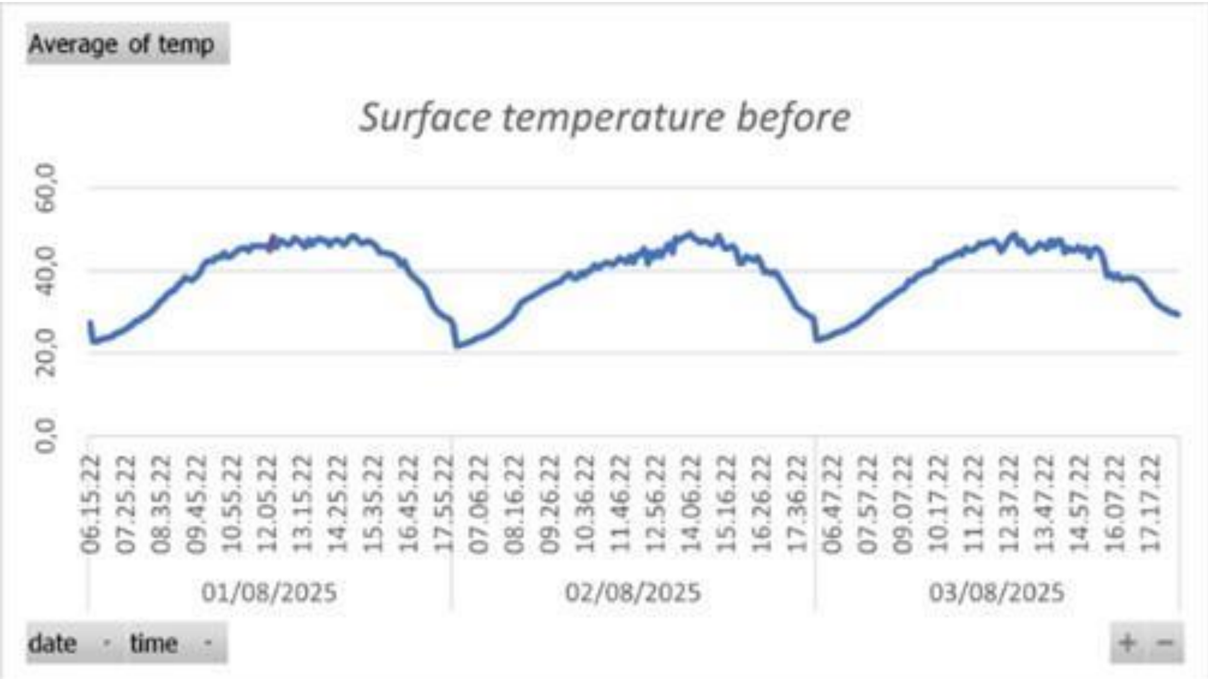

Figure 1. Surface Temperature Before Graph

Source: Researcher documentation, data obtained from Elitech RC-4 sensors and processed using ElitechLog Win application, then analyzed with Microsoft Excel (2025)

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3.2. Measurement Data before painting (Indoor Temperature)

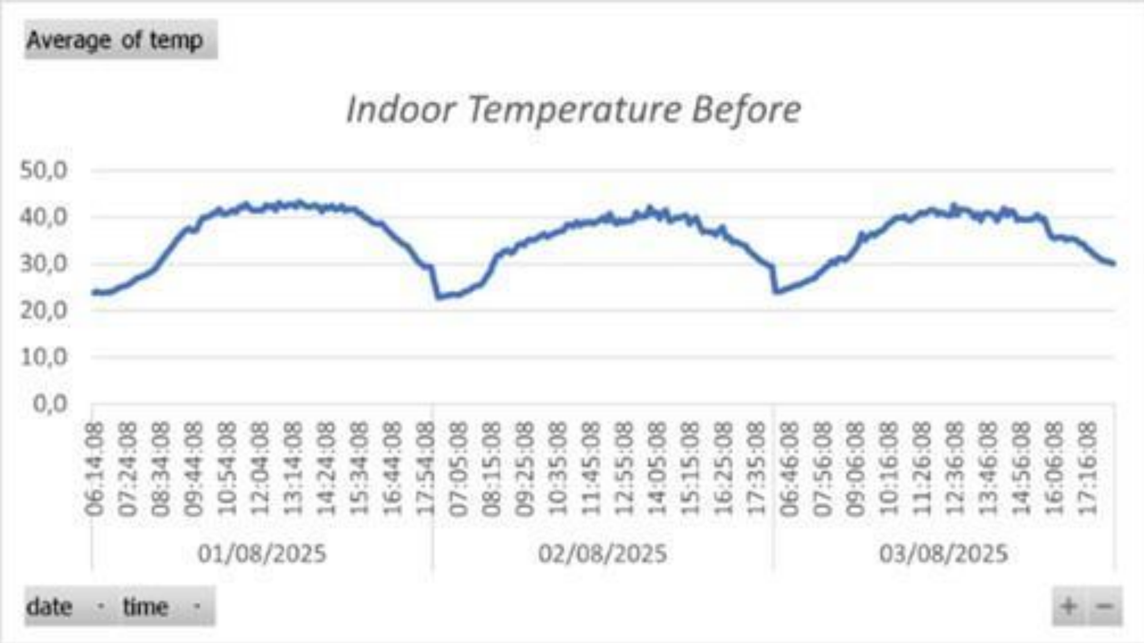

Figure 2. Indoor Temperature Before Graph

Source: Researcher documentation, data obtained from the Elitech RC-4 sensor and processed using the ElitechLog Win application, then analyzed with Microsoft Excel (2025)

3.3. Measurement Data before painting (Radiance Temperature)

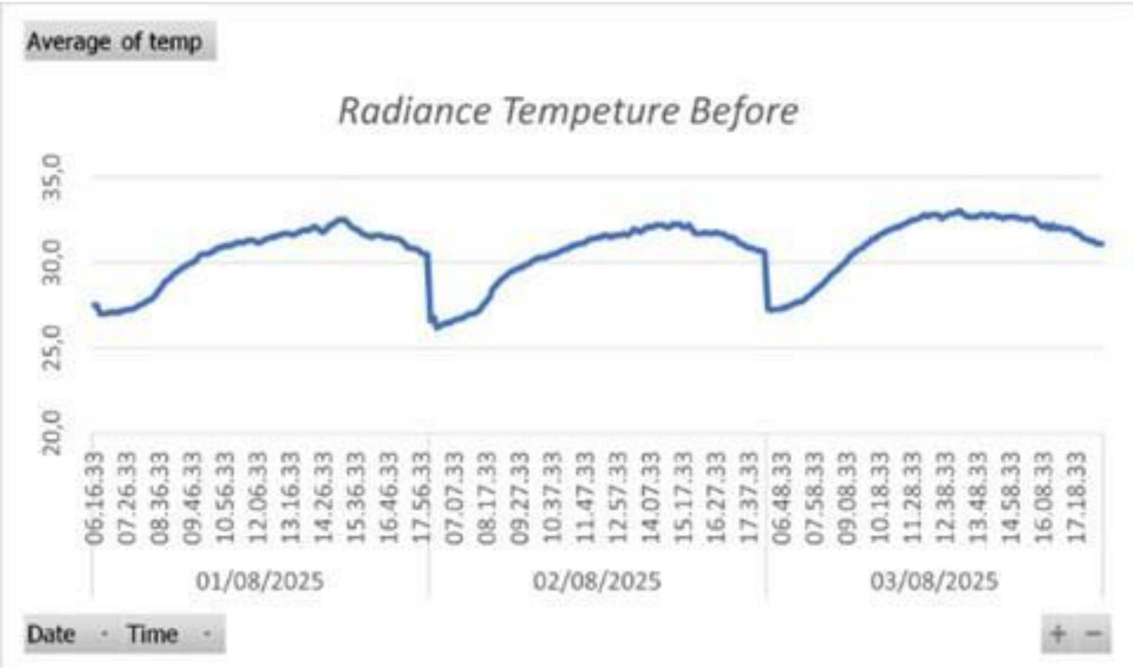

Figure 3. Radiance Temperature Before Graph

Source: Researcher documentation, data obtained from the Elitech RC-4 sensor and processed using the ElitechLog Win application, then analyzed with Microsoft Excel(2025)

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3.4. Measurement Data before painting (Outdoor Temperature, Humidity and WindSpeed)

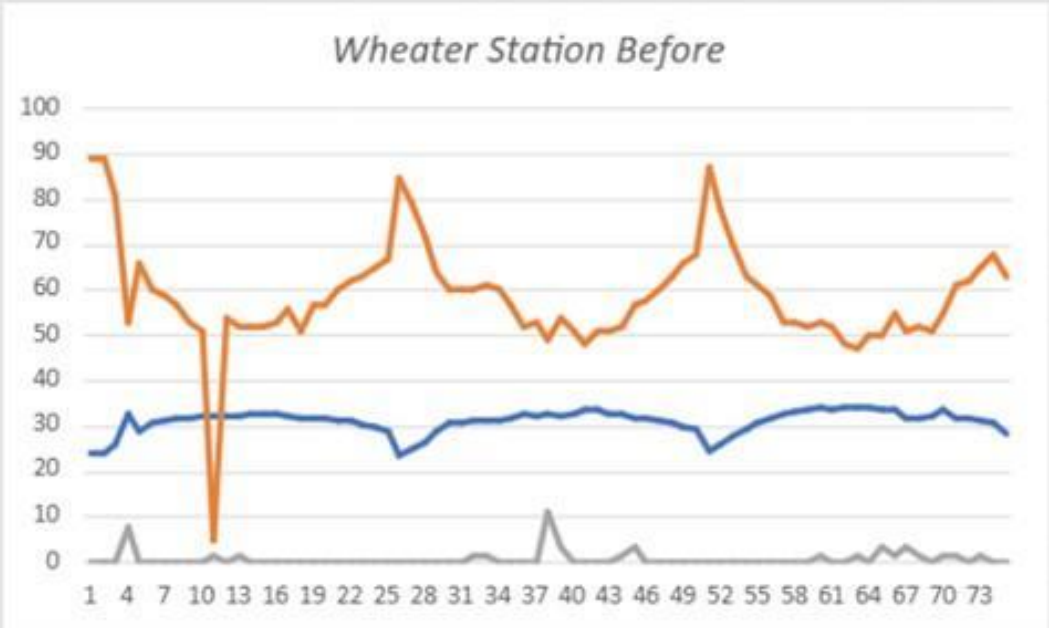

Figure 5. Weather Station Temperature, Humidity, and Outdoor Wind Speed Graph
Source: Researcher documentation, data obtained from the Elitech RC-4 sensor and processed using the ElitechLog Win application, then analyzed with Microsoft Excel (2025)

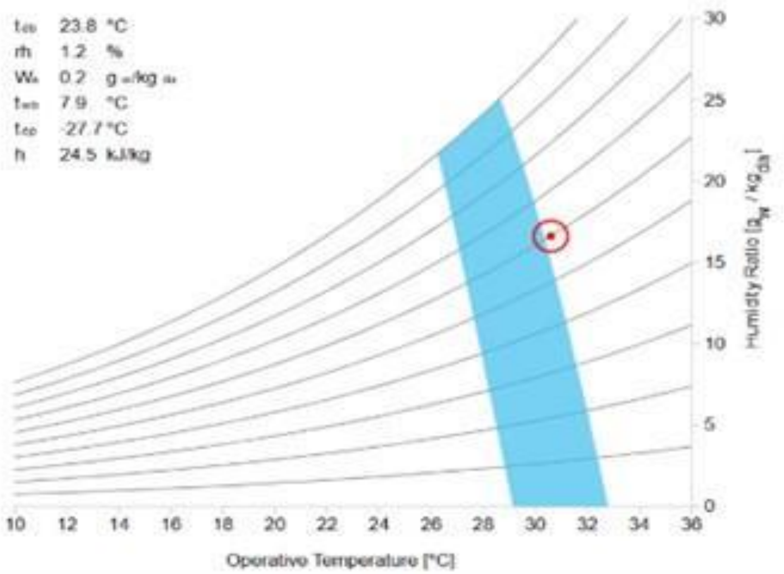

Figure 6. CBE Thermal Comfort Tools Analysis Results
Source: Researcher documentation, data obtained from Elitech RC-4 sensors and processed using the CBE Thermal Comfort Tools web application (2025)

Based on the measurement data obtained, it shows that the thermal comfort in the Nurul Iman TPA classroom is uncomfortable according to the CBE Thermal Comfort Tool calculation.

Measurement data after the application of paint was taken on August 10-13, 2025, using Elitech RC-4 and Wheater Station devices. The data collection location was at Nurul Iman TPA, KarangMulya Village, Plumbon District, Cirebon Regency, West Java.

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3.5. Measurement Data after painting (Surface Temperature)

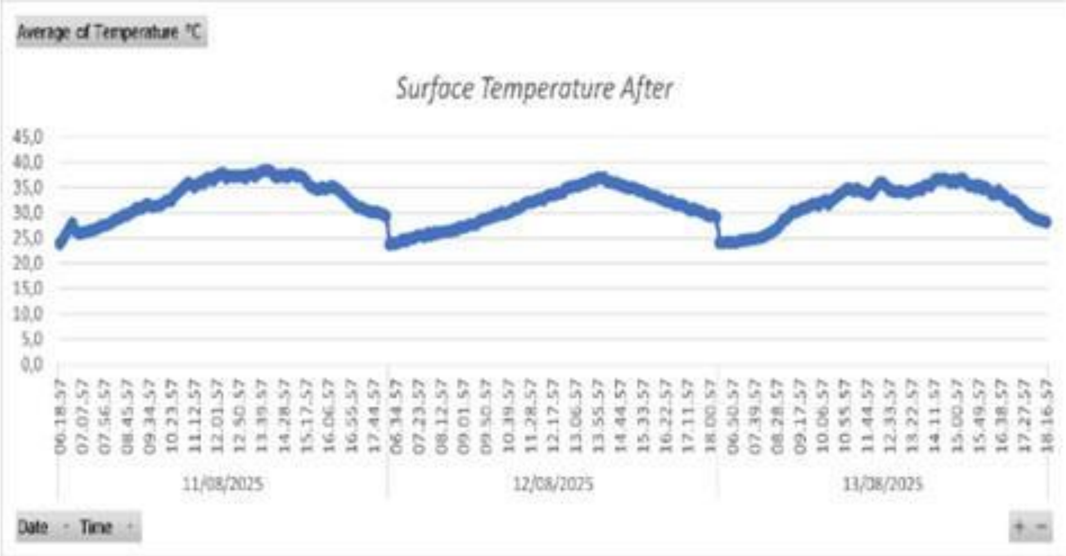

Figure 7. Surface Temperature After Graph
Source: Researcher documentation, data obtained from Elitech RC-4 sensors and processed using the ElitechLog Win application, then analyzed with Microsoft Excel (2025)

3.6. Measurement Data after painting (Indoor Temperature)

Figure 8. Indoor Temperature After Graph
Source: Researcher documentation, data obtained from Elitech RC-4 sensors and processed using the ElitechLog Win application, then analyzed with Microsoft Excel (2025)

3.7. Measurement Data after painting (Radiance Temperature)

Figure 9. Radiance Temperature After Graph
Source: Researcher documentation, data obtained from the Elitech RC-4 sensor and processed using the ElitechLog Win application, then analyzed with Microsoft Excel (2025)

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3.8. Measurement Data after painting (Outdoor Temperature, Humidity and WindSpeed)

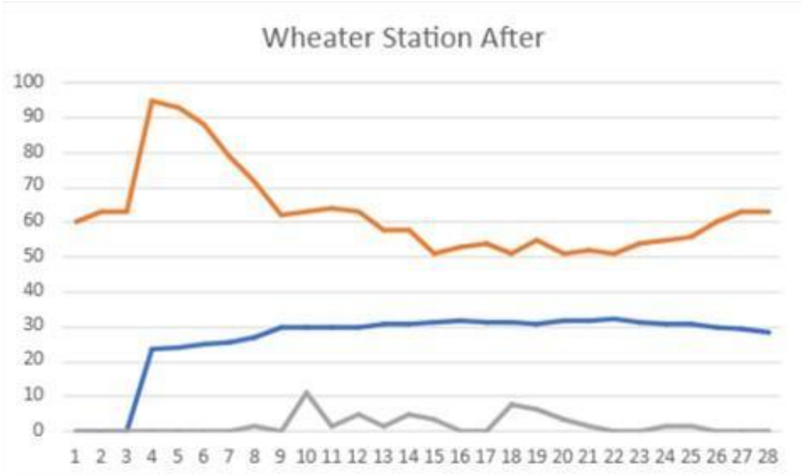

Figure 10. Weather Station Temperature, Humidity, and Outdoor Wind Speed Graph
Source: Researcher documentation, data obtained from the Elitech RC-4 sensor and processed using the ElitechLog Win application, then analyzed with Microsoft Excel (2025)

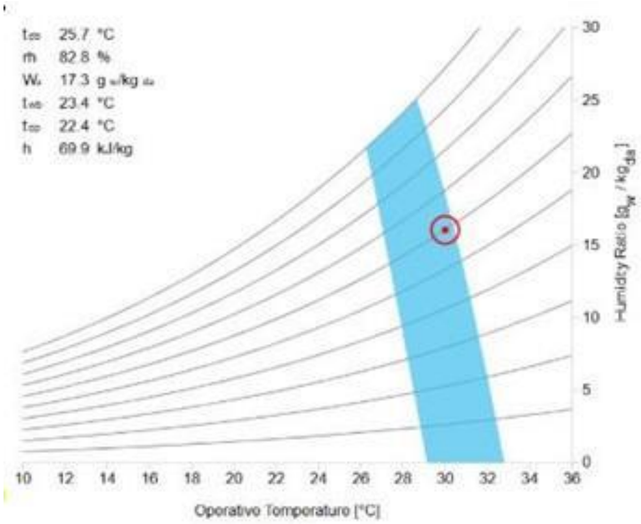

Figure 11. CBE Thermal Comfort After Analysis Results
Source: Researcher documentation, data obtained from Elitech RC-4 sensors and processed using the CBE Thermal Comfort Tool web application (2025)

The use of the CBE Thermal Comfort Tool shows that at a temperature of 25.7 °C and humidity of 82.8%, the air conditions are still within the ASHRAE 55 thermal comfort zone. However, high humidity needs to be considered as it can affect the subjective comfort of occupants and indoor air quality.

Measurements taken before the application of reflective paint showed that the conditions in the Nurul Iman TPA classroom were outside the thermal comfort zone. This was indicated by the high surface temperature of the roof, the indoor temperature, and the radiation temperature, which caused an increase in the heat load inside the classroom. These conditions caused the indoor air temperature to exceed the comfort standards set by ASHRAE 55, potentially causing discomfort for students and teachers during learning activities.

After applying BeCool paint to the roof of the building, there was a significant decrease in temperature, namely a 10–12 °C drop in roof surface temperature, a 9–11 °C drop in indoor temperature, and a 2–3 °C drop in radiation temperature. This decrease had a direct impact

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on improving the thermal quality of the room, where the air temperature after treatment was recorded at 25.7 °C with a humidity of 82.8%, falling within the ASHRAE 55 thermal comfort zone. However, the relatively high air humidity still needs to be considered as it has the potential to reduce the subjective comfort of occupants and affect the air quality in the classroom.

Therefore, in addition to the use of reflective paint, architectural design optimization in the form of adding natural openings and adjusting the orientation of the building facade needs to be considered to support the achievement of more stable and sustainable thermal comfort.

Measurement data prior to paint application was collected on August 1-3, 2025, using Elitech RC-4 and Wheater Station devices. Data collection took place at the Nurul Iman landfill, KarangMulya Village, Plumbon District, Cirebon Regency, West Java.

3.9. Discussion

The results of this study demonstrate that the application of BeCool reflective paint on the roof of the Nurul Iman TPA classroom significantly improved the indoor thermal conditions and overall comfort levels. Before the application, the recorded surface temperature of the roof, indoor air temperature, and radiant temperature were all above the comfort threshold defined by ASHRAE Standard 55, indicating a thermally uncomfortable environment for learning. Measurements taken between August 1–3, 2025, showed that the classroom was experiencing excessive heat gain due to the high solar radiation absorbed by the roof material, resulting in elevated indoor air temperatures and discomfort for the occupants. After the application of BeCool reflective paint (measured on August 10–13, 2025), a substantial decrease in temperature was observed across all parameters. The roof surface temperature dropped by 10–12°C, indoor air temperature by 9–11°C, and radiant temperature by 2–3°C. The final indoor air temperature stabilized at 25.7°C with a relative humidity of 82.8%, which falls within the ASHRAE 55 thermal comfort zone. However, the high humidity level still requires attention, as it may negatively affect perceived comfort and indoor air quality. These findings align with Djafar et al. (2024), who reported that BeCool roof coatings effectively reduced heat gain in coastal settlements by up to 11°C, enhancing indoor comfort levels.

The thermal performance improvement can be attributed to the high solar reflectance and thermal emittance properties of the reflective paint, which limit solar heat absorption and promote heat dissipation. Damayanti et al. (2025) emphasized that the application of reflective coatings can increase roof resistance to thermal transfer, thereby maintaining lower indoor temperatures. Similarly, Ristanto et al. (2024) confirmed that reflective paints applied to galvalume roofs effectively reduce building surface temperatures and contribute to environmentally friendly architectural design. Kwon et al. (2024) analyzed indoor thermal enhancement in apartment buildings through heat-reflective paint application and found similar results a notable decrease in interior heat load, leading to improved energy efficiency. In tropical climates like Indonesia, Citraningrum et al. (2024) also observed that applying cool roof paints on metal roofs could reduce indoor temperatures by up to 10°C, proving their effectiveness in mitigating excessive heat in non-air-conditioned spaces.

Despite these improvements, high humidity remains a limiting factor in achieving optimal comfort. Mahardika et al. (2023) noted that while reflective coatings lower air temperature, humidity must also be managed through adequate ventilation and material selection to ensure stable thermal comfort. Thus, architectural interventions such as optimizing natural ventilation, orienting facades to reduce direct solar exposure, and improving airflow patterns

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are recommended to complement the passive cooling effect of reflective paints (Putra & Oktafiana, 2023; Ferdyn-Grygierek & Grygierek, 2025).

4. CONCLUSION

Based on measurements taken before and after applying BeCool reflective paint to the roof of the Nurul Iman Karangmulya kindergarten, it appears that this technique is quite successful in reducing room temperature. The analysis shows a decrease in the average roof surface temperature of 10–12 °C, a decrease in indoor temperature of 9–11 °C, and a reduction in average radiation temperature of 2–3 °C. With this reduction in temperature, the thermal conditions of the room, which were previously outside the comfort limits according to the CBE Thermal Comfort Tool, are now approaching or entering the comfort zone. This shows that the use of reflective paint on building roofs is a simple, affordable, and efficient solution to overcome heat problems while improving comfort for learning in educational environments.

However, to achieve better results, improvements also need to be made in classroom design, particularly in terms of natural openings and building facade orientation, as these two elements have a major impact on light reception, air flow, and heat distribution within the room.

4.1. Research Findings

This study shows that the application of becool reflective paint can significantly reduce the temperature in classrooms with hot and dry climatic conditions. This proves that reflective materials can be an effective and economical passive solution to improve thermal comfort in buildings with architectural design limitations.

4.2. Research Recommendations

For further research, it is recommended that:

1. Reflective paint be combined with other passive strategies, such as cross ventilation and shading, to achieve more stable thermal comfort.
2. Long-term testing be conducted over a longer period than before to assess the durability and effectiveness of the paint against weather conditions and its performance over time

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