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AirCare EDU: A Smart IoT-Based Air Quality Monitoring System

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***Abstract*—The environmental problem of air pollution affects health, as well as the ability to focus, especially because of close quarters such as classrooms where someone sick from breathing in poor air due to high levels of CO2 may have more trouble focussing on tasks. The AirCare EDU project is a low-cost mechanism that enables monitoring and assessing indoor air quality at schools and in smaller buildings. This device measures temperature, humidity, and continuously tests air quality for potential contaminants. The device is built around an ESP32 microcontroller, an analog gas sensor, and a digital temperature and humidity module, with a small display screen to show the air quality assessment. The ESP32 microcontroller processes all sensor readings and provides real-time data for display. The system differs from traditional monitoring systems that require internet access. Therefore, the AirCare EDU system is both more affordable and user-friendly. The components of the AirCare EDU system were selected based on low costs, local availability, and overall quality of performance. After conducting several performance tests, we have confirmed that the device performs well and provides accurate results about air quality in a given building. The design and dimensions of the device allow it to fit anywhere without taking up much usable space; in addition, the unit uses very little power, thus making it ideal for use in a variety of applications, such as classrooms, laboratories, and residences. The AirCare EDU device is a simple way to monitor indoor air quality, while also providing useful information about air contaminants.**

***Index Terms*—AirQuality Monitoring, ESP32, Environment air quality**

I. INTRODUCTION

Air pollution is both a danger and an annoyance. More importantly, however, it can affect our health, productivity, and quality of life. For example, you could develop respiratory issues from exposure to poor air quality in classrooms, laboratories, offices, or even at home, resulting in headaches or trouble concentrating in class. Teachers and students spend most of their time inside a classroom, so it's vital to have safe indoor air. Unfortunately, most educational facilities do not continuously monitor indoor air quality.

This issue must be addressed. We developed AirCare EDU—a cost-effective solution for real-time monitoring of indoor air quality using an ESP32 microcontroller and multiple sensors. The MQ135 sensor measures particulate matter (PM2.5 and PM10), gases (carbon dioxide, carbon monoxide, etc.), and humidity; the DHT11 sensor measures both temperature and relative humidity; an LCD display interface provides visual output of the data. The ESP32 collects all data from the sensors and displays it on the LCD screen so we can immediately determine whether the air has good, fair, or poor quality.

This problem requires immediate attention. We created AirCare EDU as an affordable way to monitor indoor air quality in real time using an ESP32 microcontroller with multiple sensors. The MQ135 Sensor can tell you how much Particulate Matter (PM2.5 and PM10) and what types of Gases (carbon dioxide, carbon monoxide, etc.) and how much

Humidity is present in the air; the DHT11 Sensor gives an accurate measure of Temperature and Relative Humidity in relation to one another; and an LCD Display Interface provides visual output of all three measurements simultaneously. The system provides all three sensor measurements together on an LCD so you can easily see the Air Quality Index (good, fair and bad).

The primary focus of the AirCare EDU project is to create a portable, affordable, and energy-efficient solution for monitoring the air quality of indoor spaces without requiring an Internet connection or cellphone. AirCare EDU provides a low-cost means of informing individuals who may be living or working in buildings with poor indoor air quality, as well as to assist schools in improving Indoor Air Quality and, ultimately, providing clean, safe air for all people who spend time in schools. Ultimately, AirCare EDU will help us ensure that everyone has access to clean, safe air in the schools/resources they use today.

II. LITERATURE REVIEW

Due to increasing health threats from inadequate quality of both outside air and inside air, issues related to airborne contaminants have gained increasing attention within the scientific community as a future research area. As a result, some investigators have started developing IoT devices (Internet of Things) utilizing low-cost remote environmental sensors based on widely available wireless communication technologies. While most of the recent research has focused on measuring harmful gas emissions based on microcontroller-based sensors using such devices as Arduino, ESP8266 and/or ESP32, there also some studies that measure temperature, humidity and particulate matter using those same devices.

The IoT-Based Air Quality Monitoring Systems Study has analyzed various systems that monitor Air Quality, Gas Measurement (Harmful Gases), Temperature & Humidity Measurement using MQ135 & DHT11 Sensors; then transmit Live Data wirelessly through different communication platforms. Most of the current systems use cloud-based applications/mobile dashboard to visualize data (not require additional systems). Therefore, they can be monitored from remote areas, but require a continuous, reliable, and fast internet connection, thus making them unsuitable in most low-cost classes. Researchers also acknowledge the significance of monitoring IAQ because poor Indoor Air Quality (IAQ) can create respiratory issues & symptoms will decrease comfort, comfort and productivity. A Systematic Literature Review of IoT-based IAQ Monitoring Systems has shown that the majority of the Systems use WSN (Wireless Sensor Networks) and cloud-based monitoring & analysis for real-time monitoring and analysis. These two technical approaches lead to increases in complexity and/or cost of the Monitoring System. The following are examples of several other studies that utilize the ESP32 Microcontroller by Espressif Systems because it has built-in WiFi, Bluetooth, low Energy Consumption, and Fast Processing Speed; MQ135 Sensors are normally used to detect gases such as ammonia, carbon dioxide, smoke, and benzene, and DHT11 Sensors are usually employed to measure temperature and humidity.

Most of the literature reviewed indicates that previous monitoring systems tend to emphasize cloud-based monitoring and remote access. The proposed project will produce an inexpensive, portable, and compact air quality monitor capable of providing real-time environmental data displayed via 16×2 liquid crystal display (LCD) with no requirement for internet or outside applications. As a result, the proposed air quality monitor has the potential to be a more practical, affordable, and user-friendly option than systems currently in use at schools, commercial labs, and residence.

III. OBJECTIVES

The purpose of this study is to:
1) Study the live location of dangerous gases and potentially hazardous indoor air quality in classrooms currently being used with the MQ135 sensor.

2) Monitor temperature and humidity fluctuations locally with the DHT11 sensor, allowing for an accurate analysis of the environment.

3) Develop an independent decentralized air quality monitoring device that does not require a Wi-Fi or cell phone app.

4) Test the optimized version of the monitor in real life, displaying the results clearly using a 16x2 LCD screen.

5) Recommend a cost-efficient hardware solution that can be both constructed and manufactured in schools with no reduction in performance.

IV. METHODOLOGY

This research methodology has five steps:

• Identify a problem: Schools lack the presence of localized real-time hardware systems that can monitor the problem of indoor pollutants.

• Select components: Literature reveals a gap within many areas, however, based upon these gaps, we selected an ESP32 development board instead of using conventional microcontrollers due to the dual-core processing speed and lower power consumption. The components we selected at this point were: MQ135 (gas sensor), DHT11 (climate sensor), and an LCD 16x2 with I2C module.

• Create a circuit schematic: We created a circuit schematic as to how we were going to configure the sensors to communicate with the ESP32 microcontroller. The advantage of using the I2C protocol for the LCD module is that it allows for multiple configurations of the LCD using only 2 digital signals (SDA and SCL) while reducing wire connections to the LCD significantly.

• Program and calibrate: We programmed the ESP32 using Arduino IDE and C Language for embedded applications. We developed calibration algorithms to convert the MQ135 raw analog voltage readings into IQI values – Good, Moderate, and Bad – as defined by the standard guidelines for air quality.

• Prototype: We created an actual prototype using a breadboard and jumper wires. We then conducted a series of tests to measure the performance of our sensors when tested in a normal atmospheric environment, moderate smoke, and heavy smoke environments to determine the results of the sensors response time and performance.

V. EXPERIMENTAL SETUP

To test the design, we used a fully assembled AirCare EDU prototype that was powered via a standard 5V USB power supply. The system had an Espressif Systems ESP32 microcontroller as the central processing unit that communicated with an MQ135 gas sensor and DHT11 temperature and humidity sensor via jumper wires mounted on a breadboard, allowing for a compact, simple and easy-to-use system.

VI. COST ANALYSIS TABLE

- ESP32 Microcontroller – 400
- MQ135 Gas Sensor – ₹150
- DHT11 Sensor – ₹60
- 16×2 LCD Display – ₹150
- I2C Module – ₹60
- Jumper Wires and Breadboard
- Accessories – ₹30

Total Prototype Cost – ₹820

VII. TESTING PROCEDURE

To assess the performance and responsiveness of the prototype, it was tested indoors under a variety of air quality conditions. The first set of readings taken were normal baseline values, or fresh air values, or readings taken while the air was fresh and clean. In order to simulate polluted air, the two pollutants tested were butane (introduced via a small amount of butane gas from an unlit lighter) and smoke (from other burning substances) and each was placed adjacent to the MQ135 air air quality sensor. The MQ135 air quality sensor exhibited noticeable changes in air quality indications (e.g. alert levels) based on the pollutants introduced into the surrounding air air and how they altered the surrounding air conditions.

For the temperature and humidity sensors, a warm, moist cloth was placed in close proximity to the DHT11 sensor and each sensor detected changes in both temperature and humidity within a relatively short period of time. The ESP32 microcontroller continually monitored the data obtained from each sensor and updated the 2x16 LCD screen display with the current values obtained from each sensor in real time. The prototype operated in a consistent, stable, reresponsive ,and energy efficientmanner throughout the testing process.

VIII. CIRCUIT DIAGRAM

The AirCare EDU system effectively monitors and accurately records environmental variables at an inexpensive price of approximately ₹ 820. The various sensors employed with this system demonstrated consistent speeds and accuracy across various interior environments in their preliminary trials. Fresh hair measurements taken with the MQ135 sensor concluded that air quality was good and were given values of 1000. As soon as an analog smoke test was completed, the values measured by the sensor increased by roughly 2450, prompting the LCD to display that the air quality was poor as an example of a visual alert to notify of deterioration.

The major overall success of this design was that it could be operated without Internet connectivity (cloud or mobile app access). The ESP32 microcontroller (developed by Espressif Systems) processed all sensors in a local environment and sent the sensor information to a 16×2 LCD display via an I2C interface built into the microcontroller. This greatly simplified the operation of the system, increasing speed and ease of installation in small educational settings.

In experiments conducted as part of this project, the DHT11 appeared satisfactory. Temperature data collected from this sensor indicated temperatures of 28°C to 32°C and humidity readings between a minimum 55% and a maximum of 65% depending upon environmental conditions where testing took place.The LCD provided up-to-date information on a real-time basis without much delay.

With this project, it has been demonstrated that it is possible to build a small, lightweight, inexpensive air quality monitoring system for use in a limited area of an indoor environment without sacrificing quality and dependability. The system, if implemented in a classroom or laboratory, could also lead to improved health and environment in schools or other locations.

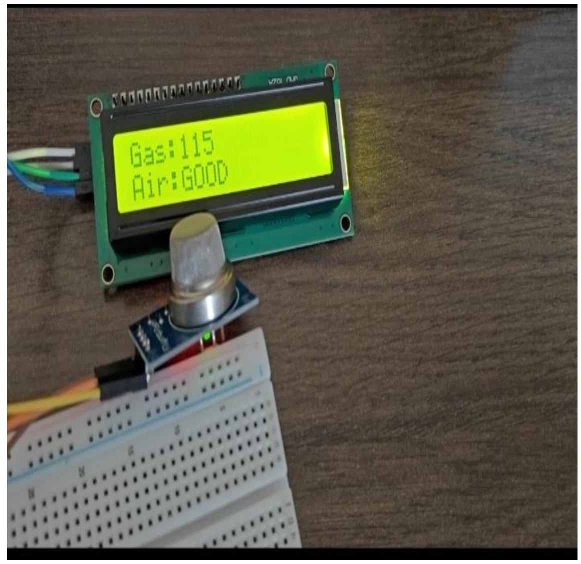

Fig1.Output of the circuit

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