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METHODS

Eco-air purifier using air filter with activated carbon

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The study aimed to design and develop an eco-air purifier using an air filter with activated carbon. The developed air purifier helps students, faculty, staff, and other stakeholders in the educational institution breathe fresh air in a room. A descriptive-development design was applied in the study. A systematic approach was employed for the development of the product. The functional acceptability of the project was assessed by three expert evaluators, consisting of electrical engineers in compliance with parts and hardware quality standards. The product was assessed in terms of functional stability, performance efficiency, usability, reliability, maintainability, portability, and also the quality of the product when using it in terms of effectiveness, efficiency, satisfaction, freedom from risk, and context coverage. The findings of the study revealed that the project performed its functionality well, performance efficiency, usability, reliability, maintainability, and portability, and when in use in terms of effectiveness, efficiency, satisfaction, freedom from risk, and content coverage, it obtained an adjectival rating of very satisfactory from the evaluators. The findings implied that the product was able to meet the criteria, specifically in safety, where it exhibited an absence of harm when in use. The development of an eco-air purifier could harness its power in sustaining and producing quality air in the room, thereby improving the lives of every student, faculty, and staff member, as well as other stakeholders, particularly during pandemics.

Keywords: eco, air purifier, filter, activated carbon, pandemic

Introduction

Indoor quality is critical to human survival since we spend 16−20 h each day inside our homes (1). In this time of pandemic, most individuals stay at home or in confined rooms that breathe highly polluted indoor air, which is typically high in carbon dioxide, and are unaware that the lack of ventilation and air exchange causes malaise, discomfort, and dizziness, as well as repeated allergies, nausea, sleepiness, and weariness. Staying at home during online learning is safe for students and might be included as a significant benefit. As the government stresses its drive to control the pandemic, students had a lower probability of getting the COVID-19 virus, indicating their high level of awareness of how quickly the virus could spread to them, their family, and their community (2). With this, the global COVID-19 pandemic has put air purifiers in the limelight, from the first strain through the delta and omicron variants.

An air purifier filters the air in an enclosed space by capturing dust, pollen, bacteria, and viruses and releasing clean air. The development of this air purifier with activated carbon helps people to minimize the potential of getting infected by COVID-19 and ensure the quality of the air they're breathing. Moreover, according to Bandosz and Ania (3), the Japanese invented the activated carbon fiber in 1970. It was regarded as one of the top air purification materials in the twenty-first century due to its benefits. It had a uniform pore size distribution, a fast-stripping speed, a short adsorption trip, a large adsorptive capacity, an efficient absorption pore, and was simple to regenerate. When used appropriately, air purifiers can help minimize airborne pollutants such as viruses in a house or confined environment. A portable air cleaner, however, is insufficient to protect humans from COVID-19. Moreover, according to the World Health Organization, air filters help to reduce the

concentration of the COVID-19 virus in the air, thus reducing the possibility of transmission. Specifically, this study aims to determine the following: (1) to create an air purifier with an activated carbon filter; (2) to use eco-friendly materials for the project, such as wooden case housing; (3) to use simple machines such as screws, wheels, and axles; and (4) to use levers to assess the quality of the product in terms of functional stability, performance efficiency, usability, reliability, maintainability, and portability, as well as to evaluate the quality of the product when using it in terms of effectiveness, efficiency, and effectiveness.

Hypothesis

If we use a multilayer of filters such as non-woven, high efficiency particulate air (HEPA) filters together with activated carbon, then there is a possibility that we could minimize the potential of getting infected by bacteria and viruses, and ensure the quality of air in the room.

Methodology

Materials

The materials used in this study are air filter with activated carbon, alternating current fan, precut plywood, wheels, duct tape, glue gun and glue stick, trolley cart, fan cover, flat wire with switch connector, switch, male plug, screws, spray paint, and expanded aluminum screen.

Development process

Prepare all the needed materials. Get the precut plywood, the blank one for the base, and attach the wheels using a screw and screw driver. Get the plywood bars and attach them by using a screw driver and screw to the base plywood. Get the flat wire and put it on the base part through the top part. Get the air filter with activated carbon and put it in the middle of the plywood bars. Put the precut plywood on the top and attach the alternating current fan using a screw and screw driver. Using screws and a screwdriver, attach the fan cover to the top plywood. Attach the switch, then get the trolly cart and attach the ready-made air purifier. Add several coats of paint to the plywood to avoid molds and degradation and cover the unwanted parts when painting. Add the expanded aluminum screen in front of the air filter for protection.

This project is equipped with four filters on each side that should be easy to remove and clean. An alternating current fan in the center of the air purifier creates airflow from the sides and out the top. When the power is turned on, the fan located above the filters creates a suction action in the empty space. The surrounding air enters this area and gets sucked into the filters. Since the researchers used multilayers of filters, which included a prefilter (non-woven) that captures most of the macro particles. Behind the prefilter, some air cleaning technology, usually a finer filter, captures smaller-sized particles, see **Figure 2**. The air that comes through is clean from harmful particles. The HEPA filter is by far the most commonly used filter due to its high performance in capturing particles. Finally, the air is made to pass through an activated carbon filter that uses a chemical reaction called adsorption to pull odors, gases, and vapors and where the microorganisms get stopped and prevented from spreading. After some time of use, particles that are captured make the

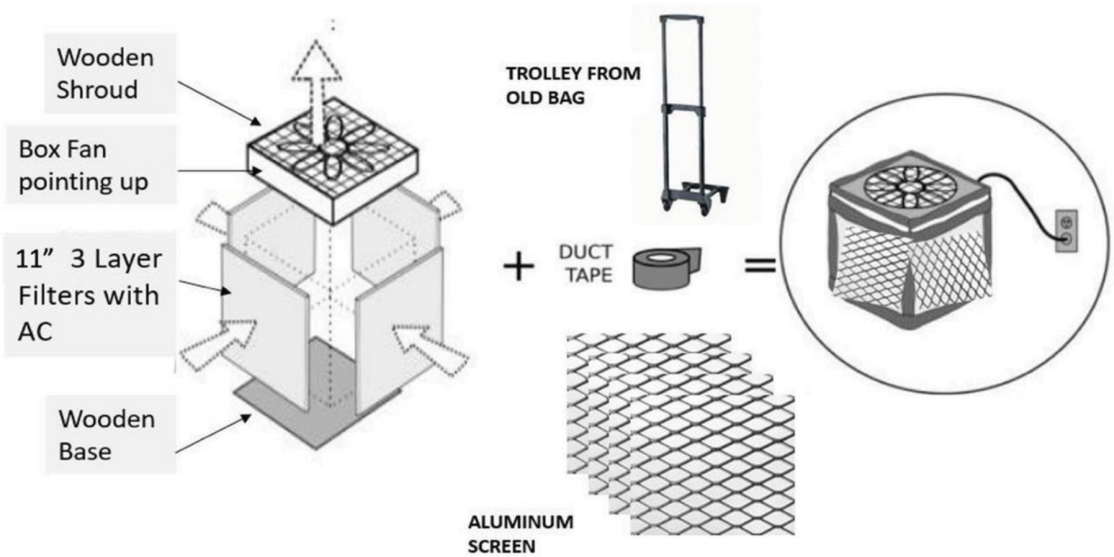

FIGURE 1 | The framework of eco air purifier with activated carbon.

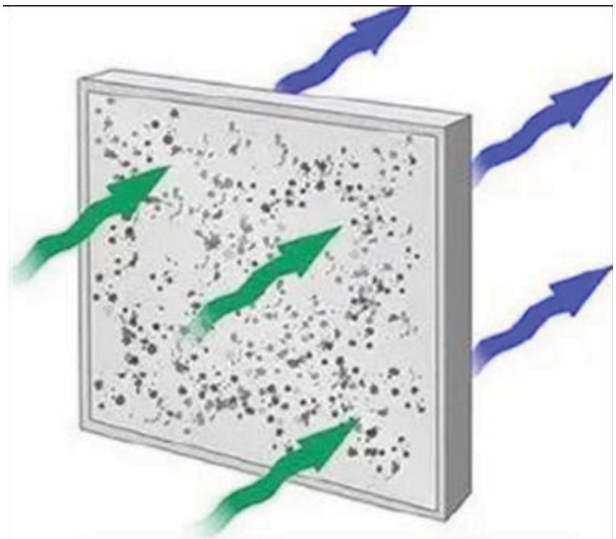

FIGURE 2 | (Filter working from www.airiusfans.com/using-filter-systems-for-indoor-air-purification).

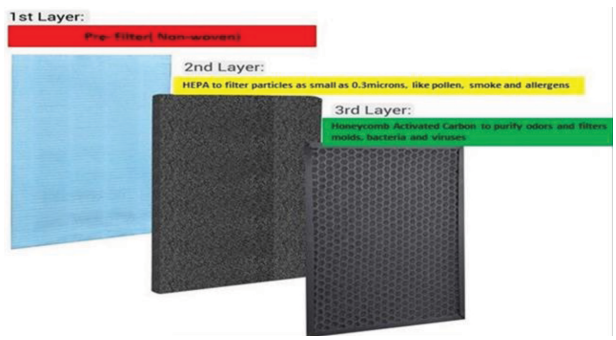

FIGURE 3 | (Layers of filter from www.lazada.com.ph/products/air-purifier-filter-replacement-air-purifier-hepa-filter-replacement-for-negative-ion-3-layers-of-filtration-filter-replacement).

filter too dirty, so the filter either needs to be cleaned or be changed after prolonged use.

This portable air purifier measures 11"× 11"× 14" (LxWxH) and weighs about 6.6 pounds (3 kg). It also features a removable handle (trolley) for easy transport. This project features a 3-stage air filtration system, with a non-woven filter followed by an HEPA filter to reduce allergens, germs and pollen, and an activated carbon filter that is highly efficient to capture the other tiny particles like dust, mold spores, bacteria, viruses, pet dander, and pollen. This purifier is built for small areas, about 48—70 square meter. It is ideal for the classroom size of 1 teacher and 25 students.

Instrument

The questionnaire used in the evaluation of the project was adapted with modification from the International Organization for Standardization and International Electro-technical Commission (ISO-IEC) 25010 based on the requirements of the study and was subjected to expert validation and reliability testing.

Numerical ratings	Descriptions
5	Excellent
4	Very satisfactory
3	Satisfactory
2	Unsatisfactory
1	Needs improvement

Results and discussion

The developed air purifier was intended for the school, students, faculty, staff, and other stakeholders to provide clean air in the room.

Evaluation result

Based on the test and evaluation done by the three experts, the project has an average weighted mean of 4 and is interpreted as very satisfactory. It means that the project meets the quality standard in terms of functional stability, performance efficiency, usability, reliability, maintainability, and portability. The project is very satisfactory when in use in terms of effectiveness, efficiency, satisfaction, freedom from risk, and content coverage. Santiago (4) explained that the functionality of devices implies that the materials used, workmanship, and design were constructed using materials that are strong enough to allow them to function and meet their specifications. It can be gleaned that through the use of a multilayer of filters such as non-woven, HEPA filters together with activated carbon in the eco-air purifier, we could minimize the potential of getting infected by bacteria and viruses, most especially COVID-19, and ensure the quality of air in the room.

Conclusions and recommendations

This project yielded the following general conclusions: the eco-air purifier using air filter with activated carbon shows a promising result for cleaning the air in a makeshift wooden case and filter chamber. Air filtration materials and techniques have become essential in our lives to reduce and eliminate high levels of atmospheric air pollutants, which affect human health and the environment. Based on the test and evaluation done by the three experts,

FIGURE 4 | The actual project. Eco air purifier using air filter with activated carbon.

FIGURE 5 | Testing of the product with smoke from Vape.

FIGURE 6 | Testing of the product in a 60 square meter room with 26 people and used for 6 h. Presence of dust and other particles are seen in the 1st layer of filter which is the non-woven.

the project has an average weighted mean of 4 and is interpreted as very satisfactory. It means that the project meets the quality standard in terms of functional stability, performance efficiency, usability, reliability, maintainability, and portability. The project is very satisfactory when in use in terms of effectiveness, efficiency, satisfaction, freedom from risk, and content coverage. It is suggested that the product must be used for a classroom size of 1:25 (1 teacher−25 students) since this project is made for a small area/room only. The conceptual air purifier evaluation on the characteristics of the project in terms of quality of the project and quality in use is not enough to consider the claimed benefits of the project. It is recommended that more extensive user tests and evaluations must be conducted. It

TABLE 1 | Evaluation of the characteristics of the product/project that was certified by the three registered electrical engineers.

	Mean	Interpretations
Product aualities		
A. Functional stability	4	Very satisfactory
B. Performance efficiency	4	Very satisfactory
C. Usability	4	Very satisfactory
D. Reliability	5	Excellent
E. Maintainability	5	Excellent
F. Portability	5	Excellent
Quality in use		
G. Effectiveness	4	Very satisfactory
H. Efficiency	4	Very satisfactory
I. Satisfaction	4	Very satisfactory
J. Freedom from risk	5	Excellent
K. Content coverage	5	Excellent
Average weighted mean	**4**	**Very satisfactory**

Legend

Numerical ratings	Descriptions
5	Excellent
4	Very satisfactory
3	Satisfactory
2	Unsatisfactory
1	Needs improvement

is also recommended to conduct a lifecycle analysis to fully be able to prove the claimed environmental benefits of this conceptual eco-air purifier and the calculation for the clean air delivery rate. The simple machines used are screw, wheel and axle (alternating current fan), and lever (trolley cart).

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