

An Intelligent Classroom Noise Monitoring System Using Sound Sensors and Multi-Threshold Alert

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ABSTRACT

Classroom noise is a common problem that can disrupt learning, reduce student focus, and make it difficult for teachers to deliver lessons effectively. To address this issue, this project presents a microcontroller-based classroom noise detection system that provides visual and audible feedback when noise exceeds a set threshold. The system uses a sound sensor (FC-04) to measure ambient noise levels in real-time and a microcontroller to process the input. Noise levels are indicated using three LED indicators — green for acceptable noise, orange for moderate noise, and red for high noise — while a buzzer provides an audible alarm when the noise exceeds the acceptable limit. The system is designed to help students become more aware of their noise levels and encourage a quieter, more productive classroom environment. By integrating hardware and simple programming, the system provides a reliable and automated approach to classroom noise management without relying solely on verbal reminders from teachers. In addition to classrooms, the system has potential applications in libraries, hospitals, industrial settings, and examination halls, where controlling noise is important for safety, focus, and comfort. The modular design also allows for future improvements, such as adjustable thresholds, data logging, or integration with automated monitoring systems. Overall, this project demonstrates the practical use of technology to improve discipline and maintain conducive learning environments. The system is simple, cost-effective, and can be easily implemented in educational settings to promote better concentration, minimize distractions, and enhance the overall teaching and learning experience.

Keywords: Classroom Noise, Sound Sensor, Microcontroller -based Classroom, visual and audible feedback, LED Indicators, Buzzer, real-time noise levels, automated classroom noise management

INTRODUCTION

A conducive classroom environment plays a vital role in supporting effective teaching and learning processes. Among the factors that influence learning conditions, noise remains a persistent issue that can negatively affect students' attention, comprehension, and overall academic performance. In many educational settings, excessive noise disrupts lesson delivery and creates challenges for teachers in maintaining classroom discipline and focus.

Conventional classroom noise management strategies primarily rely on verbal reminders and manual supervision by instructors. While these approaches are commonly applied, they are often inconsistent and may interrupt the instructional process. Over time, repeated verbal warnings can lose effectiveness, underscoring the need for a more systematic and objective approach to monitoring and managing classroom noise levels.

Recent advancements in embedded systems and low-cost sensor technologies have enabled the development of automated solutions for environmental monitoring. However, many existing noise monitoring systems are designed for industrial or commercial applications and may be costly or overly complex for classroom implementation. This presents a gap in the availability of practical, affordable, and classroom-oriented noise management solutions, particularly for educational institutions with limited resources.

This study addresses this gap by exploring the application of a microcontroller-based approach to classroom noise monitoring. The research is driven by the need to promote student awareness, encourage self-regulation, and support teachers in maintaining a productive learning environment without frequent instructional interruptions. By focusing on simplicity, cost-effectiveness, and adaptability, the proposed system demonstrates the potential of embedded technology as a practical tool for improving classroom discipline and learning conditions in educational and other noise-sensitive environments.

REVIEW OF RELEVANT THEORY, STUDIES, AND LITERATURE

Theoretical Framework

This section presents the theories and models that provide the foundation for the design and operation of the Intelligent Classroom Noise Monitoring System. These theories explain how the system collects data, processes information, and delivers appropriate responses to manage classroom noise effectively.

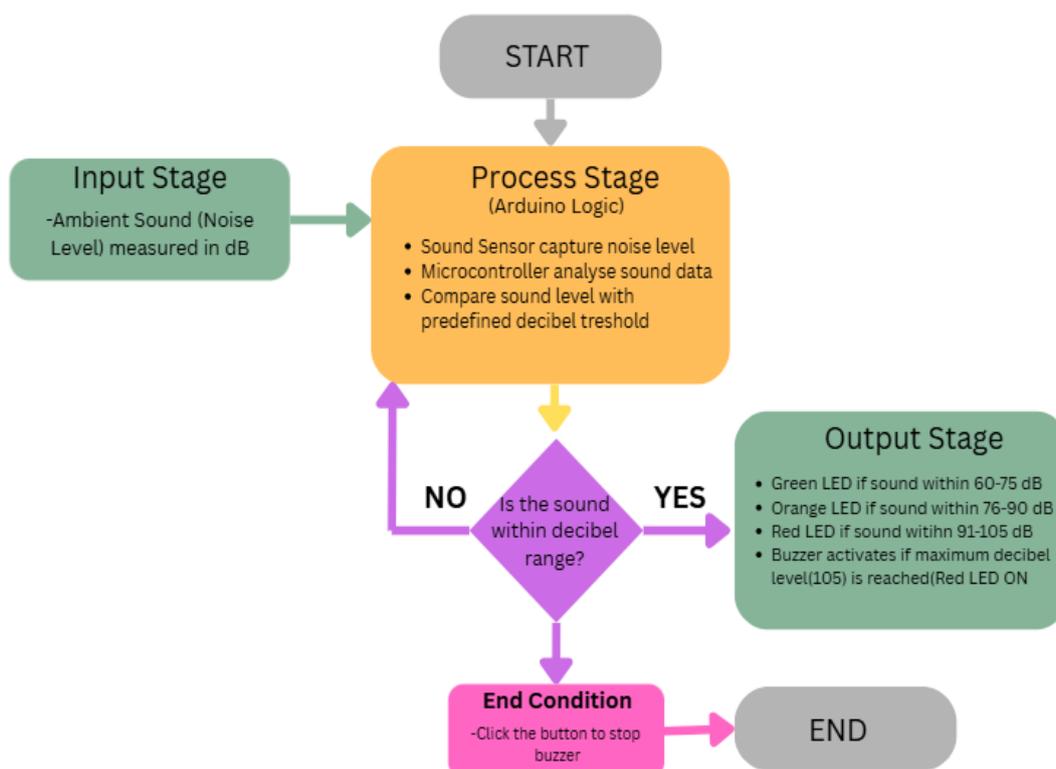
Systems Theory

Systems Theory, proposed by Von Bertalanffy (1968), states that a system is composed of interconnected components that work together to achieve a specific goal. In the proposed classroom noise monitoring system, the sound sensor, microcontroller, LED indicators, and buzzer function as individual subsystems. Each component has a specific task; however, effective noise monitoring is achieved only when all components operate as a unified system. This theory supports the integration of sensing, processing, and alert mechanisms to maintain a controlled classroom environment.

Input–Process–Output (IPO) Model

The Input–Process–Output (IPO) Model explains how a system transforms inputs into outputs through a defined process. In this study, the input is the ambient sound detected by the sound sensor. The process involves the microcontroller analyzing the sound level and comparing it with predefined noise thresholds. The output consists of visual indicators using LEDs and an audible alert through a buzzer when noise levels exceed acceptable limits. The IPO model provides a clear framework for understanding the functional flow of the noise monitoring system.

Figure 1: Input-Process-Output (IPO) Model



Embedded Systems Theory

Embedded Systems Theory explains that embedded systems are designed to perform specific functions in real time using a combination of hardware and software (Heath, 2002). The classroom noise monitoring system is an embedded system because the microcontroller continuously reads sound data, processes noise levels, and controls output devices without requiring human intervention. This theory supports the system's real-time operation and automated response to varying noise conditions.

Control Systems Theory

Control Systems Theory focuses on how systems regulate behavior by adjusting outputs based on changing inputs (Nise, 2011). The proposed system applies this theory by continuously monitoring classroom noise and responding according to multiple threshold levels. As noise increases, the system escalates visual and audible alerts, encouraging immediate corrective behavior. This ensures stability and control within the classroom environment.

Human-Computer Interaction (HCI) Theory

Human-Computer Interaction (HCI) Theory emphasizes the importance of usability, clarity, and effective communication between a system and its users (Dix et al., 2004). In this project, HCI principles are applied through the use of color-coded LED indicators and a buzzer that provide intuitive feedback. These indicators allow students and teachers to easily understand noise conditions without technical knowledge, promoting awareness and self-regulation.

Framework Summary

The Intelligent Classroom Noise Monitoring System is guided by Systems Theory and the IPO Model for structural and functional organization, Embedded Systems Theory for real-time automation, Control Systems Theory for threshold-based regulation, and HCI Theory for effective user interaction. Together, these theories support the development of a reliable, efficient, and user-friendly noise monitoring system.

Related Studies

Studies on Classroom Noise and Learning

Several studies have identified classroom noise as a major factor affecting students' concentration and academic performance. Excessive noise disrupts communication, reduces attention span, and negatively impacts learning outcomes. Research highlights the need for effective noise management strategies to maintain a conducive learning environment.

Studies on Sound Sensor-Based Noise Monitoring

Previous research has demonstrated the effectiveness of sound sensors in detecting ambient noise levels in real time. These studies show that sound sensors are capable of converting sound intensity into measurable electrical signals that can be processed by microcontrollers. Such systems have been applied in schools, libraries, and public spaces to monitor and regulate noise levels.

Microcontroller-Based Monitoring Systems

Microcontroller-based systems are widely used in automation and monitoring applications due to their flexibility and low cost. Studies indicate that microcontrollers efficiently process sensor data and control output devices such as LEDs and buzzers. These systems are suitable for educational environments because they operate autonomously and provide consistent monitoring without manual supervision.

Multi-Threshold Alert Systems

Research on alert-based monitoring systems emphasizes the advantage of using multiple thresholds instead of a single limit. Multi-threshold systems categorize noise levels into different ranges, allowing users to distinguish between acceptable, moderate, and excessive noise. Visual and audible alerts improve user awareness and encourage immediate corrective action, making them effective tools for noise control.

Noise Monitoring Applications

Noise monitoring systems have been successfully implemented in various environments, including classrooms, hospitals, libraries, and industrial workplaces. These systems help enforce noise regulations, improve safety, and enhance productivity. The effectiveness of similar systems supports the feasibility of implementing an intelligent noise monitoring system in classrooms.

Related Literature

Sound Sensor-Based Noise Monitoring

The study “**Design of a Classroom Noise Monitoring Tool Using a KY-037 Sound Sensor**” implemented a microcontroller-based system that utilized a KY-037 sound sensor to detect ambient noise levels in real time. The system provided multi-level feedback through LED indicators—green for acceptable noise, orange for moderate noise, and red for high noise—along with an audible buzzer. This approach allowed students to immediately recognize when noise exceeded acceptable limits, promoting self-regulation and a quieter classroom environment. (Rifqah et al., 2023).

Microcontroller-Based Monitoring Systems

Similarly, the “**Arduino-Based Noise Monitoring in Education Systems**” study used an Arduino Nano microcontroller paired with a sound sensor and LED display to continuously monitor classroom noise. The system converted detected sound levels into measurable signals and provided visual alerts whenever thresholds were exceeded. Findings from this study demonstrated that Arduino-based monitoring systems are reliable, cost-effective, and capable of maintaining discipline without requiring constant teacher intervention. (Arduino Nano Study).

Visual Feedback and Multi-Threshold Alert Systems

In addition, “**The Effect of Visual Feedback on Classroom Noise Levels**” explored the behavioral impact of real-time visual feedback in classroom settings. Using LED displays to indicate current noise levels, the study showed that students adjusted their behavior and reduced noise when they could see immediate feedback. This research highlights the effectiveness of visual cues and multi-threshold alerts in encouraging students to self-regulate and maintain a conducive learning environment. (van Tonder et al., 2015).

Table 1. Comparison Matrix of Related Studies and Current Research

Study/Author	Objective	Hardware/Sensors Used	Noise Thresholds/Levels	Output/Alerts	Key Results
Rifqah et al., 2023	Noise monitoring with KY-037 sensor	KY-037 + microcontroller	<45 dB, 45–55 dB, ≥55 dB	LEDs + speaker	Successful multi-threshold alerts
Arduino Nano Study	Classroom noise measurement	Arduino Nano + sound sensor	varies by study	Display/monitoring	Demonstrated feasibility

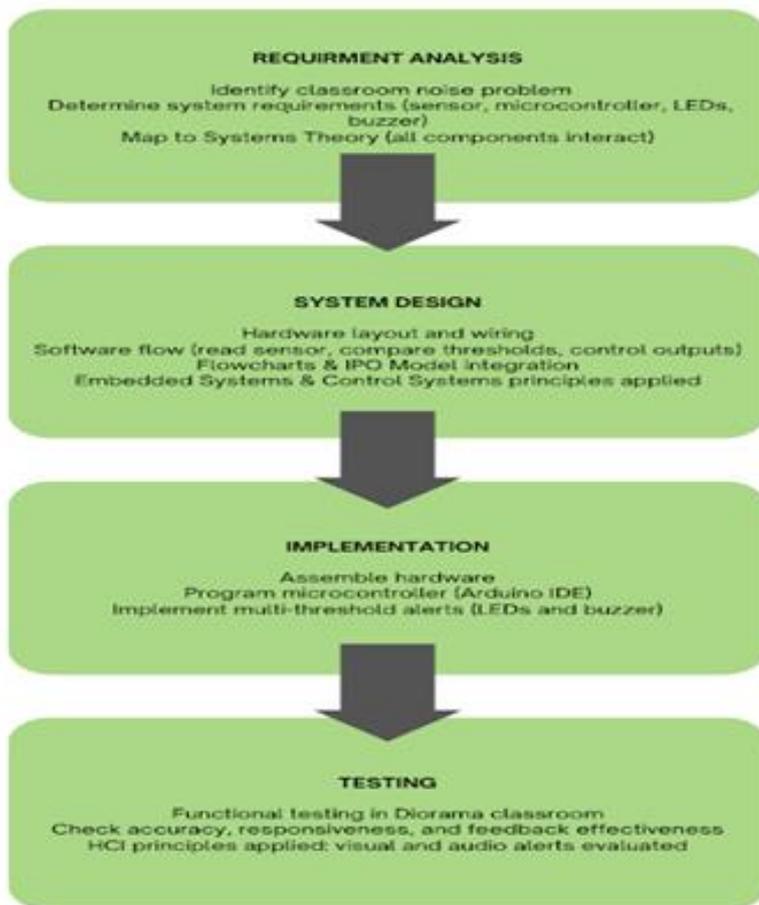
van Tonder et al., 2015	Visual feedback impact on noise	SoundEar II	Baseline vs intervention levels	LED feedback	Noise reduced with visual alerts
Current Study	Noise monitoring with FC-04 sensor	Arduino Uno + sound sensor	Baseline 60–75 dB, 76–90 dB, 91–105 dB	LED and Buzzer feedback	Threshold Indicator, Noise Monitoring system

METHODOLOGY

Research Design

This study employed a design and development research approach to create an Intelligent Classroom Noise Monitoring System. The primary goal was to design, implement, and evaluate a microcontroller-based system capable of detecting classroom noise levels and providing real-time feedback to students. The system was tested in a controlled classroom environment to assess its effectiveness in monitoring noise and encouraging self-regulation.

Figure 2: Waterfall Model



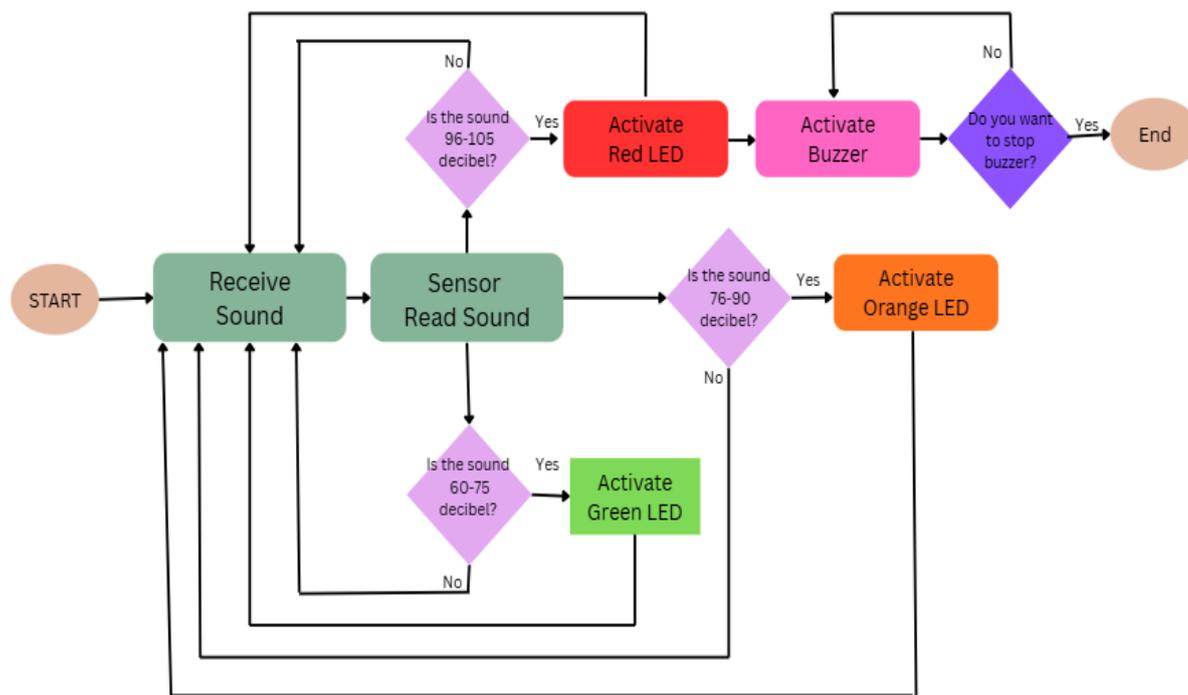
The Waterfall Model is a linear and sequential approach to system development, where each phase is completed before moving to the next. In this study, it was applied to develop the Intelligent Classroom Noise Monitoring System. The process began with requirement analysis to identify the problem of excessive classroom noise and define system needs. During system design, the hardware layout and software flow, including sensor reading, threshold comparison, and output control, were planned. In implementation, the microcontroller was programmed, and hardware components were assembled. Testing evaluated accuracy, responsiveness, and feedback effectiveness, while deployment involved installing the system in a classroom to observe student behavior. Finally, maintenance and evaluation ensured proper calibration and potential improvements. The Waterfall Model provided a structured framework, enabling systematic development and testing of the system.

Figure 3: Block Diagram



The block diagram illustrates a simple sound-activated system. The sound sensor detects audio signals from the classroom and converts them into electrical signals. These signals are sent to the microcontroller, which processes and analyzes the sound data. Based on the programmed conditions, the microcontroller determines whether the sound level exceeds a predefined threshold. When the condition is met, the microcontroller activates the buzzer or LED as an output response. This setup allows real-time monitoring of sound levels in the classroom. It can be used in applications such as noise detection, alarms, or warning systems. Overall, the system demonstrates basic hardware–software integration in an automated sensing application.

Figure 4: System Flowchart



It illustrates the flow of the Intelligent Classroom Noise Monitoring System begins when the sound sensor detects ambient noise inside the classroom. The sensor converts the sound waves into electrical signals, which are then read and processed by the microcontroller in real time. The system continuously compares the measured sound level against predefined decibel thresholds.

If the detected sound level falls within 60–75 dB, the system classifies the noise as acceptable and activates the green LED. When the noise level reaches 76–90 dB, it is considered moderate noise, prompting the system to activate the orange LED as a visual warning. If the sound level exceeds 96–105 dB, the system identifies this as high noise and activates the red LED along with a buzzer to provide both visual and auditory alerts. The buzzer continues until the condition to stop it is met, after which the system returns to monitoring mode.

Through these outputs, students receive immediate feedback and are encouraged to adjust their behavior, promoting self-regulation and maintaining a conducive learning environment. This flow demonstrates the integration of Systems Theory, Input–Process–Output (IPO) Model, Embedded Systems Theory, Control Systems Theory, and Human–Computer Interaction, ensuring efficient operation while providing intuitive and responsive feedback to users.

Potential Uses of Noise Detection System

Libraries or Study Area

- Help maintain quiet environments for reading and studying

Factories or Industrial Area

- Detects abnormal machine noise and ensures worker safety

Healthcare

- Monitor ambient noise to protect the patient's hearing, reduce stress, and maintain calm conditions.

Workplaces

- Monitor noise in open-plan offices to improve productivity

Transportation Hubs

- Monitor noise stations or waiting areas for comfort and announcements.

Examination Settings

- Detect unusual noise during exams to prevent talking or cheating

Limitation of the Study

False Trigger

- The system may activate due to short or accidental noises, not actual disturbance.

Natural Noise Interference

- Background sounds from outside such as lightning, thunder storm, and unexpected commotion within the monitored area can affect accuracy.

Type of Noise

- Due to hardware limitation, the sensor detects all kinds of sound. It does not vary from any type of noise that the surroundings produce.

Feedback from Output

- Loud buzzer or speaker sound can be detected by the sensor, causing repeated triggering.

Requirements

The developed noise alarm system operates using a 5 V Arduino-based platform designed to detect excessive sound levels and trigger warning indicators. An AA240 sound detection sensor continuously monitors ambient noise and outputs a digital HIGH signal once the sound intensity exceeds the preset threshold level adjusted through the onboard potentiometer. The Arduino Uno processes this signal in real time using a continuous program loop with an approximate response time of less than one second. Upon detection, the system activates a visual indicator (LED) that blinks at an interval of approximately 200 ms and an audible alarm using two AA249 active buzzer drivers. When the sound level drops below the threshold, all warning indicators are automatically deactivated. The system demonstrates stable operation under normal indoor conditions, making it suitable for noise monitoring applications in classrooms, laboratories, and similar controlled environments.

Table 2. Variables and Conditions of the Intelligent Classroom Noise Monitoring System Using Sound Sensors and Multi-Threshold Alert

Variable / Component	Type (Input / Output)	Parameter Measured / Controlled	Condition or Range	System Response / Action
Sound Sensor FC - 04	Input	Ambient Sound level	Digital output: LOW (no sound), HIGH (sound above threshold)	Sends detection signal to Arduino.
LED	Output	Visual Indicator	Blinks at ~200 ms interval during sound detection	Indicates presence of excessive noise.
Push Button	Input	Manual Alarm Reset	Pressed / Not Pressed	Deactivates buzzer output when pressed.
Arduino Uno	Controller	Logical processing and timing	5 V operation; <1 s response time	Reads sensor state and controls indicators.
Active Buzzer Driver	Output	Audible Alert	Active when the indicated noise threshold is surpassed.	Produces continuous alarm sound.
5 Voltage Supply	Power Source	Supplies power to Arduino Uno	5V supply	Provides stable power to the Arduino Uno and all connected components for proper system operation.

RESULT AND DISCUSSION

The test results confirm that the proposed noise alarm system operates as intended under varying sound and user conditions. The system effectively differentiates between low-level ambient noise and excessive sound, as no alarm activation was observed during quiet conditions and normal conversation. This indicates that the manually adjusted threshold of the AA240 sound sensor is appropriate for indoor environments.

When exposed to louder sound sources such as raised speech and hand clapping, the system consistently triggered both visual and audible alerts within an estimated response time of less than one second. The LED blinking and buzzer activation were sustained during continuous noise conditions, demonstrating stable system behavior and reliable real-time detection.

The inclusion of a manual reset button significantly improves the system usability. Test results showed that pressing the reset button immediately deactivated the buzzer while maintaining active sound monitoring. Subsequent noise events correctly reactivated the alarm, confirming that the reset mechanism does not interfere with the core detection logic.

The system also performed reliably under intermittent and fluctuating noise inputs. Short and rapid sound bursts did not result in false latching or unintended alarm behavior. Additionally, safe initialization was observed during system power-up, with all indicators remaining inactive until a valid sound event occurred.

Overall, the results validate the effectiveness of the proposed design as a low-cost, threshold-based noise monitoring system. Although the sound level thresholds are approximated and not calibrated in decibels, the system demonstrated consistent and repeatable performance. Future work may include calibrated sound measurements to further improve accuracy.

Table 3. Test Conditions and System Response of the Noise Alarm System

Test #	Input Condition	Observed Output	Expected Behavior	Pass / Fail	Remarks / Explanation
1	No sound detected (< ~55 dB)	LED OFF, Buzzer OFF	System remains idle	Pass	Normal ambient noise does not trigger alarm
2	Normal conversation (~55–60 dB)	LED OFF, Buzzer OFF	No alarm activation	Pass	Threshold not exceeded
3	Loud speech near sensor (~65–70 dB)	LED blinks, Buzzer ON	Alarm should activate	Pass	Sound exceeds preset threshold
4	Hand clapping (~70–75 dB)	LED blinks continuously, Buzzer ON	Immediate alarm response	Pass	System responds in <1 second
5	Continuous loud noise maintained	LED blinking continues, Buzzer remains ON	Alarm stays active	Pass	Continuous detection confirmed
6	Sound stops after detection	LED OFF, Buzzer OFF	Alarm deactivates automatically	Pass	System resets when noise drops
7	Reset button pressed while buzzer ON	Buzzer OFF, LED may remain active	Audible alarm stops	Pass	Manual reset successfully disables buzzer
8	Loud noise resumes after reset	LED blinks, Buzzer ON	Alarm reactivates	Pass	Monitoring function remains active
9	Rapid intermittent noise	LED blinks intermittently, Buzzer toggles	No false triggering	Pass	System handles short noise bursts correctly
10	System powered ON (5 V)	LED OFF, Buzzer OFF	Safe startup state	Pass	No unintended alarm during initialization

CONCLUSION AND RECOMMENDATIONS

This study successfully developed and tested an Intelligent Classroom Noise Monitoring System using a sound sensor, microcontroller, and multi-threshold alert mechanism. The system effectively detects excessive classroom noise and provides real-time visual and audible feedback through LED indicators and a buzzer. Test results confirmed that the system responds quickly, operates reliably under varying noise conditions, and accurately distinguishes between acceptable and excessive sound levels.

The use of multi-threshold indicators promotes student awareness and self-regulation, helping maintain a quieter and more conducive learning environment with minimal teacher intervention. Overall, the project demonstrates that a low-cost, microcontroller-based solution can be an effective and practical tool for classroom noise management.

Based on the findings of the study, the following recommendations are proposed:

1. Sensor Calibration for Improved Accuracy

Future implementations should use calibrated sound sensors capable of measuring noise levels in decibels (dB) to improve measurement accuracy and standardization

2. Adjustable Noise Thresholds

Incorporating user-adjustable or programmable thresholds would allow the system to adapt to different classroom activities such as lectures, group work, or examinations.

3. Noise Filtering and False Trigger Reduction

Implementing basic signal filtering techniques can minimize false triggers caused by short or unintended noise, improving overall system reliability.

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