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Development of the Unit Evaporator Cleaner Prototype in Air Conditioning

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Abstract

Air quality plays an important role in health and can also improve the performance of workers in the office. Among the reasons for the decrease in air quality in a room is because the air conditioning is not maintained at the right time. The cleanliness of the evaporator on the indoor unit can ensure that the air in the room is in good condition. The air conditioning unit evaporator cleaner prototype, which recycles the condensation water from the air conditioner, is an inventive way to create a prototype that can guarantee the evaporator runs at peak efficiency. The developed prototype is equipped with an IoT system operated through the Blynk application, making it easy for users to control and set the system to operate at the desired time. The main objective of this study is to design, develop and test the functionality of a prototype evaporator cleaner unit in air conditioning. The ADDIE model is used as a developmental model that serves as a guiding framework for this research. In addition, three experts from among air conditioning lecturers and external experts were involved in testing and evaluating the functionality of the prototype of the evaporator cleaner unit in the air conditioner that was developed. The evaluation results show that the percentage of expert agreement is 100% for two items and three items show deficiencies with 66.7%, 33.33% and 66.67% respectively for the question items in part B. While for the question items in part C, two items show a percentage of 66.67 % and four items show 100% agreement. For question items in part D, all items show a percentage of 100%. For question items that show a percentage reduction or disagree, there are comments and improvement suggestions provided by each expert to serve as a reference and guide for further improvement and improve the overall effectiveness of the product in future studies.

1. Introduction

In Malaysia, air conditioning is a must for the comfort of occupants in homes and huge structures. This is a result of Malaysia's equatorial environment, which brings year-round sunshine to our nation. According to information made public by the Malaysian Meteorological Department (Met Malaysia) in May 2023, up to 15 locations nationwide were found to have had three days of consecutively high temperatures of 37 °C. Thus, in addition to being able to regulate the humidity to always be in a suitable level, using air conditioning is an option to bring comfort.

One definition of air conditioning is the ability to regulate the temperature or purify the air in a space (Muhamad et al., 2022). Stated differently, air conditioning is a technology that assists in regulating the temperature in an area or room based on the user's comfort level. In addition, it has the ability to regulate humidity, circulate air, and remove odours and dust particles from the air. Bedrooms, offices, schools, hospitals, shopping malls, and other locations with enclosed spaces regardless of size are among the locations that frequently employ air conditioning.

Air conditioners can be divided into two categories: residential and commercial. The type of air conditioning usually seen in homes, rooms, workplaces, and classrooms is known as domestic air conditioning. Split, window, and portable air conditioners are the three most popular types. In contrast to domestic air conditioning, which is utilised in households, commercial air conditioning is utilised in large buildings with a larger capacity or area. To ensure that the air conditioner can last for a long time, all varieties of air conditioners need to be properly maintained and cared for.

Additionally, while improving each person's degree of health, air conditioning can also look out for the health of the inhabitants. Effective ventilation design, enhanced ventilation, and air conditioning systems are necessary to maintain a healthy indoor environment by preventing mould growth and condensation in the space (Nakayama et al., 2019). Because it can provide adequate and effective ventilation for the workspace, this air conditioning system may also have an impact on an employee's performance level. Because it can aid in limiting the growth of microorganisms that cause certain diseases, air conditioning is therefore widely used in healthcare facilities and is very significant.

In summary, it is abundantly evident that proper maintenance and attention are necessary to allow the air conditioning system to operate at its best. Every user should prioritise maintenance, which includes cleaning the evaporator, to guarantee that the air in the room is always clean and capable of providing the appropriate level of comfort.

1.1 Research Bacnkground

In addition to having a positive impact on health, air quality can enhance office worker productivity. Arifin (2021) asserts that a decline in indoor air quality (IAQ) directly contributes to health issues. The degree of cleanliness or pollution of the air around us is referred to as air quality. Numerous things, including both natural occurrences like forest fires and man-made ones like transportation and industrial processes, can have an impact on this. Next, improper maintenance of air conditioning, which is essential for user comfort, might result in "sickness" for a building. Sick Building Syndrome is the "sick" that is intended. Wargocki et al. (2018) also did a study in which he discovered a correlation between a decrease in SBS symptoms and raising the ventilation rate in office buildings with air conditioning. Regardless of how frequently they are used, air conditioners typically require maintenance at least twice a year (Surachat Lek-ngam et al., 2017). Frequent maintenance can assist guarantee that your device is operating at peak performance and help avert damage that might need expensive costly repairs. Although some claim that servicing an air conditioner should occur once every six months, users do not have a set plan for doing so; this all relies on how frequently the air conditioner is used. Furthermore, as a dirty evaporator can encourage the growth of mould and germs, it can lead to issues with indoor air quality. To keep the system functioning properly, it is crucial to clean and maintain the evaporator on a regular basis.

1.2 Problem Statement

It is clear from the problems covered in the research background that maintenance problems can significantly affect users. One of the challenges that arises from this is that users are unable to determine when maintenance is necessary and are unable to discern between major and small maintenance, with minor maintenance being completed without the assistance of labour. When air conditioning system maintenance is not performed accurately and on schedule, it can lead to problems that can negatively impact the system. It is abundantly evident from the challenges and problems that have been discovered that this problem requires a solution. Therefore, researchers believe that new approaches should be taken in the development of automatic evaporator cleaning solutions for air conditioning systems. This product's development makes it possible to guarantee that the evaporator runs efficiently and is constantly clean. Because this device operates automatically without the need for human intervention, it can also make maintenance performed by the workforce easier. This can also guarantee that the air in the space is always hygienic and beneficial to health.

1.3 Research Objective

In this study, several objectives have been outlined as a guide. The objectives of the study are as follows:

1. Design a unit evaporator cleaner prototype in air conditioning.
2. Develop a unit evaporator cleaner prototype in air conditioning.
3. Testing the functionality of the unit evaporator cleaner prototype in air conditioning.
    i. Time taken to clean

ii. Ability to operate automatically

2. Methodology

Research methodology is a scientific approach used by researchers to find solutions and answers to a problem to be studied and the method used to implement product development. Methodology is defined as a scientific discipline of a general nature, which studies and analyzes phenomena from a scientific point of view using the principles of objectivity, reliability, systematic approach and accuracy (Dejan Logarušić, 2021). In order to carry out the development of this product, a model has been used so that the construction process is carried out in an orderly and thorough manner. Therefore, the researcher has chosen the ADDIE model in this study. Finally, this section also clearly states the procedure used and a detailed explanation related to the model used.

2.1 Research Design

The research design for this study is a product development study with the help of the ADDIE model as a development model. The use of this model is because this model is very suitable for researching the development of a product. According to Peterson (2017), the ADDIE model provides users with a method to design instructional materials that includes an iterative process and all the phases needed to create a successful course or program. The ADDIE model has 5 main phases namely analysis, design, development, implementation and evaluate. It provides a systematic approach to effective product design and development.

Table 1 Five phase in ADDIE model

Phase	Steps in ADDIE	Prosedur
Phase 1	Analysis	• Identify the market needs and customer requirements. • Conduct market research and gather feedback from potential users. • Analyze competitors and market trends. • Define the goals and objectives for the product.
Phase 2	Design	• Create a detailed product specification based on the analysis. • Outline the features, functionalities, and user interface design. • Consider technical requirements and constraints. • Develop a prototype or mockup to visualize the product.
Phase 3	Development	• Build the product based on the design specifications. • Iteratively develop and test the product to identify and address issues. • Collaborate with cross-functional teams, including engineering, design, and marketing. • Consider scalability, reliability, and user experience during the development process.
Phase 4	Implementation	• Launch the product to the target market or user base. • Monitor and manage the product release, addressing any issues that arise. • Implement marketing and promotional strategies to increase product awareness. • Gather user feedback during the initial implementation phase.
Phase 5	Evaluation	• Collect data on the product's performance, user satisfaction, and market reception. • Analyze user feedback and assess whether the product meets its objectives. • Identify areas for improvement or refinement based on the evaluation results. • Use insights gained from the evaluation to inform future product iterations or updates.

2.2 Research Procedure

Research and material selection are crucial for developing this project, ensuring that the chosen materials are suitable for the intended final function. The main goals of product development must be achieved, aligning with the research objectives. The key components for constructing the prototype of the air conditioner unit evaporator cleaner include ESP32, stepper motor, water pump, AC-DC adapter, smartphone, and so on. As for the software aspect, this prototype requires support from Arduino IDE and Blynk Legacy software. The main framework of this prototype is constructed using iron due to its excellent characteristics, such as durability, toughness, making it suitable for the final product. Figure 2.1 illustrates the design of the developed product.

Fig. 1 *Prototypes that have been developed*

Before developing the prototype, the researcher created a three-dimensional (3D) sketch using the SketchUp application. This application was chosen because it facilitates the production of drawings by allowing the researcher to view from various angles. The 3D sketches were based on the selection of materials, sizes, and the arrangement of components that were deemed appropriate. The 3D sketches are illustrated in the Figure 2.2 below:

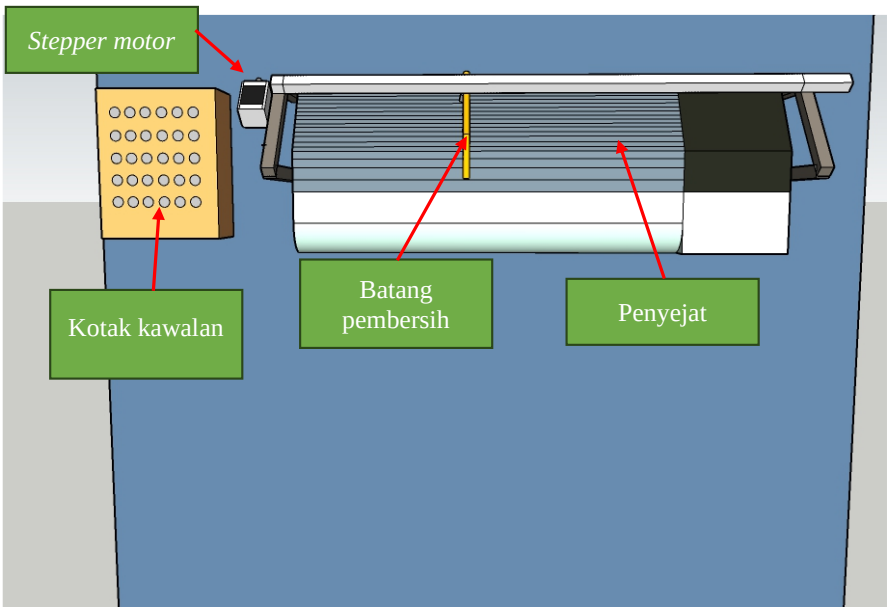

Fig. 2 *Front view's sketches*

2.3 Research Instrument

Based Research instruments are tools used by researchers to collect data for evaluation purposes. In the research instrument, the researcher wants to collect data regarding the functionality of the product as well as ensure that the product meets the objectives that have been set. In order to evaluate the functionality of this product, a checklist form will be given to 3 experts in the field of HVAC. A lecturer from KV Batu Pahat and two lecturers from UTHM have been selected as assessors for this product. In the form, there are 5 parts in the expert verification form used:

i. Part A (Respondent demographic information)
ii. Part B (Product design)
iii. Part C (Product development)
iv. Part D (Product functionality)
v. Part E (Comments and opinions) Analysis of Variance (ANOVA)

3.0 Result and Discussion

3.1 Energy Consumption

Researchers have conducted testing while analyzing the electrical energy usage of the evaporator cleaner. This analysis was performed to examine the voltage and current levels utilized by the unit's evaporator cleaner in air conditioning. To obtain energy usage values, the researchers conducted tests using a clamp meter, and the obtained values are presented in as follows.

Table 2 Value of energy consumption

Voltage value	12.23 V
Starting current value	0.19 A
Running current value	0.14 A

3.2 Technical Analysis

Technical analysis is conducted to examine several aspects observable in the prototype of this unit's air purifier. The aspects to be measured include the spraying time during cleaning and the quantity of water used. The time readings taken are as shown in Table 3.

Table 3 Time taken for cleaning movement

Number of movements	4 times
Time for each movement	45 seconds
Total cleaning time	3 minutes

In conducting the evaporator cleaner prototype, the researcher utilized the same water circulation by repurposing a water tank as a wastewater reservoir through a drainage pipe. Therefore, the researcher employed a water container capable of holding up to 9.5 liters. However, for the cleaning process, only 4 liters of water were used. This is because the water recirculation process is effective in recycling water back into the reservoir tank, which will be used for cleaning.

3.3 Analysis of Expert Agreement Percentage

After the completion and testing of the prototype development, the researcher will undertake an expert evaluation process. This assessment is conducted to examine the effectiveness of the built prototype in achieving the objectives stated in Chapter 1. The evaluation is carried out by three experts in the HVAC field, and it assesses various predefined items. This assessment not only aids the researcher in gaining insights and feedback related to the developed product but also allows for an analysis of the quantity and percentage of expert agreement on the items specified in the checklist form.

Table 4 Product Design Section Item Analysis

Number	Question	Yes	Percentage
B1	User-friendly design of this product	2	66.7%
B2	Ease of operation of this product	3	100%

B3	Neat design in terms of component arrangement	1	33.33%
B4	Product design is robust due to the use of iron as the main frame	3	100%
B5	Prototype size is suitable for the air conditioning unit	2	66.67%

Table 5 Product Development Item Analysis

Number	Question	Yes	Percentage
C1	Appropriate material selection for this product	2	66.67%
C2	The connection of each iron frame is done neatly	3	100%
C3	The connection of each wire in the electrical components is done neatly	3	100%
C4	The reuse of water from the condenser can save water usage	3	100%
C5	The use of a suitable nozzle for uniform cleaning across the filter	2	66.67%
C6	The use of components such as stepper motors, water pumps, and aluminum profiles is appropriate for the prototype design	3	100%

Table 6 Product Functionality Section Item Analysis

Number	Question	Yes	Percantage
D1	The product can operate according to the established rules	3	100%
D2	Appropriate cleaning spray time (3 minutes)	3	100%
D3	The system is easy to use with just a smartphone	3	100%
D4	The IoT system can function according to the preset rules	3	100%
D5	The cleaning tube moves smoothly during the cleaning process	3	100%
D6	Water pressure can remove dust from the filter	3	100%

3.4 Discussion

Expert 1 highlighted concerns regarding portability, noting that the product currently lacks compatibility with existing air conditioning systems. This limitation reduces its practicality and usability in real-world settings. As a result, the expert recommended enhancing the design so that the product can be adapted for use with a variety of air conditioning systems already available in the market. This are support by ASHREA (2020) which emphasizes system compatibility, retrofit adaptability, and interoperability for HVAC products intended for practical deployment. Meanwhile Ghadimi et al. (2019) mention that many HVAC studies recommend modular or adaptable designs to allow seamless integration with existing infrastructure. So it is importance to make sure that the product must fulfillment the element of portability to make sure it is practicality and usability among the students.

Besides that, feedback form expert 2 provided input focusing on the physical arrangement and organization of the system components. The expert observed a lack of neatness, particularly in the rear pipe section, where the configuration between the water reservoir tank, water pump, and the pipe channel leading to the cleaning rod appeared disorganized. This could potentially affect maintenance, usability, or safety. Therefore, the expert suggested improving the tidiness of this section to promote better system management and professional appearance. It is supported by ISO (2010), poor physical arrangement may introduce safety and maintenance risks if accessibility and clarity of system components are not adequately considered ISO.

Meanwhile, Expert 3 offered several technical suggestions aimed at improving the overall compactness and functionality of the product. The expert proposed further minimizing the size of certain components to enhance portability and efficiency. It was also noted that the water pump currently generates excessive pressure, which could be mitigated by replacing it with a smaller, more suitable pump. Additionally, the expert commented on the performance of the water spray system, recommending improvements to ensure the spray effectively covers the entire surface of the filter for optimal cleaning performance. This is in line with ASHREA (2020), the product must stress-matched pump capacity to system demand to avoid overpressure and inefficient operation. So it to make sure that the product follows the safety requirements.

4. Conclusion

In conclusion, the successful development of the prototype of evaporator cleaner in the air conditioning system has been achieved. Based on the report and expert assessments conducted, the researcher successfully met the established objectives and addressed the research questions. With the existence of this prototype, it is hoped that the industry can produce an actual product equipped with a filter cleaning system for air conditioning units in the market. This is because the filter cleaner ensures that the air conditioning system can deliver clean air into the room and also helps save maintenance costs. The current maintenance processes involve skilled labor for cleaning the filters. Despite the identified shortcomings and areas for improvement, the researcher hopes that this prototype can be perfected based on feedback and suggestions from the experts.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Mohd Khalid Hossin;* ***data collection:*** *Mohd Khalid Hossin;* ***analysis and interpretation of results:*** *Mohd Khalid Hossin,* Faizal Amin Nur Yunus*;* ***draft manuscript preparation:*** *Mohd Khalid Hossin . All authors reviewed the results and approved the final version of the manuscript.*

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