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AIRTOR: A Portable Air Quality Monitor

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Abstract

Objectives: Detecting air pollutants is a key factor in combating the Air Pollution Phenomenon. This study focused on creating an innovative air quality monitor device with a mobile application that can track personal exposure to harmful air contaminants and harmful gases. **Method**: A specific System Development Life Cycle (SDLC) model was utilized in developing the system called Prototyping. This model iterates some phases before jumping to next phase. Furthermore, the system was developed through the integration of LCD display, dust sensor, gas sensor, temperature and humidity sensor, Bluetooth module, Arduino microcontroller and a mobile application. The device can display data readings independently that has a built-in Bluetooth sharing capability. This built-in sharing feature enables the device to share data to the android application the researcher developed independently. **Result**: To measure the over-all usability of the system, alpha and beta testing was conducted using International Business Machines (IBM) Computer Usability Scale. Results indicated a grand weighted mean of 4.93 and 4.81 respectively and both can be interpreted as highly usable. This results means the system adhered to the standard set by IBM in system development. **Recommendation**: Utilization of this device is highly recommended.

Keywords: Air Monitor, Air Pollution Sensor, Air Quality, Air Quality Monitor, Pollution Detector

1. Introduction

Air pollution is the world's largest environmental health risk, causing thousands of deaths according to figures released by the World Health Organization (WHO). Globally dubious particularly on rising nations, air pollution prevention starts at measuring air contaminants. Simple as it sounds, but this turned out to be extremely difficult. Currently there are orbiting satellites and ground-based sensors that are fixed, limited to provide up-to-date readings and low accuracy especially on rural communities. New innovations of smaller and cheaper sensors could change this situation around, enabling citizens and governments to access vast amount of measurement data.

Even highly modernized cities are having a hard time understanding this phenomenal pattern. Limited to traditional mode of air quality measurement, tracking daily exposure is not fully optimized. Satellites are used for standardized air quality data. This orbiting detector scans the Earth's surface and measure air contaminants.

Air pollution sensors are devices that detects and monitor the presence of air pollution in the surrounding area. Although there are various types of air pollution sensors, some are specialized in certain aspects; the majority focuses on five components: ozone, particulate matter, carbon monoxide, sulphur dioxide and nitrous oxide. These sensors are costly in the past, but advancement in technology paved the affordability and accessibility of this

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sensors opening the understanding of our environmental issues beyond the limitation of what human can see.

According to Yoo (2011)[1], air pollution caused by exhaust gases from automobiles are nitrogen oxide, NO_x (NO and NO_2) and carbon monoxide (CO). He also defined gas sensor as a device that can substitute for human olfaction, and that converts a physical phenomenon into an electrical signal. According to him researches are being conducted to monitor air pollution by using this gas sensor the 1st decade of the 21st century has been related by some as the "Sensor Decade".

Personal monitoring helps researchers better understand the relationship between specific gaseous air pollutants and human health based on activity pattern and personal exposure[2].

Accessibility of satellites is not for everyone, for every nation for that matter. Besides, data gathered from this technology are prone to miscalculations: cloudy skies and reflecting ice and snow can mess data readings. Baseline measurement is accurate but not on real-time gauging of local pollution[3].

Facing these problems, the researcher created a Portable Air Quality Monitor to help localized tracking of air quality data. Thus, helping the government sectors to create necessary measures in preventing air pollution. Accurate data provide help to assess and map the cause and effect of air contaminants to the health of the community.

2. Objectives

This study is focused on creating an innovative air quality monitoring device that can be used by everyone in support on RA-8749 otherwise known as Philippine Clean Air Act.

Specifically, this study aimed to achieve the following objectives:

1. Develop a portable air quality monitor device that;
   a) Detects combustible gas such as Liquefied Petroleum Gas (LPG), Carbon Monoxide (CO), dust particles such as Particulate Matter (PM10 and PM2.5), temperature and relative humidity.
   b) Display and share gathered data.

2. Develop a mobile application that can display and store the portable device data remotely via Bluetooth Technology.

3. Evaluate the developed products using IBM Computer System Usability Scale.

3. Scope and Limitations

3.1 Scope

The study has the following scope:

1. The portable device has the capability of detecting harmful air contaminants such as PM10, PM2.5, CO in a given area.

2. It can detect combustible gas such as LPG on a particular area.

3. It can monitor temperature and relative humidity.

4. It can display real time readings and wirelessly broadcast it to an android device via Bluetooth technology.

3.2 Limitations

The study has the following limitations:

1. Can detect limited number of gas types and air contaminants.

2. Wireless data sharing is limited only on module range.

3. Duration of operability is limited on battery life.

4. No shock proof and waterproof features.

4. Methodology

4.1 Software Development Model

The researcher utilized a System Development Life Cycle (SDLC) model called prototype in developing the system. This model guide the researcher in developing the device, it includes iteration of some phases. Planning, designing, coding and testing are the major phases of this model.

Figure 1 shows prototype development process model to tackle the proper project integration. Reseacher always looks for a part that need to be developed based on surrounding.

4.2 System Architecture

This illustrates the interconnection of the process of the system.

4.3 Evaluation

This phase discusses how the system has been demonstrated, tested and evaluated by experts and its intended users.

4.4 Research Design

This study has been subjected to an evaluation testing. The researcher used developmental-evaluated design to test the system acceptability.

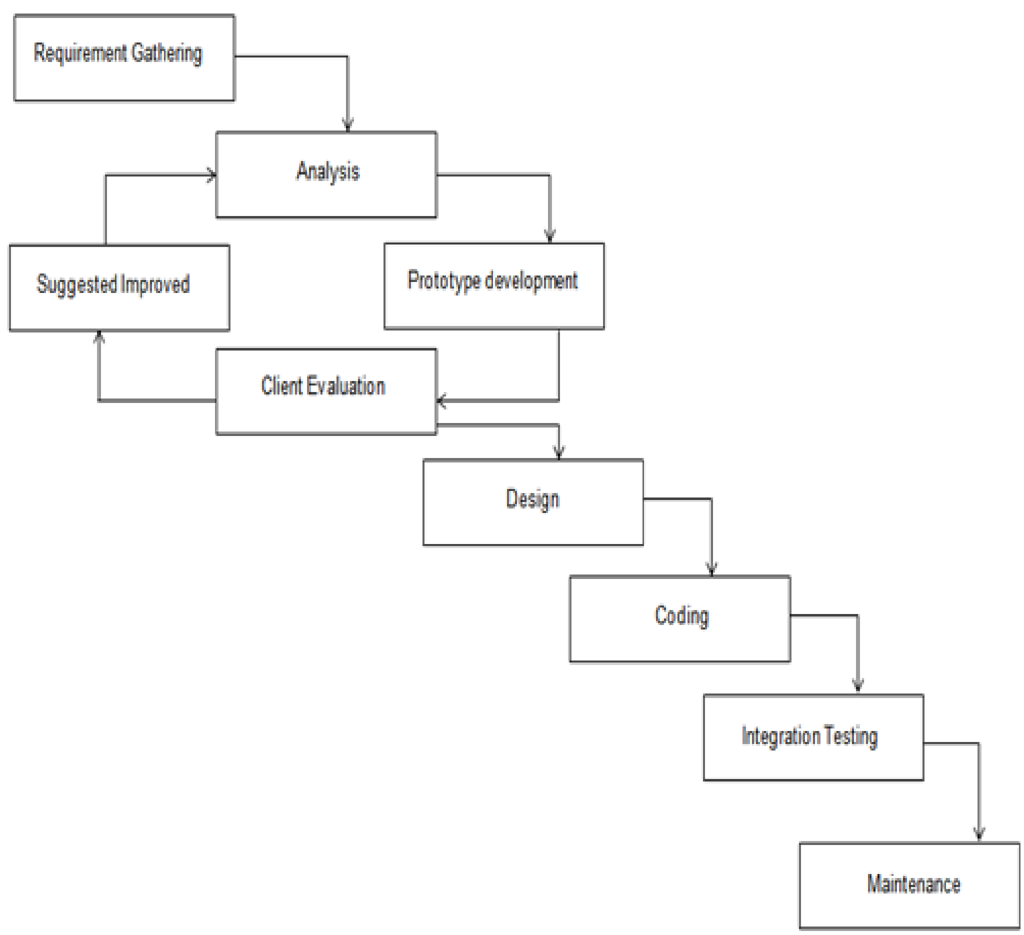

Figure 1. Evolutionary prototyping model.

4.5 Instrumentation

The system was evaluated using a Software Quality Evaluation Tool based on IBM Computer-System Usability Scale. It is consisting of questions that measure the user satisfaction with system usability. Questionnaires for system testing have been given to the respondents for the evaluation of the system.

4.6 Mean

This is the average of the scores – the mathematical center of a distribution. It used symmetrical, unimodal distributions of interval or ration scores. The formula for mean is:

$$\overline{x} = \frac{\Sigma x}{n}$$

Where:

Σx = sum of all scores

n = number of questions/Items

4.7 Coding Scheme

The respondents evaluated the system using the following scale:

5 – Strongly Agree
4 – Agree
3 – Neither Agree or Disagree
2 – Disagree
1 – Strongly Disagree

The obtained mean was interpreted using the following:

4.8 Numerical Rating Scale Adjectival Rating

5.00 – 4.20	Highly Usable
4.19 – 3.40	Usable
3.39 – 2.60	Moderately Usable
2.59 – 1.80	Moderately Unusable
1.79 – 1.00	Highly Unusable

4.9 Unit Testing

The system has undergone series of tests to determine its usability, efficiency and benefits to the user. The device and mobile application has been tested by two types of users, experts in the field of Information Technology for alpha testing and end-users for the beta test.

4.10 System Testing (Alpha Test)

The system has been tested by selected individual who has expertise in similar or related projects or in the field of Information Technology.

4.11 Acceptance Testing (Beta Test)

In this phase, the end-users were given the chance to test and confirm the usability of the system. Possible user was the subject of this test. This phase determined the system completeness and readiness for a full-scale implementation.

4.12 Output and User Interface (GUI)

Figure 2 shows the Graphical User Interface and the functionalities of the Portable Air Quality Monitor. Figure 3 shows the working portable device displaying relative humidity data. The data is collected from the DHT-11 temperature and humidity sensor integrated in the device. Figure 4 shows the working portable device displaying heat index data. The data is collected from the DHT-11 temperature and humidity sensor integrated in the device. Figure 5 shows the LPG count detected by the device. Figure 6 shows the working portable device displaying Carbon Monoxide data reading via PPM. The data is generated from the MQ-2 gas sensor integrated in the device. Figure 7 shows the working portable device displaying PM 10 data reading by PPM. The data is generated from the dust sensor integrated in the device (front-left). Figure 8 shows the working portable device displaying PM 2.5 data count by PPM. The data is generated from the dust sensor integrated in the device (front-left). Figure 9 shows the mobile application in action displaying the List Picker User Interface. This display is the starting point of the

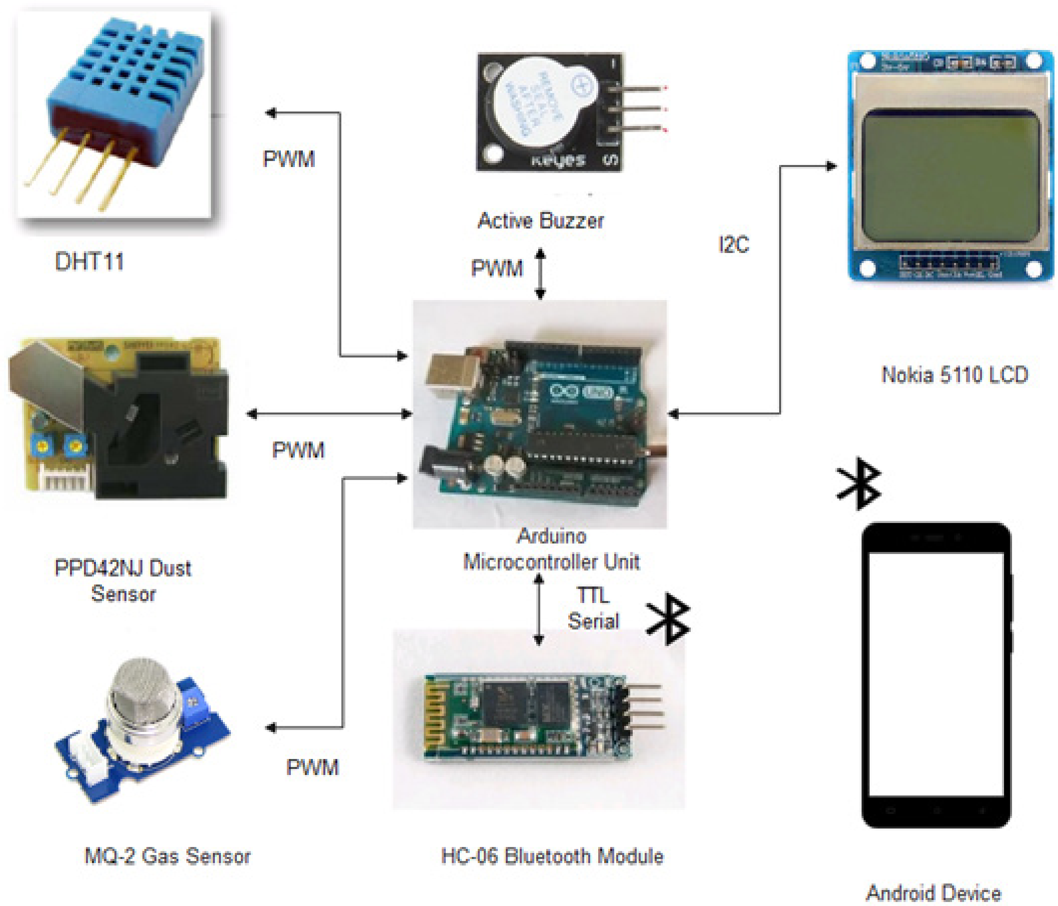

Figure 2. System architecture.

Figure 3. Portable air quality monitor (humidity).

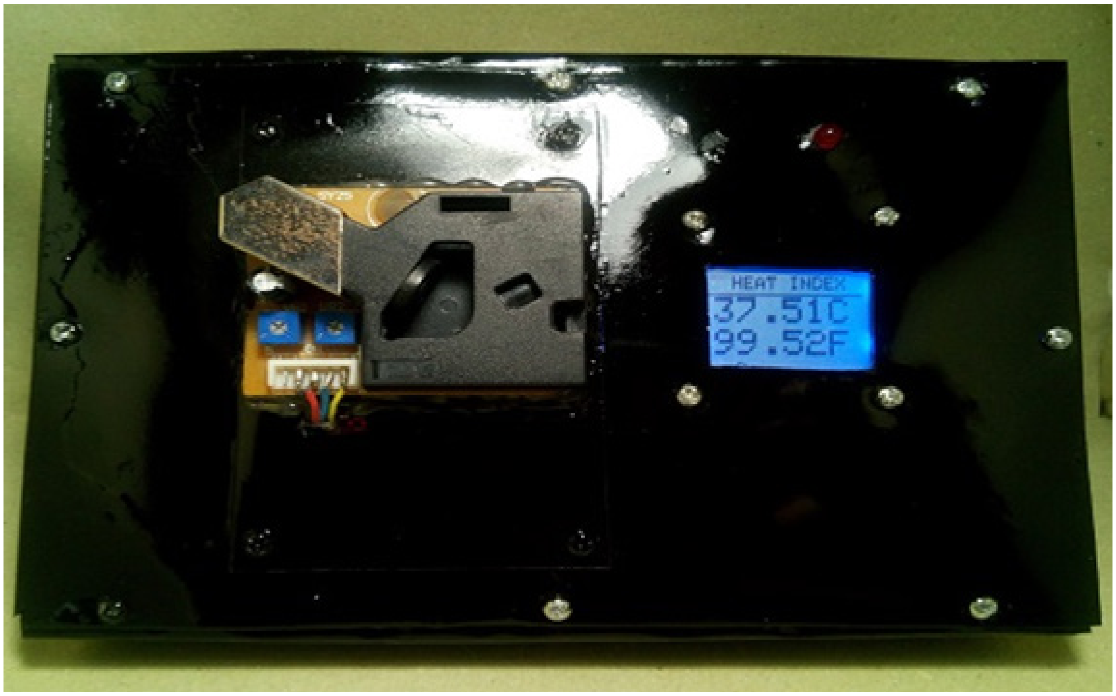

Figure 4. Portable air quality monitor (heat index).

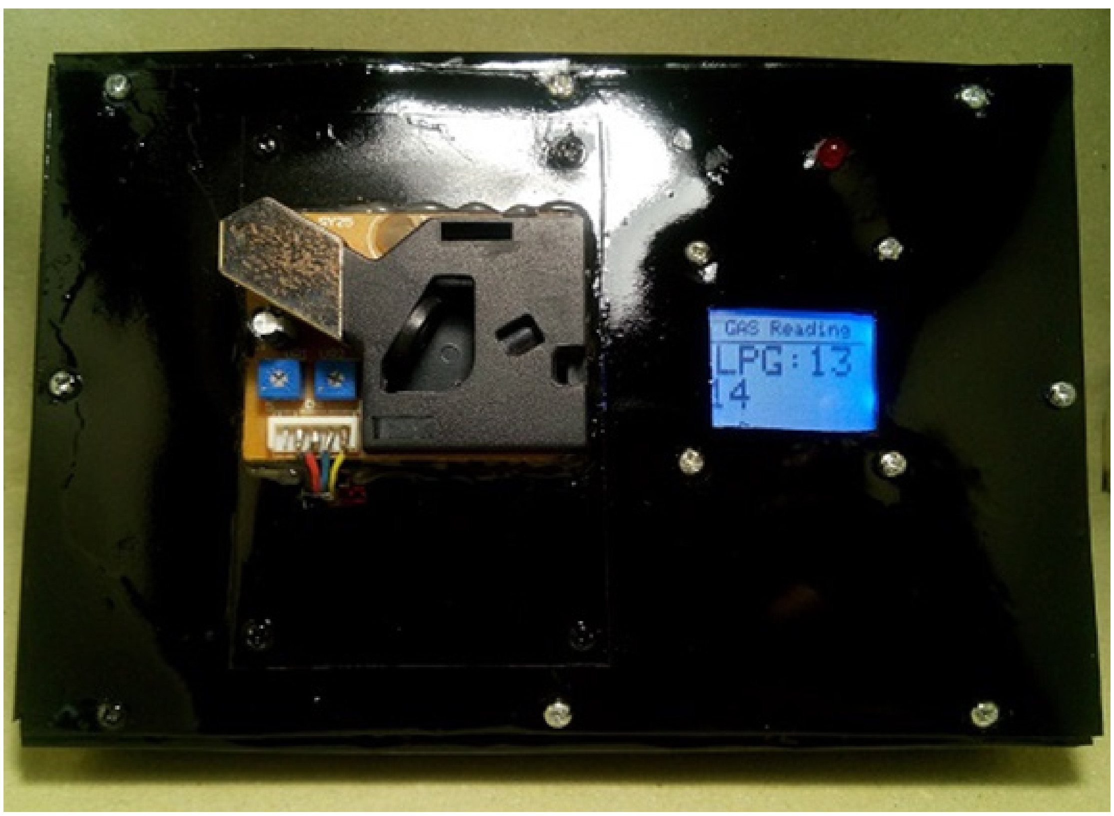

Figure 5. Portable air quality monitor (LPG count).

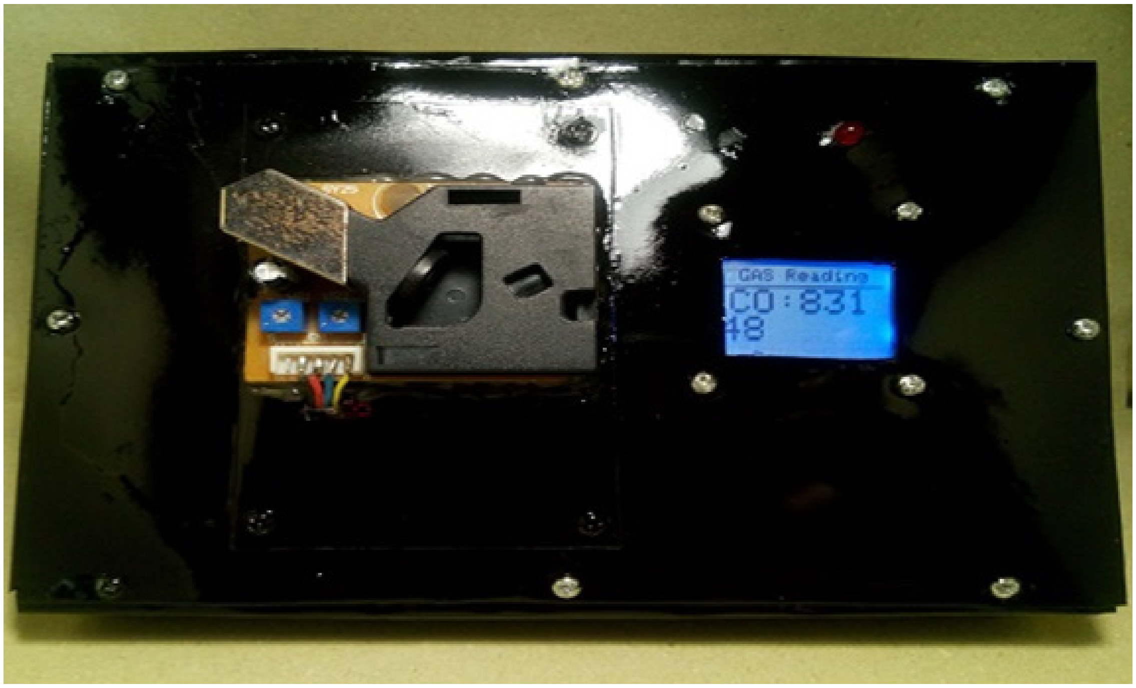

Figure 6. Portable air quality monitor (CO count).

Figure 7. Portable air quality monitor (PM10 count).

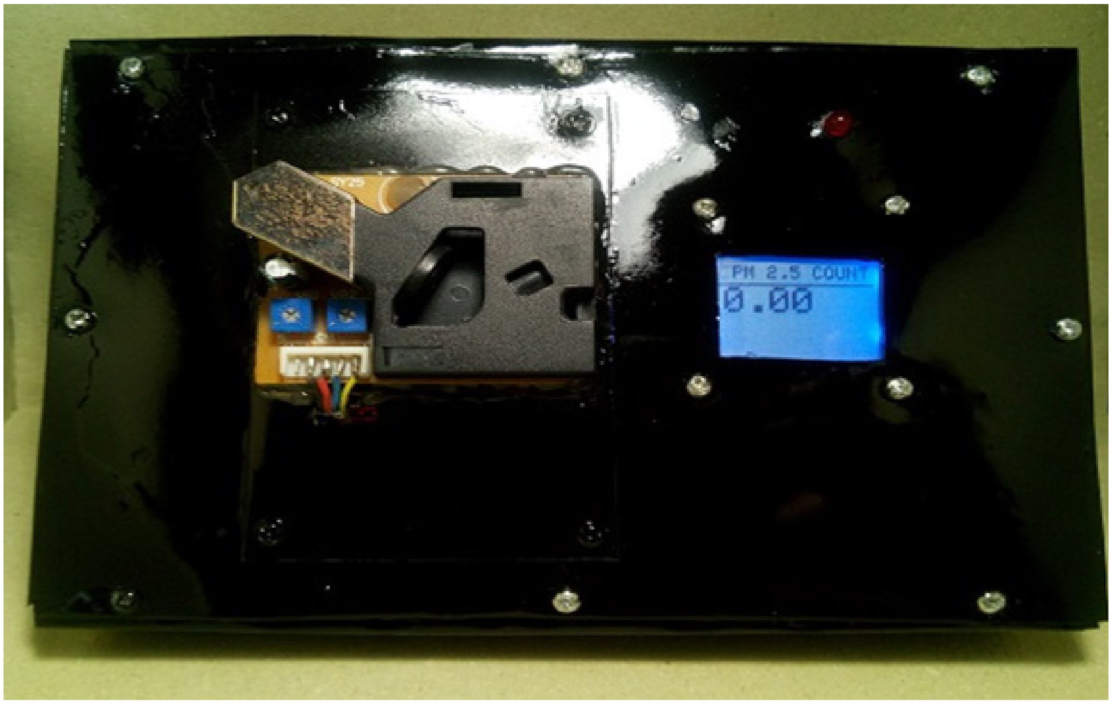

Figure 8. Portable air quality monitor (PM2.5 count).

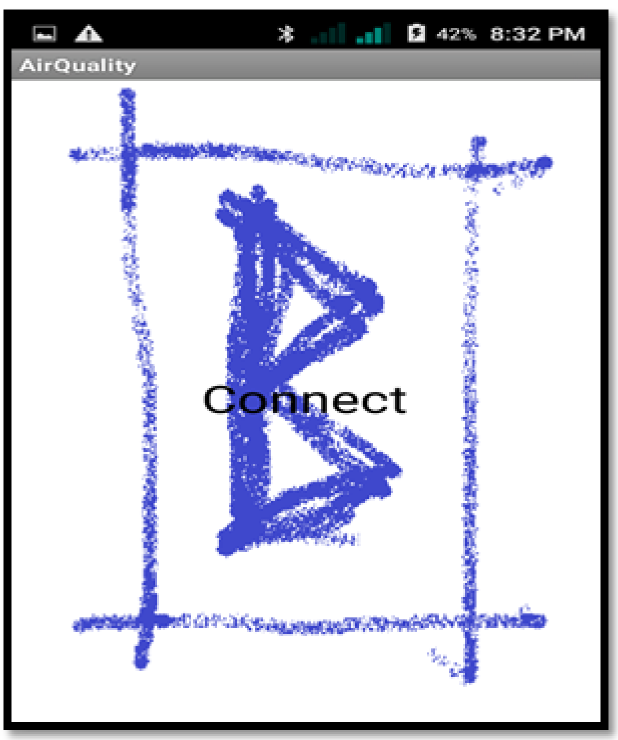

Figure 9. Air quality monitor mobile application (list picker).

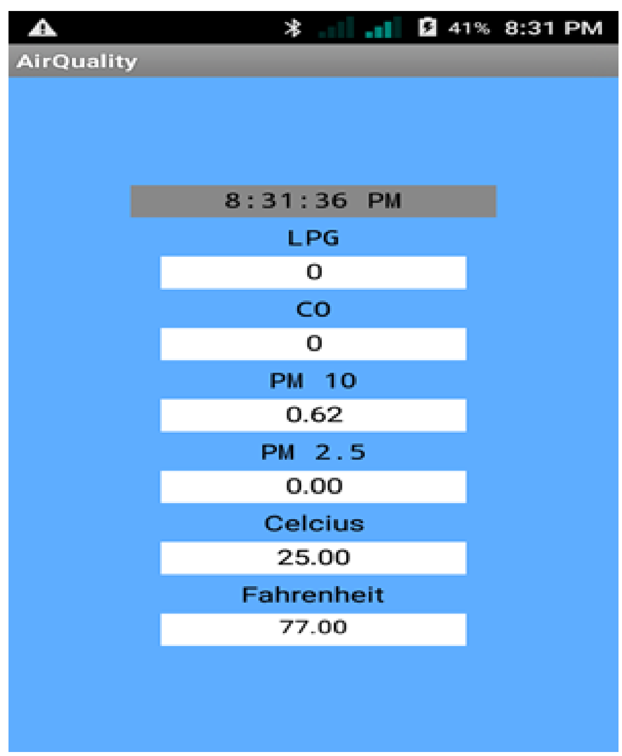

Figure 10. Air quality monitor mobile application (main form).

Table 1. Weighted mean and interpretation (expert testing)

QUESTION	WEIGHTED MEAN	ADJECTIVAL INTERPRETATION
Overall, I am satisfied with how easy it is to use this system	5.0	Highly Usable
Overall, I am satisfied with how easy it is to use this system	5.0	Highly Usable
I can effectively complete the tasks using this system	4.6	Highly Usable
I am able to complete my work quickly using this system	5.0	Highly Usable
I feel comfortable using this system	4.6	Highly Usable
It was easy to learn to use this system	5.0	Highly Usable
Whenever I make a mistake using the system, I recover easily and quickly	5.0	Highly Usable
The organization of information on the system screens is clear	5.0	Highly Usable
The interface of this system is pleasant	5.0	Highly Usable
I like using the interface of this system	5.0	Highly Usable
Overall, I am satisfied with how easy it is to use this system	5.0	Highly Usable
GRAND MEAN	4.93	Highly Usable

mobile application. Figure 10 shows the mobile application in action displaying the Main Form User Interface. The data gathered by the portable air Monitor device is displayed in real time.

5. Results and Discussion

From the five (5) experts and fifteen (15) end-users who evaluated the system, this section presents the result of the system testing and evaluation to determine the usability using the Software Quality Evaluation Tool based on IBM Computer-System Usability Scale.

Table 1 shows the grand mean of 4.93 interpreted as highly usable. It can be inferred that majority of the experts rated five (5), while one expert gave 4.6. These results show that the system is following standard based on its usability. With the over-all result of 4.93 interpreted as Highly Usable, the system adhered to the IBM standard.

Table 2 revealed the overall mean of 4.81 interpreted as highly usable. Based on this result, the system has passed the IBM standard on system usability. In addition, the results obtained imply that all the users highly appreciate the device and the mobile application.

Table 2. Weighted mean and interpretation (end-user testing)

QUESTION	WEIGHTED MEAN	ADJECTIVAL INTERPRETATION
Overall, I am satisfied with how easy it is to use this system	5.0	Highly Usable
Overall, I am satisfied with how easy it is to use this system	5.0	Highly Usable
I can effectively complete the tasks using this system	3.87	Highly Usable
I am able to complete my work quickly using this system	4.8	Highly Usable
I feel comfortable using this system	4.4	Highly Usable
It was easy to learn to use this system	4.93	Highly Usable
Whenever I make a mistake using the system, I recover easily and quickly	5.0	Highly Usable
The organization of information on the system screens is clear	4.87	Highly Usable
The interface of this system is pleasant	5.0	Highly Usable
I like using the interface of this system	5.0	Highly Usable
Overall, I am satisfied with how easy it is to use this system	5.0	Highly Usable
GRAND MEAN	4.81	Highly Usable

6. Conclusion and Recommendation

A portable air quality monitor device has been developed. With features that can detect combustible gas and dust particles along with temperature and relative humidity. It can also monitor and share data. It also includes a mobile application that can display and store data via Bluetooth technology. The expert testing resulted to a grand mean of 4.93 interpreted as highly usable system while the end-user testing resulted to a grand mean of 4.81 interpreted as highly usable. Based on the overall results, it shows that the system has passed the Software Quality Evaluation Tool test using the IBM Computer-System Usability Scale.

It is recommended to use a more advance wireless connectivity module such as a Wi-Fi module for a one-to-many connection of device and mobile application. The android application should have a graphing functionality for the interpretation of the received data to make it easier for the user to understand the given result.

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