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Research Article

Design of An Internet of Things-Based Temperature And Light Monitoring System In The Classroom of SDN Bojong 02

Mesra Betty Yel [1], Satria Wira Yudha [2], and Nandang Sutisna [3], Muhammad Rafli Fadillah [4]

1 Sekolah Tinggi Ilmu Komputer Cipta Karya Informatika (STIKOMCKI) Jakarta; Email: mesrabettyyel@stikomcki.ac.id
2 Sekolah Tinggi Ilmu Komputer Cipta Karya Informatika (STIKOMCKI) Jakarta; Email: satriawirayudha@stikomcki.ac.id
3 Sekolah Tinggi Ilmu Komputer Cipta Karya Informatika (STIKOMCKI) Jakarta
4 Sekolah Tinggi Ilmu Komputer Cipta Karya Informatika (STIKOMCKI) Jakarta
* Corresponding Author: mesrabettyyel@stikomcki.ac.id

Abstract: One of the goals of a building is to create a comfortable environment that does not affect the health and operations of its occupants, therefore a system needs to be created to ensure comfort in classrooms. To fulfill a comfortable situation, there is a standard that regulates comfort, especially thermal and visual comfort. Thermal comfort is regulated in SNI 03-6572-2001 and visual comfort is regulated in SNI 03-6575-2001. The aim of this research is to design a tool to automatically monitor temperature and lighting, determine greater accuracy, determine temperature and lighting comfort distances, and test Smart Comfort measurement results in accordance with the SNI-03-6571-2001 and SNI-03-6575-2001 conformity standards. This design uses ESP32 with IoT-based LDR and DHT11 sensors which can be seen on the web and application, determines the accuracy and range of Smart Comfort values for monitoring temperature and lighting and determines the suitability of measurement quantities in the SDN PINANG 3 classroom.

Keywords: IoT; DHT 11; ESP 32; LDR; SNI.

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1. Introduction

The quality of the learning environment is one of the important factors that influences the effectiveness of teaching and learning activities in educational institutions. A classroom that provides comfortable environmental conditions can support students' concentration, improve learning productivity, and create a more conducive learning atmosphere. Environmental comfort in a classroom is generally influenced by several factors, including thermal comfort and visual comfort. Thermal comfort is related to room temperature conditions perceived by occupants, while visual comfort is associated with the adequacy of lighting intensity available within the learning environment. In Indonesia, standards for thermal comfort in buildings are regulated through SNI 03-6572-2001, whereas standards for visual comfort and artificial lighting systems are regulated through SNI 03-6575-2001. The implementation of these standards is essential because classroom conditions that do not meet recommended comfort criteria may negatively affect students' performance and learning outcomes. Therefore, continuous monitoring of classroom environmental conditions is required to ensure that temperature and lighting levels remain within acceptable comfort ranges.

The rapid development of Internet of Things (IoT) technology has created new opportunities for implementing intelligent monitoring systems in various sectors, including environmental monitoring and building management. IoT enables sensors, controllers, and communication devices to exchange data through internet networks, allowing real-time monitoring and remote access to environmental information. Previous studies have demonstrated the effectiveness of IoT technology in monitoring environmental conditions across different application domains. Rehman et al. (2022) showed that IoT-based monitoring systems can improve environmental observation and control through the integration of wireless sensor networks and cloud-based platforms. Huang and Kieffer (2021) developed an intelligent environmental monitoring system capable of collecting multiple environmental parameters to support energy-efficient building management. Similarly, Tanasiev et al. (2021) reported that IoT integration in residential buildings improved the flexibility and effectiveness of environmental monitoring and control systems. Research conducted by Cheng et al. (2020) also demonstrated that smart lighting systems supported by distributed sensor networks can optimize lighting conditions while reducing energy consumption. These findings indicate that IoT technology has significant potential to support environmental monitoring applications through automated data collection, real-time information delivery, and improved operational efficiency.

Despite the growing adoption of IoT-based monitoring systems, existing studies have primarily focused on applications in smart agriculture, greenhouse monitoring, smart cities, residential buildings, and industrial environments. Research by Ismail and Amin (2023) emphasized the application of IoT for greenhouse monitoring, while Jasim and AlRikabi (2021) explored IoT implementation within smart city infrastructures. Other studies have investigated environmental monitoring systems for residential buildings and intelligent building management applications (Lv & Li, 2021; Tanasiev et al., 2021). However, relatively few studies have focused specifically on monitoring classroom environmental conditions by evaluating both thermal and visual comfort according to Indonesian National Standards. Furthermore, many previous studies emphasized system development and monitoring functionality without comprehensively assessing whether measured environmental parameters satisfy established comfort standards. This gap highlights the need for a monitoring system that not only collects environmental data but also evaluates classroom conditions based on recognized comfort criteria. Therefore, a study focusing on classroom thermal and lighting conditions using national comfort standards remains relevant and necessary.

Based on these considerations, this study proposes the design and implementation of an IoT-based intelligent monitoring system for temperature and lighting conditions in classrooms using ESP32, DHT11, and LDR sensors. The proposed system is designed to perform real-time monitoring and transmit environmental data to a web-based platform for remote observation. In addition to developing the monitoring system, this study evaluates the conformity of temperature and lighting measurements in classrooms at SDN Bojong 02 with the requirements specified in SNI 03-6572-2001 and SNI 03-6575-2001. The results of this research are expected to contribute to the development of smart classroom environments and provide practical recommendations for improving environmental comfort in educational facilities through the application of Internet of Things technology.

2. Literature Review

Internet of Things (IoT)

The Internet of Things (IoT) refers to a technological paradigm that enables physical devices to communicate and exchange data through internet connectivity. IoT integrates sensors, communication networks, and computing technologies to facilitate automated data collection, processing, and transmission in real time. This technology has been widely adopted in various sectors, including agriculture, healthcare, environmental monitoring, smart cities, and building management, due to its ability to improve operational efficiency and support data-driven decision-making processes (McEwen & Cassimally, 2014; Strous & Cerf, 2019). In environmental monitoring applications, IoT enables continuous observation of environmental parameters through interconnected sensors and cloud-based platforms, allowing users to access information remotely and in real time (Rehman et al., 2022).

Intelligent Monitoring

Intelligent monitoring refers to a monitoring approach that combines sensing technologies, communication systems, and information processing capabilities to provide automated and efficient supervision of environmental conditions. Unlike conventional monitoring systems, intelligent monitoring not only collects data but also facilitates analysis and decision support through real-time information delivery. The integration of IoT technologies has significantly enhanced monitoring capabilities by enabling continuous observation, rapid data transmission, and remote accessibility. Previous studies have demonstrated that intelligent monitoring systems can improve operational efficiency and environmental management in various domains, including smart buildings, industrial facilities, and urban infrastructures (Lv & Li, 2021; Huang & Kieffer, 2021).

Smart Building

A smart building is a facility that utilizes advanced information technologies, automation systems, and Internet of Things devices to improve occupant comfort, energy efficiency, operational performance, and safety. Smart buildings employ various sensors to monitor environmental parameters such as temperature, humidity, lighting intensity, and air quality. The collected data are then processed to support automated control and management of building facilities. The implementation of smart building technologies has been shown to enhance environmental quality while simultaneously reducing energy consumption and operational costs. Furthermore, IoT-based smart building systems provide greater flexibility in monitoring and controlling building environments through real-time data acquisition and remote access capabilities (Yu et al., 2020; Tanasiev et al., 2021).

DHT11 and LDR Sensors

Sensors play a critical role in IoT-based monitoring systems as they function as the primary instruments for acquiring environmental data. This study utilizes the DHT11 sensor to measure indoor temperature and the Light Dependent Resistor (LDR) sensor to measure lighting intensity. The DHT11 is a digital sensor capable of providing temperature measurements with sufficient accuracy for indoor environmental monitoring applications. Meanwhile, the LDR sensor operates based on variations in electrical resistance caused by changes in ambient light intensity. Due to their affordability, ease of integration, and reliable performance, both sensors have been widely employed in environmental monitoring systems and IoT applications (Saputri & Dhaneswari, 2022; Ridho'i et al., 2022).

Thermal and Visual Comfort in Classrooms

Thermal comfort refers to a condition in which occupants feel satisfied with the thermal environment and do not experience sensations of excessive heat or cold. In educational environments, thermal comfort is essential because it directly influences students' concentration, productivity, and learning performance. In Indonesia, thermal comfort standards for buildings are regulated by SNI 03-6572-2001, which specifies recommended temperature ranges for indoor environments. In addition to thermal comfort, visual comfort is another important factor that affects learning effectiveness. Visual comfort is closely associated with adequate lighting conditions that support reading, writing, and other classroom activities. Standards for artificial lighting systems in buildings are regulated through SNI 03-6575-2001, which establishes minimum illumination requirements based on room functions. Therefore, continuous monitoring of temperature and lighting conditions is necessary to ensure that classroom environments remain within the recommended comfort standards and support effective learning activities.

3. Materials and Method

Research Design

This study employed a design and implementation approach to develop an Internet of Things (IoT)-based intelligent monitoring system for classroom environmental comfort. The research focused on monitoring temperature and lighting conditions in a classroom at SDN Bojong 02. The system was designed to acquire environmental data through sensors, transmit the collected data to a cloud-based platform, and provide real-time monitoring through a web interface. Furthermore, the measured environmental parameters were evaluated against the thermal and visual comfort standards specified in SNI 03-6572-2001 and SNI 03-6575-2001.

The research process consisted of several stages, including literature review, system requirement analysis, hardware and software design, system implementation, sensor deployment, data acquisition, and performance evaluation. A literature review was conducted to identify previous studies related to IoT-based environmental monitoring and smart building technologies. Subsequently, the classroom environment was analyzed to determine sensor placement and system requirements.

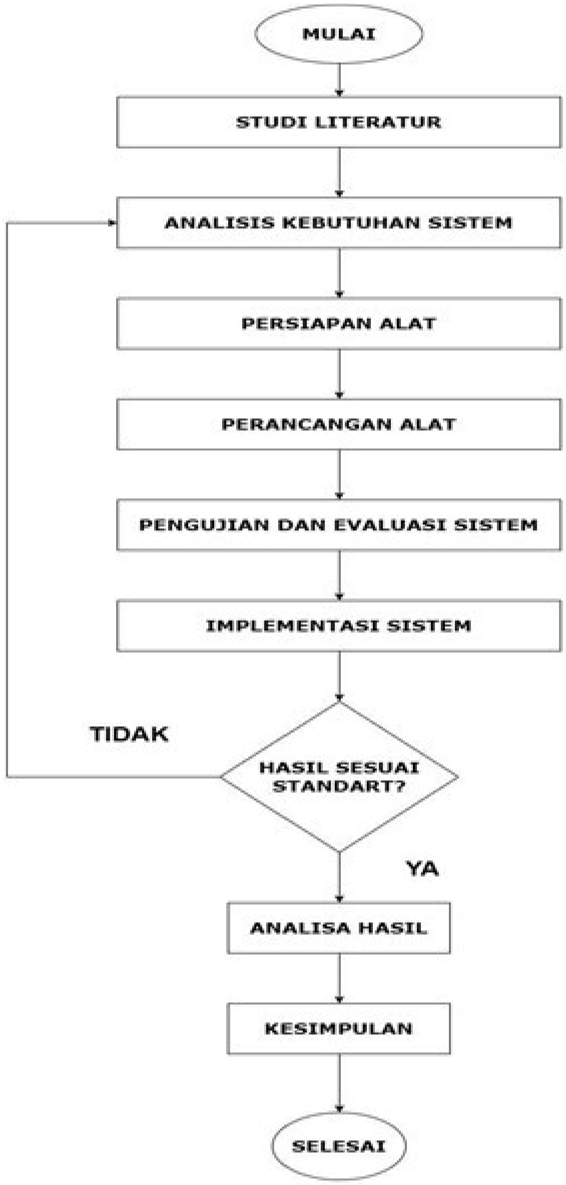

Figure 1. Research Design.

System Architecture

The proposed monitoring system consisted of an ESP32 microcontroller, DHT11 temperature sensor, LDR sensors, wireless communication modules, and a cloud-based monitoring platform. The DHT11 sensor was utilized to measure classroom temperature, while four LDR sensors were deployed to measure lighting intensity at different locations within the classroom. The ESP32 served as the central controller responsible for collecting sensor data and transmitting the information to the cloud server through a Wi-Fi connection.

The monitoring platform enabled real-time visualization of environmental data and facilitated remote observation of classroom conditions. Through this architecture, users could continuously monitor temperature and lighting levels using a web-based dashboard.

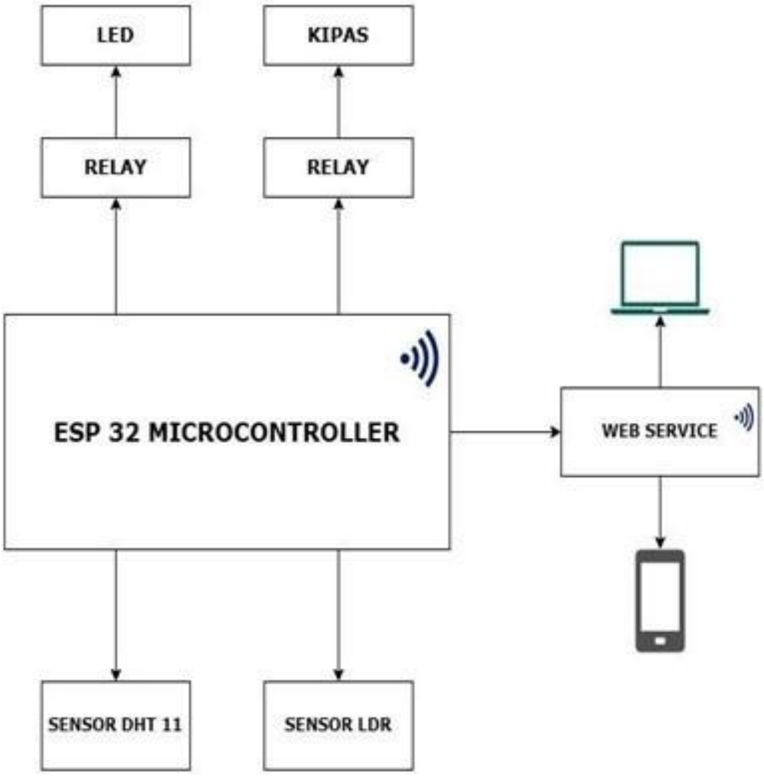

Figure 2. System Architecture.

Hardware and Software Components

The hardware components used in this study included an ESP32 DevKit V4 microcontroller, DHT11 temperature sensor, four LDR sensors, relay modules, LED lamps, cooling fans, and jumper cables. The ESP32 was selected because it provides integrated Wi-Fi connectivity and sufficient processing capability for IoT applications.

The software environment consisted of Arduino IDE for firmware development and Thinger.io cloud platform for data storage, visualization, and monitoring. Arduino IDE was used to program the ESP32 and manage sensor communication, whereas Thinger.io provided a web-based dashboard for displaying sensor measurements in real time.

Tabel 1. Hardware Components

Component	Function
ESP32	Main controller
DHT11	Temperature measurement
LDR	Light intensity measurement
Relay	Device switching
Fan	Air circulation
LED Lamp	Additional lighting

Tabel 2. Sensor Deployment

Sensor	Location	Parameter
LDR1	Point 1	Lighting
LDR2	Point 2	Lighting
LDR3	Point 3	Lighting
LDR4	Point 4	Lighting
DHT11	Center Area	Temperature

Data Collection and Experimental Procedure

Data collection was conducted in a classroom at SDN Bojong 02. Prior to system deployment, the classroom layout was analyzed to determine appropriate sensor locations. Four LDR sensors were installed at different measurement points to represent lighting conditions across the classroom, while one DHT11 sensor was positioned to measure ambient temperature.

System testing was performed under actual classroom conditions. Environmental data were collected during two observation periods, namely 10:25–10:40 and 12:58–13:13. Sensor readings were recorded at 30-second intervals. During the experiment, classroom lighting primarily relied on natural sunlight entering through the classroom windows, while cooling fans were operated to maintain air circulation.

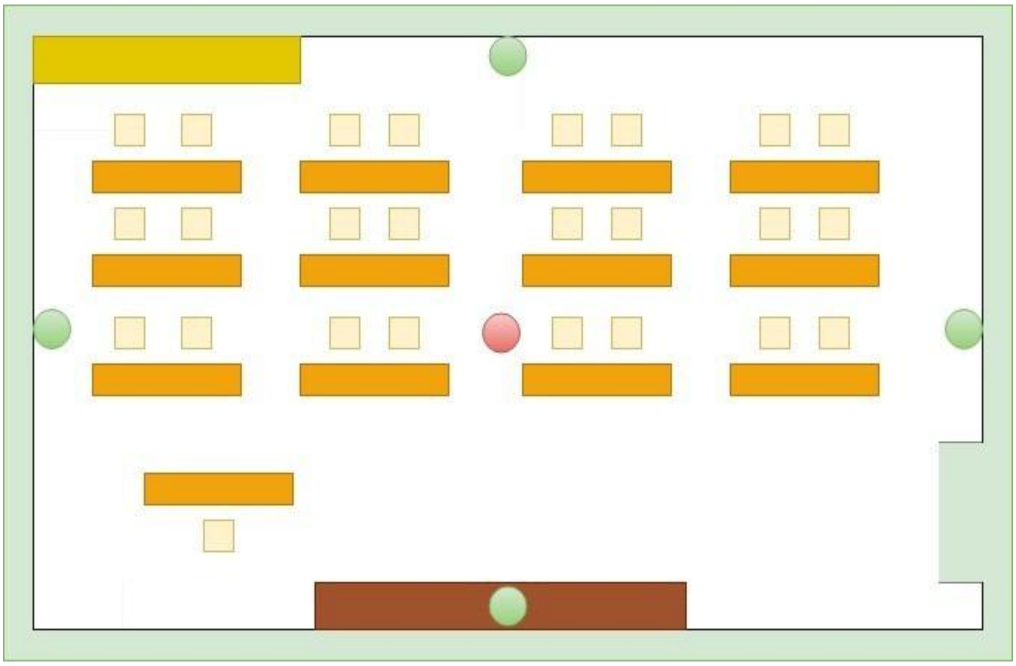

Figure 3. Data Collection

Data Analysis

The collected data were processed to determine average, minimum, and maximum values for temperature and lighting intensity. Temperature measurements obtained from the DHT11 sensor were compared with the thermal comfort criteria defined in SNI 03-6572-2001. Similarly, lighting measurements obtained from the LDR sensors were evaluated according to the visual comfort requirements specified in SNI 03-6575-2001.

The analysis aimed to determine whether classroom environmental conditions complied with the recommended comfort standards. The evaluation results were subsequently used to assess the effectiveness of the proposed IoT-based monitoring system and to identify potential improvements for classroom environmental management.

4. Results and Discussion

System Implementation

The proposed IoT-based monitoring system was successfully implemented using an ESP32 microcontroller integrated with one DHT11 temperature sensor and four LDR sensors. The system was connected to the Thinger.io cloud platform through a wireless network, enabling real-time monitoring and visualization of environmental data. Sensor measurements were transmitted automatically and displayed through a web-based dashboard, allowing users to observe classroom environmental conditions remotely.

Figure 1. IoT Monitoring Dashboard on Thinger.io Platform

The implementation demonstrated that the ESP32 was capable of acquiring sensor data continuously and transmitting information to the cloud platform without significant interruption. The monitoring dashboard provided real-time information regarding classroom temperature and lighting conditions, supporting the objective of developing an intelligent monitoring system for educational environments.

Temperature Monitoring Results

Table 3. Summary of Temperature Measurements

Observation Period	Min	Max	Average
10:25–10:40	32	33	32.2
12:58–13:13	34	35	34.3

Figure 2. DHT Monitoring Results 11

Temperature measurements were collected using the DHT11 sensor during two observation periods. During the first observation session (10:25–10:40), the recorded temperature ranged between 32°C and 33°C. The average temperature remained relatively stable throughout the observation period. During the second observation session (12:58–13:13), the temperature increased and ranged between 34°C and 35°C.

These results indicate that classroom temperature conditions were consistently higher than the recommended thermal comfort range specified in SNI 03-6572-2001. Although air circulation was assisted by operating fans during data collection, the recorded temperatures remained above the standard comfort threshold. This finding suggests that the classroom environment experienced excessive heat conditions that may affect occupants' comfort and learning performance.

Lighting Monitoring Results

Table 4. Summary of Lighting Measurements

Sensor	Session 1	Session 2
LDR1	402	228
LDR2	226	148
LDR3	370	271
LDR4	416	295

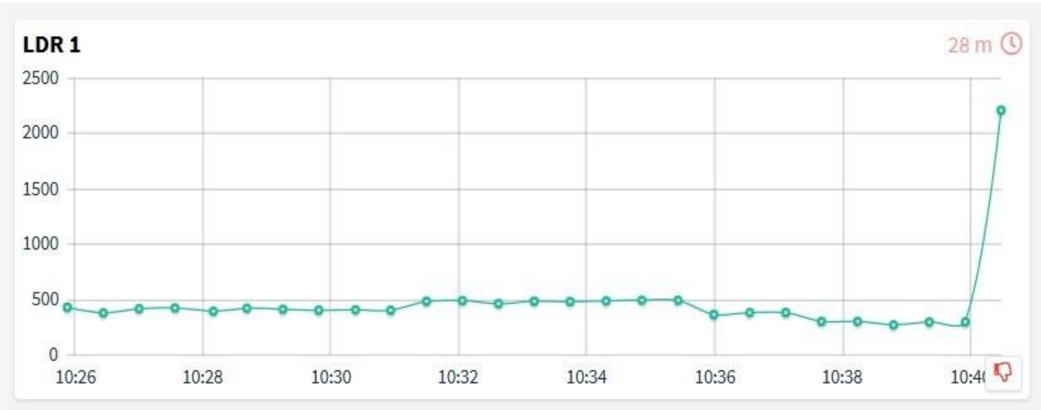

Figure 3. LDR Monitoring Results 1.

Lighting intensity was monitored using four LDR sensors placed at different locations within the classroom. During the first observation session, the average readings recorded by LDR1, LDR2, LDR3, and LDR4 were approximately 402, 226, 370, and 416 bits, respectively. During the second observation session, the average values decreased to approximately 228, 148, 271, and 295 bits.

The measurement results revealed significant variations in lighting conditions across different classroom locations. The highest lighting intensity was generally observed near areas receiving direct sunlight, whereas lower values were recorded in locations farther from natural lighting sources. These variations indicate that classroom illumination was not uniformly distributed and was highly dependent on natural daylight conditions.

Compliance with Thermal and Visual Comfort Standards

Table 5. Compliance Evaluation with SNI Standards

Parameter	Result	Standard	Status
Temperature	32–35°C	20.5–27.1°C	Not Compliant
Lighting	Several points below threshold	≥250 lux	Not Fully Compliant

The collected environmental data were evaluated against the Indonesian standards for thermal and visual comfort. According to SNI 03-6572-2001, the recommended indoor thermal comfort range is approximately 20.5°C–27.1°C. However, the measured classroom temperatures ranged between 32°C and 35°C, indicating that the thermal conditions exceeded the recommended comfort range.

Similarly, visual comfort was evaluated based on SNI 03-6575-2001, which recommends a minimum illumination level equivalent to approximately 250 lux for classroom activities. The lighting measurements demonstrated that several monitoring points produced values below the recommended threshold, particularly during the second observation period. Therefore, the classroom lighting conditions were not consistently compliant with the visual comfort requirements established by the standard.

Discussion

The results demonstrate that the developed IoT-based monitoring system successfully performed real-time environmental monitoring and provided continuous access to classroom temperature and lighting information. The implementation confirms the feasibility of integrating ESP32, DHT11, and LDR sensors into a cloud-based monitoring platform for educational environments.

However, the monitoring results also reveal that the environmental conditions of the observed classroom did not fully satisfy the thermal and visual comfort requirements defined by Indonesian standards. Elevated temperatures and insufficient illumination at several measurement points suggest the need for improvements in classroom environmental management. Additional ventilation strategies, improved air circulation systems, and optimized lighting arrangements may be required to achieve acceptable comfort levels.

These findings are consistent with previous studies emphasizing the importance of intelligent environmental monitoring systems in supporting smart building applications and improving indoor environmental quality. By providing continuous environmental information, the proposed system can serve as a practical tool for classroom management and contribute to the development of smart educational facilities.

6. Conclusion

This study successfully designed and implemented an Internet of Things (IoT)-based intelligent monitoring system for classroom environmental monitoring at SDN Bojong 02. The proposed system integrated an ESP32 microcontroller with DHT11 and LDR sensors to monitor temperature and lighting conditions in real time through a cloud-based platform. The implementation results demonstrated that the system was capable of continuously collecting, transmitting, and displaying environmental data through a web-based monitoring dashboard, thereby supporting remote observation of classroom conditions.

The monitoring results revealed that classroom temperature ranged between 32°C and 35°C during the observation periods, exceeding the thermal comfort range specified in SNI 03-6572-2001. In addition, lighting measurements obtained from the four LDR sensors indicated that several observation points did not consistently satisfy the illumination requirements recommended by SNI 03-6575-2001. These findings suggest that the thermal and visual conditions of the observed classroom have not fully met the established comfort standards.

Overall, the developed monitoring system proved effective for real-time environmental observation and can serve as a practical tool for supporting classroom environmental management. The findings of this study contribute to the implementation of IoT technology in educational environments and provide valuable information for improving classroom comfort through more effective temperature and lighting management strategies.

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