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Original Article

Developing Sound Intensity Measuring Meter to Determine Noise Pollution Level Based on the Internet of Things (IoT)

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Abstract *- The problem of noise pollution existing in the environment must be addressed immediately because it affects the balance between humans and their environment. For this reason, it is necessary to measure sound intensity level. It used the device, namely Sound Level Meter (SLM) with Deci Bel (dB) unit, which this device is only able to measure levels without giving any notifications to communities. This study deployed Research and Development (R&D) method or research intentionally, systematically, aiming/ directed to find, formulate, improve, develop, produce, and test the effectiveness of certain products, models, methods/ strategies/ techniques, and procedures that are more eminent, newer, more effective, more efficient, more productive, and more meaningful. The aim of innovation development is in terms of intensity measuring meter based on IoT. The result showed that we succeeded in making a sound intensity measuring meter based on IoT. The Arduino microcontroller was used as a controller of the device's working system. This device can be monitored remotely using a smartphone in accordance with IoT basis. By using this device, the result is expected to determine the level of noise pollution, which will later be taken into consideration for the health of the surrounding environment.*

Keywords *- Sound intensity meter, Air pollution, Internet of Things (IoT).*

1. Introduction

Noise pollution is one of the environmental problems happening in urban areas (Gökrem & Altindaş, 2019). WHO reported in 1988 and delivered by the Directorate General of CDC and EH, Ministry of Health, Republic of Indonesia (1995), that 8 to 12 % of global citizens suffered from noise effects in many ways, and this number was estimated to increase in 2011 as many as 120 million (Ministerial Regulation, Number 13). Based on the survey conducted by the Ministry of Health, which collaborated with the Faculty of Medicine, Universitas Indonesia, toward 20,000 people in seven provinces, it was recorded that about 38 million Indonesian citizens' hearings were disturbed. Besides, it was about 16.8% of Indonesian citizens suffered from hearing impairment in 1996 (Ministerial Regulation Number 13).

Although it is invisible, noise pollution becomes as dangerous as other visible pollution. Urban planning that is irregular and does not pay more attention to the environment will give more increasing noise pollution effects as the communities' activities and lifestyles increase (Kuncoro et al., 2020; Warlina et al., 2023). Urban planning can decrease noise pollution effects, but it needs further studies to give appropriate solutions (Listyarini et al., 2022; Dursun et al., 2006; Singh & Davar, 2004; Hiron et al., 2022).

The activities of communities probably result in noise with different intensity levels (Monti et al., 2020; Alesheikh & Omidvari, 2010; Joshi, 2017). A sound that is too high probably disturbs human comfort and hearing (Sani & Beauty, 2019). Many diseases and disorders result from noise in terms of psychology, physiology, communication, and hearing (Arbaiya et al., 2019; Xu et al., 2020). For example, a sound that is too loud can make humans disturbed and unable to concentrate both in industrial and residential areas (Ozer et al., 2009; Oyedepo & Saadu, 2009; Sambas et al., 2022; Segura Garcia et al., 2017).

The problem of noise pollution in the environment must be solved immediately since it affects the balance between humans and the environment (Olayinka, 2012; Yilmaz & Ozer, 2005; Marques & Pitarma, 2020). We need to measure sound intensity levels. Measuring noise pollution level is a test to determine how much noise an activity. It uses a Sound Level Meter (SLM) with a Deci Bel (dB) unit that only measures the noise pollution level without giving any notifications to communities (Lu et al., 2019; Maisonneuve et al., 2010).

The limit of sound frequency able to be heard by human hearing is between 20 to 20,000 Hz. According to the Minister of Environment Number: Kep.48/MENLH/XI/1996 on November 25, 1996, the criteria of noise level limits for residential areas require the maximum noise level outdoors as much as 55 dB. The noise level limit occurs if the sound intensity exceeds 70 dB (Ministerial Regulation, 2013).

The purpose of innovation development is in terms of sound intensity measuring meter based on the Internet of Things (IoT). Internet of Things (IoT) is a computation concept about daily objects connecting to the internet and being able to identify themselves to other devices. Based on the RFID (Radio Frequency Identification) method, the term IoT belongs to the communication method. However, it also includes other sensory technologies and wireless or QR (Quick Response) code technology. It is expected that this device can determine noise pollution levels that will later become a consideration for the health of the surrounding environment. Besides, it also helps communities in delivering information about noise levels in terms of notification. As a result, an eco-friendly environment is created. This study aimed to develop a sound intensity measuring meter to determine noise pollution levels in three states, namely safe and noisy. It is planned to be applied in surrounding areas. The ability of this device is to measure sound intensity from 50 to 90 dB, displayed in terms of digital on LCD media.

2. Methods

The study was research and development/R&D or development research. It is simply defined as a research method that intentionally, systematically aims/directed to find, formulate, improve, develop, produce, and test the effectiveness of certain products, models, methods/ strategies/ techniques, and procedures which are more eminent, newer, more effective, more efficient, more productive, and more meaningful. The procedure of this study adopted the development of the 4-D model. The development research included 4 steps, namely define, design, develop, and disseminate. The instrument of data collection was used for field testing. The procedures for this study are displayed in Figure 1, and the score of the development assessment can be displayed in Table 1.

Besides, the criteria for developing product appropriateness and revision are presented in Table 2. The technique of descriptive statistical analysis was also employed to process the data in terms of pretest and posttest, so the level of developing product effectiveness was found, therefore, to know the increase of device quality. The descriptive statistical analysis used a t-test as the following.

$$t = \frac{\overline{D}-d_0}{sd/\sqrt{n}} \sim t(n-1)\ with\ D = X - Y$$

Where:

$\overline{\mathrm{D}}$ = mean of the difference between pretest and posttest
sd = deviation standard
n = subject in a sample

Normalizing gain score is an analysis technique to know the level of increase in student learning outcome. Normalized gain score, as proposed by Meltzer (2002), can be calculated using the following formula.

$$< g >= \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score}$$

Where g is normalized gain.

Table 1. Score of development assessment

Score	Description
4	Very precise/ appropriate/ complete/ good
3	Precise/ appropriate/ complete/ good
2	Less precise/ appropriate/ complete/ good
1	Not precise/ appropriate/ complete/ good

Table 2. Criteria for developing product appropriateness and revision

No	Rating Scale	Appropriateness Level	Product Revision
1	80 – 100%	Very appropriate	No. need revision
2	66 – 79%	Appropriate	No. need revision
3	56 – 65%	Less appropriate	Need revision
4	0 – 55%	Very inappropriate	Need revision

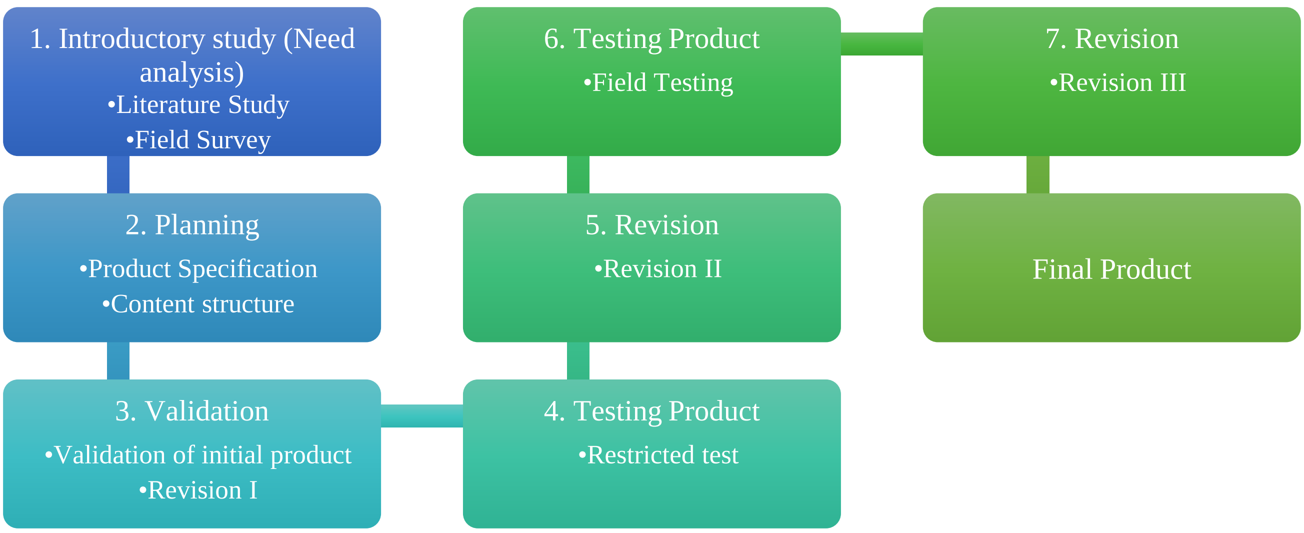

Fig. 1 Development procedures

In addition, the interpretation of the normalized gain score can be seen in Table 3.

Based on Table 3, the sound intensity measuring tool is said to be effective for determining the level of internet-based noise pollution (IoT) if the posttest and pretest results obtain an n-gain score > 0.3 with medium or high criteria.

3. Results and Discussion

3.1. System Development Method

3.1.1. Requirement Analysis

Analysis is identified as elaborating an intact system into parts of its components, aiming to identify the need for hardware and software. The need analysis for the system was conducted by analyzing the needs of inputs, outputs, hardware, and software.

The need for inputs was in terms of sound intensity and hardware input capacity data. The output was sound intensity with Deci Bel (dB) unit displayed in output devices such as LCD, LED, and Beep buzzer.

3.1.2. Design

Design was started by drawing a scheme of the circuits of the sound intensity measuring meter, as shown in Figure 2.

The initial step was a block diagram. In general, the block diagram of device planning is displayed in Figure 3.

Table 3. Interpretation of normalized gain score

Score <g>	Criteria
<g> ≥0.7	High
0.7 > <g> ≥0.3	Medium
<g> <0.3	Low

Table 4. Specification of hardware

No	Name of Component	Specification
1	Arduino	Wemos mega 2655
2	NodeMCU	ESP -12e
3	Wifi module	ESP8266
4	Sound sensor	Robotdyn
5	LCD Screen	I2C 16x2
6	LED	3 amp
7	Beep Buzzer	QQC Pas
8	Resistor	Min 100 ohm
9	Relay	Dual channel
10	Smartphone	All devices for Android
11	Breadboard	Standard
12	Cable	Male to Male, Male to Female

Table 5. Specification of software

No	Name of Component	Specification
1	Operation System	Microsoft Windows 10
2	Programming Language	C#
3	Data Basis	MySQL (Php MyAdmin)
4	Tools Case	IDE Arduino

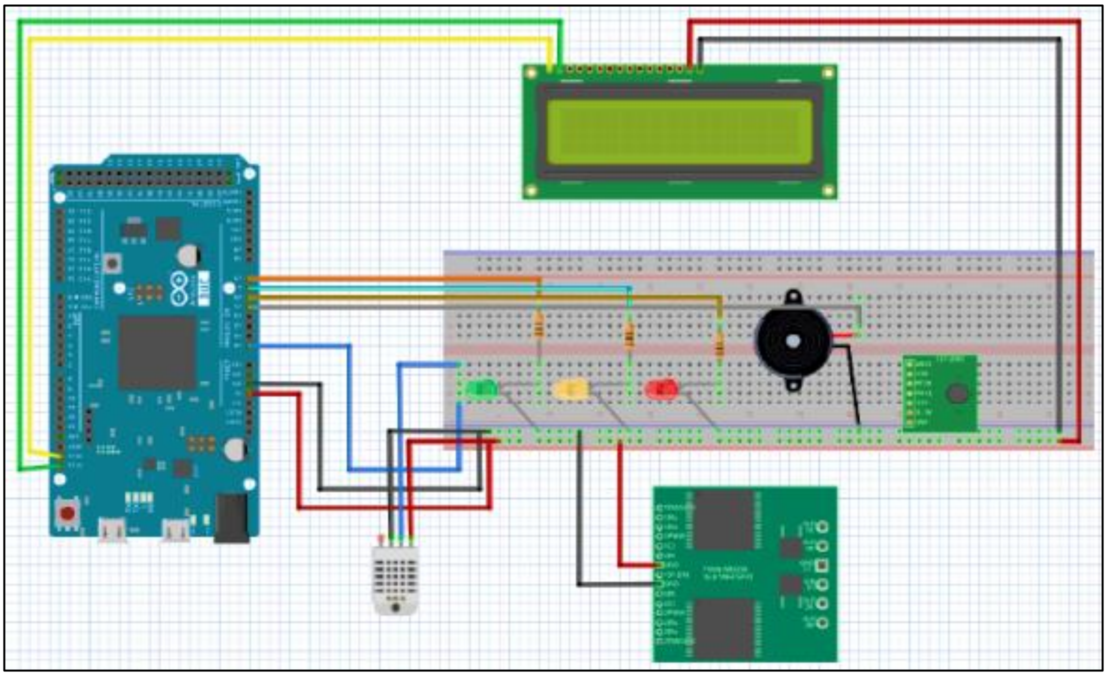

Fig. 2 Scheme of circuit

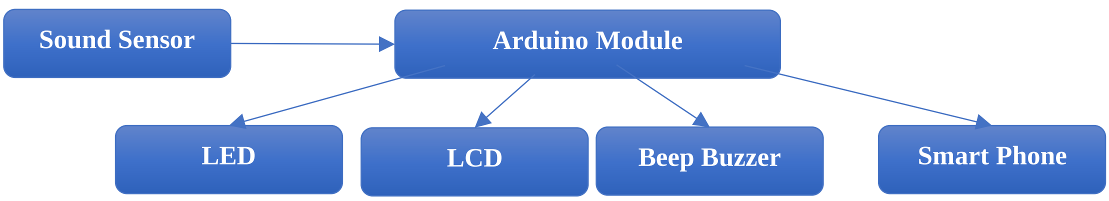

Fig. 3 Block diagram of device planning

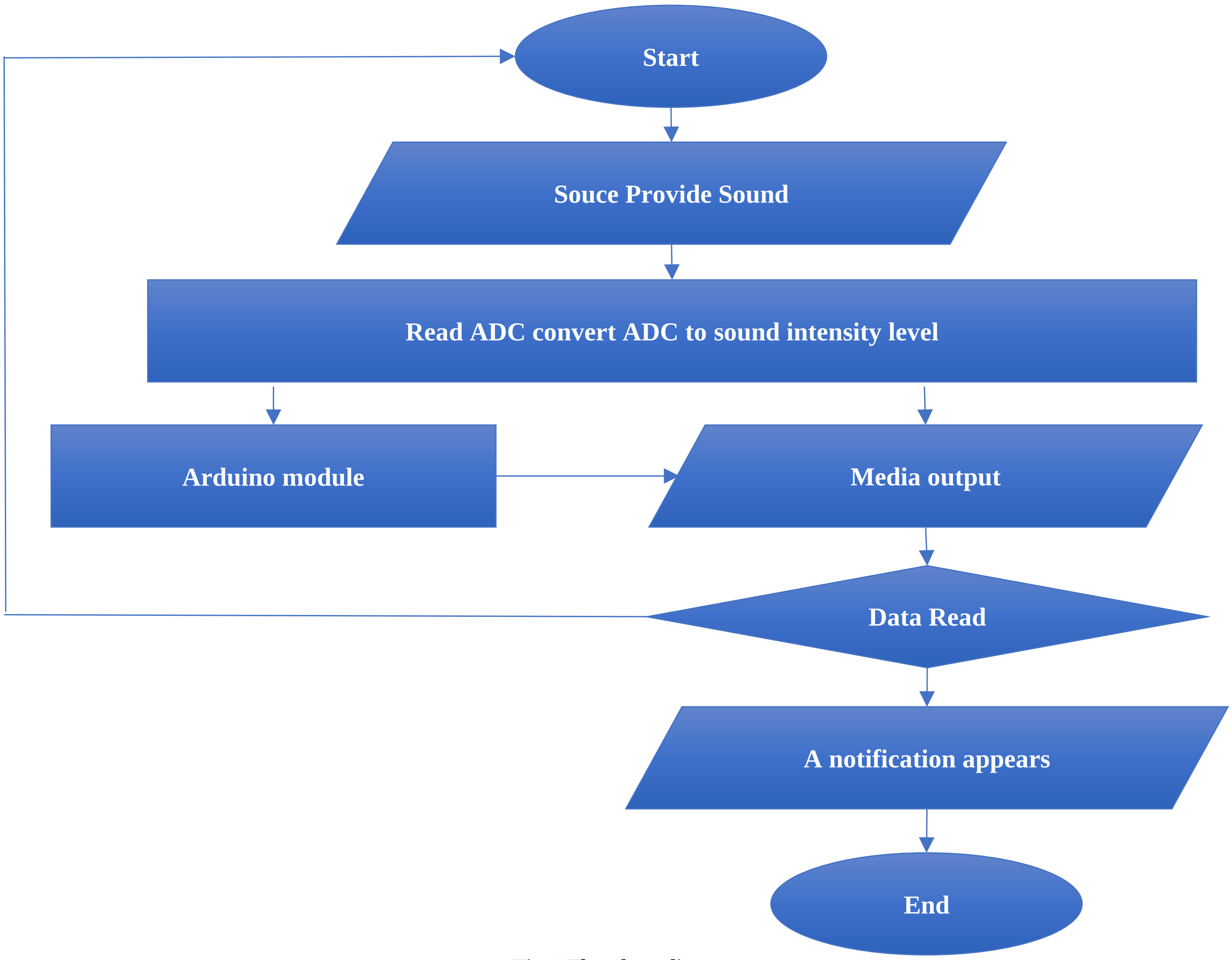

Fig. 4 Flowchart diagram

The next step was a flowchart, as displayed in Figure 4.

- Arduino is an open-source physical computing platform based on simple input/output (I/O) circuits and a development environment that implements a processing language (Trisnawan et al., 2019). Arduino can be used to develop standalone interactive objects or can be connected to software on a computer.
- LED or Light Emitting Diode is an electronic component that can emit monochromatic light when a voltage is applied with a forward bias.
- LCD is a type of display media that uses liquid crystals as the main display. LCDs have been used in various fields, for example, in electronic devices such as televisions, calculators, or computer screens.
- Beep buzzer is an electronic component whose function is to convert electrical vibrations into sound vibrations. Basically, the working principle of a buzzer is almost the same as a loudspeaker, so the buzzer also consists of a coil that is attached to a diaphragm, and then the coil is electrified so that it becomes an electromagnet; the coil will be attracted in or out, depending on the direction of the current and the polarity of the magnet, because the coil installed on the diaphragm, each movement of the coil will move the diaphragm back and forth, thereby creating air.

3.1.3. Building

The building step was to design and make a device. The device referred to the result of the design made. The steps in designing and making a device were the following.

Input Device Connection

- Prepare all input components needed regarding the need analysis result of hardware.
- Install Sound Sensor to Arduino. The sound sensor had 4 pins, namely Vcc, Gnd, A0, and D0 pins. The pins used and connected were only three, that are Vcc, Gnd, and A0.
- Connect the A0 pin to the I/O pin on Arduino using a jumper cable.
- Connect the Vcc pin to the Vcc 5Volt pin on Arduino.
- Connect the Gnd pin to the Gnd pin on Arduino.

Output Device Connection

- Prepare all output components needed based on the hardware needs analysis result.
- Install LED feet on breadboard.
- Connect all LED anode feet to input pins on Arduino.
- It was not allowed to connect LED anode feet using input pins on Arduino directly because it needs a medium in terms of resistor.

- Connect LED cathode feet to ground pins on Arduino.
- Connect Beep buzzer components to Arduino through the relay.
- Install Beep buzzer components by connecting the red cable to the Vcc connector on the relay and then the black cable on the Beep buzzer to the ground connector on the relay.
- Connect the relay to Arduino pins by connecting the Vcc pin on the relay to the Vcc pin on Arduino.
- Connect ground pins on the relay to ground pins on Arduino.
- Connect LCD device to Arduino. LCD pins connected to Arduino were Vcc, Gnd, sda, and scl pins.
- Connect the Vcc pin on the LCD to the Vcc 5Volt pin on Arduino.
- Connect the ground pin on the LCD to the ground pin on the Arduino.
- Connect the sda pin on the LCD to the sda pin on the Arduino.
- Connect the scl pin on the LCD to the scl pin on the Arduino.

Pairing Device

The next step was pairing Arduino, nodeMCU, and esp8266. The pairing process needed about 5 minutes, depending on the condition of those devices. This step was carried out manually by connecting three devices and configuring each button on those devices. The indicator that the pairing process was successful was that three devices turned on, as indicated by indicator lamps.

3.1.4. Coding

After conducting the design, the next step was coding. This step describes the script made using PHP (Hypertext Preprocessor) programming language to make an Android application and C# programming language to make a script uploaded to Arduino as its control function. There was a script of the connection process to the database, a script of the process of making the interface, and a script control system.

3.1.5. Integration

The integration step was a step to integrate noise pollution measuring meters based on the IoT concept. The ioT concept refers to the device being connected directly to a smartphone through a WiFi connection. Besides, the SSID and password of the WiFi being used were inputted into a script control in Arduino. In addition, integrating the device into an application utilized the following script.

```
#define BLYNK_PRINT Serial
#include <BlynkSimpleEsp8266.h>
char auth [] = "-ijI0QtpvYk3ofyXXdh4jct3OLMwhLEM";
```

3.1.6. Implementation

This step was to implement the result of planning into circuits and integrate it into the application made using PHP programming language (PHP: Hypertext preprocessor) and C# programming language. The sound intensity measuring meter consists of various electronic components combined with a microcontroller, which can control a condition automatically (See Figure 4 and Figure 5).

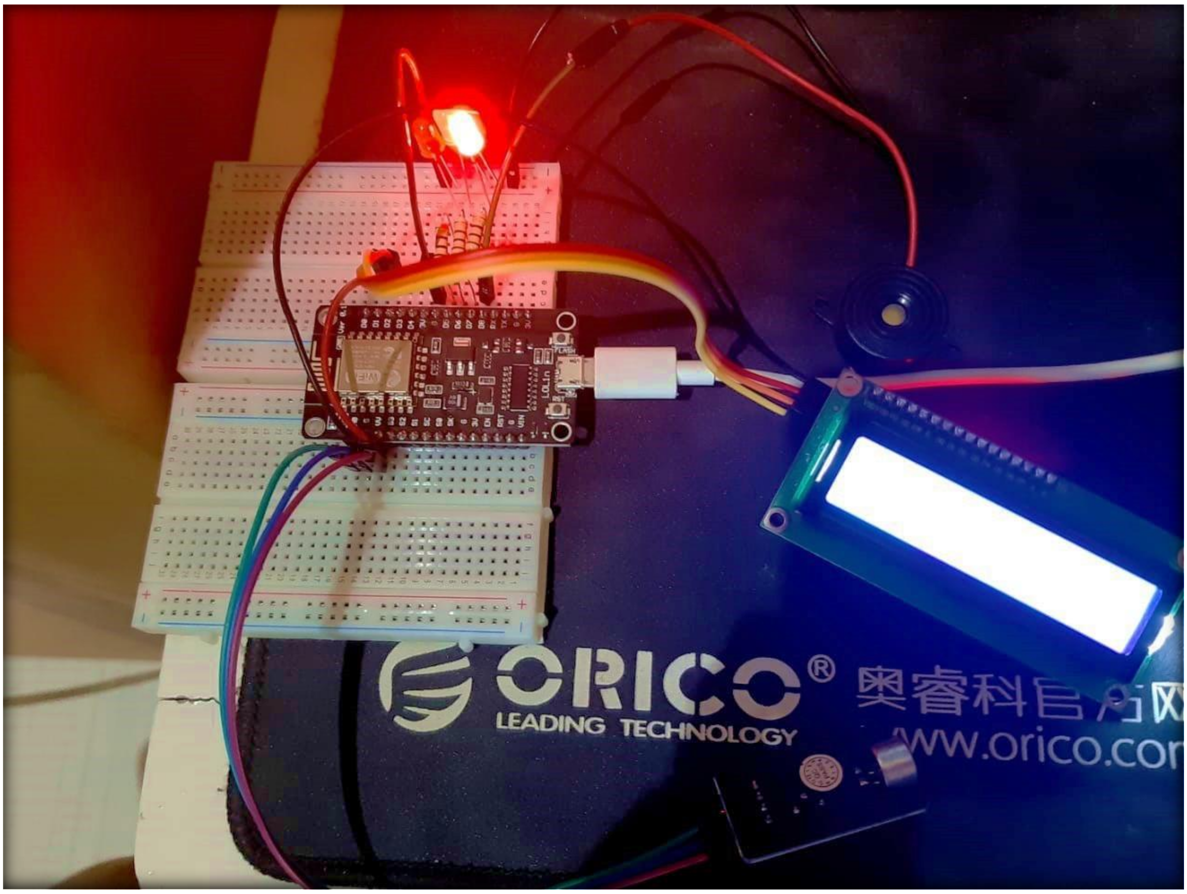

Fig. 5 Sound intensity measuring meter

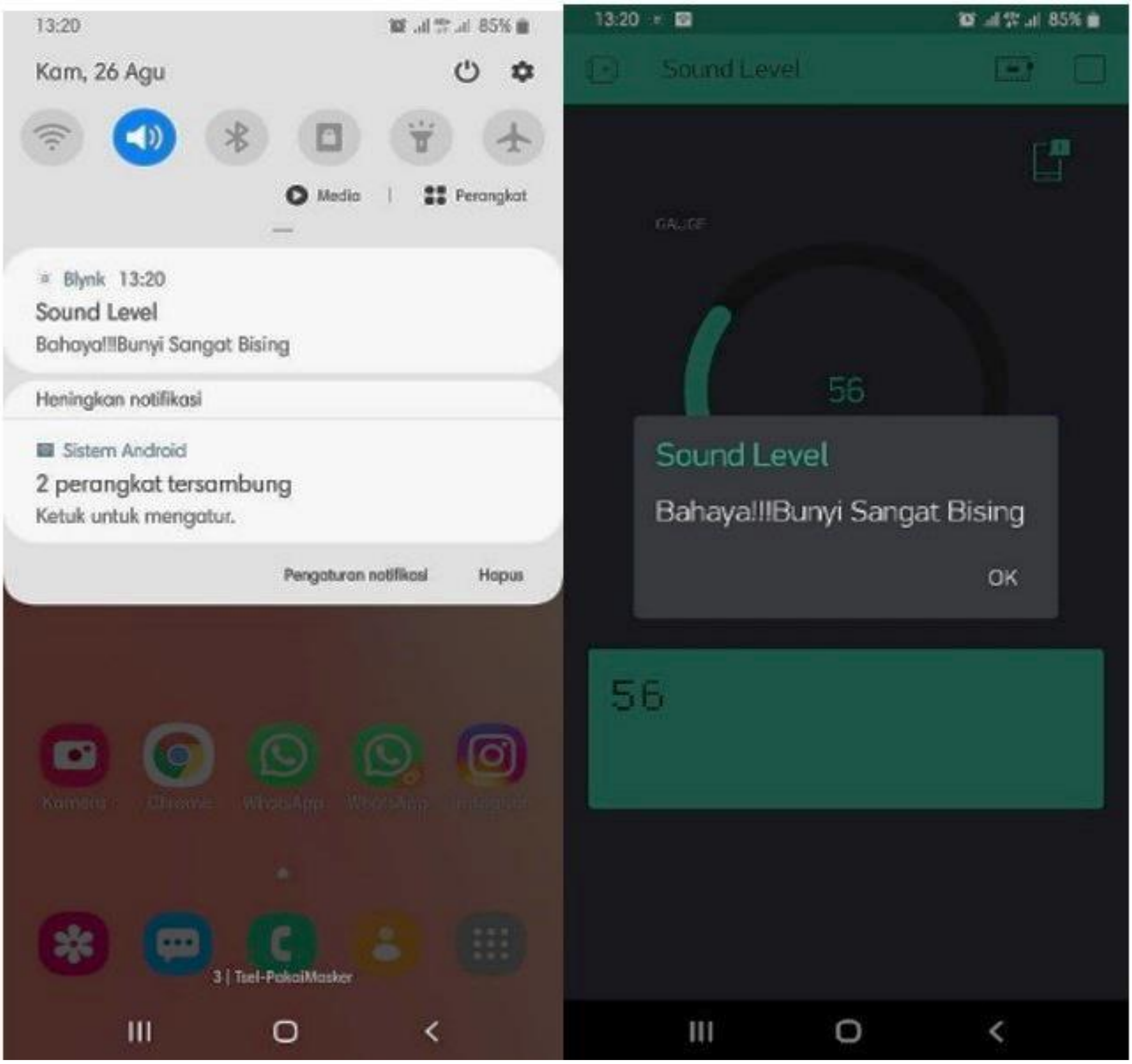

Fig. 6 Sound intensity measuring application

This sound intensity measuring application functions as an information receiver based on IoT. It will display a message when the sound intensity is high. Besides it also consists of a potentiometer that can display the real-time data of sound intensity (See Figure 6).

3.1.7. Testing

After the design and implementation steps, the next step was testing the system. It was conducted to clarify that all sub-systems in the system worked well in accordance with the system maker's will, which finally would fulfill its users' needs. The testing method was the Black-Box method.

Black box testing was conducted on the software interface to show that functions of the system worked well, dealing with the inputs being received well, the outputs being produced correctly as well, and integration from external data working well. The plan of testing described which processes would be tested items in the device and application had been finished. Table 6 shows that the item lists of testing are based on a process of adding output. Testing describes the method used for testing, namely black box testing. It was to find incorrect functions, interface errors, and errors in data structure. Table 7 shows the testing Table 7 shows that in the testing process, on the sound frequencies that appear, the program receives a response indicating a notification to the external device. Then, during the testing process, on a frequency that does not appear, the program rejects the response by indicating that the notification is not displayed.Table 8 explains the external component testing. In the testing process, there is sound intensity information; it is hoped that the sound intensity information will be displayed, and the test results show that the sound intensity information is displayed, which means that the program accepts it. In the testing process, there is no sound intensity information. It is expected that sound intensity information will not be displayed, and the tesresults show that sound intensity information is not displayed, which means the program rejects this.

Table 6. Testing plan

No.	Processing data	Testing conducted
1	Input component	Observation of data input validation.
2	Output component	Observation of data output validation.
3	Process component	Observation of data processing.
4	Application menu	Observation of application menu validation.

Table 7. Testing input component

No	Testing Process	Expected Result	Testing Result	Program Response
1	Frequency of sound that appears.	There are notifications to the output device.	Notifications are displayed.	(✓) Received ( ) Rejected
2	Frequency of sound that does not appear.	There is no. notification to the output device.	Notifications are not displayed.	( ) Received (✓) Rejected

Table 8. Testing output component

No	Testing Process	Expected Result	Testing Result	Program Response
1	There is information on sound intensity	The information of sound intensity is displayed.	The information of sound intensity is displayed.	(✓) Received ( ) Rejected
2	There is no information on sound intensity	The information of sound intensity is not displayed.	The information of sound intensity is not displayed.	( ) Received (✓) Rejected

Table 9. Testing process component

No	Testing Process	Expected Result	Testing Result	Program Response
1	Upload source code	Done uploading	Done uploading	(✓) Received ( ) Rejected

Table 10. Testing application menu

No	Testing Process	Expected Result	Testing Result	Program Response
1	Widget menu	Widget can be configured.	It appears in the menu display.	(✓) Received ( ) Rejected

Based on Table 9, the results show that in the process of uploading the source code, the expected results are in accordance with the results obtained, namely, the upload is complete and the program response is received.

Based on Table 10 shows that in the widget menu, the expected result of the widget can be configured, and it appears in the menu display; in this case, the program response is received.

3.1.8. Distribution

The last step of this system development method was distribution. This step could not be conducted thoroughly in connection to certain conditions and situations, so this step was only applied during testing time in designated places such as rice mills, railway stations, and so forth. Besides, the application can be downloaded from the Google Play Store.

This study succeeded in making the sound intensity measuring meter based on IoT. To fulfill the need of study referring to the research road map, the next step of research is planning to add a data logger and mapping concept. The data logger concept will give noise pollution level data within the specified time span, while the mapping concept will give mapping about locations where the device will be placed.

4. Conclusion

This research aims to develop a sound intensity measuring tool to determine the level of noise pollution based on the Internet of Things (IoT). Our finding shows the study succeeded in making a device to measure the level of noise pollution based on IoT. Arduino Uno microcontroller was used as a controller of the working system for the sound intensity measuring meter. This sound intensity measuring level can be monitored remotely using a smartphone on regarding IoT basis. In future research, we will propose the capabilities of the existing IoT-based sound intensity measuring tool by integrating machine learning techniques to classify and analyze noise patterns in real time. The study aims to enhance the current system's ability to not only measure noise levels but also identify and categorize different types of noise sources.

References

[1] Ali Asghar Alesheikh, and Manouchehr Omidvari, "Application of GIS in Urban Traffic Noise Pollution," *International Journal of Occupational Hygiene*, vol. 2, no. 2, pp. 79-84, 2010. [Google Scholar] [Publisher Link]

[2] Nureize Arbaiy et al., "The Construction Site Ambient Noise Monitoring System with Internet of Things (IoT)," *Computational Research Progress in Applied Science & Engineering*, vol. 5, no. 4, pp. 118-121, 2019. [Google Scholar] [Publisher Link]

[3] Şükrü Dursun et al., "Noise Pollution and Map of Konya city in Turkey," *Journal of International Environmental Application and Science*, vol. 1, no. 1-2, pp. 63-72, 2006. [Google Scholar] [Publisher Link]

[4] Levent Gökrem, and Müsemma Altindaş, "Environmental Noise Tracking System Based on Web of Things," *European Journal of Technique*, vol. 9, no. 2, pp. 175-185, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[5] Nurul Hiron et al., "Design of Hybrid (PV-diesel) System for Tourist Island in Karimunjawa Indonesia," *Energies*, vol. 14, no. 24, pp. 1-24, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[6] Lalit Mohan Joshi, "Research Paper on IoT based Air and Sound Pollution Monitoring System," *International Journal of Computer Applications*, vol. 178, no. 7, pp. 36-49, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[7] Aditiyo Hermawan Kuncoro et al., "Air Quality Monitoring System in the City of Tasikmalaya Based on the Internet of Things (IoT)," *Journal of Advance Research in Dynamical and Control Systems*, vol. 12, no. 2, pp. 2473-2479, 2020. [Google Scholar] [Publisher Link]

[8] Sri Listyarini, Lina Warlina, and Aceng Sambas, "The Air Quality Monitoring Tool Based on Internet of Things to Monitor Pollution Emissions Continuouly," *Environment and Ecology Research*, vol. 10, no. 6, pp. 824-829, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[9] Nicolasa Maisonneuve, Matthiasb Stevens, and Bartek Ochab, "Participatory Noise Pollution Monitoring using Mobile Phones," *Information Polity*, vol. 15, no. 1-2, pp. 51-71, 2010. [CrossRef] [Google Scholar] [Publisher Link]

[10] Gonçalo Marques, and Rui Pitarma, "A Real-Time Noise Monitoring System Based on Internet of Things for Enhanced Acoustic Comfort and Occupational Health," *IEEE Access*, vol. 8, pp. 139741-139755, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[11] Lorenzo Monti et al., "Raveguard: A Noise Monitoring Platform Using Low-End Microphones and Machine Learning," *Sensors*, vol. 20, no. 19, pp. 1-23, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[12] Juan Miguel Barrigón Morillas et al., "Noise Pollution and Urban Planning," *Current Pollution Reports*, vol. 4, no. 3, pp. 208-219, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[13] Chao Lu et al., "A Multi-Objective Cellular Grey Wolf Optimizer for Hybrid Flowshop Scheduling Problem Considering Noise Pollution," *Applied Soft Computing*, vol. 75, pp. 728-749, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[14] Oyedepo Sunday Olayinka, "Noise Pollution in Urban Areas: The Neglected Dimensions," *Environmental Research Journal*, vol. 6, no. 4, pp. 259-271, 2012. [Google Scholar] [Publisher Link]

[15] Olayinka S. Oyedepo, and Abdullahi A. Saadu, "A Comparative Study of Noise Pollution Levels in Some Selected Areas in Ilorin Metropolis, Nigeria," *Environmental Monitoring and Assessment*, vol. 158, pp. 155-167, 2009. [CrossRef] [Google Scholar] [Publisher Link]

[16] Serkan Ozer et al., "Evaluation of Noise Pollution Caused by Vehicles in the City of Tokat, Turkey," *Scientific Research and Essay*, vol. 4, no. 11, pp. 1205-1212, 2009. [Google Scholar] [Publisher Link]

[17] Aceng Sambas et al., "Investigation of Chaotic Behavior and Adaptive Type-2 Fuzzy Controller Approach for Permanent Magnet Synchronous Generator (PMSG) Wind Turbine System," *AIMS Mathematics*, vol. 8, no. 3, pp. 5670-5686, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[18] Sani Abba, and Beauty Ejiroghene Patrick, "Smart Framework for Environmental Pollution Monitoring and Control System Using Iot-Based Technology," *Sensors & Transducers*, vol. 229, no. 1, pp. 84-93, 2019. [Google Scholar] [Publisher Link]

[19] Jaume Segura Garcia et al., "Spatial Statistical Analysis of Urban Noise Data from a WASN Gathered by an Iot System: Application to a Small City," *Applied Sciences*, vol. 6, no. 12, pp. 1-14, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[20] Narendra Singh, and S.C. Davar, "Noise Pollution-Sources, Effects and Control," *Journal of Human Ecology*, vol. 16, no. 3, pp. 181-187, 2004. [CrossRef] [Google Scholar] [Publisher Link]

[21] Trisnawan et al., "Design of 4 Dof Robot ARM Based on Adaptive Neuro-Fuzzy (ANFIS) Using Vision in Detecting Color Objects," *International Journal of Recent Technology and Engineering*, vol. 8, no. 2, pp. 224-227, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[22] Chang Xu et al., "Study on Environmental Kuznets Curve for Noise Pollution: A Case of 111 Chinese Cities," *Sustainable Cities and Society*, vol. 63, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[23] Lina Warlina et al., "Particulate Matter Continuous Emission Monitoring System on Car Free Day Based on the Internet of Thing," *Environment and Ecology Research*, vol. 11, no. 6, pp. 942–948, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[24] Hasan Yilmaz, and Serkan Ozer, "Evaluation and Analysis of Environmental Noise Pollution in the City of Erzurum, Turkey," *International Journal of Environment and Pollution*, vol. 23, no. 4, pp. 438-448, 2005. [CrossRef] [Google Scholar] [Publisher Link]