Indoor Air Quality System: A Design of Monitoring CO and CO2 Substances for Elderly Home Using IoT

Fachri Nurmay Rohmah Dinnul Haq[1], Kurniawan D. Irianto[2]
[1,2] Department of Informatics, Universitas Islam Indonesia, Yogyakarta, Indonesia
Email: fachri.haq@students.uii.ac.id[1] , k.d.irianto@uii.ac.id[2]

Abstract

The use of an IoT-based monitoring system for CO and CO2 gases in elderly homes is a necessary innovation for remotely monitoring air quality. This work was successful in establishing a remote monitoring system that can measure CO and CO2 gases utilizing IoT technology combined with Blynk software. The MQ-7 sensors detect CO gas, while the MQ-135 sensors detect CO2. Data from these sensors is delivered to a central server, which then sends it to the I2C 16X2 LCD panel and Blynk software, allowing data visualization via an internet connection. The study's findings indicate that this system can detect and monitor CO and CO2 gas levels with a high degree of precision. This device can also monitor air quality in real time using the Blynk software. As a result, users may accurately monitor air quality (CO and CO2 gases) in elderly homes.

A. Introduction

The concluding phase of human existence is termed old age (elderly). According to Law Number 13 of 1998, an elderly individual is defined as one who is 60 years of age or above. There are three classifications of the elderly: young elderly (60-69 years), medium elderly (70-79 years), and old elderly (80 years and above) [1].

Indoor air quality is generally lower than outdoor air quality because indoor air movement is limited and outside air pollution is trapped [2]. One of the causes of poor indoor air quality is the growing number of motor vehicles, which can pollute the environment and impair interior air quality. Asthma, Chronic Obstructive Pulmonary Disease (COPD), and lung cancer are all possible outcomes of poor air quality. The main pollutants produced by motor vehicles are CO, CO2, NO, SO, and Pb gases, which can come from outside or inside the room, such as cigarette smoke, combustion products, and vehicle smoke [3].

According to the World Health Organisation, air pollution causes three times as many deaths as malaria, tuberculosis, and AIDS. Air pollution killed 7 million people worldwide in 2016, with heart disease accounting for 25%, obstructive pulmonary disease for 43%, and lung cancer for 29% [4]. Indonesia is ranked 14th among the top 30 countries with the worst air quality in 2022, with Jakarta having the world's worst air quality (ranked seventh) [5]. As a result, remote indoor air quality monitoring requires ingenuity. This system uses Blynk software to remotely monitor indoor air quality. Indoor sensors detect air contaminants. Data from the sensors is then transmitted to a central server. The central server will then communicate the data to the monitoring device's display in the room, as well as the user's smartphone, via Blynk software. This allows customers to monitor indoor air quality in real time using either the device's display or the Blynk program on their smartphone.

B. Research Method

The authors undertook five stages prior to the development of a CO and CO2 gas monitoring system for the elderly's room utilizing IoT, as illustrated in Figure 1.

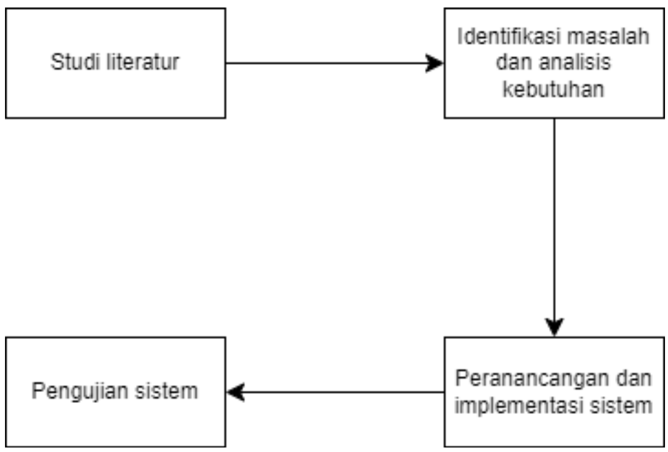

Figure 1. Research method phases

The initial step in this project is to acquire literature on the indoor CO and CO2 gas monitoring system for the elderly utilising IoT. The primary goal is to identify critical constituents before measuring air quality in the room. This is similar to determining indications or parameters of what gases affect the health of the elderly, which will then be used as a reference in constructing the system, as well as which sensors will be employed in developing the system based on the identified indicators or gas parameters. Based on this, the indicators or gas parameters that will be detected and monitored include CO gas, CO2 gas, and gas leaks. CO gas, or carbon monoxide, is a colourless, odourless, and tasteless gas found in the air and environment at concentrations of 0.1 ppm [6]. Carbon dioxide gas (CO2) is a colourless gas produced spontaneously by aerobic respiration, and its exposure varies depending on conditions [7]. Carbon dioxide, or CO2 gas, is one of the gases produced by air pollution generated by inefficient fuel combustion activities, which also comprise carbon gas [8]. The gas will be measured using the following sensors and components:

1. MQ-7 Sensor
2. MQ-135 Sensor
3. ESP32 Microcontroller
4. I2C 16X2 LCD
5. Jumper Cables
6. Breadboard

The MQ-7 sensor is highly sensitive to CO, has a reliable measurement, is long-lasting, and is ideal for application in everyday life [9]. The MQ-135 sensor is highly sensitive to a variety of contaminants, including NH3, NOx, alcohol, benzol, CO2, and others. This sensor is low-power and suitable for gas exposure due to its ability to adapt to variations in resistance levels [9]. The software needs for running the sensor and components are then addressed, specifically through the use of the Arduino IDE application. The Arduino IDE is software that allows you to develop program codes, convert them to binary codes, and upload them to the microcontroller's memory [10]. After locating the gas, sensors, and components, the following step is to gather technical knowledge about how the sensors and components operate in order to monitor air quality in the room.

When developing a CO and CO2 monitoring system in a living space using IoT, flowcharts are useful for visualising the entire system's workflow. Flowchart is a graphic representation that depicts the steps in the business process of a program [11], making it the primary tool for implementing the system. On Figure 2, illustrate a flowchart that depicts the entire system's workflow. The process begins with connecting the ESP32 to WIFI, followed by the MQ-135, MQ-7, and CO2 and C0 sensors to determine the quality of air in the room. After detecting CO2 and CO, the ESP32 will send data to the server, which will then send data to the LCD I2C 16X2 display and the blynk network, which can be accessed via smartphone to allow users to monitor the quality of the air they are breathing.

The next stage is to develop the gadget and integrate it into the system. The device design process begins with configuring a collection of sensor pins and microcontrollers for the room's CO and CO2 gas monitoring systems. Tables 1 and 2 show the configuration of the microcontroller pins to the sensor.

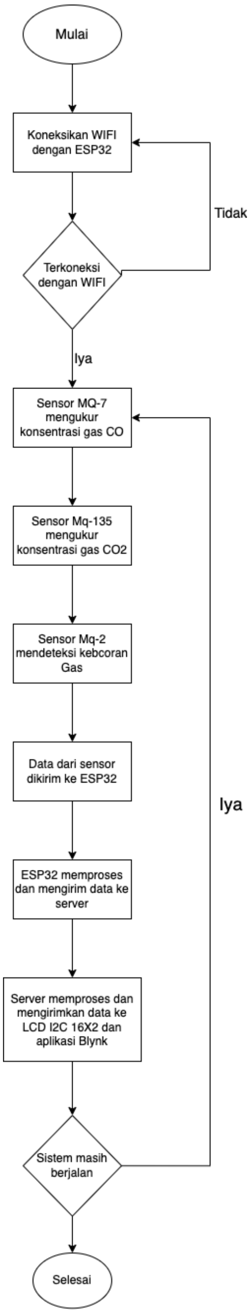

Figure 2. Flowchart of the system

Table 1. MQ-135 sensor pin configuration

No	Sensor type	Sensor Pin	ESP32 Pin	Description
1	MQ-135	VCC	VCC	Catu Daya
		GND	GND	Ground
		AOUT	GPIO34	Analog Output

There are multiple pin layouts for connecting the MQ-135 sensor to the ESP32. Connect the VCC pin of the M Q-135 sensors to the V CC ESP32 pin using the breadboard. Connect the GND pin of a MQ-135 sensor to an ESP32 GND sensor using a breadboard. Next, connect the AOUT pin of a MQ-155 sensor to a GPIO34 pin.

Table 2. MQ-7 sensor pin configuration

No	Sensor type	Sensor Pin	ESP32 Pin	Description
1	MQ-7	VCC	VCC	Catu Daya
		GND	GND	Ground
		AOUT	GPIO35	Analog Output

There are a variety of pin layouts for connecting the MQ-135 sensor to the ESP32. First, using the breadboard, connect the M Q-135 sensors' VCC pin to the V CC ESP32 pin. Then, using a breadboard, connect the GND pin of a MQ-135 sensor to an ESP32 GND sensor. Connect the AOUT pin of a MQ-155 sensor to a GPIO34 pin.

The previously developed inter-pin configuration is part of a tool design that includes multiple components that can be joined to form an integrated system with a variety of inputs, processes, and outputs. The ESP32 component serves as the system's main brain, and it communicates with other components such as the MQ-135, MQ-7, and MQ-2 sensors to detect and evaluate air quality. Once you've created a pin arrangement between components, effective integration is required to optimise the system. The next stage is to develop a network scheme for the system, as shown in Figure 3.

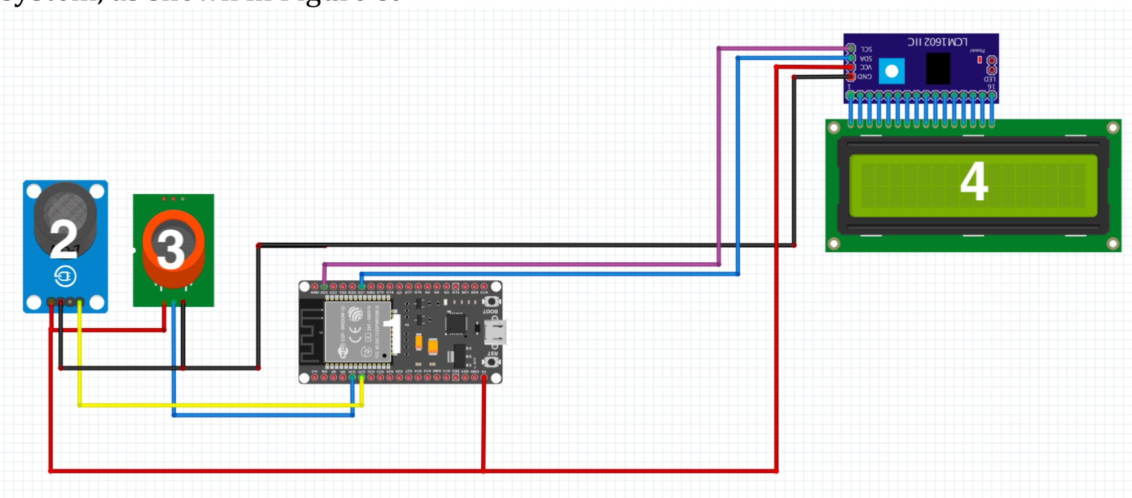

Figure 3. Schematic of the system

Descriptions:

1. ESP32 Microcontroller
2. MQ-7 Sensor
3. MQ-135 Sensor
4. LCD I2C 16X2

As seen in Figure 3. Gas sensors such as MQ-7, MQ-135, and MQ-2 detect and measure a variety of air quality characteristics. These sensors will collect information on gas concentrations and air quality factors. These are separated into three types: MQ-7, which measures CO gas, MQ-135 sensors, which measure CO2, and MQ-2, which detects hazardous gas leaks such as LPG leakage. The ESP32 microcontroller will send data from the measurement results to the server, which will then send data to the I2C 16X2 LCD display screen and the Blynk application via WIFI, which can be accessed via smartphones, allowing users to easily monitor ongoing air quality measurements.

This study made use of two key pieces of software: the Arduino IDE and the Blynk platform. The Arduino IDE is used to write programming code for the ESP32 microcontroller, which then ensures that the MQ-7 and MQ-135 sensors function properly while also processing and transmitting data to the Blynk software. Meanwhile, Blynk's software is being utilised to develop a user interface that allows users to check air quality in real time.

C. Result and Discussion

1. Measurement Result

This study successfully developed an air quality monitoring system that was effectively implemented in the room. The system's architecture includes of hardware and software components such as the ESP32 microcontroller, MQ-7 sensor, MQ-135, MQ-2 sensor, 16x2 I2C LCD, Arduino IDE, and Blynk platform. Following black bock testing, the system can be considered successful. Black bock testing is a software evaluation process that is carried out without knowledge of the application's internal mechanisms (Application Under Test, or AUT) [12]. This method is sometimes referred to as functional testing or input-driven testing. In this approach, the tester is unaware of the internal structure or how the system is being evaluated. The primary goal is to test applications' functioning and response to numerous inputs without needing to understand the code or programming logic behind them. The following are the conclusions of the evaluation utilising the black bock testing method.

A. Measurement of MQ-7 sensor for CO substance

Table 3. Result of CO level substance measurement

Time (Minute)	CO Level (PPM)
3:13:04 PM	31.50
3:14:00 PM	28.91
3:15:00 PM	31.41
3:16:00 PM	32.62
3:17:01 PM	32.71
3:18:01 PM	38.45
3:19:01 PM	27.84
3:20:01 PM	27.02
3:21:01 PM	26.55
3:22:00 PM	25.93
3:23:00 PM	25.93
3:24:00 PM	25.69
3:25:00 PM	25.59
3:26:01 PM	25.61
3:27:01 PM	25.72
3:28:01 PM	25.71
3:29:01 PM	24.43
3:30:01 PM	23.76

3:31:00 PM	23.68
3:32:00 PM	24.04
3:33:00 PM	24.04
3:34:00 PM	25.88
3:35:01 PM	31.91
3:36:01 PM	32.27
3:37:01 PM	30.42
3:38:00 PM	29.57
3:39:00 PM	29.13
3:40:00 PM	27.88
3:41:00 PM	26.63
3:42:00 PM	25.67
3:43:00 PM	25.43
3:44:01 PM	25.75
3:45:01 PM	25.47

Based on the CO level measurements in Table 3. It generates numerous distinct values. The measurements were taken in a 3 × 3.5 m room from 3:13:04 pm to 3:45:01 pm, totalling approximately 30 minutes of measurement time. The observed CO gas values range from 23.68 pm (the lowest value) to 38.45 ppm. However, all CO gas tests are under the permissible level of 25 - 32 ppm. CO has three thresholds: safe (<70 ppm), dangerous (70-150 ppm), and fatal (>150 pppm). As a result, the MQ-7 sensor can accurately measure CO gas in real time, even in short periods of time. Changes in the circumstances around the sensor caused rises and declines during indoor testing. Figure 4 shows graphical measurement results.

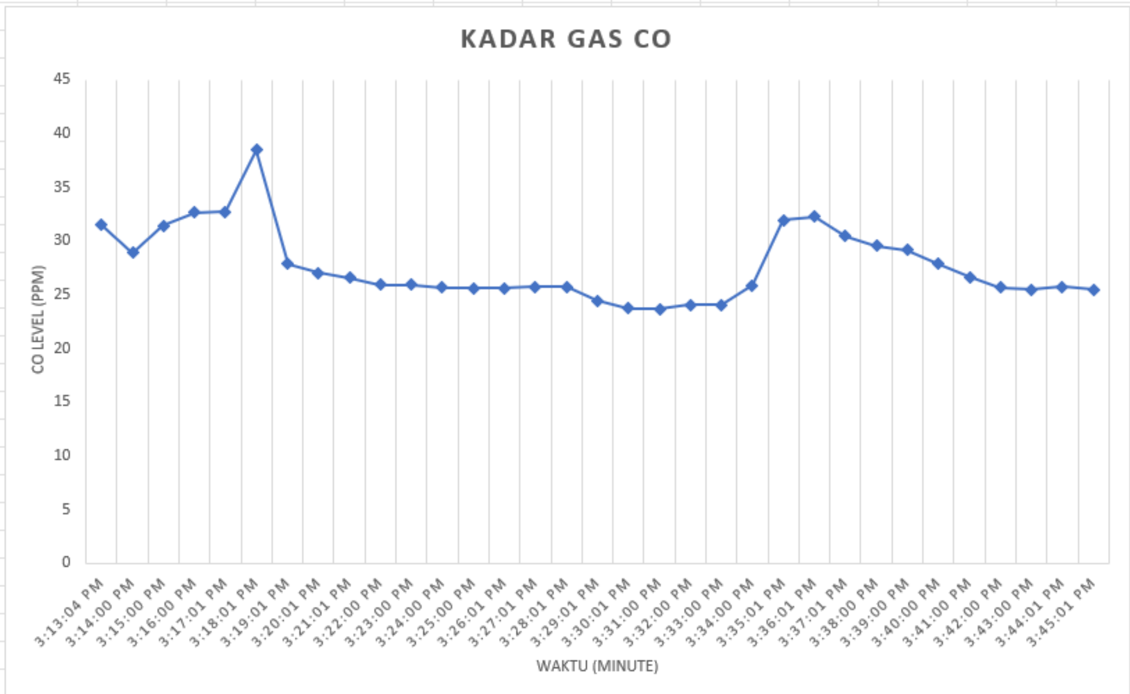

Figure 4. Graph of CO substance level measurement in the room

B. Measurement of MQ-135 sensor reading results for CO2 substance

Table 4. CO2 Substance Measurement Result

Time (Minute)	CO2 Level (PPM)
9:37:00 AM	770.24
9:38:00 AM	760.21
9:39:00 AM	835.73
9:40:01 AM	961.75
9:41:00 AM	1062.30
9:42:00 AM	1138.14
9:43:00 AM	1186.21
9:44:00 AM	1099.91
9:45:00 AM	803.45
9:46:00 AM	755.41
9:47:00 AM	727.30
9:48:00 AM	693.60
9:49:00 AM	678.27
9:50:00 AM	670.94
9:51:00 AM	676.63
9:52:00 AM	663.18
9:53:00 AM	646.52
9:54:00 AM	713.72
9:55:00 AM	886.02
9:56:00 AM	762.73
9:57:00 AM	711.12
9:58:00 AM	672.91
9:59:00 AM	668.80
10:00:00 AM	661.49
10:01:00 AM	652.51
10:02:00 AM	647.14
10:03:00 AM	639.39
10:04:00 AM	629.72
10:05:00 AM	625.85
10:06:00 AM	631.07

Based on the CO2 levels measured in Table 4. It generates various different measurement results. The measurements were taken in a 3 x 3.5 m room from 9:37:00 am to 10:06:00 am, which equates to approximately 30 minutes of measuring time. The lowest recorded CO2 gas was 625.85 ppm (10:05:00 a.m.), while the highest was 1186.21 ppm (9:42:00 a.m.). The CO2 phase began to rise and lasted around 6 minutes, ranging from 770.24 ppm to 1186.22 ppm due to the presence of cigarette smoke. However, all CO2 gas tests were within the permissible range of 600 to 700 ppm. (Zulistyawan, K. A. 2023). The CO2 gas has three thresholds: safe (5000 ppm), dangerous (5000-40000 ppm), and lethal (>400000 ppm). As a result, the MQ-135 sensor can accurately measure CO gas in real time, even over short periods of time. Figure 5 shows a graph of the measurement findings.

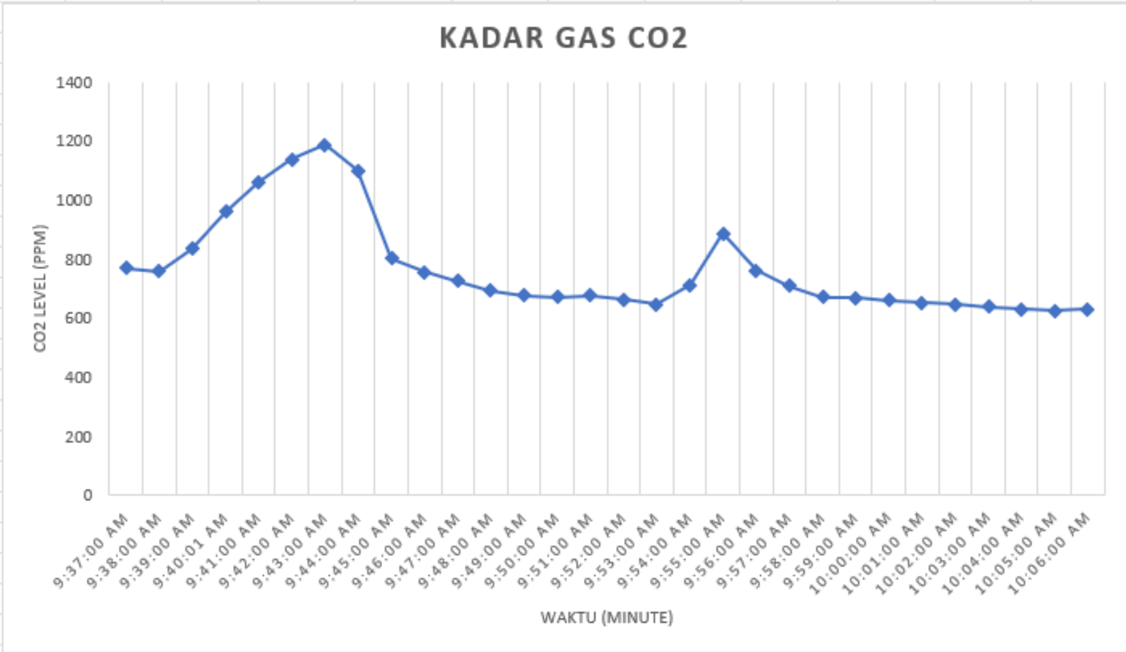

Figure 5. Graph of CO2 substance level measurement in the room

2. Result of system testing

The implementation of the CO and CO2 gas monitoring system in this room includes a set of steps to implement a system design, including the system program code and assembly of the tool. These steps indicate the process of preparing the system to operate effectively.

A. Device configuration on the CO and CO2 gas monitoring system

Figure 6. Prototype of the system

Figure 6 depicts all of the hardware components that have been assembled and stacked into a single unit to measure the CO and CO2 levels in the space. In such a configuration, there are various components, including:

1. The ESP32 microcontroller can process and transmit the read data of each sensor.

2. Sensor MQ-7, can measure CO gas.
3. Sensor MA-135, can evacuate CO2 gas.
4. LCD I2C 16X2, can display the measurement data of each sensor.
5. Jumper cable, can connect between components.
6. Breadboard, succeeded in becoming a place to create a new system.

The key components evaluated were the MQ-7 and MQ-135 sensors' accuracy in detecting and measuring CO and CO2 gases. This result is consistent with the misstatement made by (). Despite some fluctuating air quality indicators, the system successfully measured and monitored the air quality in the test room.

B. Visualize data using Blynk software

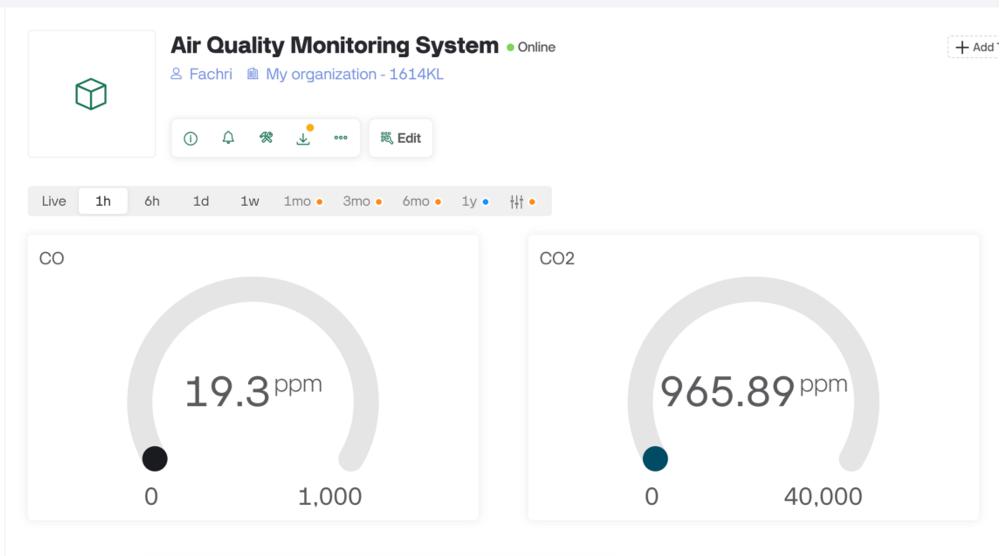

Figure 7. Data vizualitation on Blynk

Figure 7 shows a DHA visualisation display utilising the Blynk application with real-time CO and CO2 gas measurements. Blynk is software that monitors and controls external gear over an internet connection [13]. It is meant to ensure that the data generated and transmitted by the system tool frame is correctly received and shown on the Blynk application pattern without discrimination. The Blynk app can make it easier for both consumers and researchers by allowing them to remotely monitor air quality (CO and CO2 gas levels) in a room using their cell phones.

Based on the findings of the testing, the CO and CO2 gas monitoring system in this room is functional and can be used for its intended purpose. The system's black box test results demonstrated outstanding measurement precision, robust connectivity, and user accessibility. The test results also revealed that the system can detect and measure CO and CO2 gases with relatively high precision and transfer data to the Blynk application in real time. During testing, the system maintains a stable internet connection, allowing data to be transmitted to the blynk app in real time.

The integration of LCDs and the Blynk app allows researchers to easily monitor air pollution levels in the room being studied. With the delay period of 1 second, the data generated becomes clearer and allows for remote monitoring of air quality via mobile phones. The system still has several downsides despite the benefits it provides, such as sending data to the Blynk program, and it still relies largely on an Internet connection. When an internet connection fails or becomes unreliable, the measurement procedure can be hampered. Because the system is still in its original state, constant maintenance is required to optimise tool performance and prevent scraping errors or tool damage.

Overall, this investigation demonstrates that the CO and CO2 gas monitoring system in the built-in room is highly accurate. It also exhibits the capacity to detect and quantify the levels of air quality gases (CO and CO2) and transfer the measurement results to the Blynk app in real time. The findings of this investigation are also consistent with earlier research. This discovery can also be utilised to advance all aspects of air quality monitoring.

D. Conclusion

The study created a monitoring system in the room that measured the levels of air quality gases (CO and CO2). The results demonstrated that the system can detect and quantify gas quality air levels accurately. The technology then successfully relayed real-time data on the air quality gas meltdown to the Blynk app, allowing users to watch the measurements remotely via the Internet. The system achieves excellent precision in air quality monitoring by connecting microcontrollers ESP32, MQ-7 sensors, MQ-135, 16x2 I2C LCDs, and the Blynk app. As a result, customers may properly monitor the air quality in their rooms with this device.

E. Reference

[1] A. Nugroho, "Persepsi Anak Muda Terhadap Keberadaan Lansia Di Indonesia," *J. Urban Sociol.*, vol. 2, no. 2, p. 44, 2020, doi: 10.30742/jus.v2i2.996.

[2] P. Studi, T. Elektro, F. T. Industri, and U. I. Indonesia, "LAPORAN TUGAS AKHIR / CAPSTONE DESIGN Perancangan Sistem Monitoring dan Kontrol Air purifier Berbasis Android Perancangan Sistem Monitoring dan Kontrol Air purifier Berbasis Android," no. 18524041, 2022.

[3] M. A. Rizaldi, R. Azizah, M. T. Latif, L. Sulistyorini, and B. P. Salindra, "Literature Review: Dampak Paparan Gas Karbon Monoksida Terhadap Kesehatan Masyarakat yang Rentan dan Berisiko Tinggi," *J. Kesehat. Lingkung. Indones.*, vol. 21, no. 3, pp. 253–265, 2022, doi: 10.14710/jkli.21.3.253-265.

[4] WHO, "WHO global air quality guidelines," *Part. matter (PM2.5 PM10), ozone, nitrogen dioxide, sulfur dioxide carbon monoxide.*, pp. 1–360, 2021.

[5] IQAir, "World Air Quality Report 2023," *IQAir*, pp. 1–45, 2023, [Online]. Available: https://www.iqair.com/world-most-polluted-countries

[6] R. Wirosoedarmo, B. Suharto, and D. E. Proborini, "Analisis Pengaruh Jumlah Kendaraan Bermotor dan Kecepatan Angin Terhadap Karbon Monoksida di Terminal Arjosari," *J. Sumberd. Alam dan Lingkung.*, vol. 7, no. 2, pp. 57–64, 2020, doi: 10.21776/ub.jsal.2020.007.02.2.

[7] E. J. Molloy and E. P. Cummins, "Carbon dioxide as a drug in neonatology," *Pediatr. Res.*, vol. 89, no. 5, pp. 1049–1050, 2021, doi: 10.1038/s41390-020-

1051-y.
[8] R. Diharja, M. Rivai, T. Mujiono, and H. Pirngadi, "Carbon Monoxide Sensor Based on Non-Dispersive Infrared Principle," *J. Phys. Conf. Ser.*, vol. 1201, no. 1, pp. 4–11, 2019, doi: 10.1088/1742-6596/1201/1/012012.
[9] A. A. Rosa, B. A. Simon, and K. S. Lieanto, "Sistem Pendeteksi Pencemaran Udara Portabel Menggunakan Sensor MQ-7 dan MQ-135," *Ultim. Comput. J. Sist. Komput.*, vol. 12, no. 1, pp. 23–28, 2020, doi: 10.31937/sk.v12i1.1611.
[10] P. Sokibi *et al.*, "Perancangan Prototype Sistem Peringatan," vol. 10, no. 1, pp. 11–22, 2020.
[11] Z. Tuasamu *et al.*, "Analisis Sistem Informasi Akuntansi Siklus Pendapatan Menggunakan DFD Dan Flowchart Pada Bisnis Porobico," *J. Bisnis Manaj.*, vol. 1, no. 2, pp. 495–510, 2023.
[12] I. R. Dhaifullah, M. Muttanifudin H, A. Ananda Salsabila, and M. Ainul Yaqin, "Survei Teknik Pengujian Software," *J. Autom. Comput. Inf. Syst.*, vol. 2, no. 1, pp. 31–38, 2022, doi: 10.47134/jacis.v2i1.42.
[13] M. F. D. Subakti and N. Irwansyah, "Rancang Bangun Monitoring Ketinggian Air, Nilai Ph, Dan Kekeruhan Air Berbasis Internet of Things Menggunakan Blynk Pada Tandon Air," *Kohesi J. Multidisiplin Saintek*, vol. 3, no. 7, pp. 5–8, 2024.