

Smart Classroom Environment Monitoring System

Dr. C.P. Divate¹, N.R. Bhokare², Anaya Taher Shaikh³, Habiba Samir Jamadar⁴, Abid Ali Tajoodin Mulla⁵

^{1, 2, 3, 4, 5}Department of Computer Engineering, ATS. Sanjay Bhokare Group of Institute, Faculty of Polytechnic Miraj, Maharashtra, India.

To Cite this Article: Dr. C.P. Divate¹, N.R. Bhokare², Anaya Taher Shaikh³, Habiba Samir Jamadar⁴, Abid Ali Tajoodin Mulla⁵, "Smart Classroom Environment Monitoring System", *Indian Journal of Computer Science and Technology*, Volume 05, Issue 03 (September-December 2026), PP: 561-565.



Copyright: ©2026 This is an open access journal, and articles are distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by-nc-nd/4.0/); Which Permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract: Classroom conditions such as temperature, humidity, lighting and noise strongly affect student comfort and concentration, yet they are usually checked manually or not monitored continuously, so unsuitable conditions are noticed late. This paper proposes the Smart Classroom Environment Monitoring System, an IoT-based monitoring and analytics solution. An ESP32 microcontroller reads temperature, humidity, light intensity and ambient noise sensors at defined intervals, attaches date and time to each reading and sends the data to a database, where historical records are maintained. A data cleaning stage handles missing, duplicate, invalid and inconsistent readings. An interactive Power BI dashboard with KPI cards, charts, filters and trend analysis then turns the raw readings into information that helps teachers and administrators identify unusual conditions and support corrective decisions. The system is organized into four modules: environmental sensing and ESP32 data acquisition; data transmission, database and data preparation; Power BI dashboard and data analysis; and monitoring and decision support. This paper presents the architecture, methodology and planned evaluation of the proposed low-cost system.

Key Word: Internet of Things, ESP32, Smart Classroom, Environmental Monitoring, Database Management, Data Preprocessing, Power BI, Business Intelligence.

I. INTRODUCTION

In modern educational institutions, the classroom environment plays an important role in student comfort, concentration, and effective teaching and learning. Environmental factors such as temperature, humidity, lighting and ambient noise vary through the day with weather, occupancy, ventilation and classroom activities. However, these parameters are generally monitored manually or not monitored continuously, which makes it difficult to identify unsuitable conditions at the right time.

This paper proposes the Smart Classroom Environment Monitoring System, an Internet of Things (IoT) based monitoring and analytics solution. An ESP32 microcontroller acts as the central data acquisition unit and is connected to sensors that measure temperature, humidity, light intensity and ambient noise level. The sensors periodically capture readings from the classroom, and the ESP32 processes them and passes them to the software layer for storage and analysis.

The readings are stored in a database together with their date and time. Keeping historical data allows conditions to be studied over different periods instead of relying on single, manually observed values, and basic data preprocessing improves the quality and consistency of the data before analysis. For analysis, Power BI is used to build an interactive dashboard with KPI cards, charts, filters and trend visualizations, so that users can easily see variations and potentially unsuitable conditions.

The main contributions of this work are: (i) an integrated, low-cost pipeline that takes classroom data from sensing to visualization; (ii) multi-parameter sensing with date and time-stamped historical storage; and (iii) a data cleaning stage and a Power BI dashboard that support trend analysis and decision making. If realized as designed, the system can help teachers and administrators understand classroom conditions from actual data, take timely corrective action, and identify recurring environmental problems.

The rest of the paper is organized as follows. Section II reviews the literature, Section III describes the methodology as four modules, Section IV discusses the expected benefits and planned evaluation, and Section V concludes the paper.

II. LITERATURE REVIEW

Razali et al. [1] proposed a ThingSpeak-based IoT system for real-time room condition monitoring. A sensor connected to an Arduino MEGA 2560 measured room conditions, and the data were sent to the ThingSpeak platform, which stored and displayed them so that users could view the room remotely on smartphones and web applications. The study shows that IoT hardware and cloud platforms can support continuous monitoring. It concentrates on basic room parameters and remote display, and it does not include noise or light sensing, a data cleaning stage or Business Intelligence (BI) analysis.

Ritheesh et al. [2] presented an IoT approach for real-time monitoring of a classroom. The work shows that classroom conditions can be observed remotely through IoT, which supports the idea of a smart classroom. The emphasis is on real-time

observation, while structured historical storage, data preprocessing and interactive analytical dashboards are the points that the proposed system adds.

Zhidong et al. [3] designed a monitoring system for classroom environment parameters based on wireless communication. Sensing devices collect the parameters and wireless links transfer them to a monitoring system, which reduces manual observation and allows data to be gathered from different classroom locations. The study concentrates on acquisition and transmission, and it does not describe historical analysis or visual analytics of the collected data.

Navarrete-Sanchez et al. [4] studied IoT-based classroom temperature monitoring and missing-data prediction using a Raspberry Pi and an ESP32. Their work is relevant because it uses the ESP32 for classroom monitoring and recognizes the problem of missing readings. It is centered on temperature, whereas the proposed system covers four parameters and adds a dashboard for visual analysis.

Al-Kuwari et al. [5] presented a smart-home automation system based on an IoT sensing and monitoring platform, in which sensing devices collect environmental information and users monitor and control it remotely. The concept can be applied beyond homes, for example to classrooms, by using suitable sensors and a centralized monitoring platform.

Research gap. The reviewed studies mainly focus on a limited number of parameters, on real-time observation or on data transmission. None of them combines multi-parameter sensing (temperature, humidity, light and noise), ESP32-based acquisition, date and time-stamped database storage, data cleaning and an interactive Power BI dashboard in a single low-cost classroom solution. The proposed system is designed to fill this gap.

III.METHODOLOGY

The proposed system follows an IoT-based methodology that combines environmental sensors, an ESP32, data storage and Power BI analytics. The overall flow is: environmental sensors, ESP32, data processing, data transmission, database, data cleaning and preparation, Power BI dashboard, data analysis and decision support (Fig. 1). It is divided into four modules, summarized in Table I.

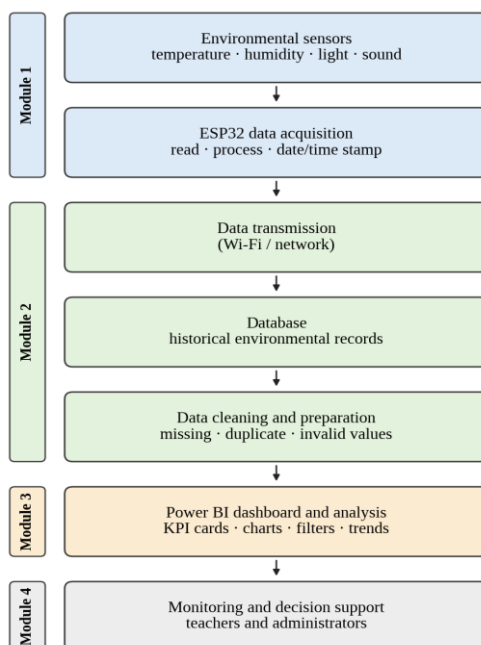


Fig. 1. Block diagram of the proposed Smart Classroom Environment Monitoring System and its four modules.

Module	Function	Key components
1. Sensing and acquisition	Measure temperature, humidity, light and noise; read, process and time-stamp the readings	Sensors, ESP32
2. Transmission and database	Transfer readings, store dated records, then check, clean and prepare the data	Network, database
3. Dashboard and analysis	KPI cards, charts, filters, trend and comparative analysis	Power BI
4. Monitoring and decision support	Condition monitoring, unusual-condition identification, database design	Dashboard, database

Table 1. Summary of the Four Modules

A. Module 1: Environmental Sensing and ESP32 Data Acquisition

- 1) **Environmental sensing:** This part collects the classroom conditions using different sensors, which provide readings to the ESP32 at defined time intervals. The temperature sensor measures the classroom temperature, and the humidity sensor measures the moisture in the air. The sound sensor detects the noise level, which shows how noise changes during teaching and other activities. The light sensor measures the light intensity, which shows whether the lighting is suitable. Periodic collection builds a continuous record for later analysis.
- 2) **ESP32 data acquisition:** The ESP32 is the main controller of the system. The temperature, humidity, sound and light sensors are connected to its input pins, and it periodically reads the value of each sensor. The readings are processed and arranged in a structured format containing all environmental parameters, and each set of readings is associated with the date and time so that changes can be studied later. The ESP32 then transmits the data to the selected storage system using its communication capability.

B. Module 2: Data Transmission, Database and Data Preparation

- 1) **Data transmission and database:** The processed readings are transferred from the ESP32 to the database through the implemented communication method. Each reading is stored as a record containing the date, time, temperature, humidity, noise level and light intensity. The database acts as a centralized store of historical classroom data, so that previously collected readings can be retrieved, and its structure is designed to keep the data organized and easy to access from Power BI.
- 2) **Data cleaning and preparation:** Before analysis, the collected records are checked and prepared to improve the quality of the dashboard. The dataset is checked for missing or incomplete readings, and duplicate records generated during collection are identified and handled. Date, time and sensor values are kept in suitable formats, and readings are validated to catch invalid or unexpected values. The cleaned data is then prepared in a structure suitable for connecting to Power BI.

C. Module 3: Power BI Dashboard and Environmental Data Analysis

- 1) **Power BI dashboard:** The prepared dataset is connected to Power BI to convert the stored data into meaningful visual information. KPI cards display important values and summary information, and charts and graphs show the variation of temperature, humidity, noise and light. Time-based analysis shows how the parameters change across dates and periods, and filters and slicers let users view specific dates, periods or parameters. These visualizations are combined in one interactive dashboard so that users can compare and understand classroom conditions easily.
- 2) **Environmental data analysis:** The collected data is analyzed to identify patterns, variations and conditions that need attention. Temperature, humidity, noise and light readings are each analyzed to find changes during the selected period, including periods of increased noise. Different parameters are compared using Power BI visualizations to see how they vary together, and previously stored readings are used for historical trend analysis to find recurring patterns.

D. Module 4: Monitoring, Decision Support and Database Design

- 1) **Monitoring and decision support:** Teachers and administrators monitor the classroom through the dashboard, where significant changes or unusual variations in the readings can be identified through the visualizations. Historical and current information supports data-based decisions on classroom conditions and helps to find areas where the environment may need improvement.
- 2) **Database design:** The database stores the readings generated by the monitoring system in a single environmental data table, whose fields are listed in Table II. The ESP32 sends the readings to this table, and Power BI uses it as the data source for charts, KPIs and other visualizations.

Field	Description
Record_ID	Unique identification number of each environmental record
Date	Date on which the reading was collected
Time	Time at which the reading was collected
Temperature	Value recorded by the temperature sensor
Humidity	Value recorded by the humidity sensor
Noise_Level	Value recorded by the sound sensor
Light_Intensity	Value recorded by the light sensor

Table II. Structure of the Environmental Data Table

The ESP32 is programmed in a suitable programming environment, and the data storage and Power BI components are used for storage and analysis. The modular design allows each module to be developed, tested and extended independently.

IV. EXPECTED BENEFITS AND EVALUATION PLAN

A. Expected Benefits

Based on the design, the system is expected to provide continuous monitoring of classroom temperature, humidity, light and noise without regular manual measurement, and to keep a structured historical record for comparing different days and times. Power BI visualization is expected to make the data easier for teachers and administrators to interpret, to help identify unusual or unsuitable conditions early, to reduce manual effort and to support data-driven classroom management. The architecture can be extended with more sensors, classrooms or dashboard features. These are design goals and not measured results.

B. Planned Evaluation

After implementation, the system will be evaluated on the following measures:

- sensor reading accuracy, by comparing readings with reference measuring devices where available;
- data acquisition performance, i.e., collection from all sensors at the defined intervals;
- data transmission reliability and the amount of data lost or failed in transfer;
- database storage and completeness, including missing, duplicate and invalid records;
- preprocessing and analytical performance in handling data-quality problems and finding trends and unusual readings;
- dashboard correctness, and the time for a new reading to become available in the dashboard.

C. Feasibility

The system is technically feasible because it uses commonly available, programmable components (ESP32 and environmental sensors) together with database and Power BI tools, and it can be developed and tested with the available laboratory computing and network facilities. It is economically feasible because low-cost sensors and an ESP32 replace expensive industrial monitoring equipment, and operationally simple because data collection is automated and the dashboard is easy to read. The project can be completed in stages (sensor interfacing, ESP32 programming, transmission, database, preprocessing, dashboard, integration and testing), and the architecture can be scaled to more sensors or classrooms.

V.CONCLUSION

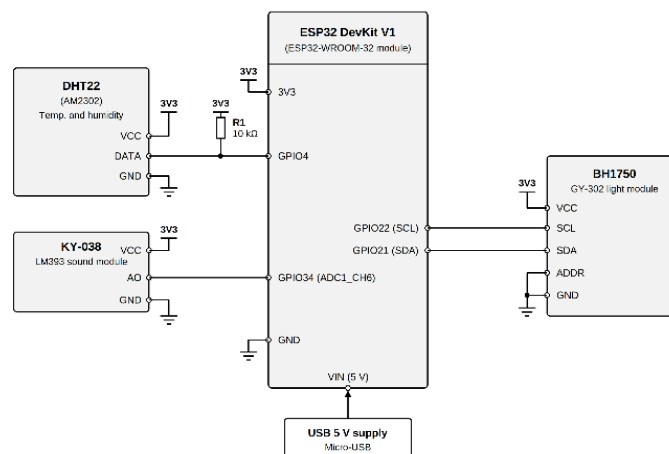
This paper proposed the Smart Classroom Environment Monitoring System, an IoT-based solution for continuous monitoring of temperature, humidity, light intensity and ambient noise in a classroom. An ESP32 collects readings from the sensors, the readings are stored with date and time in a database, they are cleaned and prepared, and an interactive Power BI dashboard turns them into information that teachers and administrators can use. By replacing manual observation with automated, data-driven monitoring, the system aims to support better classroom comfort and management at low cost.

The modular architecture makes the system easy to test, maintain and extend. Future work includes completing the implementation, evaluating the system as planned in Section IV, and extending it to multi-classroom monitoring, additional environmental parameters, alerts and automation, advanced analytics and smart-campus monitoring.

Acknowledgment

The authors thank Dr. C. P. Divate for guidance and support during this project.

Fig. 1: Circuit Diagram of the ESP32-Based Environmental Monitoring Node



REFERENCES

1. M. A. A. Razali, M. Kassim, and N. A. Sulaiman, "A ThingSpeak IoT on real time room condition monitoring system," 2020.
2. P. Ritheesh, N. K. Kumar, and K. Singh, "Smart classroom: Real time monitoring of classroom through IoT," 2023
3. L. Zhidong, G. Liqing, and X. Yanfeng, "Design of monitoring system for classroom environment parameter based on wireless communication,"
4. M. A. Navarrete-Sanchez, R. Olivera-Reyna, and R. Olivera-Reyna, "IoT-based classroom temperature monitoring and missing data prediction using Raspberry Pi and ESP32," 2025.
5. M. Al-Kuwari, A. Ramadan, and Y. Ismael, "Smart-home automation using IoT-based sensing and monitoring platform," 2018.