***TECHNOVAIR*: ARDUINO-BASED AUTOMATED AIR FILTRATION, INDOOR AIR QUALITY MONITORING, AND NOTIFICATION SYSTEM**

A Capstone Research Project Presented to

The Senior High School Department

Malayan Colleges Mindanao

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In Partial Fulfillment
Of the Requirements for the
STEM 9 Capstone Research Course

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Republic of the Philippines
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Declaration of Originality

We, **ALLIAH ANGEL M. BALIO, ANGELA COLEEN M. ACEBEDO, ROBBIE AL C. ANDAYA, RANIA A. ANGAS, MIKAELA KATE M. BANAAG, NEIL ANDREW PUSO,** and **JOSH ALEC M. MORATA**, declare that this research is original to the best of our knowledge. We declare further that this activity was undertaken by us.

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MAY 2022
APPROVAL SHEET

This research paper entitled, **"*TECHNOVAIR*: ARDUINO-BASED AUTOMATED AIR FILTRATION, INDOOR AIR QUALITY MONITORING, AND NOTIFICATION SYSTEM,"** prepared and submitted by **ALLIAH ANGEL M. BALIO, ANGELA COLEEN M. ACEBEDO, ROBBIE AL C. ANDAYA, RANIA A. ANGAS, MIKAELA KATE M. BANAAG, NEIL ANDREW PUSO,** and **JOSH ALEC M. MORATA**, in partial fulfillment of the requirements for the subject STEM9: Capstone Research Project, has been examined and is, hereby, recommended for the corresponding oral presentation, approval, and acceptance.

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ACKNOWLEDGMENT

The completion of this undertaking could not have been possible without the participation and assistance of so many people whose names may not all be enumerated. Their contributions are sincerely appreciated and gratefully acknowledged. However, the group would like to express their deep appreciation and indebtedness, particularly to the following:

To Mr. Marjhuvyn B. Lapiras, their Capstone teacher, and Ms. Cielo Batingal, their Inquiries, Investigations, and Immersion teacher, for their support and words of encouragement and also for giving them a long time to craft this manuscript;

To Mr. Raffy S. Centeno, their capstone adviser, for his support, advice, guidance, valuable comments, suggestions, and provision that benefited the researchers much in the completion and success of this study;

To Engr. Kenny Walter C. Diolola, their project expert, for extending his knowledge in the field and electronics and engineering. His timely suggestions with kindness, enthusiasm, and dynamism have motivated the researchers to continue their research pursuit;

To Malayan Colleges Mindanao teaching and non-teaching staff, any project would not be successful if it did not rely on the reference material. In this context, the researchers would wish to express a profound sense of gratitude to them for giving them a supportive environment throughout the whole school year.

To Mr. Rommel G. Acebedo and Mrs. Louchelle Fatima M. Acebedo, Mr. Robert B. Andaya and Mrs. Alma C. Andaya, Mr. Musib G. Angas and Mrs. Lukaya A. Angas, Mr. Alfonso S. Balio Jr. and Mrs. Marjury M. Balio, Ms. Michelle M. Banaag, Mr. Alexander T. Morata and Mrs.Fely M. Morata, Mr. Sang Gil Park and Ms. Bevelyn J. Puso, and others who, in one way or another, shared their endless support, kind and understanding spirit throughout the manuscript making process;

And finally, all praises for the Great Almighty, the author of knowledge and wisdom, for his countless love, for letting them through all the difficulties, and for experiencing His guidance day by day. He is always there to support the researchers and strengthen their faith when hardships occur, and problems arise during the preparation of the research paper.

We, the researchers, thank you.

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CHAPTER 1

INTRODUCTION

Background of the Study

Smart-Air, an IoT-based indoor air quality monitoring platform, was developed to counter the growing concern of consuming air pollutants indoors (Jo et al., 2020). Since an infectious disease, COVID-19, has forced everyone to stay within their homes, ensuring the cleanliness of the indoor air quality (IAQ) is now imperative (Agarwal et al., 2021). With that, proper ventilation and filtration can decrease harmful air particles. This device, developed in 2020, incorporates multiple sensing devices, such as a laser dust sensor, Volatile Organic Compounds (VOCs) sensor, carbon monoxide sensor, carbon dioxide sensor, and a temperature and humidity sensor, which are programmed to forward the collected data to the server used, the Amazon Web Services (AWS).

However, air purifiers and air filtration systems, in general, that run for 24 hours a day can consume up to 450 kilowatts a year and thus are extensive in using electricity (Energy Star, 2018). Another problem with some air filtering systems, known as ionizers, is that they generate ozone, which can aid in particle removal, but the ozone is actively harmful to the user’s health (Yoda et al., 2020). Furthermore, although the operating costs of the air purifiers today are low, the initial purchase of the system is high-priced, and the usual system available on the market is not a portable device, resulting in the lack of indoor air quality monitoring systems in households (Liu et al., 2021).

In the global context, a study presented by the Maharashtra Institute of Technology from India introduced an air purification system intended to improve indoor air quality within small public spaces and apartments. To lessen the dangers brought by air pollutants, the invention is equipped with basic sensors, filters (dust filter, pre-filter, and fine filter), and an air monitoring system, all controlled by a microcontroller of the Arduino Uno Series (Panicker et al., 2020). However, the system's main limitation is its incapability to have a decent notification system as the system Is only equipped with a Liquid Crystal Display (LCD) informing the user about the air parameters and the quality of air being purified.

In addition, in the national setting, a device invented by Polytechnic University of the Philippines students used the microcontroller Arduino Mega 2560 with its specialized gas and dust sensor systems. As one of the most prevalent concerns of the Philippines, air pollution was chosen as the subject of study by the researchers. They utilized low-cost sensors to develop a portable Air Quality Monitoring System to identify various air pollutants. This prototype was then tested in Tagaytay City because of the Taal Volcano's recent eruption (Balatbat et al., 2021). Regardless of how advanced the system is, it could still be incorporated with a filtering system through different filters available in the market and an enhanced notification system aside from using LCD to allow real-time monitoring to the users. Also, the device should be tested indoors and not just the Air Quality Index (AQI) outdoors for everyone's air quality and environment safeguard and health protection.

In the local setting, a study conducted by the Mindanao State University – Iligan Institute of Technology introduced and tested an Arduino-based air quality testing, air filtering, and disinfecting device, initially aimed at addressing the air pollutants within hospital rooms that are necessary to filter and disinfect regularly. The invention comprises an Arduino Uno Board, multiple filters, sensors, and a UV lamp, which are tested to be of ideal use in these spaces (Positos et al., 2017). However, this project can still be improved, built with low-cost materials to meet market demand, and can be used by everyone, especially those living in densely populated areas where constant monitoring will provide them with knowledge about environmental changes and an understanding of the proper management control of particulate pollution in the environment.

Looking at these contexts in different settings, it is evident how current research in this field of study needs to be further explored. Hence, this project is designed to develop a portable automated air filtration and monitoring system, which calibrates the IAQ, filters out the pollutants, and maintains a healthy air quality level to avoid the intake of contaminated air. TECHNOVAIR will feature multiple sensors, such as the PMS5003 fine particulate matter (PM) Air Quality Sensor that detects PM1, PM2.5, and PM10 dust concentrations, MQ131 Gas Ozone Detection Sensor for ozone (O_3) concentration identification, and SGP30 Multi-Pixel Gas Sensor for VOCs and equivalent carbon dioxide reading that will be utilizing Arduino Mega to reduce the amount of energy required through mechanization.

As for the filtration of criteria pollutants, the device will be integrating a High-Efficiency Particulate Air (HEPA) filter, Activated Carbon Filter, and Pre-filter. Lastly, the device will include a monitoring and notification system that sends updates to the user through a phone and personal computer application. This system will base its air quality indices (attached as Appendix A, B, and C) on the data provided by the Philippine Clean Air Act of 1999 (as cited in "Philippine Clean Air Act of 1999, Republic Act No. 8749," 2022) and US Environmental Protection Agency (as cited in Breen et al., 2010).

Through this device, not only can the users avoid any airborne disease, but they can also improve their indoor living by guaranteeing the cleanliness of the air they breathe.

Project Objectives

This research project study aims to achieve the following objectives at the end of the course:

1. To design an automated air filtration and monitoring system that notifies its user about the particulate matter level, ozone gas concentration, VOCs, and equivalent carbon dioxide utilizing Arduino software.
2. To test the automated air filtration and monitoring system unit in terms of its:
    a. Functionality
    b. Usability

   c. Reliability
   d. Performance
   e. Supportability
3. To decrease pollutants in the air using a project with less required energy consumption through automation and inform individuals regarding the households' IAQ condition.

Significance of the Study

The project will provide an understanding of Indoor Air Quality (IAQ) monitoring while highlighting significant knowledge gaps for future studies. In particular, the study holds its importance as a benefit for the following:

Household Members. Air filters can decrease indoor air pollution and further make the members' stay efficient and refreshing without worrying about airborne diseases that might be brought home after going out or by the presence of visitors, considering that a pandemic, the COVID-19, is also penetrating households.

Workers in Enclosed Spaces. Office workers, hospital workers, and other similar workers frequently stay within enclosed spaces, which are considered their work areas. The lack of outdoor air exposure for hours can lead them to feel fatigued, unmotivated, or even drowsy. Therefore, adding an air filter rather than solely relying on HVAC systems could enhance their work productivity by providing clean air that mimics fresh outdoor air.

Individuals with Respiratory Ailment. These individuals are the most vulnerable and negatively affected ones when inhaling polluted air, as it quickly triggers or worsens their condition. Hence, with the presence of an air filtration system around them, it would be less likely that their condition would escalate, nor will they find their surroundings uncomfortable.

Government Sectors – Department of Environment and Natural Resources (DENR) and Department of Science and Technology (DOST). One of DENR's objectives is to manage the pollution concerns within the country. At the same time, DOST also aims to utilize science and technology to formulate innovative solutions to lead a better quality of life. Similarly, this study seeks to achieve the same mandates, which will make it beneficial for both sectors once successfully done.

Future Researchers. The study will serve as a reference for future studies discussing related topics, providing new knowledge from today's current events. The study may also serve as a cross-reference that will help give future researchers an overview of discussed topics.

Scope and Delimitation of the Study

To address the growing concern of indoor air pollution, this project will be conducted to produce a portable automated air filtration and IAQ monitoring system that will be useful to household owners, workers within enclosed areas, people with respiratory ailments, and the government sectors, specifically the DENR and DOST. However, considering the COVID-19 pandemic, which has prohibited the developers from gathering simultaneously, they will be pursuing an alternative setup in conducting the project, which is online. Furthermore, the project will be applying a qualitative research design, wherein the developers will utilize nonnumerical data to define the device's performance and determine its functionality. As qualitative research design is known for its subjectivity, it allows the developers to gather unique opinions and experiences from the respondents regarding their device (MacKellar, 2022). This approach will allow them to gain different perceptions since the respondents can provide varying answers to open-ended questions. By that, the researchers will analyze the gathered data and take necessary measures to ensure that the device runs smoothly.

The study also delimits the abilities of the device as it will be utilizing sensors with certain technical specifications. The PMS5003 sensor can distinguish particles as small as 0.3 micrometers, and its effective range in PM2.5 standard is about 0~500 μ g/m³, with a maximum range of ≥1000. To power this sensor, a minimum of 4.5 Volts (V) and a maximum of 5.5V DC power supply is needed (Yong, 2016). In addition, the MQ131 Gas Ozone Detection Sensor can only sense a 10-1000ppm Ozone concentration. Its sensitivity can be negatively affected when in contact with water, frozen, or when used with a higher voltage. Furthermore, its heating voltage is 5.0V±0.2V AC or DC, while the loop voltage is ≤24V DC ("MQ131 Semiconductor," 2022). Lastly, the SGP30 Multi-Pixel Gas Sensor's specified measurement range for Ethanol signal is 0.3 ppm to 30 ppm and 0.5 ppm to 10 ppm for H2 signal. Its minimum supply voltage is 1.62V, and its maximum is 1.98V ("Datasheet SGP30," 2017).

With the help of the selected sensors, the device will cover the filtration of the following criteria pollutants: dust concentrations, ozone concentration, VOCs, and equivalent carbon dioxide. Dust particles in the air determine the particulate matter. The dust density in the air is measured in micrograms per cubic meter ($\mu g/m^3$), VOCs and ozone concentration in parts per billion (ppb), and carbon dioxide in parts per million (ppm). However, the specific room coverage of the sensors is yet to be determined as it is not stated in the manual. Also, the phone and personal computer (PC) notification system will only be functional within a certain distance from the room outwards, limiting its ability to send notifications within 200m on computer application and 30m on phone application. In addition, these applications will only be compatible for Windows and Android devices. The project will be conducted during the academic year 2021-2022 and is presumed to develop its concept design from January to May of 2022. No final product will be presented as the project only aims to design the said device.

CHAPTER 2

REVIEW OF RELATED LITERATURE AND SYSTEM

This section will mainly cover the related literature regarding indoor air filters and air purifiers. Moreover, to help elucidate the project's intentions, five (5) related systems that are highly associated with the project will be tackled, together with the theoretical and conceptual frameworks that will be the study's foundation. To ensure the clarity of the content, multiple terms will also be provided alongside their operational definitions. The developers have gathered several studies, articles, and other data to aid in understanding the project's concept and visualize the desired product's features and application.

Related Literature

While there are a wide variety of air filters and air purifiers, common indoor prototypes will specifically be focused on in this study. The developers conducted extensive readings concerning its different key aspects, and after careful consideration, this segment has been divided into five themes. To have a better idea as to what indoor air filters and purifiers are, the anatomy, systems, and how they function should be well understood. Thus, the developers will expound on the features of various projects, their applications in different settings, and the multiple concerns that arose while using these systems. In addition, the system development tools and different sequential modeling techniques will be discussed and how they can improve the existing indoor air filtration systems.

Common Indoor Air Filters and Air Purifiers

Typical air filters like Carrier Air Purifier CADR260 comprises a cardboard frame that encloses a bunch of spun material, pleated material, or cloth (Consumer Reports, 2022). There are two methods by which they work based on its materials. The first method is mechanical filtration. It filters air pollutants by letting it run through a microfine fiberglass media, which is stabilized and folded many times over for higher effectivity. Conversely, its second purpose is to trap and paralyze charged particles on flat plates or surfaces. (Liu et al., 2017)

In addition, further studies showed that an overlooked component of the Heating, Ventilation, and Air Conditioning (HVAC) System is the air filter used within a home’s furnace, air conditioner, or heat pump. It is necessary to consider several aspects that fall under the user’s intention before buying something too costly or cheap. As stated by Kabrein et al. (2017), there is a hierarchy in filter efficiency, and one of those that needs to be considered is the varying sizes of the proximity where the filter will be used. Once a factor is overlooked, the user may not experience the machine’s full potential they purchased.

For that reason, some purchasers ask experts advice about the Minimum Efficiency Reporting Value (MERV) rating, which is crucial as it determines the filter’s efficiency and performance. The standard MERV values range from 1 to 16, indicating how well the air filter can purify the air. Ordinary standard filters of 1 to 4 offer basic filtration levels, 5 to 8 are often used for residential areas, and 9 to 12 are mid-range filters of high quality. Lastly, 13 to 16 are the best versions that filter particles as small as 0.3 particulates (Stephens et al., 2016).

However, regardless of how compatible the air filter is with the designated area, its efficiency may decrease once left dirty. After continuous usage, it is most likely to get clogged, leading to HVAC system malfunctions and more cost and energy used to fix it. It can also amplify the air impurities circulated in the household (Davis Air Conditioning & Heating, 2015). Additionally, other purifiers, such as a negative ion emitting air purifier, may sound very proficient, but the possibility of creating ozone emissions is the downside to this resort.

Despite the multiple disadvantages of air filters or air purifiers, users could still benefit from their abilities. They help maintain pure air and are commonly good for personal use as they ensure ventilation for users' private space, especially in this time when viruses are everywhere (Park et al., 2016). The benefits of using air purifiers lie in how it helps in alleviating symptoms and preventing reactions. These include sickness triggers for people with low immunity and or high sensitivity. After continued use, there is an increasing possibility of experiencing fewer allergic reactions, asthma symptoms, and the like (van Boven et al., 2020).

To maximize their efficiency, the air filters should be built with a fibrous filter, which is the best material. Room air filters should also be designed to maximize the Clean Air Delivery Rate (CADR). The optimization of such relies not only on the subjective aspects but also on how the users will be using them. Users should always have them turned on, around the clock, and placed in a single room. Keeping the windows and doors closed would also be a huge factor in helping these machines function better and less costly (Vijayan et al., 2015).

Usage of Indoor Air Filters and Air Purifiers

A study was conducted within three European cities to determine the significance of air purifiers within households. It observed air purifiers in bedrooms with indoor PM2.5 concentration and perceived indoor air quality, resulting in the reduction of PM concentrations by 45% to 69%. It also presumes that the common reason for using air purifiers was that it provide a cooling effect in the rooms. In addition, another motivation to use air purifiers may be the users' health condition, for multiple participants were experiencing respiratory issues (Cooper et al., 2022).

Similarly, during winter, a case study was set in an apartment in Delhi, India, with considerably high air pollution levels. The test rooms represent the upper-class residences, and the results indicate that outdoor air particle count varied during the observation. It is also stated that when outdoor air pollutions are high, air purifiers and air filters can worsen the levels indoors, depending on the leakages and rate of filtration. Even though air purifiers and filters can reduce particulate matter, the number of particles left remains concerning to users (Vyas et al., 2016).

Meanwhile, a study set in a hospital within Melbourne, Australia, studied the airflow and efficacy of air purifiers in a ward used by COVID-19 patients. Glycerine-based aerosol was deployed to replicate the SARS-CoV-2, and results show that the sole use of HVAC systems is not enough to clear aerosols. With that, air cleaners can protect the staff from airborne diseases. Two air cleaners in a patient room can take up to 5.5 minutes to clear 99 percent of aerosols, and it is quite cheap for medical facilities (Buising et al., 2021).

Another study took place in a kindergarten in Gliwice, Poland. It was done to address the increased susceptibility of children to air pollution, and at the end of the study, it was deduced that humans are the main source of most bioaerosols within the building. A figured ratio of indoor/outdoor bacteria ranged from 1.72-4.12, which means air pollution is higher indoors than outdoors. Air purifiers can reduce these by 18 percent, with a maximum efficiency value of 26 percent (Brągoszewska & Biedroń, 2021).

In addition, another observation was done in high school classrooms in a school in Germany during the Coronavirus (COVID-19) pandemic. Air purifiers with HEPA filters were utilized, resulting in its confirmed ability to reduce the virus-containing particles that infected persons may respire. In just two hours of being with an infected person within a closed room, the estimated inhaled dose can decrease by a factor of six if the air purifier's air exchange rate is 5.7 h^{-1}. However, it is also noted that its noise levels must be low to avoid class disruptions (Curtius et al., 2021).

Lastly, a study set in a workplace was conducted in four countries: China, India, the United Kingdom, and the United States of America. Specifically, PM2.5 concentrations inside the buildings were recorded, and findings indicate that indoor concentrations are generally lower in facilities that utilize mechanical ventilation and filtration. The filters are highly effective during operating hours. Those with the highest MERV ratings can provide the safest space for employees to occupy. They also reduce the mortality ratio due to related diseases (Jones et al., 2021).

Problems Encountered in Present Indoor Air Filters and Air Purifiers

Efficiency. Indoor air quality (IAQ) refers to the quality of air inside buildings, with a focus on the health and comfort of those who live there (Heitzmann, 2015). Air cleaners are highly effective at removing particles, while others are not as reliable. A cleaner with a high air-circulation rate but a less efficient collector will not be effective, nor will one with a low air-circulation rate but a more efficient collector. Most air cleaners are not built to remove a variety of gaseous air pollutants.

Health concerns. Zeng et al. (2021) conducted a series of studies to evaluate the effectiveness of a commercially available induct bipolar ionization device in eliminating gas and particles, and the likelihood of byproduct formation. While the ionizing device reduced some VOCs, it raised others, most notably oxygenated VOCs, which are commonly found in paints and aerosol sprays. As a result, VOC exposure has been linked to a variety of health issues, including nausea and liver, kidney, and central nervous system damage (Study Finds Safety Concerns With Air Purifiers, 2021).

Contradictions. Outside of Japan, air filtration has been shown to reduce indoor concentrations of PM2.5 and allergens, hence relieving asthma symptoms (Yoda et al., 2020). Furthermore, air purification has improved cardiovascular and pulmonary functioning in the elderly. However, numerous contradicting data demonstrate no discernible alterations in cardiovascular and pulmonary functions in the elderly. These studies show that the effects of air purification have been tested in older people or patients with respiratory illnesses such as asthma.

System Development Tools Used in the Study

Microcontroller gas-sensing devices are well-suited for air quality sensing because it is accessible to both non-experts and professionals in programming languages (Heyasa & Galarpe, 2017). With that, the designed air quality monitoring system will be primarily made up of PMS5003 fine Particulate Matter (PM) Air Quality Sensor, MQ131 Gas Ozone Detection Sensor, and SGP30 Multi-Pixel Gas Sensor. These sensors will help detect criteria pollutants that harm human health and the environment and cause property damage.

In addition, this study will present the utilization of a set of filters for improving air quality in indoor areas. The developers will use a Pre-filter, High-Efficiency Particulate Air (HEPA) filter, and an Activated Carbon filter to trap the air pollutants in the filtration system (Chan et al., 2016). Also, the application of a text-based information system using the Global System of Mobile Communications (GSM) module and Liquid Crystal Display (LCD) will be incorporated in the design for data dissemination. In this way, users will know the meaning of each air quality index reading.

Arduino Mega 2560 Microcontroller. To address indoor air pollution issues, a study conducted by Panicker et al. (2020) showed that a functional air filtration system should be used in enclosed spaces. With that, instead of the conventional way of turning on the filtration system all day, using an Arduino Mega 2560 Microcontroller and low-cost gas sensors through Arduino Software Integrated Development Environment (IDE) could save a significant amount of energy (Louis, 2016).

PMS5003 sensor. PMS5003 sensor is a digital and universal particle concentration sensor that will specify the amount of particle matter (PM) concentration (PM1, PM2.5, and PM10) and output the data digitally. The laser scattering principle is used for such a sensor, which produces scattering by radiating suspended particles in the air with a laser, then collecting scattering light to a certain degree, and obtaining the curve of scattering light change over time (Bulot et al., 2019).

Incorporating this sensor in the design is essential since clinical studies have found that PM air pollution significantly influences health more than gaseous components. It has numerous adverse effects on human health, notably the cardiovascular system. Exposure to PM air pollution, both acute and chronic, is associated with a higher risk of fatal injury from cardiovascular diseases such as ischemic heart disease, cardiac arrest, and ischemic/thrombotic stroke (Hamanaka & Mutlu, 2018). Thus, it is essential to know this specific pollutant before reaching a critical threshold in our households.

MQ131 Gas Ozone Detection Sensor. MQ-131, a low concentration ozone gas sensor, contains the detection compound known as Tungsten trioxide (WO_3). This sensor can measure concentrations in the range of 10–1000 ppb. It has lower conductivity in pure air and higher conductivity when there is a high ozone concentration (Carrillo-Amado et al., 2020). If the gas and air in the sensor exchange well, the sensor is more sensitive and quicker response and recovery time.

Although the focus on air quality has been on particulate matter, particularly PM2.5, in fast-expanding nations such as China and India in past years, “invisible” ozone pollution is progressively recognized as a significant health threat (Ma et al., 2016). Ground-level ozone concentrations are usually most significant on hot days with low humidity and stagnating wind. Thus, having this sensor would benefit everyone, especially those staying indoors with lesser air ventilation, especially those living in the Philippines, a tropical country.

SGP30 Multi-Pixel Gas Sensor. According to Al-Okby et al. (2022), the Sensirion Gas Platform (SGP) multi-pixel gas sensor is based on a heated film of metal-oxide (Mox) nanoparticles used in the SGP30. The oxygen on the metal-oxide particles absorbs oxygen, adapts with the target gas, and emits electrons. The sensor measures the electrical resistivity of the metal-oxide layer, allowing quantification of Total Volatile Organic Compounds (TVOC) levels and the equivalent Carbon Dioxide (eCO_2). This sensor provides long-term stability that traditional metal-oxide gas sensors do not.

This sensor will be essential in providing users with the number of pollutants and harmful gases in the indoor air in specific areas. This notion is supported by Shuai et. Al. (2018) where their study showed that VOCs emission by an industrial company in Korea could have negative cancer and non-cancer health effects and that risk management is required. Thus, many studies have cited these findings suggesting that VOCs should be monitored for better regional air quality due to their apparent effects on the environment and human health.

Pre-filter. Filter systems should guarantee mechanical separation and be capable of capturing or neutralizing undesirable chemical compounds (Smith et al., 2019). For filtration, pre-filters are the first phase in the air filtering process of an air purifier. A pre-filter prevents the central air filters from becoming clogged with debris, allowing them to trap microscopic pollutants. This pre-filter is typically the least expensive of the filters in the device, and it is used to extend the life of the main filters.

High-Efficiency Particulate Air (HEPA) filter. The HEPA air filter will be used to thoroughly purify the air, composed of many fine fibers arranged into a matt to trap both microscopic and larger particles. HEPA filters, by definition, can capture nearly 100% of particulates in the atmosphere that are 0.3 microns or smaller (Basińska et al., 2021). Thus, HEPA filters have at least almost 100% effectiveness for stripping away all particles, with even higher efficiencies for particles larger and smaller than 0.3 microns. This filter has become an essential component in the preservation of biological safety.

Activated Carbon filter. On the other hand, activated carbon filters have unique properties that enable them to clear away volatile organic compounds (VOCs), odors, and other gaseous pollutants from the air (Madiraju et al., 2020). It does so differently from other air purifiers, such as HEPA, which only filter particulate pollution from the air. Activated carbon filters can particularly benefit people who suffer allergies or aggravation from impure air, including secondhand smoke.

Since urban and rural localities have grown as a result of urbanization, inevitably, this causes terrible air pollution and poses a danger to public health and the environment. With that, a study by Rajapandian et al. (2019) showed that air filtration is one of the essential factors in cleaning indoor air. It improves human health by combating allergies, offensive odors, and snoring. His findings showed that fiber air filtration is the most widely used and developed among the various air-cleaning techniques.

Processing Integrated Development Environment (IDE). Processing open-source application allows users to create interactive applications in a variety of programming languages that includes Java, Android, Python, and Javascript. The main goal of this program is to visually teach non-programmers the fundamental concepts of computer programming. In terms of structure, the Processing IDE is comparable to Arduino and they can communicate via serial communication which aids in sending data from the Arduino to the Processing IDE and from the Processing IDE to the Arduino (Miller, 2021).

MIT App Inventor. MIT App Inventor is a web-based development platform that users can use to solve problems in the real world. It offers a web-based “What you see is what you get” (WYSIWYG) editor for creating Android and iOS mobile phone apps. It makes use of Google Blockly, a block-based programming language (Fraser, 2013). The user does not need to write instructions because all they have to do is choose and organize the options available on the website so that they can quickly build an application by finding the appropriate blocks.

Implications of the System Development Tools Used in the Study

Most widely used room ventilation systems lack an adequate mechanism for monitoring and cleaning households' air (Smith et al., 2019). The motivation for tackling this issue stems from the desire to provide the beneficiaries with access to air free of mechanical and chemical pollution, which harms human health. As a result, this whole design collaborates with the air quality monitoring system and filter consisting of many layers, which will operate so that each function is highly connected and operates concurrently.

People have recently preferred appliances that feature innovative air purification technologies while highlighting reliable performance and high energy efficiency (Alavy & Siegel, 2019). Thus, the process of improving indoor air quality will be based on reactionary air purification by the device if an anomalous concentration of one of the detected contaminants is identified. With that, an Arduino Mega development board will be used to strike a precarious balance between energy consumption and the system's processing speed (Tuyen & Hieu, 2019).

Overall, air filters and purifiers impact a home's interior air quality. However, relying solely on HVAC systems to remove certain toxins is ineffective (Buising et al., 2021). There have been reports of health issues and concerns despite reducing PM2.5 levels indoors. As a result, the Arduino Software IDE will be used to control the gas sensors whenever the presence of criteria pollutants reaches a specified threshold. It should also perform mechanical separation and neutralization of undesired chemical components.

Related System

This section evaluates existing related systems that will have to be explored, serving as a benchmark in this study. These related systems are the following: Household Gas and Air Quality Safety Monitoring Device by Xue and Xue (2017), Contaminant Monitoring and Air Filtration System by Pliskin (2019), AIR-MO-FY: An Air Quality Index Monitoring and Purifying Device by Maminta (2019), Selective Gas Detection and Measurement System by Clifford (1985), and Air Treatment System by Pippel et. Al. (2012). These related systems provide explanations and logical connections between previous research and the present work.

Xue and Xue (2017), Household Gas and Air Quality Safety Monitoring Device, CN108317546

This system, originated from China by Xue Zhenggen and Xue Dahai in 2017, mainly focuses on the innovation of monitoring device for household gases. The monitoring system can detect the household's air quality, and then the device can optimize the air quality. The gadget may immediately alert and stop the gas solenoid valve when the gas leakage amount surpasses. The benefit of this system is to help the people in the household optimize their household's air quality, especially when cooking. When cooking, many gases are found in the kitchen, such as carbon monoxide, carbon dioxide, nitrogen dioxide, and water vapor. Thus, this helps remove those gases found in the kitchen as it can detect the gas and automatically optimize the kitchen's air quality.

The 22rduinoes a PM2.5 sensor, camera, wireless signal receiving device, wireless signal transmitting device includes a control module, a power supply module, a temperature monitoring module, an exhaust module, a gas alarm, and an electromagnetic gas valve, where the power supply module is connected to the control module. The temperature monitoring module is connected to the control module's input end, the gas alarm is connected to the control module's input end, and the control module's output end is connected to the electromagnetic gas valve.

This device comprises indoor formaldehyde, VOC, carbon dioxide, carbon monoxide, and PM2.5 detection sensor. Also, its fresh air system control device and air purifier control device are both parts of the air optimization system control device, which are transmitted wirelessly to the system host. The system host transmits signals when the gas sensors send the detected values. Following the comparison of the gas level of the kitchen to the setpoint, the processing is carried out. When the detected value exceeds the setpoint, the system host instructs the fresh air system control device and the air purifier control device to turn on.

Despite what preceded, the system is not portable, and its materials are quite expensive. In addition, although there are several sensors included in the study, its maximum reach is not widespread, causing the scope of the research to be only in the kitchen. With that, the device can be improved by adding sensors that will not be limited to being a kitchen gas monitoring device and instead can be used in the overall scope of a household. Also, to become energy-efficient, an enhanced microcontroller can be used to save electricity as the research setting is inside the households. These observations will be utilized to make a householdfriendly indoor air quality monitoring device currently proposed. In the design's coding, the researchers will use a logical technique in which the device will foresee that the IAQ level detected is close to the critical threshold, thereby mitigating the impact of criteria pollutants before they reach the dangerous threshold. Also, for the monitoring and notification system of the device, it will incorporate a phone and personal computer applications, which is a convenient and cost-effective method to keep track of the sensor's data.

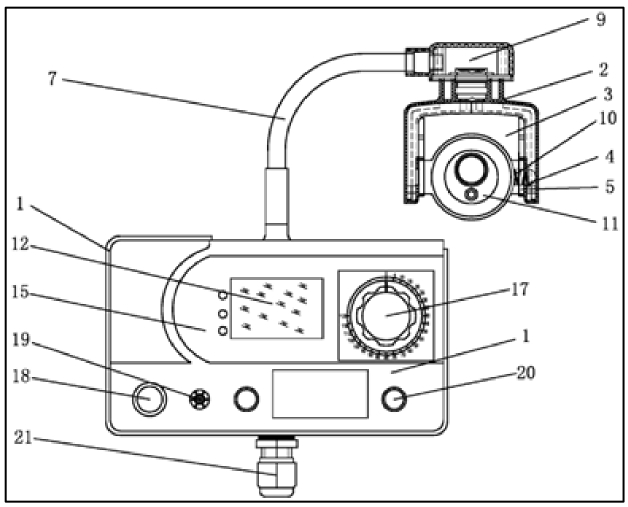


Figure 1. Xue and Xue (2017), Household gas and air quality safety monitoring device, CN108317546

Pliskin (2019), Contaminant Monitoring and Air Filtration System, US10422727B2

Invented by Harry Leon Pliskin in 2019, this device is a contaminant monitoring and air filtration system from the United States of America. Implementations of the current disclosure specifically cover equipment for air intake, monitoring, sampling, analysis, and filtering. Since every year, he stated that around 99,000 individuals die because of healthcare-associated infections, also known as HAIs, an innovation needs to be made to prevent this. His invention is especially for those who live in communities in hospitals and other healthcare settings. The system determines and monitors the particulate concentration levels in the room; depending on the level of particulate concentration, the system will enhance the filtration based on the increased needs. The air filtration system can be converted to portable, wall-mounted, ceiling-mounted, and corner mounted.

Furthermore, the materials used in the device are the following: cabinet, power cord, speed control device, inlet arrows, exhaust vent, outlet arrows, blower, inlet filter, pre-filter, final filter, air sampling device, microprocessor, sound absorption material, indicator lights, hosted server, communication network, communication channel, and wheels and handles for the portable air filtration system. Devices and methods for communicating with a system, including air filtering units with advanced features such as connectivity and reporting, are provided. The device and its strategies can perform various operations, including reporting and remediation, based on identified values associated with the air contamination and particulate matter formed in the air.

However, this system can be improved by adding microcontroller gas-sensing sensors and more efficient air purifiers through filters that are powerful enough to clean the air in enclosed spaces and inexpensive enough that it is reasonable to have a wider spread throughout the area. With that, this will be incorporated into the current research proposed. The researchers will also use a logical technique in the design’s coding. As a result, the device will indicate that the detected IAQ level is nearly equal to the critical threshold, consequently offsetting the influence of criteria pollutants before they attain the dangerous level. In addition, a phone and personal computer application will be included in the device's monitoring and notification system, making it a suitable and cost-effective way to take control of the sensor's data.

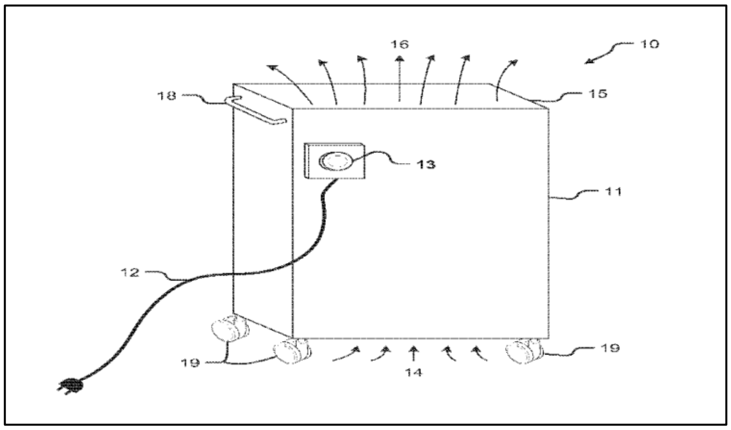


Figure 2. Pliskin (2019), Contaminant Monitoring and Air Filtration System, US10422727B2

Maminta (2019), AIR-MO-FY: An Air Quality Index Monitoring and Purifying Device, PH12019050128A1

Karize Ann Maminta's (2019) device, which originated in the Philippines and was invented in 2019, is an air quality monitoring device allowing everyone to take precautionary measures to adjust to their environment. Growth and concentration of population in cities and how people consume energy in urban areas through transportation or heating and air conditioning systems, among other things, result in the emission of massive amounts of harmful gases. With that, the researcher invented a device that used an Arduino Uno microcontroller, six led bulbs, six resistors, 16 x 2 I2C LCD, MQ135 gas sensor module, single 5V relay, air revitalizer, and plastic casing, and adopted a schematic diagram that will serve as the project's framework with an expert in the field of electronics. The wiring of the device was completed following the schematic diagram. An expert technician was in charge of overseeing all wiring jobs and used the Arduino program to create lines of code that were later uploaded to the Arduino Uno in order for the system to function. The device was tested to oversee and document various air quality readings in various locations.

Data collected at various locations were tabulated for comparison to take the necessary actions. After collecting air quality indexes for each area, the air quality can be classified as good, moderate, unsafe, very unsafe, or hazardous for human settlement. The location tested can be classified as either air polluted or safe for human habitation using this information. It asserted that the Air Quality Monitoring Device interprets the same air quality of a particular location and that AQI is higher in urban areas than in rural areas. It also led to the realization that workplaces such as rice mills, power stations, and construction sites have a greater capacity to contribute to air pollution.

Thus, the device can be improved by adding more sensors that specify which gas is prominent in the area and strengthening the information dissemination system. The current proposed study will implement these observations. Similar to the preceding related systems, the logical technique, which is not applied in this device, will be used in the design's coding by the researchers. As a result, the device will predict that the detected IAQ level is close to the critical threshold, thus offsetting the impact of criteria pollutants before they reach the dangerous level.

Figure 3. Maminta (2019), AIR-MO-FY: An Air Quality Index Monitoring and Purifying Device, PH12019050128A1

Clifford (1985), Selective Gas Detection and Measurement System, EP0161266A1

With a country of origin from the United States of America, this system made by Paul Clifford in the year 1985 can selectively detect, measure, and identify a certain amount of carbon monoxide, hydrocarbons, hydrogen, acetone, ammonia, hydrogen sulfide, alcohol vapors, solvent vapors, and several more gases in the environment. Once the gas is determined, the processor will signal if a particular gas concentration reaches a predetermined value or when gas concentrations or combinations of gas concentrations surpass predetermined threshold values displayed on the system's interface.

This system only has one sensor, the Taguchi Semiconductor Gas Sensor. While responsive to combustible or lessening gases at the parts per million level, this homogeneous semiconductor sensor is restricted by its response nonlinearity and absence of selectivity. In practice, a gas sensor is only helpful if it can identify the intended gas in the existence of background constituents. As a result, their main applications have been confined to smoke detection rather than gas identification or low-concentration gas detecting. The main restriction of this device is that it reacts to many reducing gases to varying degrees, so current measuring systems equipped with these sensors can only be used to determine the cumulative impact of the combustible gas components of the mixture of gases and cannot be used to differentiate one gas from another.

Regardless of its limitation, this innovation employs a homogeneous semiconductor gas sensors model that explains the causative factors of their poor selectivity, attempts to measure their response to gas combinations, and presents a comprehensive understanding of gas interactions. With that, it can still benefit the users as it can alarm a signal through the use of the gas detection system composed of the array, an approach to measuring the resistances of the array's sensors, an electronic processing unit, and a signal interface if an identified gas is harmful to humans for them to be alert to their environment. Because this system has an alarm signal that alarms if the gas is dangerous or not, this would be useful if people wanted to know if their environment is safe.

Many leading-up sensors can be used in this invention, significantly increasing its utility. If a study's system has multiple sensors, the gas detection will be more precise and detect a broader range of gases. The device can also be added with different filters or semipermeable membranes, incorporating its monitoring device. These observations will be assimilated to enhance further the system proposed in this study.

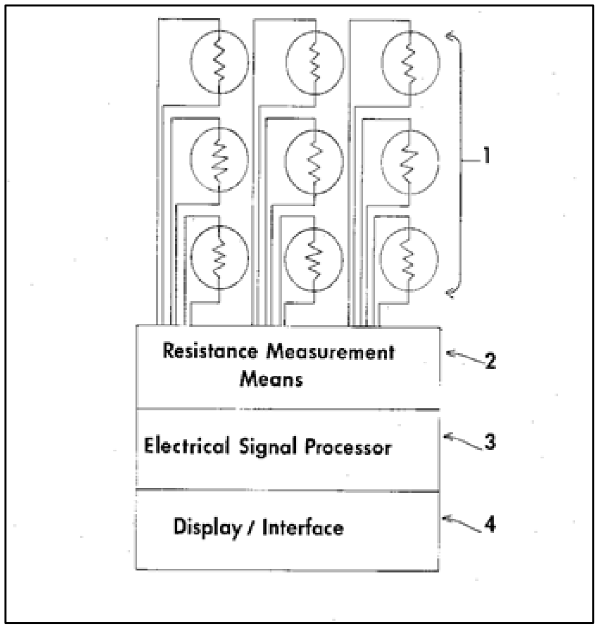


Figure 4. Clifford (1985), Selective gas detection and measurement system, EP0161266A1

Pippel et. Al. (2012), Air Treatment System, KR101209974B1

This device by Bradley Pippel, Gregory Evans, Michael Miles, and James Dodds is an air treatment system that originated from Korea and was invented in the year 2012; where the key drivers of this innovation are improved health awareness and increased understanding of the problems connected with polluted air. Airborne pollutants, for example, can cause or contribute to a variety of respiratory issues, such as respiratory infections, asthma, and allergies.

Furthermore, some pollutants transported by air might emit an unpleasant odor. Thus, consumers who want better air quality will significantly benefit from this system.

The system uses various filters and sensors to have better quality air; it filters and purifies the air supplied to human living or working spaces. The system also has a gas separation or purification device that is adapted for specific applications for cleaning the air in buildings. This device’s traditional air treatment systems are incorporated with blowers that allow air to travel through the filter elements and are available in various configurations. The blower and filter element are usually housed together, with the blower set to suction or exhaust air via the filter element. With that, the materials used in the system are the following: filter housing, front portion, a rear portion, pre-filter, particulate filter, antimicrobial filter, outlet duct, blower, electronic control system, finger guard, motor gasket, sensor airflow passage, particulate sensor, sensor plug, remote-control, remote-control holder, particulate filter frame, and filter frame.

To expand the process, when the blower is turned on, it introduces ambient air into the system via the front shield, pre-filter, particulate filter, and malodor filter. Each filter operates to eliminate particulate matter and bad smells from the air as it goes through it. Following that, air reaches the impeller’s front through the finger guard and is compressed radially outward through the impeller’s side to be pushed into the compartment of the outlet duct. At high speeds, the filtered air is pushed outward and upward through the second cutout of the outlet duct and exits the mechanism through the rear shell grille. Air flows forward of the device and then upwards apart from the system's rear, flowing freely around the room in which it is used.

Although the device can be deemed beneficial, changes can still be made for maximum usability. This system will be improved by adding a monitoring system that helps check and maintain the criteria pollutants in enclosed spaces. Also, the system is innovated by automation using Arduino products that guarantee low-cost materials and improved energy-saving features. Lastly, since household appliances need portability to move quickly, the device will be made portable in the proposed project design.

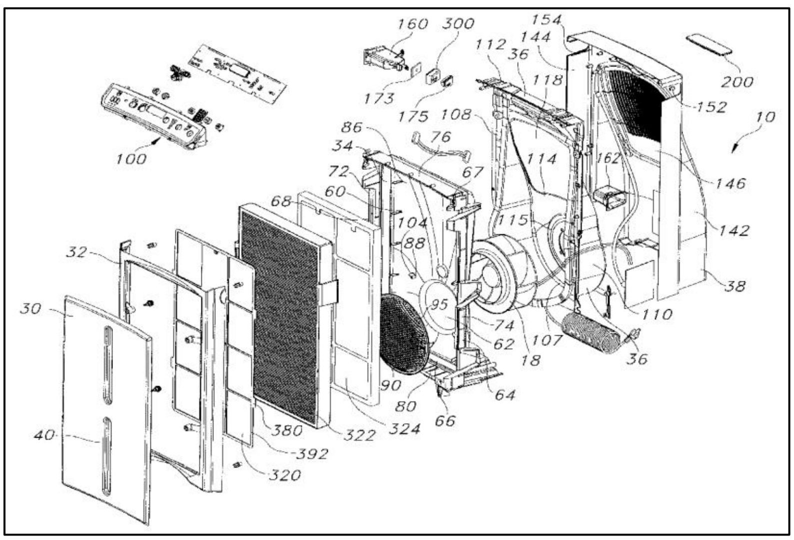


Figure 5. Pippel, Evans, Miles and Dodds (2012), Air Treatment System, KR101209974B1

Theoretical Framework

This section discusses relevant theories for the advancement of this research. Task-Technology Fit Model by Goodhue and Thompson (1995) and Theoretical Perspectives on Adaptive Automation by Scerbo (1996) are the two conjectures selected as they are particularly relevant to the study. These fields, terminologies, and models lay the groundwork for subsequent discussions while also strengthening the logic and veracity of the claims and analysis presented in subsequent sections.

Task-Technology Fit Model by Goodhue and Thompson (1995). The Task-Technology Fit Model written by Goodhue and Thompson (1995) offers a lens to view technology adoption and its significance to the users. The model assumes that the valuation of technology is produced by the conformity, or fit, of the task requirements and its technical characteristics that enable the user to carry out the tasks in an environment where individuals use technology to perform these tasks. The analysis by Goodhue and Thompson sought to demonstrate that a beneficial impact of technology necessitates a good. As a result, when technology is tailored to the task characteristics it is intended to facilitate, it should lead to improved outcomes. Improved performance is generally the result of a smooth implementation of the project, a reduction in the cost of performing the task, or working to make the task easier to complete.

The theory contributes to the current study by presenting a 32rduinoral model for predicting technology adoption through the proposed Indoor Air Quality filtration and monitoring system for users' healthy lifestyles. Understanding the present air quality level in enclosed spaces can warn people to wear appropriate protective defenses and raise environmental consciousness, allowing them to take the initiative to regulate air pollution. With that, in order to ensure a positive impact on individuals' health performance, researchers must posit that the innovation concocted must be a good fit with the task (or have a correspondence between its functionality and the task requirements). Keeping in mind the methodology formed by the researchers and their proper knowledge in programming, their innovation will benefit their target beneficiaries.

Theoretical Perspectives on Adaptive Automation by Scerbo (1996). The Theoretical Perspectives on Adaptive Automation authored by Scerbo (1996) states that human-computer systems wherein the "division of labor" or the interface among both human and machine intermediaries is not fixed but rather dynamic. In this theory, function allocation serves as a design decision that determines which processes are to be executed by humans and by machinery to obtain the necessary system goals, and it is tightly linked to the issue of automation. Based on the theory, it is not advisable to automate as many tasks as possible to develop an efficient and adaptable human-machine system. Although machine performance in some areas is exceptional, hardware and software are not always reliable. As a result, the human is frequently assigned the supervisor's role, with the power to influence when automation fails. Humans are thought to learn faster and outperform machines when performing tasks in a novel or unexpected situations, such as intervening when machines fail to function as intended. The anticipated benefit of adaptive automation is that humans and machines can work together, when necessary, taken in and out of the loop. The effectiveness of the human-machine system is assured by dynamically allocating work to humans or machines, regardless of disturbances in the capabilities of its components or change of environment demands.

This theory, in turn, has important implications in the development of the study. Indoor Air Quality filtering and monitoring involves cleaning particulate matter and other criteria pollutants in the atmosphere, which will run the whole day. With that, machines alone cannot work correctly if left uncalibrated or unchecked. All mechanical components and sensors will show signs of wear over time. Thus, calibration is essential to ensure that the sensor performs as well as it did on day one. Aiming to improve human health, the users and the machine have the same purpose of ensuring the quality of life for people living in the household. Overall, the theory supports the idea that choices about the onset, interruption, and type of mechanization in adaptive systems are shared by the human operator and machine intelligence for a common intention.

These theories claims that for innovation to succeed, it must be well-suited to the job at hand. Researchers suggest an Indoor Air Quality filtering device for consumers' healthy lifestyles in this instance. Filtering and monitoring indoor air quality include removing particles and other criteria pollutants from the environment throughout the day. Over time, all mechanical components and sensors will exhibit indications of wear. If machines are left uncalibrated or uncontrolled, they will not function properly. With that, coordination of the users and the device is needed in order to achieve the objectives needed to obtain.

Conceptual Framework

This project follows the flow of the Input-Process-Output (IPO) model as its conceptual framework. In general, three requirements need to be met in the input: knowledge, software, and hardware requirements. Upon meeting these prerequisites, the developers will then conduct the study. In the process, a series of tasks are designated for the project to flow seamlessly and for the timeline to remain organized. After accomplishing the procedure, a successfully tested model of TECHNOVAIR is presumed to exist by the end of the study.

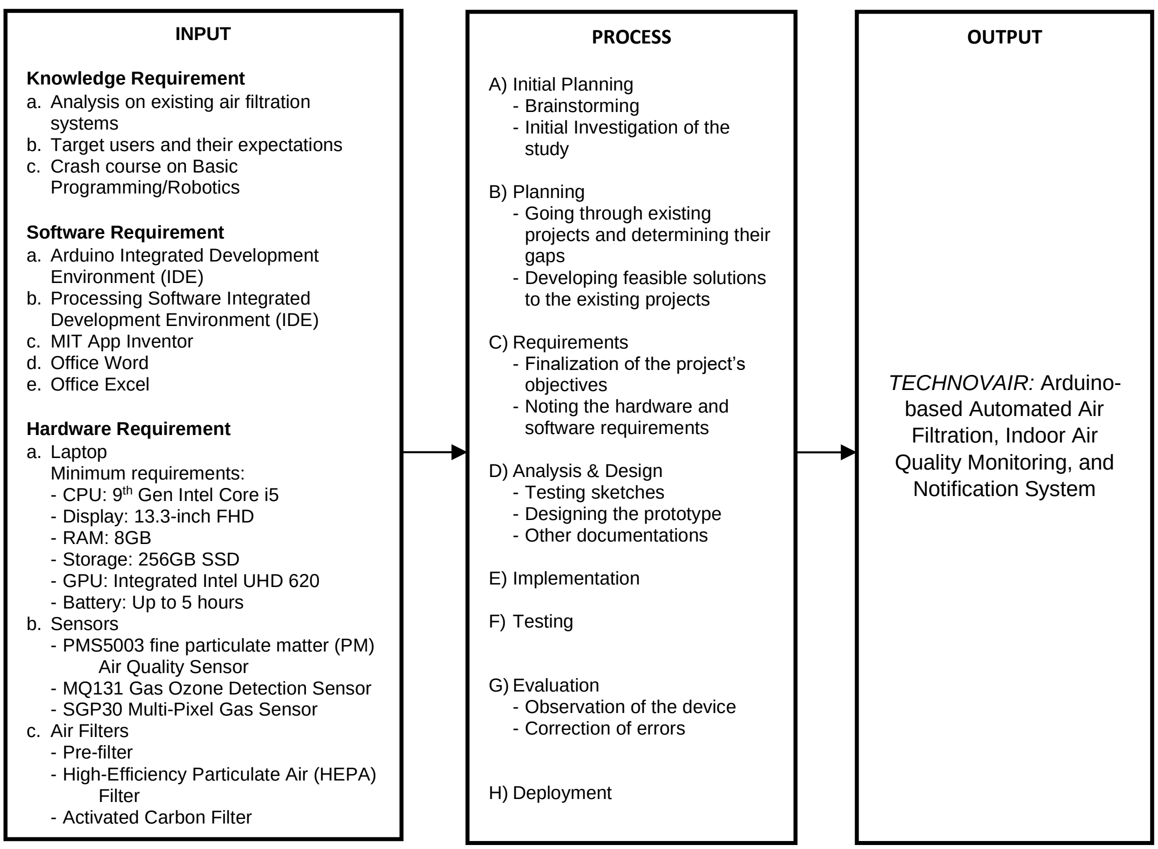


Figure 6. Input-Process-Output (IPO) Conceptual Framework for TECHNOVAIR: Arduino-based Automated Air Filtration, Indoor Air Quality Monitoring, and Notification System

Before the developers commit to the project, they must consider the following requirements under input. They should gather initial data about the topic of interest to develop an overview of the project. Hence, it is necessary to have knowledge of the indoor air filtration systems, the product's target users, and their expectations. In addition, a crash course in basic programming is crucial in creating the desired device as it Involves formulating codes that will allow it to effectively perform its functions. Apart from this, three software must be installed in the developers' laptops, including the Arduino Integrated Development Environment (IDE), Office Word, and Office Excel. Lastly, the hardware requirements will contain the minimum laptop specifications so that the developers may experience little to no inconvenience while constructing the system. Sensors and filters that will be incorporated into the system are also included. When these requirements are met, the developers will advance to the process of designing TECHNOVAIR.

The procedure will begin by investigating the selected system and collating ideas within the group. The developers will also explore existing projects, determine their gaps, and identify solutions for their innovation. This will be followed by developing the project's objectives and specifying requirements. Running multiple codes, designing the device's blueprint, and documenting the entire process will fall under the next task. Afterward, the device will be constructed and then undergo trials to be evaluated. The developers will rectify its errors and take more run-throughs before deployment. Once found to be as close to the envisioned project, the product will then be the developers' output, the official prototype of TECHNOVAIR.

Operational Definition of Terms

This section contains definitions of unfamiliar terms that appear and are mentioned in the research paper relevant to the study.

Air Quality Monitor – a device that measures and monitors the level of common air contaminants of indoor air and is used to oppose its serious concern on the research locale of the study

Criteria Pollutants – air pollutants for which tolerable exposure limits can be calculated, and an ambient air quality standard has been established. These include particulate matter, ozone concentration, VOCs, and their equivalent carbon dioxide

Equivalent Carbon Dioxide (eCO_2) – a method of comparing greenhouse emissions based on their global warming potential (GWP) by converting amounts of other gases to comparable concentrations of carbon dioxide with the same GWP.

Indoor Air Quality (IAQ) – air quality found within the household.

Micrograms per Cubic Meter ($\mu g/m_3$) – is the unit used to measure the air’s particulate matter or dust density.

Ozone (O_3) – a colorless hazardous, poisonous gas that is one of the criteria pollutants that the air quality monitoring device will detect.

Particulate Matter (PM) – refers to the tiny particles found in the air that is one of the criteria pollutants that the air quality monitoring device will detect.

Parts per million (ppm) – a unit of measurement used to measure ozone concentration.

Parts per billion (ppb) – a unit of measurement used to measure volatile organic compounds (VOCs).

Sensor – a device that detects the amount of air pollutants indoors and records, indicates or responds through cellular phone and computer applications.

Volatile Organic Compounds (VOCs) – are any carbon compounds that participate in atmospheric photochemical reactions that will be totaled by the sensor and are one of the criteria pollutants that the air quality monitoring device will detect.

CHAPTER 3

METHODOLOGY

This chapter will primarily discuss the project's methodology. It will comprise the research design and process model implemented in the study and the chosen setting for the research locale. The respondents will also be specified, along with their selection criteria and the sampling method that will be utilized in the selection process. In addition, the developers will also expound on the research assessment tool, system development tools, and the data collection procedure. Finally, the developers take the study's trustworthiness and the ethical considerations into account in determining the project's outcome.

Research Design and Process Model

As the study aims to design a device that will be implemented in live environments, it will be best performed by applying qualitative research design. It is a subjective approach, focusing on producing an in-depth understanding of events and looking for unique insights rather than numerical evidence, hence using words as data ("Qualitative Study Design," 2013). Moreover, as it is interpretive and naturalistic, the developers do not have to alter the environment because they may study their product in its natural setting ("Qualitative Research," 2019). They can perform direct observations of the product during trials and conduct focus group discussions with industry experts to inquire about their own observations and feelings toward the device (Busetto et al., 2020). This can further improve the product because the respondents may provide meaningful ideas and solutions to troubleshoot the device's errors. Therefore, this approach is highly suited to the study as it can prevent costly project errors in the future ("What is Qualitative Design?," 2012).

In addition, the developers will be implementing the Iterative Process model as its Software Development Life Cycle (SDLC) Process model. This approach provides the developers an opportunity to test the device and gain feedback from their respondents to improve its function by repeating the process. As stated by Martins (2021), it is a trial-and-error methodology as it allows the developers to refine their product until it has met all the project's objectives. Hence, the product may initially be constructed with flaws until it is gradually shaped into the developers' intended prototype (Eby, 2019). The process will mainly involve eight (8) phases: Initial Planning, Planning, Requirements, Analysis and Design, Implementation, Testing, Evaluation, and Deployment.

Initial Planning. The process begins with the brainstorming of the developers and the selection of a topic of interest. Once they have chosen a topic, they will be performing initial investigations regarding its background.

Planning. During this phase, the developers will be diving deeper into the topic, exploring various existing projects, determining their gaps, and considering this for their prototype.

Requirements. The developers will construct the project's objectives and identify the hardware and software requirements necessary to build the product.

Analysis & Design. Once the objectives have been finalized, the developers will proceed to create a plan for the prototype. Here, they will incorporate necessary codes and design its software and hardware. In addition, they will be consulting industry experts to ensure that the design can effectively pursue the device's intended functions.

Implementation. After creating a blueprint, the developers will begin to construct the said prototype. The individual requirements will be combined to generate the idealized concept design.

Testing. The product will undergo testing to ensure that the system is running as planned. The developers will do this with the industry experts to help them identify the bugs and errors of the prototype.

Evaluation. In this phase, the developers will be having a Focus Group Discussion (FGD) with the industry experts to point out the malfunctions they have assessed during the testing phase. Once they conclude that there is a need for improvement, the process will return to the first phase to tweak the device or troubleshoot the errors.

Deployment. Once all trials are done and both the developers and industry experts are satisfied with the results, the device will be endorsed as TECHNOVAIR in a live environment.

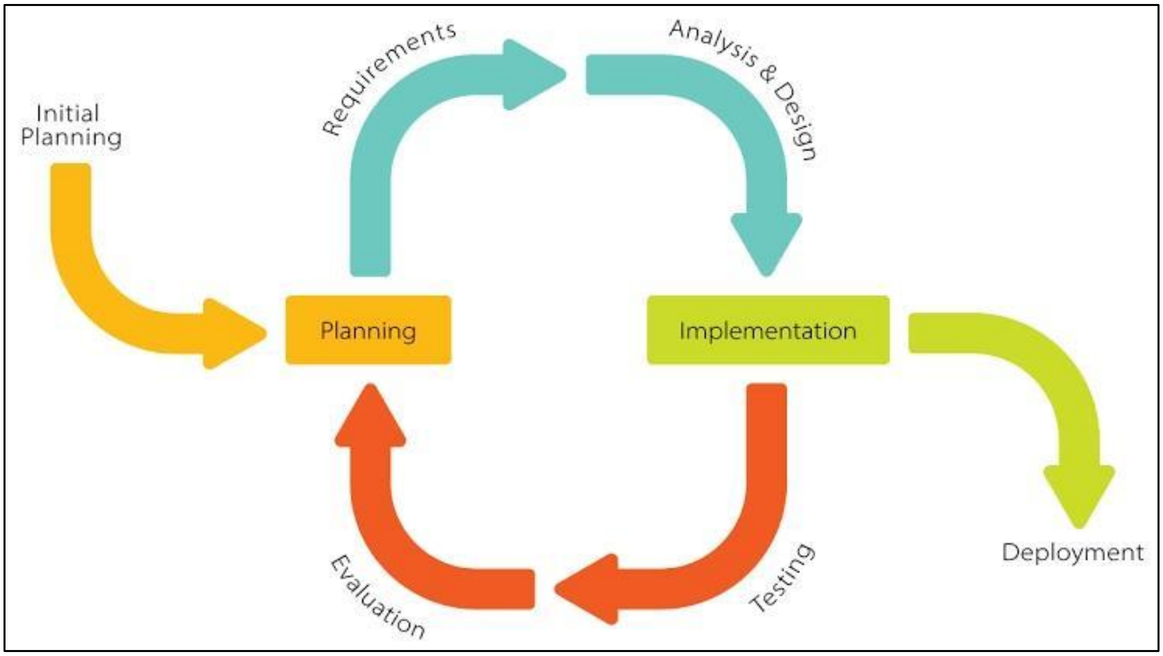


Figure 7. The Iterative Process Model

Research Locale

The developers will conduct this study in a house located in Astana Subdivision in Matina Pangi, Davao City, Davao Region. Davao City is the administrative capital of the Davao Region and is Mindanao's most populated city and the Philippines' third largest. It is known for its dynamic economic growth, urban development, and modern facilities and is one of the island's most important economies and the Philippines' third most crucial metropolitan hub (Infrastructure Modernization for Davao City 2045, 2022). Because the researchers and the targeted respondents are currently situated in this city, the developers have purposefully selected this location for its efficiency and advantages in obtaining the data. It is also evident that the citizens who stay mainly at home would greatly benefit from this project because of the new setup society has today in both work and education. Thus, the researchers decided to choose the subdivision indicated above, and the device will be tested inside the bedroom of the house. With this, it creates awareness regarding the Indoor Air Quality (IAQ) pollution that directly affects people, especially the household members, allowing everyone to intervene in the environmental phenomena. Due to the circumstances that the pandemic has pushed everyone into, the study will be conducted online.

Research Respondents

The respondents of this project are the different industry experts who are skilled and knowledgeable regarding the research design development and the device in general. Mainly, the sample size would be a total of four respondents who will answer the open-ended questionnaire provided by the developers to guide them in troubleshooting the device. The researchers will make use of the purposive sampling method as this involves finding and choosing individuals or groups of persons who are particularly educated or experienced about a topic of interest (Cresswell & Clark, 2017). The purposive sampling method may prove to be effective when only limited numbers of people can serve as primary data sources. It is one of the most cost-effective and time-effective sampling methods available.

The research capstone respondents are selected through the following criteria:

A. Air Quality Control Specialist: Must be a resident of Davao City who is a professional that is trained to conduct research, inspections, and investigations on levels of air pollution, as well as to take the required procedures to ensure adequate air quality to address public health problems. Also, he or she should voluntarily participate in the research capstone project.

B. Software Developer: Must be a resident of Davao City who is a professional with the technical ability to construct programs or supervise the researchers' device. Through testing and maintenance, they can keep track of the quality and performance of the invention. Also, he or she should voluntarily participate in the research capstone project.

C. Mechanical Engineer: Must be a resident of Davao City who is a professional trained to guarantee that all mechanical systems of the device operate safely and effectively to meet users' needs. Also, he or she should voluntarily participate in the research capstone project.

D. Electrical Engineer: Must be a resident of Davao City who is a professional responsible for carrying out risk evaluations and ensuring adherence to safety standards and electrical engineering codes. Also, he or she should voluntarily participate in the research capstone project.

Research Assessment Tool

This study will utilize a self-made research questionnaire based on the FURPS software product quality model. FURPS, a Hewlett-Packard quality model, was released in 1995. It is also referred to as a quality characteristics table (Vern & Dubey, 2013). The FURPS model used in this study will be developed based on its Flexibility, Usability, Reliability, Performance, Scalability, or Supporting capabilities. The overall items for each component will be converted into a 22-item, open-ended questionnaire (attached as Appendix D). The respondents in this study will be asked to answer the questions through FGD to ensure that the device is ready for deployment to the end-users. To guarantee that the researchers are posing questions that assess the non-functional and functional requirements of the product, the questionnaire will be validated.

System Development Tools

In this research, the Arduino Mega 2560 microcontroller board will serve as the central data processing element for all sensors and displays in the device. The sensors that continuously monitor the air environment will provide the input and transmit electronic signals to the Arduino Mega 2560 Microcontroller through data-transmitting electronic cables. The microcontroller will subsequently process the data collected by the sensors. The result will then be shown on the LCD, phone, and computer applications. If the device detects the air quality near the critical threshold based on the logical technique applied in the design's coding, the device will notify the owner through the applications to start the filtration process.

Development Tool	Description	Function
Arduino Integrated Development Environment (IDE)	Arduino IDE is the software for the Arduino microcontroller. It's used to write code, compile it to see if there are any issues, then upload the code to the Arduino. It is compatible with the C/C++ programming languages.	The main text editing program used for the device programming which connects to the Arduino hardware to upload programs and communicate with them.

Processing Integrated Development Environment (IDE)	An open-source programming language for making images, animations, and interactive experiences. It is based on Java, and all of the code is precompiled and converted straight into Java code.	It is used mainly for building proofs-of-concept for visualizations of the system. It enables the users to have a monitoring and notification system through a personal computer application.
MIT App Inventor	Using a web browser and either the connected phone or an emulator, App Inventor allows users to create Android/IOS apps. The App Inventor servers record users' projects and store their work.	A starter program used for phone application building to keep track of sensor data and used for notification in case the indoor air quality reaches near the critical threshold.
Arduino Mega 2560 Microcontroller	This is a microcontroller based on the Atmega2560 capable of computing and programming through languages such as C/C++. It comes with everything the researchers need to start the design by plugging it into a computer with a USB cable or powering it with an AC-to-DC adapter or battery.	It will perform general functions serving as the device's brain that performs the code, engaging with modules such as the sensors, relay, and other inputs and outputs.
NRF24L01	This is essentially a wireless extension of a serial interface used to transmit data from a computer to an Arduino wirelessly.	Used to connect Arduino to the computer
MOSFET-IRFZ44n	This is what is utilized to open or close a circuit. Because of its low power consumption, this transistor is typically utilized as a switch in electrical devices	It will be used to turn on/off the filtration system of the device before reaching the critical threshold.

	exclusively for low voltage applications. This makes it possible for current to flow (or not) in other parts of the circuit.	
PMS5003 sensor	The PMS5003 is a laser dust sensor that measures the value of dust particles suspended in the air using the laser light scattering technique.	It will be utilized as the particulate matter concentration sensor to determine the quality and quantity of dispersed particulate matter in the air in terms of unit volume and a digital interface in the form of output.
MQ131 Gas Ozone Detection Sensor	This sensor, which has high sensitivity and a very fast response time, can determine the ozone concentration (10～1000ppb) in ambient air. Tin dioxide (SnO_2) is the sensor's sensitive material, and it has a low conductivity when the air is clean, but it increases in the presence of ozone.	It will be used as the ozone detection sensor to determine the quality and quantity of dispersed ozone in the air in terms of unit volume and a digital interface in the form of output.
SGP30 Multi-Pixel Gas Sensor	This is a gas sensor designed for indoor air quality monitoring that can detect a wide variety of Volatile Organic Compounds (VOCs) and H_2. When connected to the microcontroller, it will provide a Total Volatile Organic Compound (TVOC) reading as well as an equivalent carbon dioxide reading (eCO2) over I2C.	It will be used as the VOCs detection sensor to determine the quality and quantity of dispersed VOCs in the air in terms of unit volume and a digital interface in the form of output.
HC05 Bluetooth Module	The HC-05 is a common wireless two-way (full-duplex) module that can be used in a variety of projects. Users can use	It will be used to connect the TECHNOVAIR mechanical device to the computer and phones of the users in order to

	this module to communicate between two microcontrollers, such as an Arduino, or with any Bluetooth-enabled device, such as a phone or laptop.	receive data for monitoring and notification purposes.
Pre-filter	A pre-filter is a type of air filter that eliminates big particles from the air, such as dust, dirt, and hair. Pre-filters are the initial step in an air purifier's air filtration process.	A pre-filter will keep the primary air filters from becoming clogged with debris, allowing them to collect microscopic contaminants. Because HEPA filters have no trouble absorbing these massive particles, the pre-filter will not affect the purifier's performance. Instead, the notion is that it will lengthen one's life. The advantage of pre-filters over HEPA filters is that they may be washed and cleaned regularly.
High-Efficiency Particulate Air (HEPA) filter	HEPA filter is a kind of air filter that can theoretically remove 99.97% of dust, pollen, mold, germs, and any other particles larger than 0.3 microns (m).	HEPA filters will be designed to trap microscopic particles successfully, but they do not filter out gasses or odor molecules. This will be used in conjunction with the pre-filter to extend its lifespan.
Activated Carbon filter	Activated carbon filters are used in air purifiers to collect volatile organic compounds, which are the chemicals that cause odors and are also known to be critical indoor air pollutants. On the other hand, activated carbons aren't employed to filter particulates.	The Activated Carbon filter will work in tandem with the HEPA filter to collect other microscopic particles such as dust, lint, mold spores, pet dander, and pollen. Beyond the particulate filtration given by HEPA filters, an activated carbon filter adds an

		additional layer of filtration.
20x4 Liquid Crystal Display (LCD)	LCDs are widely used in many electronic applications because they are ideal for presenting simple information, such as sensor data, while inexpensive.	This will be used to project real-time pollutant levels to inform the users of indoor air quality in their households.

Table 1. System Development Tools

The entire system is powered by a combination of codes for each sensor and the LCD. It combines the fundamental Arduino, Javascript and C++ Programming methods with additional sensor-specific functionalities. The code begins with sensor and display initialization and then runs continuously throughout the test, projecting data from the sensors to the LCD, phone, and personal computer application, which is refreshed every 15 minutes and loops throughout the test duration.

Data Collection Procedure

The developers will use a self-made research questionnaire using the FURPS software product quality model to help gather information for convenience, not only for the researchers but also for the respondents. The air filtration system will be used in various rooms with different levels of particulate matter, ozone gas concentrations, VOCs, and equivalent carbon dioxide, and it should be able to notify the user of the about it. The developers will gather data using an online assessment tool following the alpha testing. Because the respondents of the beta testing have a degree and are of consenting age, the developers will obtain informed consent from them, indicating that they are a part of the analysis and are able to understand the purpose of their participation. The developers will then send links for the beta testing questionnaire. In addition, the developers will submit a letter of approval and permission to the principal and the school's guidance counselor to obtain authority to continue the report and assessment. Furthermore, the data gathered during the beta testing by the industry experts will be discussed with the researchers, and the data will be handled securely and confidentially.

Phase 1: Development Stage

Once the assessment tool has been finalized, the alpha and beta testing will start. The developers will gather the initial data as well as issues and bugs during the alpha testing process. Afterwards, the device will be tested by the industry experts to gather data and issues to be fixed during the beta testing stage. Additionally, all the data gathered during both testing processes will remain confidential, and the industry experts will be informed regarding their involvement in the project and the testing process. To make sure that the device is ready for the second phase, the focus group discussion will be initialized for the deliberation of the problems identified during the first testing.

Phase 2: Re-development Stage

After the first beta testing process, the developers will fix the issues, bugs, and concerns discussed by the industry experts. The discussion during the previous stage will be helpful and will be used to improve the device's quality and functionality once it is ready for the market. Once the device is redeveloped, it will be tested once again by the respondents and another discussion will follow. Moreover, this process will be repeated as needed until the respondents are satisfied with the device.

Trustworthiness of the Study

Credibility. To enhance the credibility of this research, researchers ensured that rigor was maintained throughout the data collection process, particularly during the surveys, where researchers avoided making conclusions from the surveys and instead relied solely on factual data obtained directly from the respondents. This is supported by Suter (2012), who states that credibility refers to the confidence in the believability of the findings, which is enhanced by evidence such as confirming evaluation of conclusions by research respondents.

Transferability. Researchers detailed the research context and essential assumptions to address transferability and displayed all data transparently as feasible. Readers can make judgments about transferability based on the rich and detailed descriptions. The reader may transfer information from this article to different situations and assess whether the findings can be transmitted.

Confirmability. To avoid data distortion, researchers left aside personal beliefs, assumptions, and judgments to address the confirmability of the study. To verify all of the given data, the researchers will present it to the respondents to evaluate and verify all of the statements they have made to support the research. Respondents will also scrutinize it before confirming that it is fit for publication. If participants wish to exclude, redact, or alter their statements, their requests will be considered, and researchers must conform.

Dependability. A third-party evaluator will be brought in to evaluate the research assessment tool developed to guarantee the data's dependability. The evaluator will scrutinize the questions and ensure that they will produce results that are consistent and unvarying, as well as results that will be beneficial in the research study. They will evaluate the questions and suggest adjustments to enhance the questions that will be used and any required proofreading.

Ethical Consideration

As addressed in the consent form, the developers will always secure the individual's right to privacy and guarantee their safety. While maintaining identity and confidentiality, it will be thoroughly vetted. The data collected from the questionnaire will not be disclosed to others, and nothing will be intrinsically linked with the tester's name. They have the right to alter their minds and withdraw from the study if they do not want to be a part of it. This ensures that the researchers and respondents avoid accidents and unnecessary delays to the research. The researchers will manage the respondents honestly and fairly and stick and follow their principles as a researcher. When addressing people at the societal level, the developers will consider all data ethics, specifically transparency, justice, privacy, confidentiality, and safety.

Transparency. The researchers will not withhold any information related to the research and will relay it to the respondents and update the respondents regarding the progress of the research and its usability. The researchers will not force their respondents to participate in the research if they are unwilling and will respect the respondents' decision and will not use force, blackmail, or any underhanded methods to achieve the desired results. Furthermore, transparency also pertains to the developers being objective and trustworthy about their behavior, including consistent with their principles.

Justice. The researchers will comply with the benefits and terms that have been agreed upon between the researchers and the respondents. The concept of justice refers to the ethical imperative to fairly distribute the benefits and drawbacks of research. Developers must not exploit the weak and vulnerable or exclude some who stand to benefit from project testers for humanitarian purposes.

Informed Consent. Implied consent is one of the ethical principles' core concepts. According to the developers, respondents should join the study willingly (voluntarily) after getting complete instructions about what it entails and giving their approval before doing so. As a result, people are given the freedom to choose and answer questions at their leisure and supply information via Google forms.

Social Value. This capstone project takes extensive precautions to ensure that the testers' experiences are entirely safe. Because no direct benefits are expected from the respondents, the benefit aspect of the risk analysis is presented.

Privacy and Confidentiality. Research respondents' privacy and confidentiality state that an individual participating in human subject research has privacy rights. Many survey participants are upset because their privacy was violated due to their participation in research. It results in a situation in which a researcher is aware of the identity of a research tester but takes action to prevent the identity from being revealed to others. Topic confidentiality is not as standard in human subject research as in other fields because most human research requires signed documentation of consent. The researchers will not use any information acquired regarding its respondents without their approval, as it is part of their principles as a researcher.

Risk, Benefits, and Safety. The safety of testers is fully considered during project design and ethical review. The researchers oversee assessing potential risks and estimating the likelihood of the risk occurring. As a result, they will ensure the safety and benefits of the testers as the project is improved.

Qualification of the Developers. The developers will ensure that the capstone project will be subjected to consideration, suggestions, consultations, and a thorough justification of the content by capstone research examiners. As a result, the developers will provide the required approval sheets and documents as proof that the capstone project is being carried out at Malayan Colleges Mindanao.

Adequacy of Facilities. Data collection will begin once the researcher obtains a document from the Department of Education and obtains permission from the testers’ parents to collect information using Google Forms. Because the data will be collected online, the developers will keep the information between the testers and the developers to a minimum.

Community Involvement. This capstone project ensures that no indigenous customs, history, or people are disrespected or jeopardized. The report, on the other hand, will be made available for academic purposes as well as for the benefit of society. This research will be presented at conferences on education and migrant workers, with a focus on Science and Technology.

CHAPTER 4

PROJECT DESIGN

This section will expound on the Project Model, the Project Mechanism and Source Code, the Project Manual, and the Project Cost of the study. To understand the project's appearance, a blueprint will exhibit the envisioned look of the product and application, while the details are to follow. In addition, the full specifications of the project will summarize the system development tools utilized in the project, and a schematic diagram will be used to simplify the representation of the product's components and their connections. Meanwhile, the Project Mechanism or Source Code will focus on the step-by-step creation of both the product and application. Lastly, the Project Manual will guide how users will use the device, and the Project Cost will summarize all the project's expenses throughout the study.

Project Model

This part will deliberately explain the materials utilized and the machine application-based system required for TECHNOVAIR's project design assembly. This includes the project blueprint, the application blueprint, the system's service description, product and application details, the device's complete specification, and its application requirement. It functions as a clear and visual representation of how the system should be implemented and what it looks when effectuated.

Blueprint of the Project

Using SketchUp, an intuitive 3D modeling application, the front, top, side, and back views of TECHNOVAIR, including its interior features, were modeled in this subsection. The device was visualized as a 28cm x 18cm x 10cm rectangular machine using PLA (polylactic acid) plastic as its cover to ensure the product's portability. Inside the device, the tools were arranged to consume less space and provide a compact space. This design makes the device's interface neat and transferable.

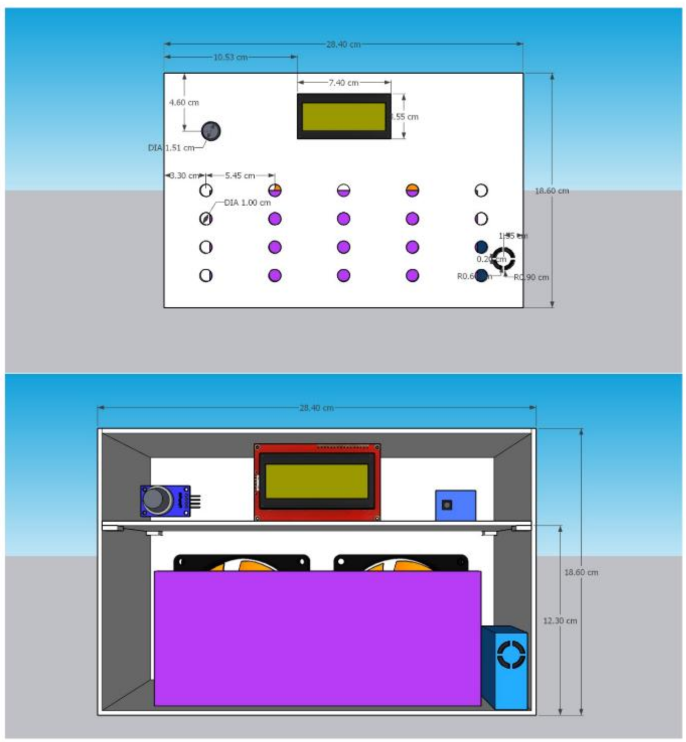


Figure 8. Front view of TECHNOVAIR

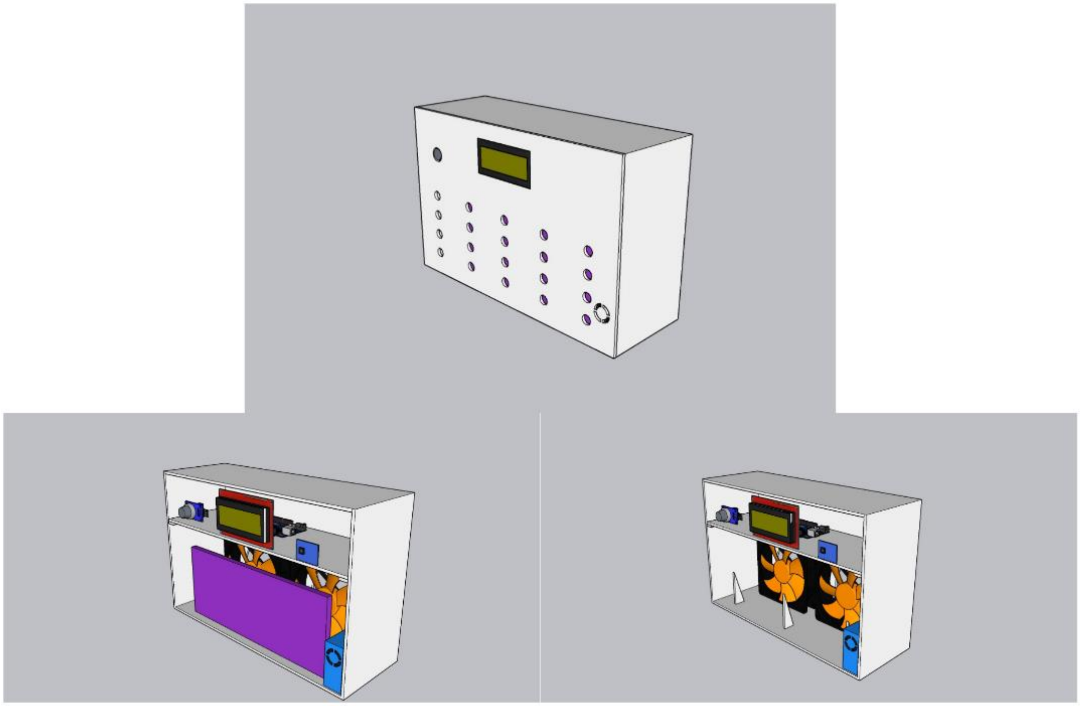


Figure 9. Top view of TECHNOVAIR

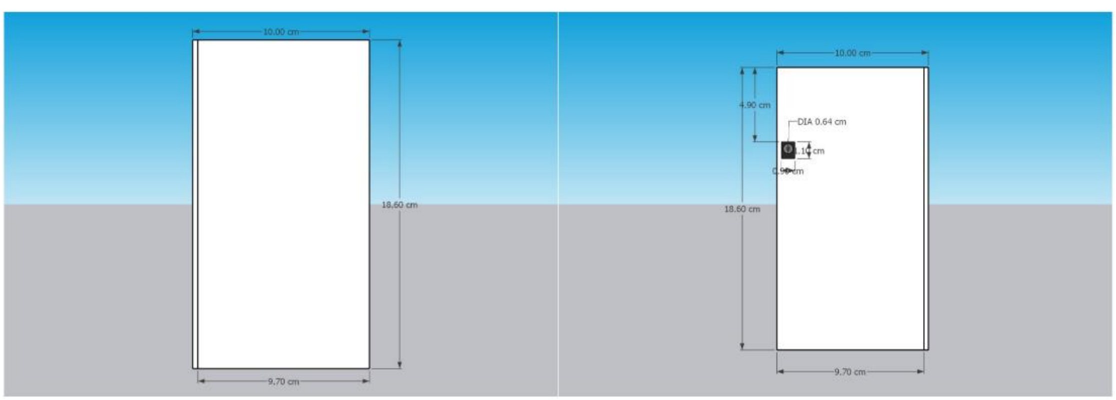


Figure 10. Left and Right views of TECHNOVAIR

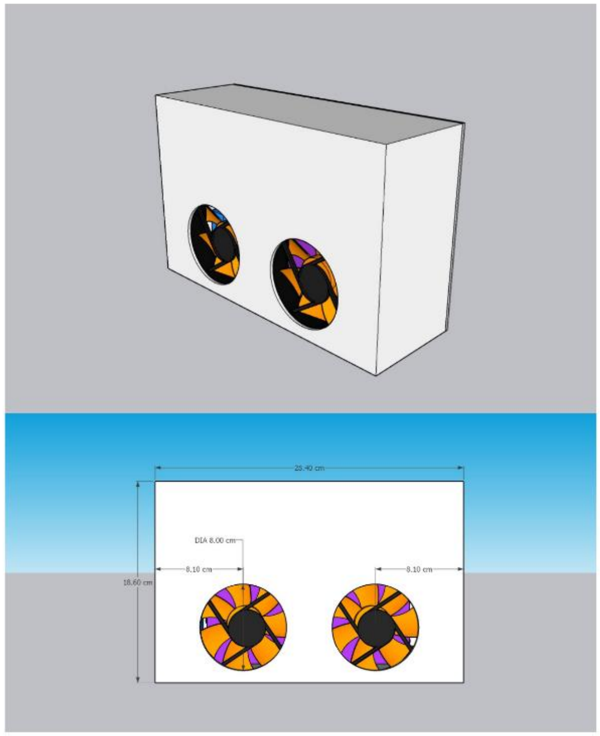


Figure 11. Back view of TECHNOVAIR

Application Blueprint and Service Description

The PC and phone applications are contrived in this subsection using the Processing Integrated Development Environment (IDE) and MIT App Inventor. For these two applications to work, the computer should be within the 200m radius, while the phone should be within the 30m radius ranging from the TECHNOVAIR, as these devices are connected to the machine using the HC05 Bluetooth Module. These applications, in general, serve as the monitoring and notification system of the machine to address the concern of indoor air pollution in our research locale.

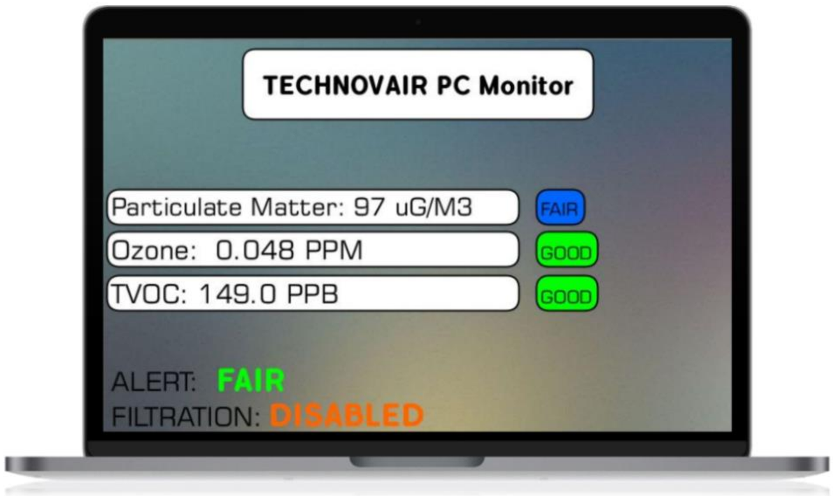


Figure 12. TECHNOVAIR's PC Application Blueprint

TECHNOVAIR's computer application will serve as one of the monitoring and notification tools for the device. Since TECHNOVAIR will detect indoor air quality every 15 minutes, these data will be projected on the device's display and the PC and phone applications. This PC application is an efficient monitoring and notification system compatible with Windows as this can collocate with a video surveillance system that also uses computer monitors in different households. It only requires basic computer requirements and consumes only tiny storage space. Also, having a monitoring and notification system that uses a wireless connection is cost-efficient compared to a GSM-based system that needs a prepaid load and an IOT-based system that requires an internet connection. Overall, having this lets users raise environmental consciousness, allowing them to take steps to reduce indoor air pollution.

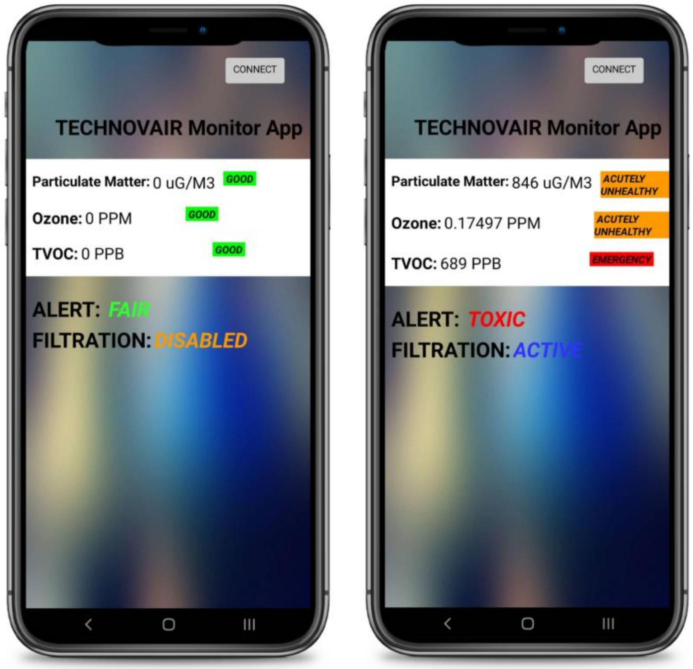


Figure 13. TECHNOVAIR's Phone Application Blueprint

A phone application has also been set up for the users to monitor and be notified more comfortably with the PC application. This application also has the same content as the PC application; however, it is more convenient and portable, allowing users to carry the monitoring and notification system anywhere. This can be used with Android phones. In addition, phone monitoring consumes less energy, thus, making them an excellent option for users instead of looking over computer monitors. Although the developers' phone application prototype can only reach within a 30m radius, this can still be improved by using a different Bluetooth module, subject to a recommendation from the developer for future researchers. Thus, having applications on different devices, the users are allowed to choose which application they will use depending on personal circumstances and preferences.

Product Details

This subsection discusses vital information about the features of the device. This helps users know more about the product quality and the materials the developers chose, and it comprises technical details of the product in order for users to understand TECHNOVAIR's capabilities.

***TECHNOVAIR:* Product Details**	
DEVICE	
Weight	370g
Dimensions	28cm x 18cm x 10cm
Material of Housing	PLA (polylactic acid) plastic
Measuring Parameter	Total Suspended Particles of Particulate Matter, Ozone Concentration, and Volatile Organic Compounds Concentration
Measuring Unit	Total Suspended Particles of Particulate Matter in µg/m3, Ozone Concentration in ppm, and Volatile Organic Compounds Concentration in ppb
Measuring Interval (Device Data Transmission)	Every 15 minutes
Function	Automatic Control, Monitoring, Measurement, Filtration
Usage	Indoor (Households, Offices, Hospital Rooms, etc.)
Portable	Portable
Display	20x4 LCD (Digital)
Fan Type	Exhaust
LCD Refresh Interval	5 seconds
Data Transmission (Device to Application) Wavelength Range	200m on PC Application and 30m on Phone Application
Input Power	220V AC
Power Supply	12V DC (Electrical)
Maximum Current Consumption	Approximately 700mA
Power Consumption	Approximately 8.4W
Power Interface	12V/2A DC Power Supply

Table 2. TECHNOVAIR's Product Details

Application Details

This section will exhibit the look of the home page interface for both the PC and phone applications. Designed to have a simple structure and a straightforward function, the application presents the latest reading of each sensor for the particulate matter, ozone, and TVOC concentration. An alert reading is also found below in bigger text size, together with the state of the filtration system for better emphasis. Lastly, a few technical details, such as the approximate application size and the application window size, and the color-coding interpretation of the results are stated to complete the visualization of the PC and phone applications.

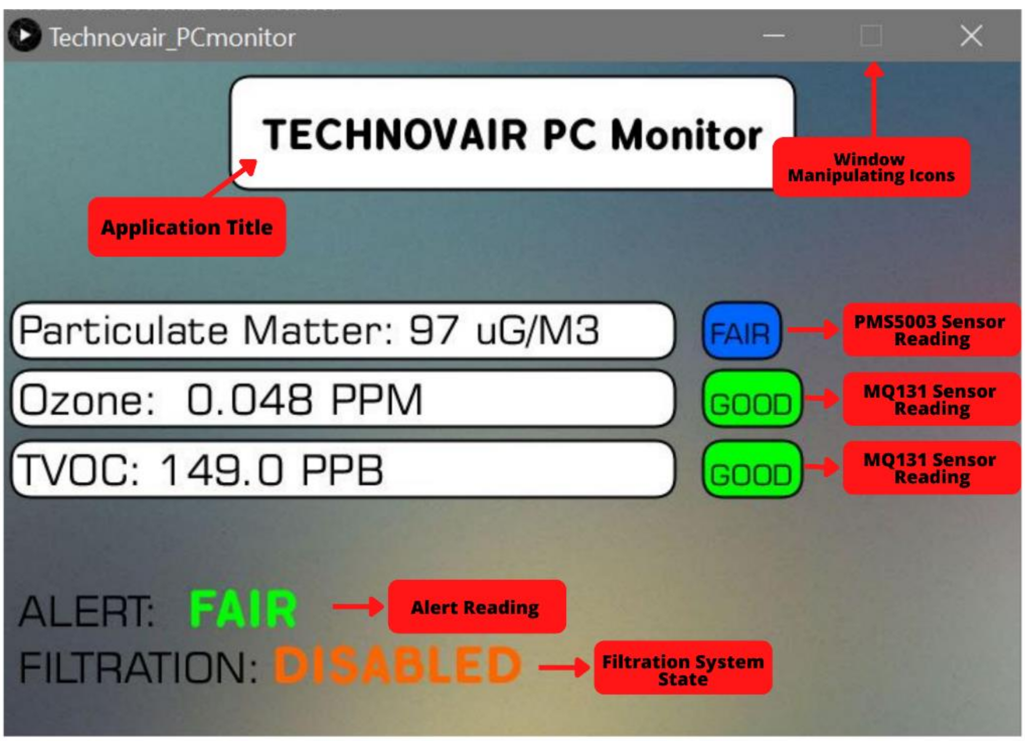


Figure 14. TECHNOVAIR's PC Software Application Home Page Interface

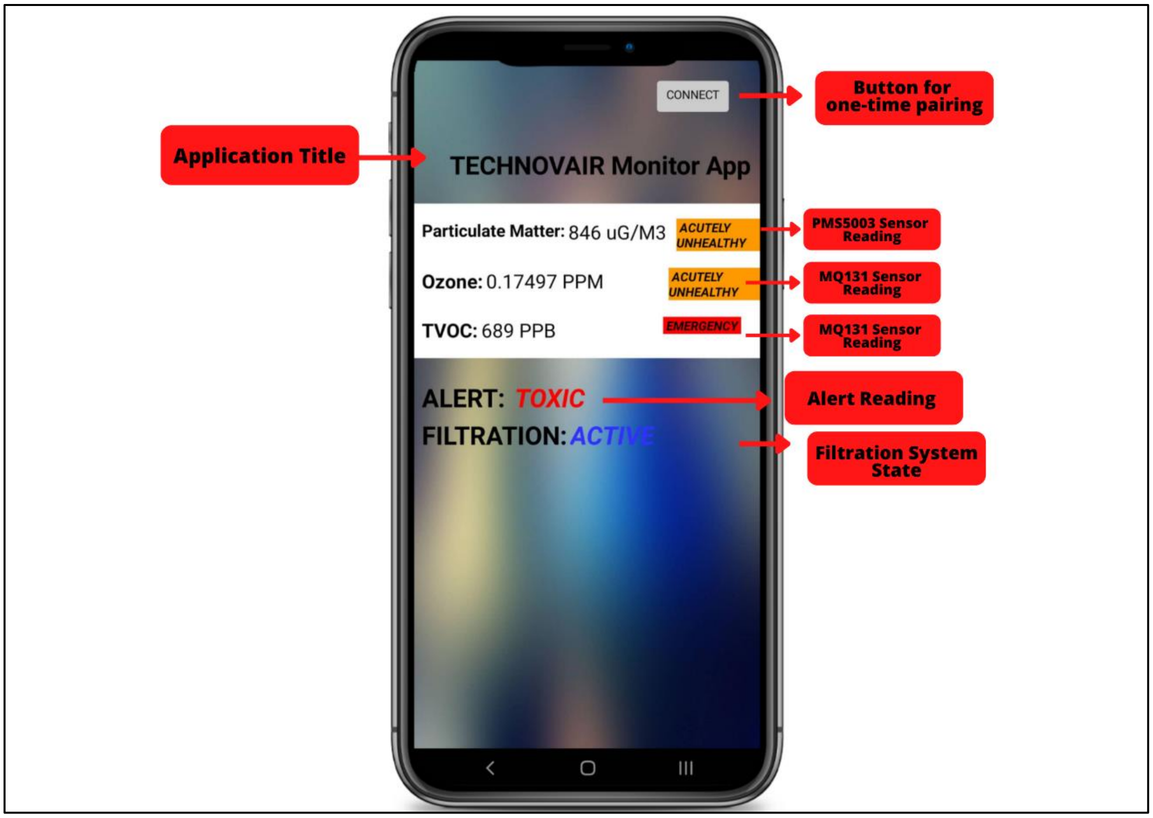


Figure 15. TECHNOVAIR's Phone Software Application Home Page Interface

***TECHNOVAIR:* Application Details**	
PC Application	
Approximate Application Size	195 MB (205,405,365 bytes)
Application Window Size	720p x 480p
Phone Application	
Approximate Application Size	10.15 MB (10,150,000 bytes)
Foreground Usage/Power Consumption	3 minutes 30 seconds / 5.98 mAh
Background Running Time/Power Consumption	11 sec / < 1 mAh

Table 3. TECHNOVAIR's Application Details

In addition to the application details attached to the table above, the following tables are the color-coding of the air quality indices projected to the applications. These air quality indices are based on the Philippine Clean Air Act of 1999 and the US Environmental Protection Agency. For easier visualization of the users, color-coding was applied for the different levels of the three criteria pollutants: Green, Blue, Light Blue, Yellow, Orange, and Red for both particulate matter and ozone concentration, and Green and Red for the VOCs Concentration.

Particulate Matter in μg/m^3	
Total Suspended Particles	
Good	0 – 80
Fair	81 – 230
Unhealthy for Sensitive Groups	231 – 349
Very Unhealthy	350 – 599
Acutely Unhealthy	600 – 899
Emergency	900 – and above

Table 4. TECHNOVAIR's Application Color-coding for Particulate Matter

Ozone Concentration in ppm	
Good	0.000 – 0.064
Fair	0.065 – 0.084
Unhealthy for Sensitive Groups	0.085 – 0.104
Very Unhealthy	0.105 – 0.124
Acutely Unhealthy	0.125 – 0.374
Emergency	0.375 – and above

Table 5. TECHNOVAIR's Application Color-coding for Ozone Concentration

VOCs Concentration in ppb	
Maximum Allowable Air Concentration Standard	
Healthy	500 – and below
Unhealthy	501 – and above

Table 6. TECHNOVAIR's Application Color-coding for VOCs Concentration

Complete Specifications

The schematic diagram of the device and a table of the full details of the system development tools were provided for the complete specifications of TECHNOVAIR. This subsection is deemed essential for the study’s trustworthiness as it asserts the product’s transferability. Also, selecting materials for a research work requires consideration of the visual appeal, initial and ongoing costs, life cycle assessment considerations (such as material performance, accessibility, and environmental impact), and the capacity to reuse, recycle, or dispose of the material at the point of disposal. Thus, having a list of specific technicalities of the system development tools will help future researchers benchmark this study.

The figure below shows the unambiguous representation of how TECHNOVAIR’s circuit components are interconnected. Its primary purpose is to clearly and understandably describe the wiring or connection between the parts to create a prototype easily. Here, the main components for the monitoring and notification systems are the PMS5003 sensor, SGP30 sensor, MQ131 sensor, and LCD connected to the Arduino Mega board. On the other hand, the MOSFET-IRFZ44n will be used for the filtration system to turn on/off the two DC exhaust fans depending on the threshold values detected by the three sensors.

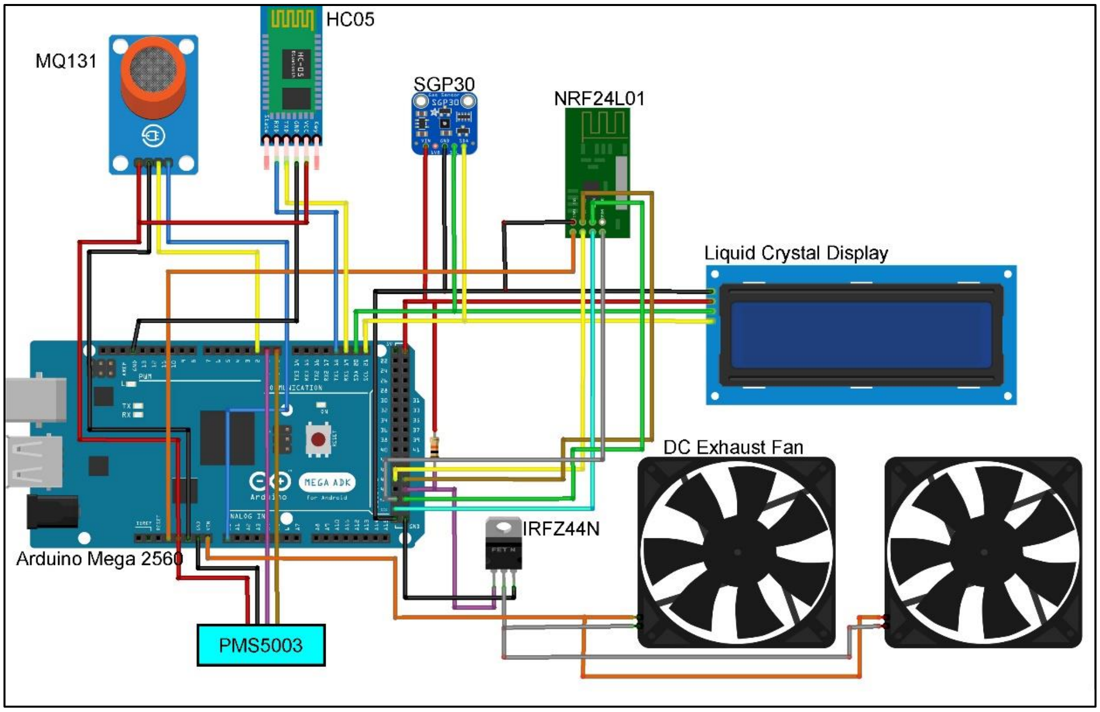


Figure 16. Schematic Diagram of TECHNOVAIR

In relation to the schematic diagram above, a table is provided to summarize the complete specifications of the product. Found below are the following system development tools utilized in the product development and the detailed stipulations that allow the proper function of each tool:

***TECHNOVAIR:* Complete Specifications**	
SYSTEM DEVELOPMENT TOOLS	
Arduino Mega 2560	
Microcontroller	Atmega 2560
Operating Voltage	5V
Input Voltage (recommended)	7V-12V
Input Voltage (limit)	6V-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA

Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	SRAM
EEPROM	4 KB
Clock Speed	16 MHz
I2C 20x4 LCD	
LCD display module with blue backlight.	
Wide viewing angle and high contrast.	
Built-in industry standard HD44780 equivalent LCD controller.	
LCM type	Characters
Display	2-lines X 16-characters
Voltage	5V DC
Module dimension	80mm x 35mm x 11mm
Viewing area size	64.5mm x 16mm
1602 I2C interface 4-wire 1602 screen	
IO port of control board is only 20, so IO ports is not enough for many sensor, SD card, relay modules	
The original 1602 screen need 7 IO ports to drive up, and this module can save 5 IO ports	
NRF24L01	
Worldwide license-free 2.4GHz ISM band operation	
250kbps, 1Mbps and 2Mbps on-air data-rate options	
Enhanced ShockBurst?	Hardware protocol accelerator
Ultra low power consumption?	Months to years of battery lifetimeSpecifications
Power supply	1.9~3.6V
IO port working voltage	0~3.3v / 5v
Transmitting rate	+7dB
Receiving sensitivity	-90dB
Transmission range	250m in open area
Dimension	15x29mm
PMS5003 Sensor	
Range of measurement	0.3~1.0；1.0~2.5；2.5~10 Micrometer（μ m）
Counting Efficiency	50%@0.3μ m 98%@>=0.5μ m
Effective Range	PM2.5 (standard）0~500 μ g/m³
Maximum Range	PM2.5 (standard）*≥1000 μ g/m³
Resolution	1 μ g/m³
Maximum Consistency Error (PM2.5 standard data)	±10%@100~500μ g/m³ ±10μ g/m³@0~100μ g/m³
Standard Volume	0.1 Litre（L）
Single Response Time	＜1 Second（s）
Total Response Time	≤10 Second（s）
DC Power Supply Type	5.0 Min:4.5 Max: 5.5 Volt（V）

Active Current	≤100 Milliampere（mA）
Standby Current	≤200 Microampere（μ A）
Interface Level L	<0.8 @3.3 H >2.7@3.3 Volt（V）
Working Temperature Range	-10~+60 ℃
Working Humidity Range	0~99%
Storage Temperature Range	-40~+80 ℃
MTTF	≥3 Year（Y）
Physical Size	50×38×21 Millimeter（mm)
MQ131 Sensor	
With signal output indicator light	
Dual signal output (analog output and TTL level output)	
TTL output effective signal is low level; (the signal light is on when the output is low level, and can be connected to the IO port of the single-chip microcomputer)	
High sensitivity to ozone gas, (detection concentration range 10PPB-2PPM)	
Size	32mm X22mm X27mm length X Width X height
Main chip	LM393, MQ-131 gas sensor
Working voltage	DC 5V
It has a long service life and reliable stability of KE	
Fast response and recovery characteristics	
With mounting holes, convenient for fixed installation	
The probe can be plugged and unplugged, which is convenient for testing	
Application	Ozone gas detection devices used in homes and atmospheric environments
Material	Plastic, metal
Color	Blue
SGP30 Sensor	
High quality	The SGP30 is a metal oxide gas sensor with multiple sensing elements on a single chip.
It integrates	four gas sensing elements with a fully calibrated air quality output signal.
Wide usage	SGP is easy to integrate and integrates metal oxide gas sensors into mobile devices, opening up new possibilities for environmental monitoring in smart homes, home appliances and IoT applications.
Circuits are simple and reasonable structure, simple operation.	
5.Made of high-quality metal materials, wear-resistant and anti-corrosion, more stable performance and longer service life.	
Description	Lightweight, easy to install and easy to operate.

Adopt synchronous rectifier technology.	
Model Number	GY- SGP30
Power compatible	2v---5v
Color	blue
Size	13 mm x 10.5mm x 2.6mm
DC Exhaust Fan	
Product Name	Computer Case Cooling Fan
Rated Voltage	DC 12V
Rated Current	0.2A
Connector	2 Pins Connector
Size	80 x 80 x 25mm / 3.1-inch x 3.1-inch x 1 inch (L x W x H)
2 Pin connector cooling fan for desktop computer case, keeps computer working well.	
Help push the hot air out of your computer when mounted on the back or draw in fresh air if you mount it at the front of the case	
Cable Length	18cm
External Material	Plastic
Color	Black
HC05 Bluetooth Module	
Use the CSR mainstream Bluetooth chip, Bluetooth V2.0 protocol standards.	
Module Working Voltage	3.3 V
Potter default rate of 9600, the user can be set up.	
Core Module Size	28 mm x 15 mm x 2.35 mm
Working Current	Matching for 30 MA, Matching the Communication for 8 MA
Dormancy Current	No Dormancy
Used for the GPS navigation system, water and electricity gas meter reading system	
With computer and Bluetooth adapter, PDA, seamless connection equipment	
Commercial Series	Bluetooth module board Series
With LED indicator light, use 150mA and 3.3V regulation chip.	
With VCC.GND.TXD.RXD foot for the Bluetooth	
Compatible with Bluetooth master module “slave module” or master-slave(whole) module.	
Input Voltage	3.3V-6V

Table 7. TECHNOVAIR’s Complete Specifications

The Arduino Mega 2560 microcontroller board will be used as the central data processing element for all the device’s sensors and display in this study’s monitoring and control network. The three sensors that regularly monitor indoor air quality will supply input and transfer electronic signals to the microcontroller through data-transmitting electronic wires. The data collected by the sensors will then be processed by the microcontroller and will then be displayed on the LCD, phone, and PC applications using the HC05 Bluetooth Module. These data will then be analyzed based on their equivalent air quality indices (Appendix A, B, and C). Based on the logical technique used in the design's coding, if the device detects air quality near the critical threshold, it will alert the owner via the applications to begin the filtering process assisted by the MOSFET-IRFZ44n.

The code starts with sensor and display initialization and constantly continues through testing, reflecting data from the sensors to the LCD, phone, and personal computer application, which is reloaded every 15 minutes and loops for the entire test. This code combines the basic Arduino, JavaScript, and C++ programming approaches with sensor-specific functionality. If the data received by the microcontroller is near the critical threshold, rotation of DC exhaust fans starts, pushing in polluted air from outside to undergo the filtration process using the three filters. Healthy air will then be released after the filtration in the holes situated in the front interface of TECHNOVAIR.

Application Requirement

For the TECHNOVAIR applications to work, a few requirements need to be met. To assure that the project may still be cost-effective while highlighting its best performance, the developers took into consideration the minimum standards that are still compatible with each of the applications. Since the device is designed to send updates via an application on both the PC and smartphone, the developers prepare two separate requirements. Hence, after assuming all possible scenarios wherein the device may need to communicate information to the user, the following conditions are deemed best for the smooth usage of the applications:

***TECHNOVAIR:* Application Requirement**	
PC Application	
System Requirement	Windows 10 and higher
System Type	x32-based or x64-based PC
Memory (RAM)	Minimum 2GB
Processor	Minimum 1.8 GHz; Recommended 2GHz or more
Monitor Resolution	1280x800; Recommended: 1920x1080
Bluetooth Version	Bluetooth 5.0
Internet	No internet connection is required for software activation
Phone Application	
Must be Android 7.0 and higher. (Not compatible with IOS)	
User's Free Internal Memory	100MB
Memory (RAM)	Minimum 2GB
Bluetooth Version	Bluetooth 5.0
Internet	No internet connection is required for software activation

Table 8. TECHNOVAIR's Application Requirement

Project Mechanism/Source Code

This section addresses the processes of how the machine and application of TECHNOVAIR are created, as well as the step-by-step procedure on how the product and application work. In addition, the source code of the device will be affixed to this part to provide the foundation of software creation, allowing the paper to become a reference through sharing the processes and code for learning purposes or by recycling portions of it for other applications.

Product Creation Process

This process illustrates the step-by-step creation of the device. With the assistance of the expert, the developers design the air filtration unit, starting with the wiring of the product, followed by attaching its components together as well as connecting the wires to the Arduino pins and closing the unit housing afterward.

Part I. Preparing the Connection

1. Using a soldering iron, set it to 350 degrees Celsius. Then, solder some wires to the output pin of the components.
2. Then, solder some wires to the LCD pins: VCC, GND, SDA, and SCL. Add some shrinkable tubes or Kapton tape to prevent pins from shorting with other components.
3. Solder some wires to the PMS5003 module pins: VCC, GND, RST, TX, and RX. Add some shrinkable tubes or Kapton tape to prevent pins from shorting with other components.
4. Next, solder some wires on the NRF24L01 Module. The output pins involved are 3.3, GND, CE, CSN, MOSI, MISO, and SCK. Add some shrinkable tubes or Kapton tape to prevent pins from shorting with other components.

5. Next is to solder some wires on the SGP30 module pins: VCC, GND, SDA, and SCL. Add some shrinkable tubes.
6. Solder also wires on the MQ131 module pins: VCC, GND, AO, and DO. Add some shrinkable tubes.
7. Finally, solder some wires on the IRFZ44n pins: Gate, Source, and Drain. Add some shrinkable tubes also.

Part II. Placing the Components

1. The first thing is to install the LCD.
2. Install the MQ131 in its place.
3. Place the SGP30 and PMS5003.
4. Install the DC Exhaust Fans in its place.
5. And lastly, install the Arduino Mega 2560.

Part III. Connecting To the Arduino

1. You may connect to the bottom side of the Arduino Mega's PCB where the pins are soldered, or you may install a male pin header for your connections.
2. The first step is to connect the LCD pins. Cut the wires to the appropriate length so that nothing will snap when opened. Connect the VCC of the LCD to the 5V of the Arduino and GND to GND. Connect SDA to pin A4 and SCL pin to pin A5 of the Arduino.
3. The next thing is to connect the SGP30 pins. Cut the wires to the appropriate length so that nothing will snap when opened. Connect the VCC

of the SGP30 to the 5V of the Arduino and GND to GND. Connect SDA to pin A4 and SCL pin to pin A5 of the Arduino (parallel to the LCD).

4. Next, connect the MQ131 pins. Cut the wires to the appropriate length so that nothing will snap when opened. Connect the VCC of the MQ131 to the 5V of the Arduino and GND to GND. Connect the AO to pin A0 and DO to pin 2 of the Arduino.
5. Then, connect the PMS5003 pins. Cut the wires to the appropriate length so that nothing will snap when opened. Connect the VCC of the PMS5003 to the 5V of the Arduino and GND to GND. Connect the TX of the PMS5003 to RX1 of the Arduino and RX of the PMS5003 to TX1 of the Arduino.
6. Now it is time to connect the MOSFET (IRFZ44N) and the Fan. Connect the VCC of the Fan to the Vin pin of the Arduino. The GND of the fan to the Drain of the IRFZ44N, the Source of the IRFZ44N to the GND of the Arduino, and finally, the Gate of the IRFZ44N to pin 49 of the Arduino (with 10K Ohm pull up resistor).
7. Next is to connect the HC05 Module to the Arduino. Since the HC05 Module only accepts 3.3V for its power, connect the VCC pin of the HC05 Module to the 3.3V pin of the Arduino and GND to GND. Then connect the TX and RX of the WIFI Module to pin 19 (RX1) and 18(TX1) of the Arduino, respectively.
8. Finally, connect the NRF24L01 Module to the Arduino. Connect the VCC and GND pin of the NRF24L01 Module to the 5V and GND of the Arduino,

respectively. Then connect the data pins; RST to pin 48, MISO to pin 50, MOSI to pin 51, and SCK to pin 52.

Part IV. Closing the Housing

1. Before closing the housing, make sure to align the wires neatly.
2. Load the firmware.
3. Close the back cover of the housing. The product creation is done.

Machine Mechanism

This study will only dispense the mechanical system's block diagram as there is no physical hardware. For additional information, attached below the figure is the operational flowchart of the step-by-step process of how the product works involving the components found on the diagram.

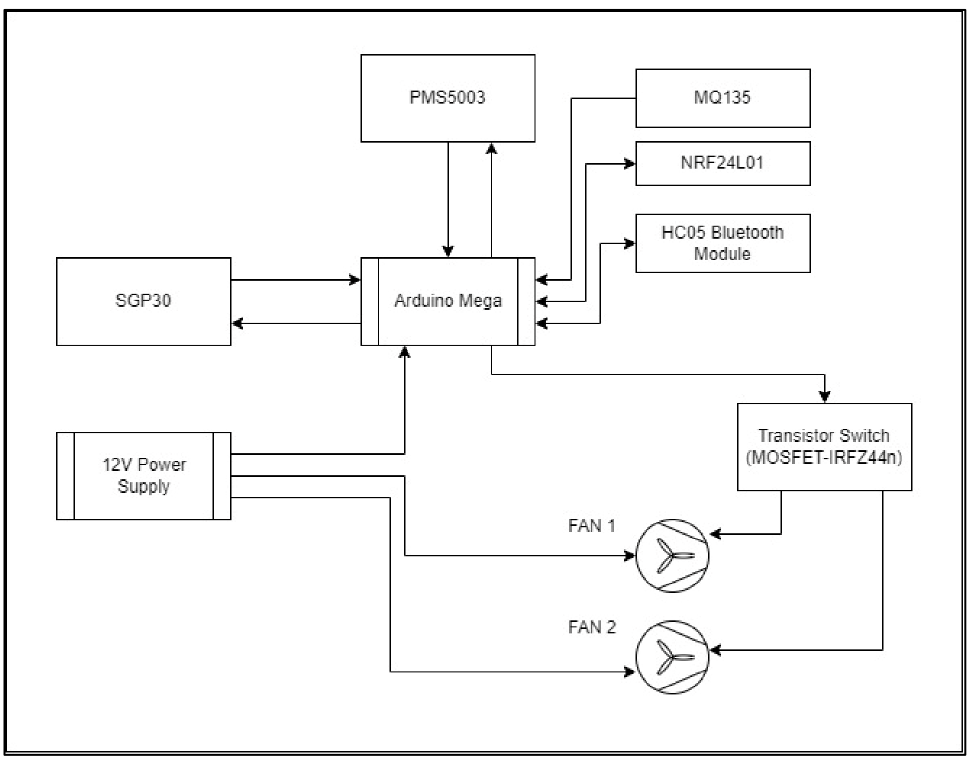


Figure 17. Machine Block Diagram of TECHNOVAIR

To understand the usage of the device, a step-by-step process is provided and is summarized in the machine operational flowchart found below.

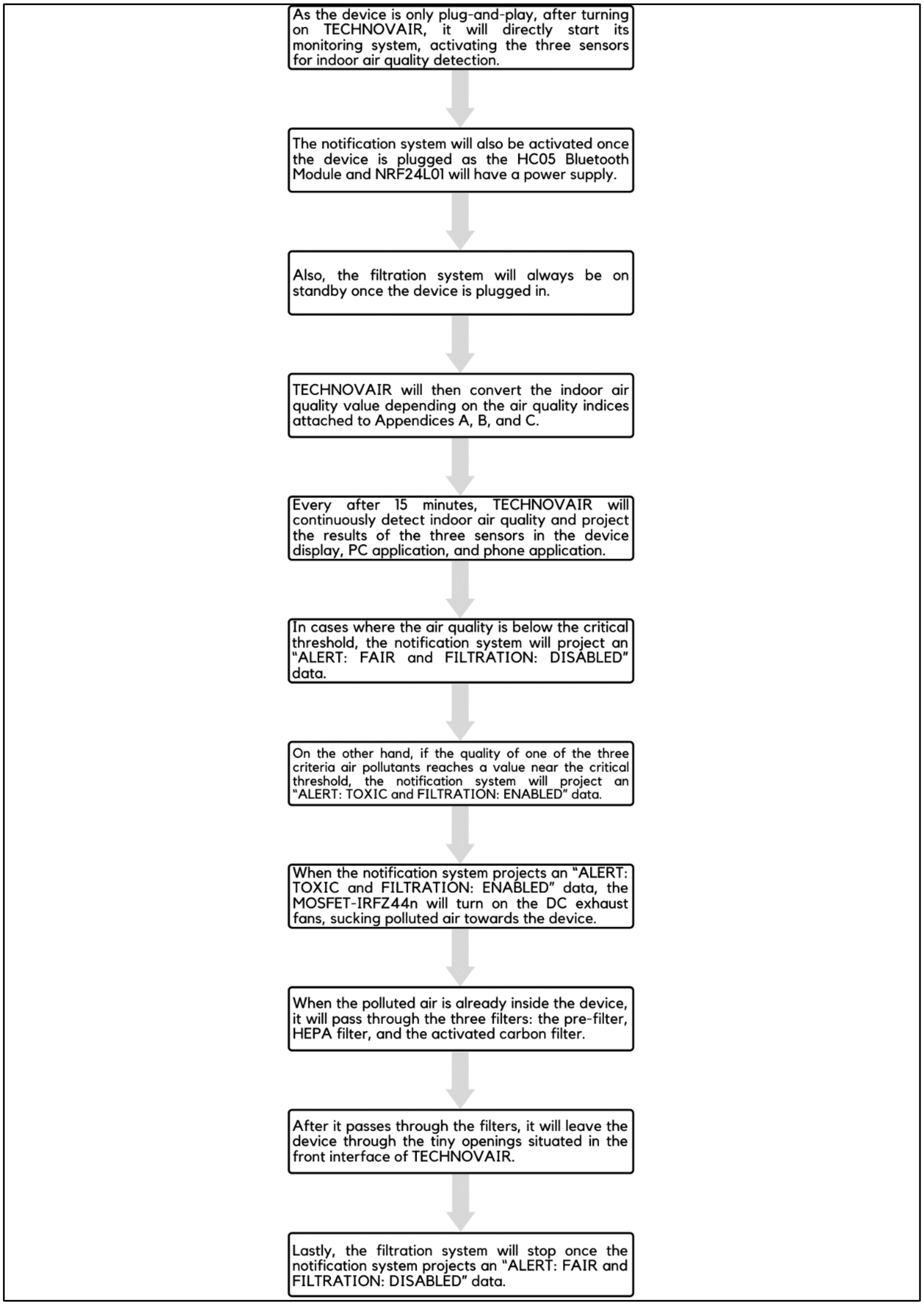


Figure 18. TECHNOVAIR's Machine Operational Flowchart

Application Source Code

To allow the device and applications to carry out their purpose, they must follow a source code that will contain all the commands they need to perform. Therefore, with the knowledge of the developers and an expert combined, three source codes were established for the project: one for the TECHNOVAIR device itself and another for the PC and phone application. Attached below is the series of codes which have been tested and are found to be effective in enabling the device and applications to perform their functions.

Here is the source code for the Arduino:

```cpp
/*
   Technovair Arduino Code
   04-27-2022
*/
#include <Wire.h>
#include <SPI.h>
#include <RF24.h>
#include <MQ131.h>
#include <LiquidCrystal_I2C.h>

#include <nRF24L01.h>
#include "PMS.h"
#include "SparkFun_SGP30_Arduino_Library.h"

#include <SoftwareSerial.h>

SoftwareSerial mySerial(19, 18); // RX, TX

LiquidCrystal_I2C lcd(0x27, 20, 4); // set the LCD address to 0x27 for a 16 chars and 2 line display

SGP30 mySensor; //create an object of the SGP30 class

RF24 radio(46, 47); // CE, CSN
const byte address[6] = "MCMTV";


PMS pms(Serial);
PMS::DATA data;


//Technovair data
unsigned long update_interval = 900000;
unsigned long prev_millis = 0;

int data_pm = 0;
double data_ozone = 0.0;
int data_tvoc = 0;


String radio_msg = " ";

#define FAN_pin 49

void setup()
{
  pinMode(FAN_pin, OUTPUT);
  //MYSERIAL
  mySerial.begin(9600);

  //PMS5003
  Serial.begin(9600);    // GPIO1, GPIO3 (TX/RX pin on ESP-12E Development Board)
  Serial1.begin(9600);   // GPIO2 (D4 pin on ESP-12E Development Board)

  //SGP30
  Wire.begin();
  //Initialize sensor
  if (mySensor.begin() == false) {
    Serial.println("No SGP30 Detected. Check connections.");
    while (1);
  }


  // Init the sensor
  // - Heater control on pin 2
  // - Sensor analog read on pin A0
  // - Model LOW_CONCENTRATION
  MQ131.begin(2, A0, LOW_CONCENTRATION, 1000000);
  Serial.print(MQ131.getR0());
  Serial.print(MQ131.getTimeToRead());


  //Initializes sensor for air quality readings
  //measureAirQuality should be called in one second increments after a call to initAirQuality
  mySensor.initAirQuality();

  //NRF24L01
  radio.begin();
  radio.openWritingPipe(address);
  radio.setPALevel(RF24_PA_MAX);
  radio.stopListening();

  lcd.init();


  prev_millis == millis();
}
```

Figure 19. TECHNOVAIR’s Arduino Source Code – Lines 1-86

```
void loop() {

  if ((millis() - prev_millis) == update_interval) {
    while (!data_update()) {
      data_update();
    }
  }

  //Print the Particulate Matter Value on the LCD
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("PM:");
  lcd.print(data_pm);
  lcd.print(" uG/M3");

  //Print Alert Level for Particulate Matter
  lcd.setCursor(12, 0);
  lcd.print("AL:");
  lcd.print(getAlertLevel_PM(data_pm));

  //Print the Ozone Value on the LCD
  lcd.setCursor(0, 1);
  lcd.print("Ozone:");
  lcd.print(data_ozone);
  lcd.print(" PPM");
  //Print Alert Level for Ozone
  lcd.setCursor(12, 1);
  lcd.print("AL:");
  lcd.print(getAlertLevel_ozone(data_ozone));

  //Print the TVOC Value on the LCD
  lcd.setCursor(0, 1);
  lcd.print("TVOC:");
  lcd.print(data_tvoc);
  lcd.print(" PPB");
  //Print Alert Level for TVOC
  lcd.setCursor(12, 2);
  lcd.print("AL:");
  lcd.print(getAlertLevel_TVOC(data_tvoc));


  //Display the overall alert and  filter activity
  if (!getAlertLevel_TVOC(data_tvoc)) {
    if (getAlertLevel_PM(data_pm) < 2 && getAlertLevel_ozone(data_ozone) < 2) {
      lcd.setCursor(0, 3);
      lcd.print("FAIR  ");
      lcd.print("F:Disabled");
      digitalWrite(FAN_pin, LOW); //TURN OFF THE FAN (FILTER)
    } else if (getAlertLevel_PM(data_pm) >= 2 || getAlertLevel_ozone(data_ozone) >= 2) {
      lcd.setCursor(0, 3);
      lcd.print("TOXIC  ");
      lcd.print("F:Active");
      digitalWrite(FAN_pin, HIGH); //TURN ON THE FAN (FILTER)
    }
  } else {
    if (getAlertLevel_PM(data_pm) >= 2 || getAlertLevel_ozone(data_ozone) >= 2) {
      lcd.setCursor(0, 3);
      lcd.print("TOXIC  ");
      lcd.print("F:Active");
      digitalWrite(FAN_pin, HIGH); //TURN ON THE FAN (FILTER)
    }
  }

  //SEND THE DATA TO THE PC APP
  radio_msg = "A" + String(data_pm) + "," +  String(data_ozone) + "," +
  String(data_tvoc);
  radio.write(&radio_msg, sizeof(radio_msg));

  //SEND THE DATA TO THE PHONE APP
  mySerial.println("A" + String(data_pm) + "," +  String(data_ozone) + "," +
  String(data_tvoc));
  delay(3000);

}


bool data_update() {

  bool pms_updated = false;

  //PMS5003 UPDATE DATA
  if (pms.read(data))
  {
    Serial1.print("PM 1.0 (ug/m3): ");
    Serial1.println(data.PM_AE_UG_1_0);

    Serial1.print("PM 2.5 (ug/m3): ");
```

Figure 20. TECHNOVAIR's Arduino Source Code – Lines 87-172

```
    Serial1.println(data.PM_AE_UG_2_5);

    Serial1.print("PM 10.0 (ug/m3): ");
    Serial1.println(data.PM_AE_UG_10_0);

    Serial1.println();
    data_pm = data.PM_AE_UG_1_0 + data.PM_AE_UG_2_5 + data.PM_AE_UG_10_0;
    pms_updated = true;
  }

  //MQ131 UPDATE DATA
  Serial.print(MQ131.getO3(PPB));
  Serial.println(" ppb");
  data_ozone = MQ131.getO3(PPB);

  //SGP30 UPDATE DATA
  mySensor.measureAirQuality();
  Serial.print("CO2: ");
  Serial.print(mySensor.CO2);
  Serial.print(" ppm\tTVOC: ");
  Serial.print(mySensor.TVOC);
  Serial.println(" ppb");
  data_tvoc = mySensor.TVOC;

  return pms_updated;
}



int getAlertLevel_PM(int PM_value){
  if(PM_value>=0 && PM_value<80){
    return 0;
  }else if(PM_value>=80 && PM_value<230){
    return 1;
  }else if(PM_value>=230 && PM_value<350){
    return 2;
  }else if(PM_value>=350 && PM_value<600){
    return 3;
  }else if(PM_value>=600 && PM_value<900){
    return 4;
  }else if(PM_value>=900){
    return 5;
  }

  return 0;
}

int getAlertLevel_ozone(float ozone_value){
  if(ozone_value>=0 && ozone_value<0.065){
    return 0;
  }else if(ozone_value>=0.065 && ozone_value<0.085){
    return 1;
  }else if(ozone_value>=0.085 && ozone_value<0.105){
    return 2;
  }else if(ozone_value>=0.105 && ozone_value<0.125){
    return 3;
  }else if(ozone_value>=0.125 && ozone_value<0.375){
    return 4;
  }else if(ozone_value>=0.375){
    return 5;
  }
  return 0;
}

boolean getAlertLevel_TVOC(int tvoc_value){
  if(tvoc_value>=500){
    return true;
  }
  return false;
}
```

Figure 21. TECHNOVAIR's Arduino Source Code – Lines 173-242

Here is the source code for the PC Application:

```
//Technovair PC Monitor app
import processing.serial.*;

Serial myPort;  // Create object from Serial class

PImage img_backdrop;

PFont font_bebasneue;
PFont font_regularBold;
PFont font_regular;
PFont font_regularcontent;

int part_matter=98;
float ozone= 0.041;
int tvoc= 131;

int updateTime= 900000;
int prevmillis=0;

boolean flag_dataUpdate=false;

void setup() {
  String portName = Serial.list()[0];
  myPort = new Serial(this, portName, 115200);
  img_backdrop= loadImage("bg.jpg");

  font_regularBold = createFont("regularBold.ttf", 36);
  font_bebasneue = createFont("BebasNeue-Regular.ttf", 36);
  font_regularcontent= createFont("square_721_bt.ttf", 36);
  size(720, 480);
  background(255);
  prevmillis=millis();
}


void draw() {
  background(255);
  image(img_backdrop, 0, 0);

  header();
  measuredValues();


  if (flag_dataUpdate) {

    getData();

    flag_dataUpdate=!flag_dataUpdate;
    prevmillis= millis();
  } else {
    if (millis()-prevmillis>=updateTime) {
      flag_dataUpdate=true;
    }
  }

  println(millis());
}


void header() {
  fill(255);
  stroke(2);
  rectMode(RADIUS);
  rect(width/2, 50, 200, 40, 15);

  stroke(0);
  fill(0);
  textAlign(CENTER, CENTER);
  textFont(font_regularBold);
  textSize(30);
  text("TECHNOVAIR PC Monitor", width/2, 50);
}

void measuredValues() {
  strokeWeight(2);
  fill(255);
  rectMode(CORNER);
  rect(5, 170, 470, 40, 15);

  rect(5, 218, 470, 40, 15);

  rect(5, 268, 470, 40, 15);

  stroke(0);
  fill(0);
  textAlign(TOP, LEFT);
  textFont(font_regularcontent);

```

Figure 22. TECHNOVAIR’s Software Application Monitor Source Code

```
textSize(28);
text("Particulate Matter: "+str(part_matter)+" uG/M3", 10, 200);

String PM_description="";
switch(getAlertLevel_PM(part_matter)) {
case 0:
  fill(#00ff00);
  PM_description="GOOD";
  rect(495, 170, 70, 40, 15);
  break;
case 1:
  fill(#0066ff);
  PM_description="FAIR";
  rect(495, 170, 55, 40, 15);
  break;
case 2:
  fill(#66ffff);
  PM_description="UNHEALTHY";
  rect(495, 170, 130, 40, 15);
  break;
case 3:
  fill(#ffff00);
  PM_description="VERY UNHEALTHY";
  rect(495, 170, 190, 40, 15);
  break;
case 4:
  fill(#ff9900);
  PM_description="ACUTELY UNHEALTHY";
  rect(495, 170, 220, 40, 15);
  break;
case 5:
  fill(#ff0000);
  PM_description="EMERGENCY";
  rect(495, 170, 140, 40, 15);
  break;
}

fill(0);
textSize(20);
text(PM_description, 500, 200);




fill(0);
textSize(30);
text("Ozone:  " +  str((float)ozone) + " PPM", 10, 250);

String ozone_description="";
switch(getAlertLevel_ozone(ozone)) {
case 0:
  fill(#00ff00);
  ozone_description="GOOD";
  rect(495, 218, 70, 40, 15);
  break;
case 1:
  fill(#0066ff);
  ozone_description="FAIR";
  rect(495, 218, 55, 40, 15);
  break;
case 2:
  fill(#66ffff);
  ozone_description="UNHEALTHY";
  rect(495, 218, 130, 40, 15);
  break;
case 3:
  fill(#ffff00);
  ozone_description="VERY UNHEALTHY";
  rect(495, 218, 190, 40, 15);
  break;
case 4:
  fill(#ff9900);
  ozone_description="ACUTELY UNHEALTHY";
  rect(495, 218, 220, 40, 15);
  break;
case 5:
  fill(#ff0000);
  ozone_description="EMERGENCY";
  rect(495, 218, 140, 40, 15);
  break;
}
fill(0);
textSize(20);
text(ozone_description, 500, 250);


String tvoc_description="";
if (getAlertLevel_TVOC(tvoc)) {
```

Figure 23. TECHNOVAIR's Software Application Monitor Source Code

```
void getData(){
  if ( myPort.available() > 0) {  // If data is available,
    s_val[0] = myPort.read();         // read it and store it in val
    //println(s_val[0]);
  }

  int count=1;
  if (s_val[0]=='A') {
    while (count<=4) {
      while (myPort.available()==0) {
      }
      s_val[count] = myPort.read();
      count++;
    }
  }

  if (s_val[0]=='A' && s_val[4]=='B') {
    println("val0: "+ s_val[0] + "\t val1: " +s_val[1]+ "\t val2: " +s_val[2]+ "\t
    val3: " +s_val[3]+ "\t val4: " +s_val[4]);
    part_matter=s_val[1];
    ozone=s_val[2];
    tvoc=s_val[3];
  }
}
```

Figure 24. TECHNOVAIR's Software Application Monitor Source Code

```
      fill(#ff0000);
      tvoc_description="EMERGENCY";
      rect(495, 268, 140, 40, 15);
    } else {
      fill(#00ff00);
      tvoc_description="GOOD";
      rect(495, 268, 70, 40, 15);
    }

    fill(0);
    textSize(20);
    text(tvoc_description, 500, 300);

    fill(0);
    textSize(30);
    text("TVOC: " + str((float)tvoc) + " PPB", 10, 300);


    fill(0);
    textSize(30);
    text("ALERT:", 10, 400);
    text("FILTRATION:", 10, 440);

    if (getAlertLevel_TVOC(tvoc)) {
      fill(#FF0000);
      textFont(font_regularBold);
      text("TOXIC", 130, 400);

      fill(#0000FF);
      textFont(font_regularBold);
      text("ACTIVE", 190, 440);
    } else {
      if (getAlertLevel_PM(part_matter)>1 || getAlertLevel_ozone(ozone)>1 ) {
        fill(#FF0000);
        textFont(font_regularBold);
        text("TOXIC", 130, 400);

        fill(#0000FF);
        textFont(font_regularBold);
        text("ACTIVE", 190, 440);
      } else {
        fill(#00FF00);
        textFont(font_regularBold);
        text("FAIR", 130, 400);

        fill(#ff6600);
        textFont(font_regularBold);
        text("DISABLED", 190, 440);
      }
    }
  }


```

Figure 25. TECHNOVAIR's Software Application Data Collection Source Code

```
int getAlertLevel_PM(int PM_value){
  if(PM_value>=0 && PM_value<80){
    return 0;
  }else if(PM_value>=80 && PM_value<230){
    return 1;
  }else if(PM_value>=230 && PM_value<350){
    return 2;
  }else if(PM_value>=350 && PM_value<600){
    return 3;
  }else if(PM_value>=600 && PM_value<900){
    return 4;
  }else if(PM_value>=900){
    return 5;
  }

  return 0;
}

int getAlertLevel_ozone(float ozone_value){
  if(ozone_value>=0 && ozone_value<0.065){
    return 0;
  }else if(ozone_value>=0.065 && ozone_value<0.085){
    return 1;
  }else if(ozone_value>=0.085 && ozone_value<0.105){
    return 2;
  }else if(ozone_value>=0.105 && ozone_value<0.125){
    return 3;
  }else if(ozone_value>=0.125 && ozone_value<0.375){
    return 4;
  }else if(ozone_value>=0.375){
    return 5;
  }
  return 0;
}

boolean getAlertLevel_TVOC(int tvoc_value){
  if(tvoc_value>=500){
    return true;
  }
  return false;
}
```

Figure 26. TECHNOVAIR's Software Application Alert Source Code

Here is the source code for the Phone Application:

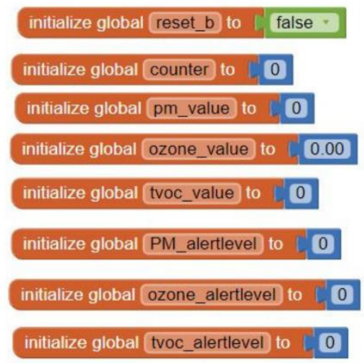


Figure 27. TECHNOVAIR's Phone Application Variable Source Code

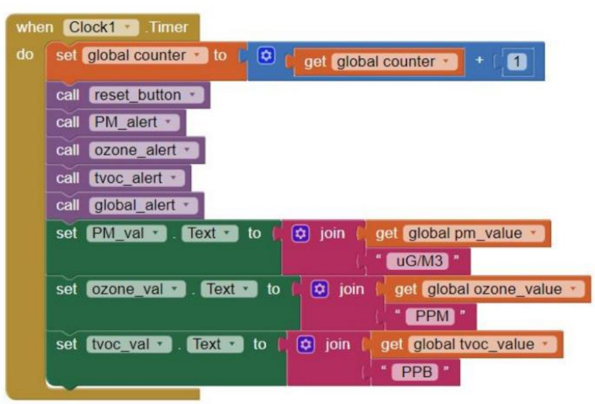


Figure 28. TECHNOVAIR's Phone Application Clock Source Code

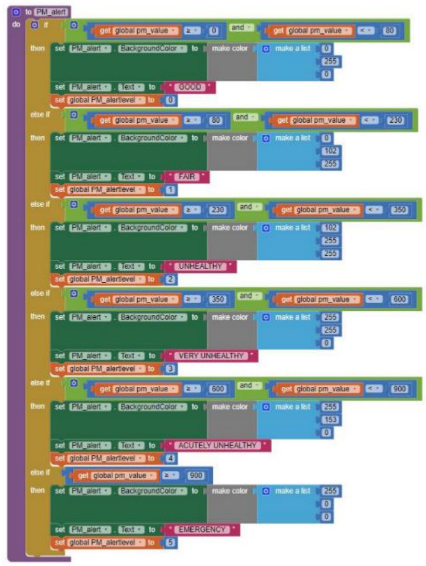


Figure 29. TECHNOVAIR's Phone Application PM Alert Source Code

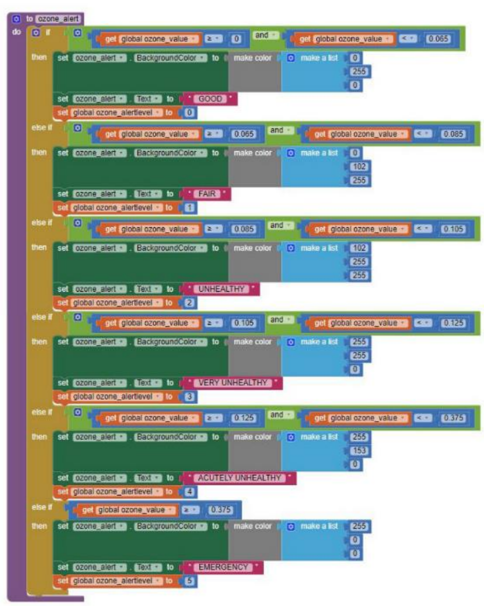


Figure 30. TECHNOVAIR's Phone Application Ozone Alert Source Code

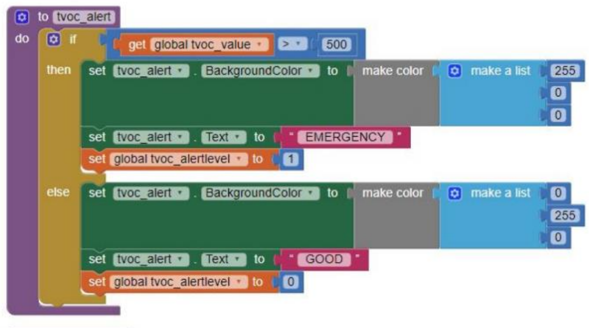


Figure 31. TECHNOVAIR's Phone Application TVOC Alert Source Code

Figure 32. TECHNOVAIR's Phone Application Global Alert Source Code

Application Mechanism

This study will utilize the data flow block diagram to visualize the application mechanism. Attached in the figure below is the mapping out of the data inputs and outputs from the air quality sensors. For additional information, attached below the figure is the operational flowchart of the step-by-step process of how the application works involving the components found on the diagram.

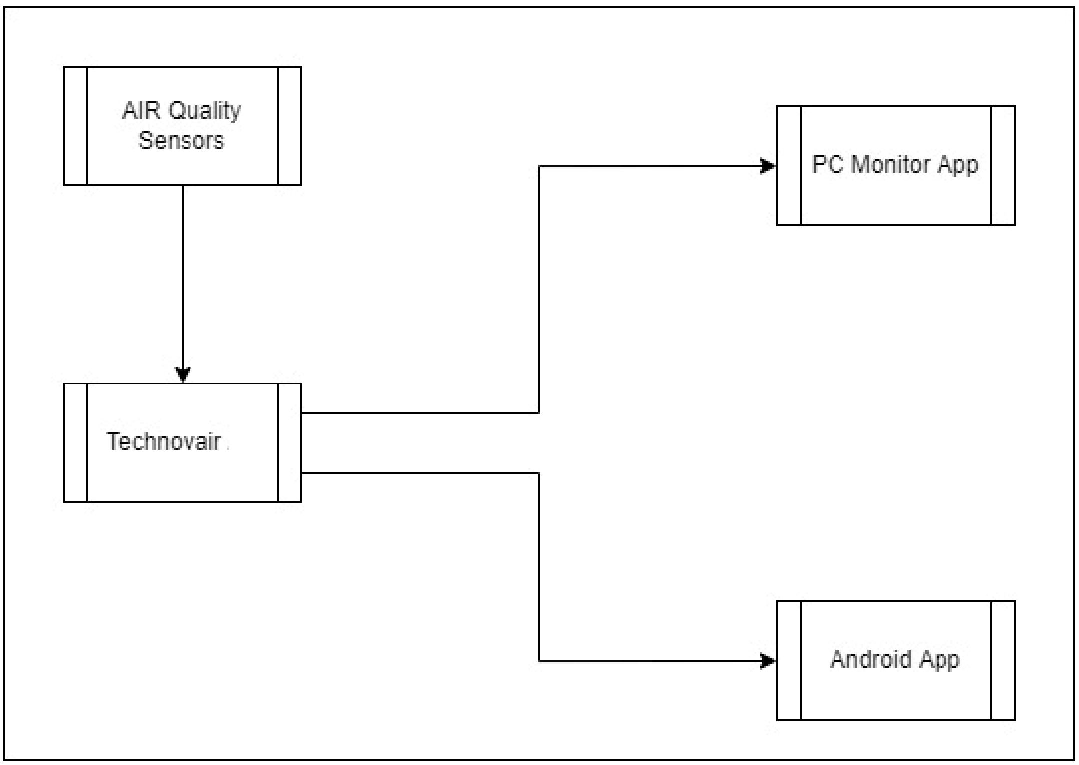


Figure 33. Data Flow Block Diagram of TECHNOVAIR

To understand the usage of the application, an operational flowchart is used to separate the steps by block. A total of six steps are determined to let the users smoothly use the application, and these are the following:

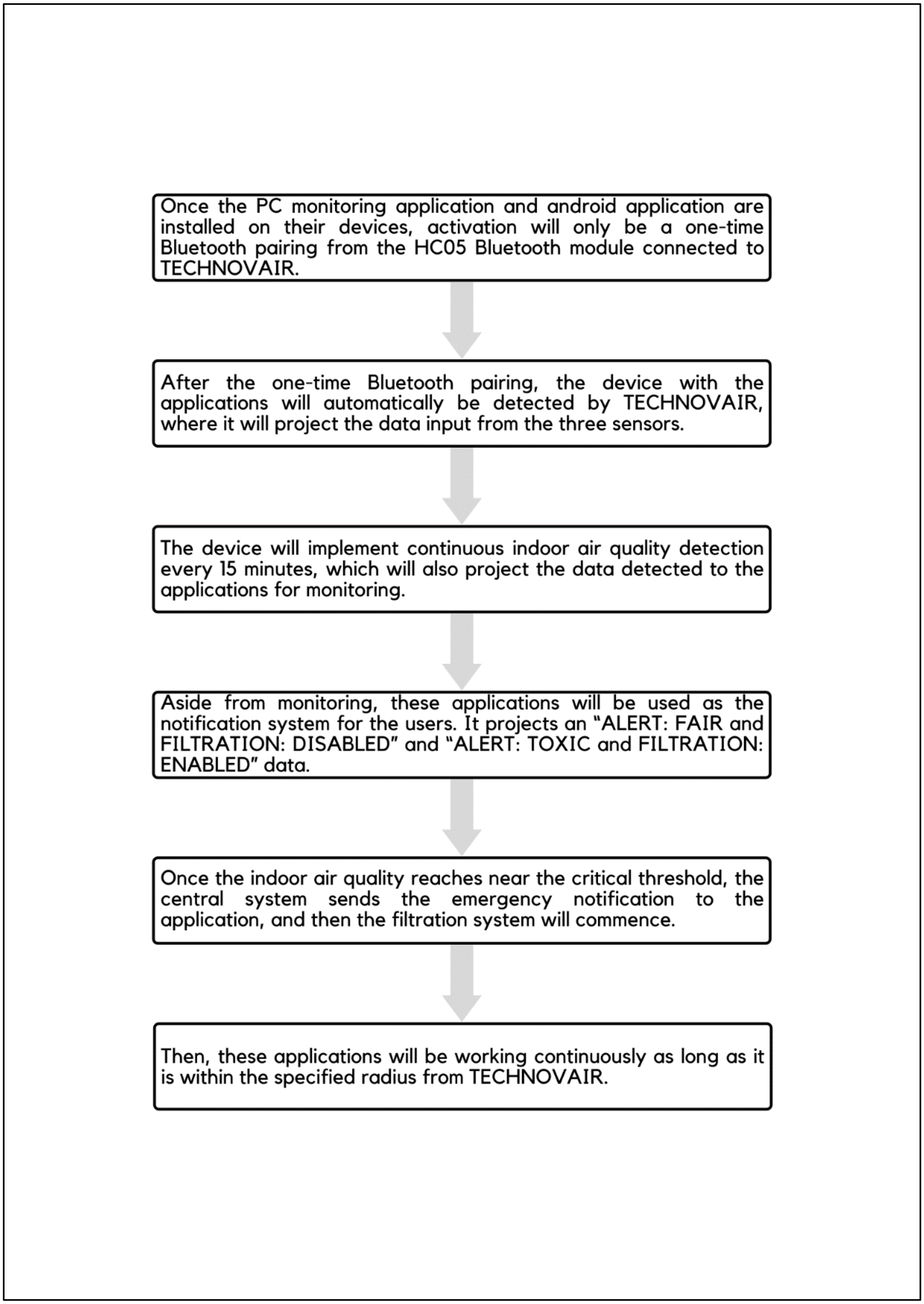


Figure 34. TECHNOVAIR's Applications Operational Flowchart

Project Manual

This section mainly discusses technical instructions intended to provide information on using TECHNOVAIR. The manual includes explanations on how to use the product successfully and efficiently, as well as step-by-step guides and images to provide adequate usage instructions and limit the danger of the product becoming inoperable.

PC Application Installation

1. Download the installation file named ‘technovair.application.windows64.zip’ given by the developers. Depending on the size of the file and your connection speed, downloading software might take anywhere from a few minutes to many hours.
2. Create a temporary folder, then move the downloaded file.
3. Right-click on the zip file and select ‘Extract Here’.
4. Inside the extracted folder, open the Technovair_Pcmonitor.exe. This is already the PC Application.
5. Wait for the TECHNOVAIR to connect automatically (the value changes from all zeros).
6. In case of system hang up, go to Task Manager, click Technovair_Pcmonitor.exe and select ‘End Task’.

Phone Application Installation

1. Download the APK installation file named ‘Technovair.apk’ given by the developers. Depending on the size of the file and your connection speed,

downloading software might take anywhere from a few minutes to many hours.

2. Install the application on your phone.
3. Open the application and wait for TECHNOVAIR to connect automatically (the value changes from all zeros).
4. View the air quality values.
5. In case of system hang up, just go to Settings>Applications>Technovair and select 'Force Stop'.

Device Operation Instruction

1. Plug the power cable to the power source to turn on the TECHNOVAIR.
2. Turn on the Bluetooth of both computer and phone with the applications installed to allow its discoverability.
3. For first-time users, pair with the HC05 Bluetooth Module installed in TECHNOVAIR. This process is only done one time. Thus, pairing is unnecessary for old users, as long as step 2 is followed.
4. Once all the steps above are followed, the device and the applications are ready for use.

Troubleshooting

1. If you experience general problems, you may inspect the product by yourself.
2. Immediately turn off the TECHNOVAIR by unplugging it and wait for 15 seconds to turn it back on to prevent damage to the system and other hazards.

3. Also, restart your computer and phone devices.

Project Cost

Lastly, this segment will provide the breakdown of the actual projected cost of the product and the difference in the monetary value invested in this project as compared to the selected existing products, the Carrier Air Purifier CADR260 and Medion MD 10444 Air Purifier. This section is highly essential to ensure the transparency of the developers in terms of the consumption of allotted funds. Moreover, this will help them prove the cost-effectiveness of the product, as well as to establish a concrete reason as to why it is worth advancing to the markets. Thus, after performing this project, the project's total cost has been deduced to be approximately PHP13,526.

Actual Projected Cost of the Product

To easily understand the breakdown of the project costs, the following are enumerated: the system tools used, the unit price per piece, the quantity of each component, and the total cost for each tool. Found in Table 9 is the table that summarizes them all and the final total cost after computing all individual purchases and for the references of each price, attached in Appendix I, the complete list of links of the items.

***TECHNOVAIR:* Actual Projected Cost**			
System Tool	**Unit Price (per pc)**	**Quantity**	**Total Cost**
Internal Components of TECHNOVAIR			
Arduino Mega 2560	₱469	1	₱469
PMS5003 Sensor	₱820	1	₱820
MQ131 Sensor	₱803	1	₱803
SGP30 Sensor	₱1,099	1	₱1,099
HC05 Bluetooth Module	₱209	1	₱209
NRF24L01 Transistor Switch	₱50	1	₱50
MOSFET-IRFZ44n	₱35	1	₱35
DC Exhaust Fan	₱61	2	₱122
Pre-filter	₱800 3-in-1 set	1	₱800
High-Efficiency Particulate Air (HEPA) filter			
Activated Carbon filter			
IIC 20x4 LCD	₱229	1	₱229
Jumper Wires	₱59/set	40 pcs/1 set	₱59
Plug Cable	₱56	1	₱56
Shipping Expenses			
Shipping Fee	₱300	1	₱300
Device Housing			
Device Casing (3D Printed)	₱5/gram	95	₱475
Professional Fee			
Engineer's Fee	₱8,000	1	₱8,000
		TOTAL COST	₱13,526

Table 9. TECHNOVAIR's Actual Projected Cost

As TECHNOVAIR is hampered to be conducted as an actual functional device, the project design of the system is regarded as the final output of the research. This project design will be done online in order to build the mechanical circuits and the software coding. Thus, as shown in Table 9, the total projected cost for the project design when made as a functional device and software of TECHNOVAIR is ₱13,526. This total cost is the overall composition of the system's internal components, the device housing, which is 3D printed, shipping expenses for the components that will be ordered online, and the engineer's fee who actualized TECHNOVAIR and crafted the PC and smartphone applications. Although the professional fee is high-priced compared to the project design cost if it will be built in actuality, the price is compensated as the two software applications the engineer constructed is part of the TECHNOVAIR systems themselves.

Project Cost Analysis

Since TECHNOVAIR's costs have been totaled, the developers have dedicated this segment to proving that it is both affordable and more favorable than other existing products in the market. The developers have undergone research and selected two products that are on par with the device with minor contrasts. The devices found that fit the context are the Carrier Air Purifier CADR260 and the Medion MD 10444 Air Purifier.

***TECHNOVAIR:* Project Cost Analysis**			
Project Product Cost	**Existing Products Cost**	**Cost Difference**	**Difference Percentage**
₱13,526 (TECHNOVAIR)	₱18,751 (Carrier Air Purifier CADR260)	₱5,225	A decrease of 27.87%
	₱14,104.91 (Medion MD 10444 Air Purifier)	₱578.91	A decrease of 4.28%

Table 10. TECHNOVAIR's Project Cost Analysis

The Carrier Air Purifier CADR260, a standing Ultraviolet (UV) air purifier, has been selected as the first product to be compared with the TECHNOVAIR.

One of their considerable similarities is that they both have a 3-stage filtration system: the Pre-filter, HEPA filter, and the Activated Carbon filter (Lazada, 2022). In addition, both devices have an air quality monitor, but instead of three criteria pollutants, the CADR260 only senses and displays the PM2.5 concentrations. Meanwhile, it is also worth mentioning that this device utilizes a UV light and a photocatalyst to kill bacteria and viruses that linger within the air. However, another disadvantage is that it cannot notify the user from a distance since its air quality monitor is embedded in the device, and no other feature is added (Carrier, 2022).

Another product, the Medion MD 10444 Air Purifier, is selected for comparison with TECHNOVAIR. Like the previous product, MD 10444 has three filters, and these are the same ones used by TECHNOVAIR (Medion, 2022). The device can filter a maximum of 60m2 (PriceSpy, 2022) and is compact with a size of 35 x 45 x 22 cm. In addition, MD 10444 is inclusive of a touch control panel that is attached to the device. Furthermore, it can be controlled through an application downloaded on smartphones and tablets. It differs from TECHNOVAIR as the device can be controlled through these gadgets, while TECHNOVAIR uses an app to indicate the values of the criteria pollutants and view the device’s status. This contrast is essential as TECHNOVAIR automatically functions without waiting for the user’s instructions and utilizes the app to inform users. Meanwhile, MD 10444 lets the users operate the app to set the timer or put the device in sleep or automatic mode (Conrad, 2022). Apart from this, the device originates in Germany, making it difficult to acquire from a different country. Therefore, for people living in far-set countries like the Philippines, even the delivery fee can be pretty expensive.

Compared to the Carrier Air Purifier CADR260 and Medion MD 10444 Air Purifier, TECHNOVAIR provides an efficient solution to users. It involves an application for the PC and smartphone that informs users about the overall IAQ and the values of the PM2.5 concentration, ozone concentration, VOCs, and equivalent carbon dioxide, two of which the CADR260 did not prioritize, although both devices have the same 3-way filtration system. Not to mention that TECHNOVAIR is portable, making it easier to transfer within different indoor settings. Also, TECHNOVAIR will only consume approximately 8.4W for its electric consumption compared to Carrier Air Purifier CADR260 with 23W and Medion MD 10444 Air Purifier with 38W power consumption. This product entails the practice of using less energy in order to lower costs and reduce environmental impact. On top of that, the TECHNOVAIR is priced at ₱13,526, which is ₱5,225 or 27.87% less than the Carrier Air Purifier CADR260 and ₱578.91 or 4.28% less than Medion MD 10444 Air Purifier. Hence, after assessing these factors, it is worth considering that TECHNOVAIR may have positive feedback in the market once deployed to consumers.

REFERENCES

Abbas, F. N., Sandoon, M. I. M., Abdalrdha, Z. K., Abud, E. N. (2020). Capable of gas sensor MQ-135 to monitor the air quality with Arduino uno. *International Journal of Engineering Research and Technology, 13*(10), 2955-2959. https://dx.doi.org/10.37624/IJERT/13.10.2020.2955-2959

Agarwal, N., Meena, C. S., Raj, B. P., Saini, L., Kumar, A., Gopalakrishnan, N., Kumar, A., Balam, N. B., Alam, T., Kapoor, N. R., & Aggarwal, V. (2021). Indoor air quality improvement in COVID-19 pandemic: Review. *Sustainable cities and society, 70*, 102942. https://doi.org/10.1016/j.scs.2021.102942

Alavy, M. & Siegel J. (2019). IAQ and energy implications of high efficiency filters in residential buildings: A review. *Science and Technology for the Built Environment, 25*(3), 261-271, DOI: 10.1080/23744731.2018.1526012

Al-Okby, M. F. R., Neubert, S., Roddelkopf, T., Fleischer, H., & Thurow, K. (2022). Evaluating of IAQ-index and TVOC parameter-based sensors for hazardous gases detection and alarming systems. *Sensors, 22*(4), 1473. https://doi.org/10.3390/s22041473

Balatbat, J., Bello, C., Bautista, R., De Guzman, A., Garraez, R., Pingol, F., Soliman, S., & Tan, L. (2021). *Portable Arduino based air quality monitoring system.* [Thesis, Polytechnic University of the Philippines]. PDFCoffee. https://pdfcoffee.com/chapter-1-5-revised-pdf-free.html

Basińska, M., Michalkiewicz, M., & Ratajczak, K. (2021). Effect of air purifier use in the classrooms on indoor quality—Case study. *Atmosphere, 12*(12), 1606. https://doi.org/10.3390/atmos12121606

Brągoszewska, E., & Biedroń, I. (2021). Efficiency of air purifiers at removing air pollutants in educational facilities: A preliminary study*. Frontiers in Environmental Science, 9.* https://doi.org/10.3389/fenvs.2021.709718

Breen, M.S., Isakov, V., Prince, S., McGuinness, K., Egeghy, P.P., Stephens, B., Arunachalam, S., Stout, D., Walker, R., Alston, L., Rooney, A., Taylor, K., & Buckley, T. (2021). Integrating personal air sensor and GPS to determine microenvironment-specific exposures to volatile organic compounds. *Sensors*, *21*(5659). https://doi.org/10.3390/s21165659

Buising, K. L., Schofield, R., Irving, L., Keywood, M., Stevens, A., Keogh, N., Skidmore, G., Wadlow, I., Kevin, K., Rismanchi, B., Wheeler, A. J., Humphries, R. S., Kainer, M., McGain, F., Monty, J., & Marshall, C. (2021). Use of portable air cleaners to reduce aerosol transmission on a hospital COVID-19 ward. *Infection, Disease, and Health.* https://doi.org/10.1101/2021.03.29.21254590

Bulot, F., Johnston, S., Basford, P., Easton, N., Apetroaie-Cristea, M., Morris, A., Cox, S., & Loxham, M. (2019). Long-term field comparison of multiple low-cost particulate matter sensors in an outdoor urban environment. *Scientific Reports, 9*, 7497. https://doi.org/10.1038/s41598-019-43716-3

Busetto, L., Wick, W., & Gumbinger, C. (2020). How to use and assess qualitative research methods. *Neurological Research and Practice, 2*(14). https://doi.org/10.1186/s42466-020-00059-z

Carcone, A., Hasan, M., Alexander, G., Dong, M., Eggly, S., Hartlieb, K., Naar, S., MacDonell, K., & Kotov, A. (2019). Developing machine learning models for behavioral coding. *Journal of Pediatric Psychology, 44*(3), 289-299. Doi: 10.1093/jpepsy/jsy113

Carrier. (2022). *Carrier air purifier user manual.* https://drive.google.com/file/d/1G-_-p3p6MhCYvCzFF4S1FBJTn1q0ctcq/view

Carrillo-Amado, Y. R., Califa-Urquiza, M. A., & Valencia, J. A. R. (2020). Calibration and standardization of air quality measurements using MQ sensors. *Respuestas, 25*(1), 70-77. https://doi.org/10.22463/0122820X.2408

Chan, W. R., Parthasarathy, S., Fisk, W. J., & McKone, T. E. (2016). Estimated effect of ventilation and filtration on chronic health risks in US offices, schools, and retail stores. *Indoor Air, 26*(2), 331–343. DOI: 10.1111/ina.12189

Clifford, P. (1985). *Selective gas detection and measurement system.* (European Patent No. EP0161266A1). European Patent Office. https://worldwide.espacenet.com/patent/search/family/024122628/publication/US4542640A?q=pn%3DUS4542640A

Conrad. (2022). Medion MD 10444 air purifier 60 m² white, black. https://www.conrad.com/p/medion-md-10444-air-purifier-60-m-white-black-2391125?WT.srch=1&vat=true&utm_source=google&utm_medium=organic&utm_campaign=shopping

Consumer Reports. (2022). *Air purifiers. https://www.consumerreports.org/cro/air-purifiers/buying-guide/index.htm*

Cooper, E., Wang, Y., Stamp, S., Nijsen, T., de Graaf, P., Hofman, J., Inki, T., Driessen, R., Liebmann, J., Geven, I. T. M., Vervoort, K., La Manna, V. P., Valster, S., de Wolf, P., Peltonen, S., Burman, E., Salminen, A., van Galen, R., & Mumovic, D. (2022). Why do people use portable air purifiers? Evidence from occupant surveys and air quality monitoring in homes in three European cities. *Building Research & Information 50*(1-2), 213-229. https://doi.org/10.1080/09613218.2021.2001303

Creswell, J., & Clark, V. (2017). *Designing and conducting mixed methods research third edition*. https://doc1.bibliothek.li/acd/FLMF050277.pdf

Curtius, J., Granzin, M., & Schrod, J. (2021). Testing mobile air purifiers in a school classroom: Reducing the airborne transmission risk for SARS-CoV-2. *Aerosol Science and Technology, 55*(5), 586-599. https://doi.org/10.1080/02786826.2021.1877257

Datasheet SGP30 Sensirion gas platform. (2017). Mouser Electronics. https://www.mouser.com/pdfdocs/Sensirion_Gas_Sensors_SGP30_Datasheet_EN-1148053.pdf

Davis Air Conditioning & Heating. (2015, February 4). *Air filters: Understanding their function and how to choose the right one.* https://davisac.com/article/air-filters-understanding-function-choose-right-one

Eby, K. (2019, January 2). *The power of iterative design and process.* Smartsheet. https://www.smartsheet.com/iterative-process-guide#:~:text=At%20the%20most%20basic%20level,initial%20planning%20and%20overall%20requirements.

Fraser, N. (2013). *Blockly: A visual programming editor.* Blockly. https://developers.google.com/blockly/.

Friedlander, S. K. (2002). Theory of aerosol filtration. *Industrial & Engineering Chemistry*, *50*(8), 1161–1164. https://doi.org/10.1021/ie50584a036

Goodhue, D. & Thompson, R. (1995). Task-technology fit and individual performance. *MIS Quarterly, 19*(2), 213-236. https://doi.org/10.2307/249689

Hamanaka, R., & Mutlu, G. (2018). Particulate matter air pollution: Effects on the cardiovascular system. *Frontiers in Endocrinology, 9.* https://doi.org/10.3389/fendo.2018.00680

Heitzmann, B. (2015, June). *Challenges, considerations, and concerns of indoor air quality.* Pennsylvania Housing Research Center. https://www.phrc.psu.edu/assets/docs/Publications/PHRC%20IAQ%20BB%20FINAL.pdf

Heyasa B., & Galarpe, V. (2017). Initial development and testing of microcontroller-MQ2 gas sensor for university air quality monitoring. *Journal of Electrical and Electronics Engineering, 12*(3), 47-53.

Infrastructure Modernization of Davao City 2045. (n.d.). *Davao City Infrastructure Development Plan*. https://www.jica.go.jp/activities/issues/urban/ku57pq000019fbsv-att/104rduino104ne_01en.pdf

Jo, J., Jo, B., Kim, J., Kim, S., & Han, W. (2020). Development of an IoT-based indoor air quality monitoring platform. *Journal of Sensors*, 1-14. https://doi.org/10.1155/2020/8749764

Jones, E. R., Laurent, J. G. C., Young, A. S., MacNaughton, P., Coull, B. A., Spengler, J. D., & Allen, J. G. (2021). The effects of ventilation and filtration on indoor PM2.5 in office buildings in four countries. *Building and Environment, 200*. https://doi.org/10.1016/j.buildenv.2021.107975

Kabrein, H., Harin, A., Leman, A., Noraini, N., Yusof, M., & Afandi, A. (2017). Impact of the air filtration on indoor particle concentration by using combination filters in offices building. *IOP Conference Series: Materials*

Science and Engineering, 243. https://doi:10.1088/1757-899X/243/1/012051

Lazada. (2022). Carrier air purifier CADR 260 (up to 31 sqm) CAUN026LC1. https://www.lazada.com.ph/products/carrier-air-purifier-cadr-260-up-to-31-sqm-caun026lc1-i1206548084.html

Lim, B. & Zohren, S. (2020). Time series forecasting with deep learning: A survey. *The Royal Society Publishing.*

Liu, G., Xiao, M., Zhang, X., Gal, C., Chen, X., Liu, L., Pan, S., Wu, J., Tang, L. & Clements-Croome, D. (2017). A review of air filtration technologies for sustainable and healthy building ventilation. *Sustainable Cities and Society, 32*, 375-396. https://doi.org/10.1016/j.scs.2017.04.011

Liu, Y., Zhou, B., Wang, J., & Zhao, B. (2021). Health benefits and cost of using air purifiers to reduce exposure to ambient fine particulate pollution in China. *Journal of Hazardous Materials, 414*. https://doi.org/10.1016/j.jhazmat.2021.125540.

Lokesh, MR, Sharath, S., Shreyas, R., Subramanya, HL, & Supreeth, K.S. (2021). Cyber-air quality monitoring system: A review. *International Journal of Innovative Research in Technology, 7*(9).

Louis, L. (2016). Working principle of Arduino and using it as a toll for study and research. *International Journal of Control, Automation, Communication and Systems, 1*(2). https://doi.org/10.5121/ijcacs.2016.1203

Ma, Z. Hu, X., Sayer, A., Levy, R., Zhang, Q., Xue, Y., Tong, S., Bi, J., Huang, L., Liu, Y. (2016). Satellite-based spatiotemporal trends in PM2.5 concentrations: China, 2004-2013. *Environmental Health Perspectives, 124*(2), 184-192. Doi: 10.1289/ehp.1409481

MacKellar, F. (2022). *Subjectivity in qualitative research.* Simon Fraser University. https://www.sfu.ca/educ867/htm/subjectivity.htm

Madiraju, S., Raghunadh, G., & Kumar, R. (2020). Prototype of eco-friendly indoor air purifier to reduce concentrations of CO_2, SO^2 and NO_2. *Nature Environment and Pollution Technology, 19*(2), 747-753. https://doi.org/10.46488/NEPT.2020.v19i02.030

Maminta, K. (2019). *Air-mo-fy: an air quality index monitoring and purifying device.* (Philippine Patent No. PH12019050128A1). European Patent Office. https://worldwide.espacenet.com/patent/search/family/074667888/publication/PH12019050128A1?q=pn%3DPH12019050128A1

Martins, J. (2021, April 20). *Understanding the iterative process, with examples.* Asana. https://asana.com/resources/iterative-process

Medion. (2022). MEDION® 3in1 air purification filter MD 10378 and MD 10444, consisting of pre-filter grid, HEPA filter (H13), activated carbon filter. https://www.medion.com/at/shop/p/haushalt-zubehoer-medion-3in1-luftreinigungsfilter-md-10378-und-md-10444-bestehend-aus-vorfiltergitter-hepa-filter-h13–aktivkohle-filter-50067183A1

Miller, S. (2021, January 2). *Hidden gem: The "Processing IDE" for PC and Linux to engage your embedded projects.* Element 14. https://community.element14.com/products/107rduino/107rduino-projects/b/blog/posts/hidden-gem-the-processing-ide-for-pc-and-linux-to-engage-your-embedded-projects

MQ131 semiconductor sensor for ozone. (2022). Sensors Portal. https://www.sensorsportal.com/DOWNLOADS/MQ131.pdf

Omomule, T. G., Ajayi, O. O., and Adekile, S. B. (2020). Sensor-based mobile pigeonhole alert system. *International Journal of Biosensors & Bioelectronics, 6*(1), 4-12. DOI: 10.15406/ijbsbe.2020.06.0018

Panicker, D., Kapoor, D., Thakkar, B., Kumar, L., & Kamthe, M. (2020). Smart air purifier with air quality monitoring system. *International Journal for Research in Applied Science & Engineering Technology, 8*(5). http://dx.doi.org/10.22214/ijraset.2020.5244

Park, H., Cheng, K., Tetteh, A., Hildemann, L., & Nadeau, K. (2016). Effectiveness of air purifier on health outcomes and indoor particles in homes of children with allergic diseases in Fresno, California: A pilot study. *Environmental Determinants: Journal of Asthma, 54(4), 341-346.* https://doi.org/10.1080/02770903.2016.1218011

Philippine Clean Air Act of 1999, Republic Act No. 8749. (2022). Food and Agriculture Organization of the United Nations. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC045271/

Pippel, B., Gregory, E., Miles, M., & Dodds, J. (2012). *Air treatment system.* (Korean Patent No. KR101209974B1). United States Patent and Trademark Office. https://globaldossier.uspto.gov/#/result/publication/KR/101209974/1

Pliskin, H. L. (2015). *Contaminant monitoring and air filtration system*. (United States Patent no. US10422727B2). United States Patent and Trademark Office. https://patentcenter.uspto.gov/#!/applications/14822706

Positos, J., Boransing, P. A., Divino, K., Escabarte, A. B., & Ridad, G. (2017). Arduino-based air testing, air filtering and disinfecting device design and effectivity testing for hospital rooms. *International Journal of Trend in Research and Development, 4*(5).

PriceSpy. (2022). Medion MD 10444. https://pricespy.co.uk/home-garden/heating-cooling/air-purifiers/medion-md-10444–p5881915

Qualitative research. (2019). Physiopedia. https://www.physio-pedia.com/Qualitative_Research

Qualitative study design. (2013). Deakin University. https://deakin.libguides.com/qualitative-study-designs

Rajapandian, G., Pandiyan, B., Chandrasekar, L., Krishnan, K., Sebastian, J., Kesavel, M., & Sudharsan, V. (2019). Review on air purifier. *GSC Biological and Pharmaceutical Sciences, 7*(1), 1–5.

Scerbo, M. (1996). *Theoretical perspectives on adaptive automation.* CRC Press.

Shuai, J., Kim, S., Ryu, H., Park, J., Lee, C., Kim, G., Ultra, V., & Yang, W. (2018). Health risk assessment of volatile organic compounds exposure near Daegu dyeing industrial complex in South Korea. *BMC Public Health, 18*, 258. https://doi.org/10.1186/s12889-018-5454-1

Smith, B., Hoff, S., Harmon, J., Andersen, D., Zimmerman, J., & Stinn, J. (2019). Factors affecting pre-filter loading and strategies to manage excessive loading. *ASABE Annual International Meeting, 7.* Doi:10.13031/aim.201900326

Stephens, B., Brennan, T., & Harriman, L. (2016). Selecting ventilation air filters to reduce PM2.5 of outdoor origin. *ASHRAE Journal.* https://www.conforlab.com.br/wp-content/uploads/2016/10/2016Sep_012-021_HarrimanFiltersToReducePM2.5.pdf

Study Finds Safety Concerns with Air Purifiers. (2021). CleanLink. https://www.cleanlink.com/news/article/Study-Finds-Safety-Concerns-With-Air-Purifiers---26882

Suter, W. (2012) Introduction to educational research: A critical thinking approach. *Sage Publications, Thousand Oaks,* 342-386.

Tuyen, M. & Hieu, N. (2019). On a Mega 2560 application in the development of a smart module used for sanitary ware. *International Journal of Latest Research in Engineering and Management, 3*(12), 1-5.

Van Boven, F. E., de Jong, N. W., Braunstahl, G. J., & Arends, L. R. (2020). Effectiveness of the air purification strategies for the treatment of allergic asthma: A meta-analysis. *International Archives of Allergy and Immunology.* https://doi.org/10.1159/000506284

Vern, R. & Dubey, S.K. (2013). A survey on evaluation of the quality of software system by using fuzzy logic approach. *Global Journal of Computer Science and Technology Software & Data Engineering, 13*(1).

Vijayan, V., Paramesh, H., Salvi, S., & Dalal, A. (2015). Enhancing indoor air quality – the air filter advantage. *Lung India, 32*(5), 473-479. http://dx.doi.org/10.4103/0970-2113.164174.

Vyas, S., Srivastav, N., & Spears, D. (2016). An experiment with air purifiers in Delhi during winter 2015-2016. *PLOS ONE 11*(12). https://doi.org/10.1371/journal.pone.0167999

What is qualitative research? (2012). Interaction Design Foundation. https://www.interaction-design.org/literature/topics/qualitative-research

Xue, Z. & Xue D. (2017). *Household gas and air quality safety monitoring device.* (Chinese Patent No. CN108317546B). European Patent Office. https://worldwide.espacenet.com/patent/search/family/062893995/publication/CN108317546B?q=pn%3DCN108317546B

Yoda, Y., Tamura, K., Adachi, S., Otani, N., Nakayama, S. F., & Shima, M. (2020). Effects of the use of air purifier on indoor environment and respiratory system among healthy adults. *International journal of environmental research and public health, 17*(10), 3687. https://doi.org/10.3390/ijerph17103687

Yoda, Y., Tamura, K., Adachi, S., Otani, N., Nakayama, S. F., & Shima, M. (2020). Effects of the use of air purifier on indoor environment and respiratory system among healthy adults. *International Journal of Environmental Research and Public Health, 17*(10), 3687. https://doi.org/10.3390/ijerph17103687

Yong, Z. (2016). *Digital universal particle concentration sensor.* South Coast Air Quality Management District. https://www.aqmd.gov/docs/default-source/aq-spec/resources-page/plantower-pms5003-manual_v2-3.pdf

Zeng, Y., Manwatkar, P., Laguerre, A., Beke, M., Kang, I., Ali, A. S., Farmer, D. K., Gall, E. T., Heidarinejad, M., & Stephens, B. (2021). Evaluating a commercially available in-duct bipolar ionization device for pollutant removal and potential byproduct formation. *Building and Environment, 195*, 107750. https://doi.org/10.1016/j.buildenv.2021.107750

APPENDICES

APPENDIX A:

Philippine Air Quality Indices of Particulate Matter based on the Philippine Clean Air Act of 1999

Particulate Matter in μg/m³	
Total Suspended Particles	
Good	0 – 80
Fair	81 – 230
Unhealthy for Sensitive Groups	231 – 349
Very Unhealthy	350 – 599
Acutely Unhealthy	600 – 899
Emergency	900 – and above

APPENDIX B:

Philippine Air Quality Indices of Ozone Concentration based on the Philippine Clean Air Act of 1999

Ozone Concentration in ppm	
Good	0.000 – 0.064
Fair	0.065 – 0.084
Unhealthy for Sensitive Groups	0.085 – 0.104
Very Unhealthy	0.105 – 0.124
Acutely Unhealthy	0.125 – 0.374
Emergency	0.375 – and above

APPENDIX C:

Air Quality Indices of VOCs Concentration based on the US Environmental Protection Agency

VOCs Concentration in ppb	
Maximum Allowable Air Concentration Standard	
Healthy	500 – and below
Unhealthy	501 – and above

APPENDIX D:

CONSENT LETTER FOR THE RESEARCH PARTICIPANTS

Consent Letter

May 16, 2022

Dear Research Respondent,

Greetings!

The developers of the study "*TECHNOVAIR*: Arduino-Based Automated Air Filtration, Indoor Air Quality Monitoring, and Notification System" invite you to conduct the testing and data collection procedure of the study. You, the chosen participant, will evaluate the device of the developers during the beta testing and join a Focus Group Discussion (FGD) along with the other participants. Your knowledge and expertise will help the researchers determine the effectiveness and performance of TECHNOVAIR in terms of the FURPS evaluation tool, which covers the device's functionality, usability, reliability, performance, and supportability. Moreover, taking part in this data gathering procedure is voluntary, and you have the right to withdraw consent at any moment. Furthermore, the researchers shall explain to you, the respondent, what data needs to be collected and describe the purpose of the study before the survey is conducted.

We are interested in hearing about your knowledge as an expert in your field. This study will provide information for the beneficiaries regarding Indoor Air Quality (IAQ) pollution and the cost-effective device the researchers have developed that effectively mitigates this phenomenon. We hope that the study can show us ways to improve humans' well-being and help the environment that has suffered much due to pollution.

If you agree to participate in this study, you will be interviewed face-to-face with the other experts at a time convenient for you. The interview will be tape-recorded and transcribed with your consent as we have a qualitative research design for the study.

Interviews are confidential and anonymous. All the information collected during the study, such as tape-recorded interviews, written texts, and transcripts, will be confidential and viewed only by the researchers directly involved in this project. This consent will be stored separately from your interview tape, surveys, and transcripts to protect your identity, and all material will be kept in locked filing cabinets. No one but the immediate research team will know who was interviewed for this study or have access to any identifying information about who participated. We will never identify you or your work personally in any published material.

This research may be published after the study is complete, and we may present the study results at conferences and workshops. We may use the information gathered from our interviews for other research studies in the future. The same condition will apply: all data will be confidential, anonymous, and protected.

Your participation in this study is voluntary. You can refuse to answer any of the questions posed and withdraw from the study at any time. If you decide to stop the interview or withdraw from the study, we will destroy the interview records unless you tell us that we are allowed to use it.

While you may not benefit directly from the study, we hope the beneficiaries stated in our manuscript may benefit from this study as it will help us understand their needs and the current gaps in the field of study. We hope the findings of this study will help us suggest improvements to help everyone stay safe and healthy from air pollutants.

Sincerely,

The Developers

By signing up and filling in the information, you have agreed to the terms and conditions of the study and decided to participate in the data collection procedure.

Respondent's Name over Printed Signature with Date

APPENDIX E:

LETTER TO THE PRINCIPAL

May 16, 2022

Dr. Flora Mae Yparaguirre
Senior High School Department Principal
Malayan Colleges Mindanao

Dear Dr. Yparaguirre,

Greetings!

This academic year, one of the final requirements of Grade 12 Senior High School students is conducting the capstone paper related to our field. Thus, we are venturing into a study entitled "*TECHNOVAIR*: Arduino-Based Automated Air Filtration, Indoor Air Quality Monitoring, and Notification System." The study entails to conduct survey have four (4) industry experts as willing respondents which the device's testing will be conducted in Astana Subdivision, Davao City.

In line with this, we are requesting your upright office to allow us to conduct the survey. Your approval on this matter will be highly appreciated and be a great help in pointing out the concern of the chosen respondents in line with the topic.

Thank you and God Bless!

Sincerely,
The Developers

Noted by:

Mr. Marjhuvyn Lapiras	Mr. Raffy S. Centeno
Research Capstone Teacher	Research Adviser
Malayan Colleges Mindanao	Malayan Colleges Mindanao

Approved by:
Dr. Flora Mae Yparraguire

APPENDIX F:

Questionnaire for Focus Group Discussion

***TECHNOVAIR*: ARDUINO-BASED AUTOMATED AIR FILTRATION, INDOOR AIR QUALITY MONITORING, AND NOTIFICATION SYSTEM**

Questionnaire

Please answer each question as honestly and accurately as possible. This survey will be kept confidential by the developers. It asks for your name, age, and signature, but your response will not be used for any other purposes than the research that is carried out. If you are uncomfortable answering any question, you can leave that question blank.

Name of the Industry Expert: ______________________ Age: ________

Functionality

What were the defects and errors observed affecting the product's functionality?

a. During the monitoring of criteria pollutant's level

____
____
____

b. During the filtration process

____
____
____

c. During the activation of notification System on LCD screen, pc application, and phone application

____
____
____

Usability

What were the defects and errors observed affecting the product's usability?

a. During the operation, control, and appropriate use

____
____
____

b. During the observation for its overall responsiveness

____
____
____

c. During the scrutinization for its appeal to the market

____
____
____

Reliability

What were the defects and errors observed affecting the product's reliability?

a. During the device's mechanism under normal operation

____
____
____

b. During the observation for its accessibility when required for use

____
____
____

c. During the device's mechanism despite hardware or software faults ____________________ ____________________ ____________________
d. During the observation of the device's ability to recover wholly from failure ____________________ ____________________ ____________________
Performance
What were the defects and errors observed affecting the product's performance? a. During the monitoring for the response of the applications to the filtration process ____________________ ____________________ ____________________ b. During the start filtration system before reaching the critical threshold ____________________ ____________________ ____________________ c. During the discontinuation of filtration system when back to normal threshold ____________________ ____________________ ____________________
Supportability
What were the defects and errors observed affecting the product's supportability? a. During the device's installation and uninstallation for the testing in different environments ____________________ ____________________ ____________________
Overall Questions
For the errors detected during the testing of the device, what changes need to be applied for TECHNOVAIR to work better? ____________________ ____________________ ____________________ For the errors detected on the applications, what changes need to be applied for the improvement of TECHNOVAIR? ____________________ ____________________ ____________________ Overall, what are the strong points and weak points of TECHNOVAIR? ____________________ ____________________ ____________________

____

Signature over Printed Name of the Industry Expert

APPENDIX G:

Questionnaire Validation Sheet

VALIDATION CHECKLIST

Name of Evaluator: Kenny Walter C. Diolola
Degree: BS Electronics Engineering
Position: Application Engineer
Number of Years in Teaching: _

To the evaluator: Please check the appropriate box for your rating.

5 – Excellent **4** – Very Good **3** – Good **2** – Fair **1** - Poor

Items Criteria	5	4	3	2	1
1. The content covered is extensive.		✓			
2. The important concepts are covered.	✓				
3. The questions are clearly written.		✓			
4. It is well organized and neat.		✓			
5. It has correct grammar with the proper usage of punctuation marks, proper spacing, and proper sentence construction.	✓				
6. There is a logical flow of representing ideas.		✓			
7. It supports and supplements the study.		✓			

Additional comments and suggestions of the validator for the survey questionnaire:

Checked and validated by:
Date:

Kenny Walter Diolola
05-24-2022

Printed Name and Signature

APPENDIX H:

Project Manual

TECHNOVAIR

Arduino-based Automated Air Filtration, Indoor Air Quality Monitoring, and Notification System

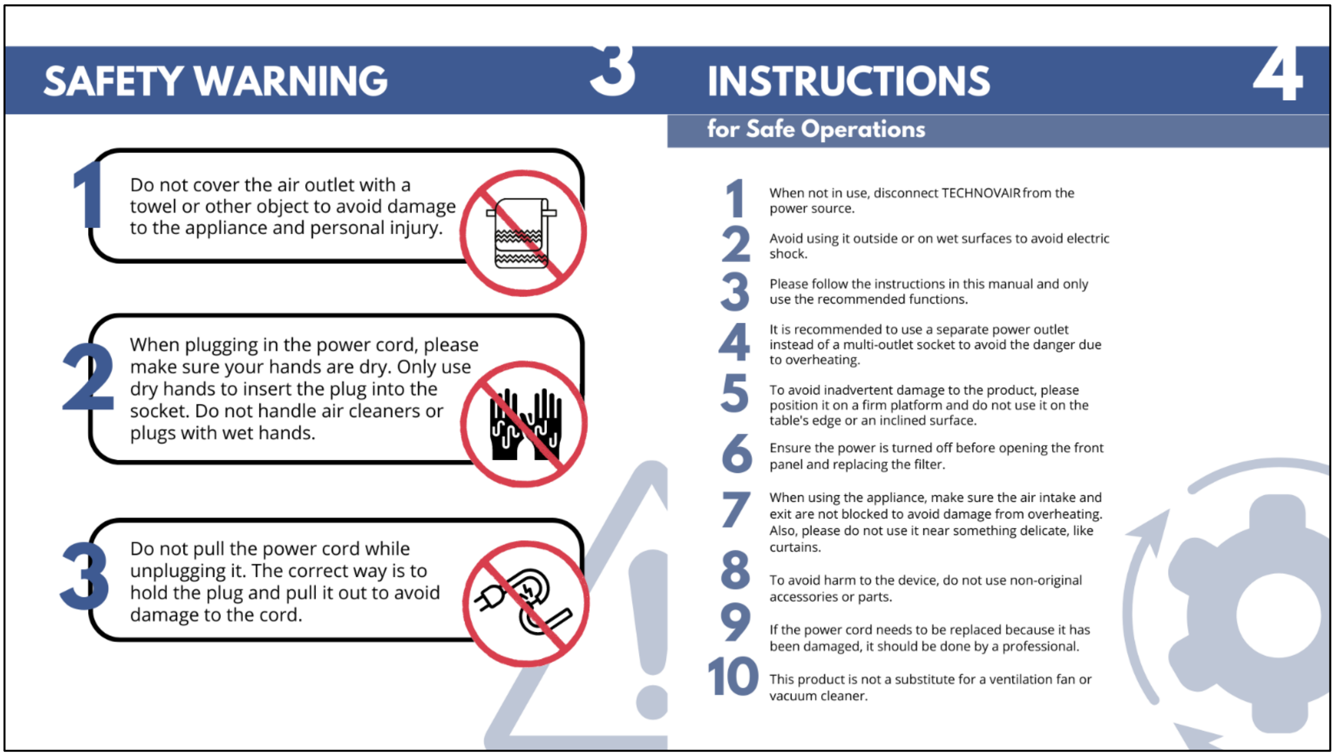
Users Manual

- Please read this manual carefully before use.
- After reading it, please keep this manual together with the invoice.

Thank you for purchasing our products. For better and safer use, please read this manual carefully before operation and keep it properly for future reference.

Contents

TECHNOVAIR: Product Specifications	
Device	
Weight	370g
Dimensions	28cm x 18cm x 10cm
Material of Housing	PLA (polyactic acid) plastic
Measuring Parameter	Total Suspended Particles of Particulate Matter, Ozone Concentration, and Volatile Organic Compounds Concentration
Measuring Unit	Total Suspended Particles of Particulate Matter in µg/m3, Ozone Concentration in ppm, and Volatile Organic Compounds Concentration in ppb
Measuring Interval	Every 15 minutes
Function	Automatic Control, Monitoring, Measurement, Filtration
Usage	Indoor (Households, Offices, Hospital Rooms, etc.)
Portable	Portable
Display	20x4 LCD (Digital)
Fan Type	Exhaust
LCD Refresh Interval	5 seconds
Data Transmission (Device to Application) Wavelength Range	200m on PC Application and 30m on Phone Application
Input Power	220v AC
Power Supply	12V DC (Electrical)
Maximum Current Consumption	Approximately 700mA
Power Consumption	Approximately 8.4W
Power Interface	12V/2A DC Power Supply



SAFETY WARNING 3

1 Do not cover the air outlet with a towel or other object to avoid damage to the appliance and personal injury.

2 When plugging in the power cord, please make sure your hands are dry. Only use dry hands to insert the plug into the socket. Do not handle air cleaners or plugs with wet hands.

3 Do not pull the power cord while unplugging it. The correct way is to hold the plug and pull it out to avoid damage to the cord.

INSTRUCTIONS 4

for Safe Operations

1. When not in use, disconnect TECHNOVAIR from the power source.
2. Avoid using it outside or on wet surfaces to avoid electric shock.
3. Please follow the instructions in this manual and only use the recommended functions.
4. It is recommended to use a separate power outlet instead of a multi-outlet socket to avoid the danger due to overheating.
5. To avoid inadvertent damage to the product, please position it on a firm platform and do not use it on the table's edge or an inclined surface.
6. Ensure the power is turned off before opening the front panel and replacing the filter.
7. When using the appliance, make sure the air intake and exit are not blocked to avoid damage from overheating. Also, please do not use it near something delicate, like curtains.
8. To avoid harm to the device, do not use non-original accessories or parts.
9. If the power cord needs to be replaced because it has been damaged, it should be done by a professional.
10. This product is not a substitute for a ventilation fan or vacuum cleaner.

PC Application Installation 5

1 Download the installation file named 'technovair.application.windows64.zip' given by the developers. Depending on the size of the file and your connection speed, downloading software might take anywhere from a few minutes to many hours.

2 Create a temporary folder, then move the downloaded file

3 Right-click on the zip file and select 'Extract Here'

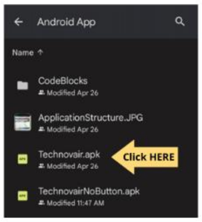
6

4 Inside the extracted folder, open the Technovair_PCmonitor.exe. This is already the PC Application

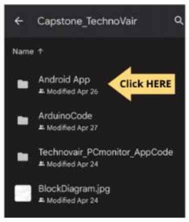
5 Wait for the TECHNOVAIR to connect automatically (the value changes from all zeros).

6 In case of system hang up, go to Task Manager, click Technovair_PCmonitor.exe and select 'End Task'.

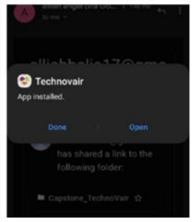
Phone Application Installation 7



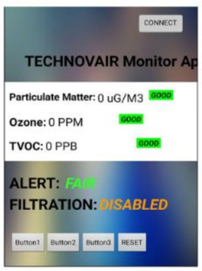
1 Download the installation file named 'technovair.application.windows64.zip' given by the developers.

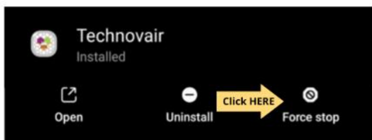


2 Install the application on your cellphone.



3 Open the application and wait for TECHNOVAIR to connect automatically.





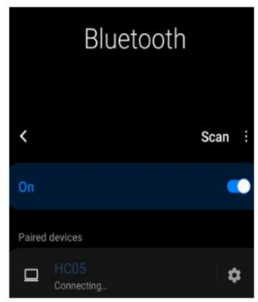
4 View the air quality values.

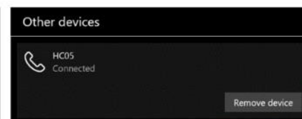
5 In case of system hang up, just go to Settings > Applications > Technovair and select 'Force Stop'.

Device Operation Instruction 8

1 Plug the power cable to the power source to turn on the TECHNOVAIR

2 Turn on the Bluetooth of both computer and phone with the applications installed to allow its discoverability.





3 For first-time users, pair with the HC05 Bluetooth Module installed in TECHNOVAIR. This process is only done one time. Thus, pairing is unnecessary for old users, as long as step 2 is followed.

4 Once all the steps above are followed, the device and the applications are ready for use.

AIR QUALITY INDICES 9

for PC and Phone Application

Particulate Matter in µg/m3	
Total Suspended Particles	
Good	0 - 80
Fair	81 - 230
Unhealthy for Sensitive Groups	231 - 349
Very Unhealthy	350 - 599
Acutely Unhealthy	600 - 899
Emergency	900 - and above

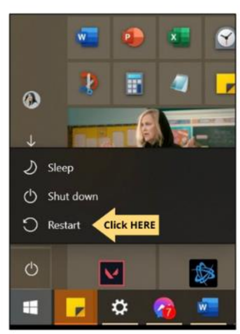
Ozone Concentration in ppm	
Good	0.000 - 0.064
Fair	0.065 - 0.084
Unhealthy for Sensitive Groups	0.085 - 0.104
Very Unhealthy	0.105 - 0.124
Acutely Unhealthy	0.125 - 0.374
Emergency	0.375 - and above

Particulate Matter in µg/m3	
Maximum Allowable Air Concentration Standard	
Healthy	500 - and below
Unhealthy	501 - and above

Troubleshooting 10

1 If you experience general problems, you may inspect the product by yourself.

2 Immediately turn off the TECHNOVAIR by unplugging it and wait for 15 seconds to turn it back on to prevent damage to the system and other hazards.



3 Also, restart your computer and phone devices.

APPENDIX I:

Price References for Actual Projected Cost and Cost Analysis

TECHNOVAIR: Actual Projected Cost	
System Tool	**Price Link**
Internal Components of TECHNOVAIR	
Arduino Mega 2560	https://bit.ly/3sD3v3F
PMS5003 Sensor	https://bit.ly/3wA70cf
MQ131 Sensor	https://bit.ly/3yI2evW
SGP30 Sensor	https://bit.ly/3FTjWOw
HC05 Bluetooth Module	https://bit.ly/3MsQIbP
NRF24L01 Transistor Switch	https://bit.ly/3lmhiHO
MOSFET-IRFZ44n	https://bit.ly/3PtjACH
DC Exhaust Fan	https://bit.ly/3sGEdl4
Pre-filter	https://bit.ly/3lnKiz0
High-Efficiency Particulate Air (HEPA) filter	
Activated Carbon filter	
IIC 20x4 LCD	https://bit.ly/3wkP6vc
Jumper Wires	https://bit.ly/38EhaR3
Plug Cable	https://bit.ly/39vD0X4
Shipping Expenses	
Shipping Fee	Estimated Price by the Engineer
Device Housing	
Device Casing (3D Printed)	Estimated Price by the Engineer

TECHNOVAIR: Project Cost Analysis	
Project Product	**Existing Products**
₱13,526 (TECHNOVAIR)	₱18,751 (Carrier Air Purifier CADR260) https://bit.ly/3wA29Yx
	₱14,104.91 (Medion MD 10444 Air Purifier) https://bit.ly/3FTQc4j

APPENDIX J:

Expert Coordination Certificate

This is to certify that this capstone research project paper entitled, **“*TECHNOVAIR*: ARDUINO-BASED AUTOMATED AIR FILTRATION, INDOOR AIR QUALITY MONITORING, AND NOTIFICATION SYSTEM”** prepared and submitted by **ALLIAH ANGEL M. BALIO, ANGELA COLEEN M. ACEBEDO, ROBBIE AL C. ANDAYA, RANIA A. ANGAS, MIKAELA KATE M. BANAAG, NEIL ANDREW PUSO,** and **JOSH ALEC M. MORATA** in partial fulfilment for the course STEM9: Capstone Research Project has been collaborated and reviewed by the expert undersigned.

Engr. Kenny Walter C. Diolola

Ger-Per Engineering

Application Engineer

APPENDIX K:

Project Time Table

Major Phase	Components	Estimated Class Hours/Days to Complete
Phase 1: The Project Title Proposal	Pre-proposal Topic Brainstorming	8 class hours
	Capstone Topic Selection	3 class hours
	Preliminary Task List/Timeline	3 class hours
	STEM Topic Proposal Sheet	3 class hours
	Project Title Proposal Defense	2 class hours
Phase 2: The Project Proposal Paper (Chapter 1 and 2)	Research Problem: Rationale for Studying this Concern	4 class hours
	Background of the Study	3 class hours
	Project Objectives	2 class hours
	Significance of the Study	2 class hours
	Scope and Delimitations of the Study	4 class hours
	Checking by Capstone Teacher and Research Adviser for Chapter 1	1 class hour
	Revision for Chapter 1	4 class hours
	Related Literature	7 class hours
	Related Systems	4 class hours
	Theoretical Framework	3 class hours
	Conceptual Framework	3 class hours
	Operation Definition of Terms	2 class hours
	Checking by Capstone Teacher and Research Adviser for Chapter 2	1 class hour
	Revision for Chapter 2	4 class hours
Phase 3: The Project Proposal Paper (Chapter 3)	Research Design and Process Model	2 class hours
	Research Locale	1 class hour
	Research Respondents	1 class hour
	Research Assessment Tool	2 class hours
	System Development Tools	3 class hours
	Data Gathering Procedures	2 class hours
	Data Analysis	3 class hours
	Trustworthiness of the Study	1 class hour

	Ethical Considerations	1 class hour
	Checking by Capstone Teacher and Research Adviser for Chapter 3	1 class hour
	Revision for Chapter 3	4 class hours
	Finalization of Research Proposal Paper	2 class hours
	Research Proposal Paper Defense	2 class hours
Phase 4: The Crafting of Chapter 4 and Final Capstone Defense	Coordination with Project Expert	4 class hours
	Project Model	2 class hours
	Project Mechanism	2 class hours
	Source Code	2 class hours
	Project Manual	2 class hours
	Project Cost	2 class hours
	Checking by Capstone Teacher and Research Adviser for Chapter 4	1 class hour
	Revision for Chapter 4	2 class hours
	Finalization of Final Capstone Defense Paper	2 class hours
	Final Capstone Defense	2 class hours
TOTAL NUMBER OF HOURS		109 class hours

CURRICULUM VITAE

PERSONAL INFORMATION

Name: Angela Coleen M. Acebedo
Birthday: March 27, 2003
Age: 19
Grade and Section: 12-Bismuth
Strand: STEM
Address: Dacudao Ave., Palm Village, Bajada, Davao City
Contact Number/s: 09437260913
Email Address: angelacoleenacebedo@gmail.com

EDUCATIONAL BACKGROUND

Senior High School: Malayan Colleges Mindanao
Junior High School: Davao Christian High School
Elementary: Davao Christian High School

AWARDS/ACHIEVEMENTS

2nd Runner-Up, Digital Poster Pasikatay 2022	March 2022
2nd Runner-Up, Digital Poster Pasikatay 2021	March 2021
2nd Place, Eco-Banner Contest STEM Festival 2019	November 2019
1st Runner-Up, Essay Writing Communication Arts 2019	March 2019
2nd Place, Quiz Bee Chinese Language Arts Festival 2019	February 2019
1st Runner-Up, Essay Writing Communication Arts 2017	November 2017
2nd Place, Spelling Bee	September 2012

OTHER SKILLS AND INTEREST

Skill/s: Programming, Baking
Talents: Singing
Hobbies: Drawing

CURRICULUM VITAE

PERSONAL INFORMATION

Name: Robbie Al C. Andaya
Birthday: 03/07/2003
Age: 19
Grade and Section: 12-Bismuth
Strand: STEM
Address: Andaya St. Daliao Toril Davao City
Contact Number/s: 09153469061
Email Address: robbieal.andaya7@gmail.com

EDUCATIONAL BACKGROUND

Senior High School: Malayan Colleges Mindanao
Junior High School: General Santos Hope Christian School
Elementary: General Santos Hope Christian School

AWARDS/ACHIEVEMENTS

List your awards/achievements in your extracurricular activities from elementary up to present in reverse chronological order (present to past). Example:

3rd Place, Cluster Force Pasikatay 2022	March 2022
1st Place, Doubles Badminton, Intramurals	November 2019

OTHER SKILLS AND INTEREST

Skill/s: Communication, Photo & Video Editing
Talents: Adaptability
Hobbies: Exercise, Listening to music, Photography

CURRICULUM VITAE

PERSONAL INFORMATION

Name: Rania A. Angas
Birthday: January 10, 2004
Age: 18
Grade and Section: 12-Bismuth
Strand: STEM
Address: Galinato Village, Isulan, Sultan Kudarat
Contact Number/s: 09664778844
Email Address: rAngas@mcm.edu.ph

EDUCATIONAL BACKGROUND

Senior High School: Malayan Colleges Mindanao
Junior High School: Notre Dame-Siena College of Tacurong Inc.
Elementary: Al-Andalus International School

AWARDS/ACHIEVEMENTS

2nd Place, Street Dance Pasikatay 2022	March 2022
2nd Place, Cluster Force Pasikatay 2022	March 2022
1st Place, SHS Breakthrough Challenge (Science) MCM HS Department Math-Sci Culmination	October 2021
3rd Place, Street Dance Pasikatay 2021	April 2021
5th Runner Up, Quiz Bee 2019 Sultan Kudarat SUPER Consumer Quiz on Air	October 2019
Champion, Cheerdance Philippine International Schools Athletic Meet 2016	December 2016
1st Runner Up, Badminton Doubles Philippine International Schools Athletic Meet 2015	December 2015

2nd *Runner Up,* Badminton Doubles December 2014
Philippine International Schools Athletic Meet 2014

OTHER SKILLS AND INTEREST

Skill/s: Creative Writing, Planning, Organizing, Photo Manipulation, Baking, Analyzing, Interior Designing, Playing Badminton, Playing Volleyball
Talents: Drawing, Hip-Hop Dancing, Social Media Management, Bullet Journaling
Hobbies: Reading, Singing, Photography, Watching

CURRICULUM VITAE

PERSONAL INFORMATION

Name: Alliah Angel M. Balio
Birthday: October 17, 2003
Age: 18
Grade and Section: 12 -Bismuth
Strand: STEM
Address: Alvania Subdivision, Nabunturan, Davao de Oro
Contact Number/s: 09276760170
Email Address: alliahbalio17@gmail.com

EDUCATIONAL BACKGROUND

Senior High School: Malayan Colleges Mindanao
Junior High School: Nabunturan National Comprehensive High School
Elementary: Nabunturan Central Elementary School SPED Center

AWARDS/ACHIEVEMENTS

2nd Place, Cluster Spirit — March 2022
Pasikatay 2022

3rd Place, Cluster Force — March 2022
Pasikatay 2022

1st Place, SHS Breakthrough Challenge (Science) — October 2021
MCM HS Department Math-Sci Culmination

3rd Place, Short Film — April, 2021
Pasikatay 2021

7th Pace, Science Fair - Robotics (JHS) — March 2020
National Science Quest

2nd Runner Up, Quiz Bee — November 2019
First Philhealth Regional Quiz Bee

Qualifier, Pagsulat ng Isports — August 2019
Division School's Press Conference

1st Runner Up, Essay Writing October 2018
Division Level - Values Education Festival of Talents

Qualifier, Pagsulat ng Editoryal August 2018
Division School's Press Conference

1st Runner Up, Capture It Contest (JHS) July 2018
2018 National Youth Science Technology, and Environment Summer Camp

Qualifier, Pagsulat ng Editoryal August 2017
Regional School's Press Conference

Qualifier, Pagsulat ng Isports January 2017
National School's Press Conference

Qualifier, Women's Softball November 2016
Compostela Valley Provincial Athletic Association Meet

OTHER SKILLS AND INTEREST

Skill/s: Creative Writing and News Writing
Talents: Teaching, Influencing, and Self-management
Hobbies: Community Service, Reading, Exercising and Healthcare

CURRICULUM VITAE

PERSONAL INFORMATION

Name: Mikaela Kate M. Banaag
Birthday: February 16, 2003
Age:19
Grade and Section: 12-Bismuth
Strand: STEM
Address: Countryhomes, Cabantian. Davao City
Contact Number/s: 09206328165
Email Address: mikaelakatebanaag@gmail.com

EDUCATIONAL BACKGROUND

Senior High School: Malayan Colleges of Mindanao
Junior High School: Stella Maris Academy of Davao
Elementary: Stella Maris Academy of Davao

AWARDS/ACHIEVEMENTS

1st Place, Battle of the Bands Intramurals 2022	April 2022
2nd Place, Vocals Solo Intramurals 2021	April 2021
2nd Place, Battle of the Bands, Buwan ng Wika Celebration 2020	October 2020
2nd Place, Battle of the Bands, Pasikatay 2021	2020
2nd Honors, Grade 10 Moving Up	2020
With Honors, Elementary Graduation	2016

OTHER SKILLS AND INTEREST

Skill/s: Graphic Design
Talents: Playing the Piano and Guitar, Singing

Hobbies: Watching anime

CURRICULUM VITAE

PERSONAL INFORMATION

Name: Neil Andrew Puso
Birthday: March 30, 2003
Age: 19 years old
Grade and Section: 12-Bismuth
Strand: Stem
Address: Doña Mercedes Rd. Sasa, Davao City
Contact Number/s: 09983595848
Email Address: neil.andrew.park30@gmail.com

EDUCATIONAL BACKGROUND

Senior High School: Malayan Colleges Mindanao
Junior High School: Davao City Special National Highschool
Elementary: Academic Learning Institution Incorporated

AWARDS/ACHIEVEMENTS

3rd Place, Cluster Force — March 2022
Pasikatay 2022

1st Place, Chess — August 2015
Intramurals

OTHER SKILLS AND INTEREST

Skill/s: Swimming, Analyzing, Poem Writing, Communication
Talents: Adaptability
Hobbies: Reading, Playing Online Games

CURRICULUM VITAE

PERSONAL INFORMATION

Name: Josh Alec M. Morata
Birthday: September 8, 2003
Age: 18
Grade and Section: 12-Bismuth
Strand: STEM
Address: Montclair Highlands, Buhangin, Davao City
Contact Number/s: 09663056236
Email Address: joshalecmorata@gmail.com

EDUCATIONAL BACKGROUND

Senior High School: Malayan Colleges Mindanao
Junior High School: Stella Maris Academy of Davao
Elementary: Stella Maris Academy of Davao

AWARDS/ACHIEVEMENTS

Champion, Davao Association of Catholic Schools	2015
Best in Sports - Volleyball	2018
Most Valuable Player – Volleyball Intramurals	2018

OTHER SKILLS AND INTEREST

Skill/s: Interpersonal Skills and Technical Skills
Talents: Singing and Dancing
Hobbies: Playing Volleyball