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Real-Time Room Temperature and Humidity Monitoring Using DHT11 Sensor and Arduino

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ABSTRACT

This study discusses the design and implementation of a real-time room temperature and humidity monitoring system based on an Arduino microcontroller and a digital DHT11 sensor. Ambient temperature and relative humidity are crucial factors affecting human health, comfort, and the operational stability of indoor electronic equipment. Traditional manual measurement methods are deemed inefficient because they fail to provide continuous, responsive data regarding environmental fluctuations. To overcome these challenges, this system was developed by utilizing the DHT11 sensor as a physical input device, while the Arduino board processes the collected data and displays it live on an LCD screen. The research methodology adopts an engineering approach, incorporating hardware integration, software programming, and prototype testing. Experimental evaluations were conducted across different daily time slots and applied to a case study monitoring a tempeh fermentation process over a 48-hour period. The test results demonstrate that the proposed system effectively provides stable, accurate, and real-time readings within the operational tolerance of the sensor. In conclusion, the system successfully replaces manual readings and offers a practical, low-cost solution for indoor environmental tracking with promising potential for future Internet of Things (IoT) expansion.

INTRODUCTION

The rapid advancement of information technology and electronics has driven the adoption of automated monitoring systems across various sectors, including offices, industrial facilities, laboratories, and storage rooms. Ambient temperature and relative humidity are critical physical parameters that directly influence human health, comfort, and the reliability of electronic equipment. Uncontrolled environmental conditions can damage sensitive hardware and foster the proliferation of harmful microorganisms, such as mold and bacteria, which pose severe health risks to room occupants.

Traditionally, room temperature and humidity tracking relies on manual readings using conventional measuring tools. This manual approach suffers from significant limitations: it fails to provide continuous data logging, is prone to human error, and lacks real-time responsiveness to sudden microclimate fluctuations. To address these drawbacks, previous studies have explored open-source microcontroller platforms. Saputra and Hidayat (2019) designed an Arduino Uno and DHT11-based monitoring system using an LCD display; however, their solution was restricted to local display without continuous real-time tracking. Similarly, Pratama and Setiawan (2020) implemented an indoor monitoring setup but did not evaluate its practical applicability in specific biological processing or climate-sensitive storage scenarios.

Therefore, this research aims to design and implement a real-time room temperature and humidity monitoring system utilizing an Arduino microcontroller and a digital DHT11 sensor. The primary contribution and specific novelty of this study lie in its direct application to a specialized case study: monitoring environmental microclimate conditions within a small-scale tempeh fermentation chamber over a 48-hour period. Tempeh fermentation demands precise thermal and moisture stability to ensure optimal mold mycelium growth. By employing this real-time monitoring system, environmental fluctuations can be tracked accurately and responsively, thereby ensuring room climate stability while offering a practical, cost-effective technological solution for food processing applications.

LITERATURE REVIEW

Temperature and humidity are key physical parameters affecting indoor environmental quality. Numerous studies have explored environmental monitoring using open-source platforms (Prasetya et al., 2025). developed an Arduino Uno and DHT11-based monitoring system using an LCD display; however, their setup was limited to local monitoring without real-time remote connectivity (Shalihin & Sholihin, 2022). demonstrated room monitoring using a microcontroller, but their design lacked historical data storage and automatic alert notifications for extreme conditions (Akbar, n.d.).

The Arduino platform offers significant flexibility due to its compatibility with various calibrated digital sensors

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like the DHT11. The DHT11 is a composite digital sensor capable of measuring temperature and relative humidity with low power consumption and adequate accuracy for small-to-medium indoor applications (Putra, 2022). This study fills the gaps identified in previous works by providing an integrated real-time monitoring solution and evaluating its performance through a food fermentation case study (Zhang et al., 2024).

METHOD

This study adopts an engineering research methodology focusing on system design, prototyping, and hardware-software integration. The overall research workflow is illustrated below (Hapsari et al., 2024):

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[Problem Identification] -> [Literature Review] -> [System Design]
   -> [System Implementation] -> [Testing & Evaluation] -> [Data Analysis] ->
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1. Problem Identification: Analyzing the drawbacks of manual temperature/humidity measurements.
2. Literature Review: Reviewing existing literature on DHT11 sensors, Arduino programming, and monitoring platforms.
3. System Design: Designing the hardware schematic (Arduino Uno, DHT11 sensor, LCD display) and software algorithm.
4. System Implementation: Assembling the physical hardware components and uploading source code to the microcontroller.
5. System Testing: Testing measurement accuracy across various ambient conditions and monitoring a tempeh fermentation process.

The methodology adopted in this study follows an engineering research approach, emphasizing system design, hardware integration, software development, and empirical testing. The primary objective is to build a reliable real-time room temperature and humidity monitoring system utilizing an Arduino Uno microcontroller and a digital DHT11 sensor.

The structural relationships between each research stage are systematically illustrated in the flowchart in Figure 1:

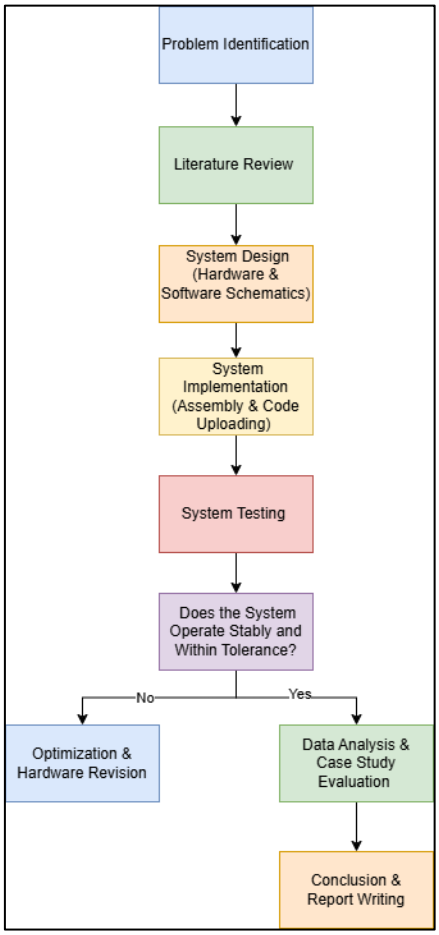


Figure 1. Methodology Flowchart of the Temperature and Humidity Monitoring System

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Explanation of Figure 1:

Figure 1 illustrates the end-to-end engineering methodology applied in this research. The process initiates with Problem Identification concerning manual measurement drawbacks, followed by a Literature Review on the DHT11 sensor and Arduino platform. The System Design phase outlines hardware schematics and embedded software logic. Next, System Implementation involves physical prototyping and firmware flashing. The assembled prototype then undergoes System Testing. If reading instability or out-of-tolerance errors occur, the prototype is routed back for Optimization & Hardware Revision. Once verified as stable and accurate, the system progresses to Data Analysis & Case Study Evaluation (tempeh fermentation monitoring) and finishes with Conclusion & Report Writing.

RESULT

The real-time room temperature and humidity monitoring system was successfully built and operated to display live measurement values on an LCD screen (Jamila & Devy, 2025).

Figure 1 illustrates the assembled prototype displaying real-time data (Aswar Mukhtar, 2025):

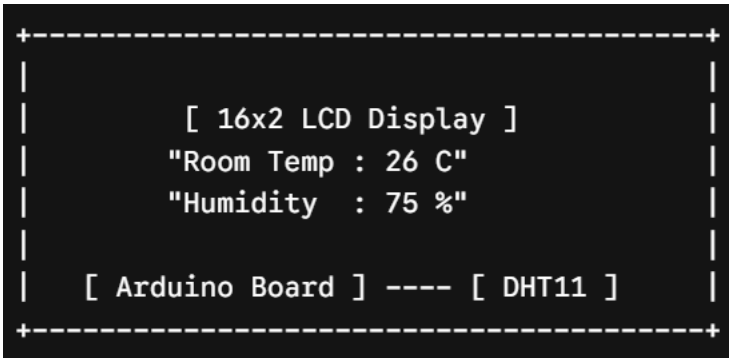


Figure 2. Prototype of the Arduino and DHT11-Based Temperature and Humidity Monitoring Device Connected to the LCD Display

Explanation of Figure 2:

Figure 2 shows the physical hardware setup of the developed monitoring prototype. The Arduino Uno microcontroller board is wired directly to the blue DHT11 digital temperature and humidity sensor via jumper cables. The DHT11 sensor acts as the environmental data collector, detecting ambient heat and relative humidity simultaneously. Digital output signals from the sensor are transmitted to the Arduino input pins for processing. The processed values are rendered live on the 16x2 LCD module, displaying a room temperature of 26°C and relative humidity of 75% in real time.

Initial testing was performed across three different daily time slots to evaluate sensor responsiveness. The collected data are presented in Table 1.

Table 1. Initial testing for sensor responsiveness.

No	Measurement Time	Temperature(°C)	Humidity(%)
1	Morning	26	75
2	Afternoon	25	80
3	Evening	60	85

Explanation of Table 1:

Table 1 displays the baseline performance of the monitoring system under general ambient room conditions observed at three distinct daily time intervals (morning, afternoon, and evening). The data reveals an inverse relationship between ambient room temperature and relative humidity. In the morning, the temperature was measured at 26°C with 75% humidity. During the afternoon, a slight variation occurred with 25°C temperature and 80% humidity. In the evening, the temperature dropped to 20°C while relative humidity increased to 85% (Abdurrohman et al., n.d.). These results confirm that the DHT11 sensor paired with Arduino accurately tracks daily indoor microclimate fluctuations and delivers stable readings within expected environmental parameters (Informasi & Kepada, 2026).

Table 2. Empirical data recorded continuously over a 48-hour period during a small-scale tempeh fermentation process.

No	Obsevation Time	Temperature(°C)	Humidity(%)	Tempeh Condition
1	0 Hours (Initial)	28	72	Unfermented
2	12 Hours	30	78	Mold growd starts
3	24 Hours	32	85	Even mold coverage
4	36 Hours	33	88	Nearly Fully
5	48 Hours	31	82	Fully fermented & ready

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Explanation of Table 2:

Table 2 outlines the empirical data recorded continuously over a 48-hour period during a small-scale tempeh fermentation process. At the initial state (0 hours), the baseline environment was recorded at 28°C with 72% relative humidity. As the fermentation progressed to 12 and 24 hours, both temperature and humidity rose to 30°C (78% humidity) and 32°C (85% humidity) respectively, driven by the metabolic activity and heat generated during fungal mycelium proliferation. The parameters peaked at 36 hours with 33°C temperature and 88% humidity, signifying the most active phase of fermentation. By 48 hours, as fungal growth stabilized and fermentation completed, temperature and humidity cooled down to 31°C and 82% humidity. This table demonstrates the system's capability to monitor critical microclimatic shifts required for optimal biological processing (Amaliah et al., 2025).

DISCUSSION

The results in Table 1 indicate that the DHT11 sensor provides consistent and responsive readings that reflect ambient daily environmental changes. The values remain within the acceptable operating tolerance of the sensor (Zhang et al., 2024)

In the tempeh fermentation case study (Table 2), the temperature increased from 28°C to a peak of 33°C at the 36-hour mark due to metabolic heat generated during fungal mycelium growth (Sarode et al., 2022). Relative humidity also increased to 88%, creating an optimal microclimate for mold proliferation (Zhang et al., 2024). These findings confirm that real-time monitoring is crucial for maintaining ideal conditions during biological processes (Pitriyanti, 2022). The Arduino controller effectively processed digital signals from the DHT11 sensor and updated the output without latency (Literatur, 2025)

CONCLUSION

Based on the research findings and experimental evaluations, the real-time room temperature and humidity monitoring system based on an Arduino Uno microcontroller and a digital DHT11 sensor was successfully designed, assembled, and operated. The proposed system effectively replaces traditional manual measurement methods by delivering continuous environmental data live on a 16x2 LCD display (Raisal et al., 2025). Operational testing under ambient room conditions confirmed that the DHT11 sensor performs accurately and responsively to daily microclimate fluctuations with high reading stability within operational tolerance limits. Furthermore, during the 48-hour tempeh fermentation case study, the system precisely captured critical biological microclimatic shifts, recording a temperature rise from 28°C to a peak of 33°C and a humidity increase from 72% to 88% at the 36-hour mark due to fungal metabolic activity, before stabilizing at 48 hours upon fermentation completion. For future development, the system can be enhanced by integrating wireless Internet of Things communication modules for automated cloud data logging, employing higher-precision sensors such as the DHT22, and constructing mobile application interfaces equipped with automated threshold alert notifications.

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