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Development of Refrigeration Simulation to Enhance Teaching and Learning for Commercial Refrigeration System.

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Abstract: The lack of teaching aids in line with current needs and technology becomes a necessity in ensuring the existence of new products or innovations of existing products. Therefore the development of this product is to ease and enhance teaching and learning session of teacher and students in Commercial Refrigeration System course. The development of this product based on ADDIE model. For the functionality test, this product will test a few variable like the display of the temperature and pressure of the refrigerator in smartphone by using Blynk application to perform Mollier Chart and reading of Coefficient of Performance (CoP). Temperature and pressure were detected by sensor and connected to Arduino Wemos board that was programmed by Arduino Ide. All the information was sent to cloud and can be access the server by using smartphone. Based on result, all the functionality going well. For improvement, expert panel suggest that the display of temperature and pressure reading can be shown with easy and clearly to read. As conclusion the objectives of this product achieve to reduce high level of dependency on textbooks, enhance student's ability to focus and improve several of teaching aids that moderate in quality.

Keywords: Mollier Chart, Coefficient of Performance, Internet of Things, Technical and Vocational, Refrigeration Simulation System,

1. Introduction

Use of teaching aids is the factor and element for teachers to explain a concept in a clearer way than verbal explanations (Azhari, 2014). This is supported by Jasmi, (2011), high level of dependency in textbooks is one of the conventional method. Teaching aids encompasses many important aspects

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related to stimulus variation and is one of the essentials used by teachers to enhance the development of individual potential to a higher level and is used for students with different levels of cognitive ability and skills.

There are several of teaching aids in the modern age which are at a moderate level and affect quality of teaching and learning sessions of teachers to be in low level (Widiyatmoko, 2013). Thus, technological change has led to the traditional conversion of the teaching aids concept to the modern style. This is important because students will have an up-to-date knowledge of the technology as teachers use concept of the Internet of Things (IoT) in the teaching aids in line with the Industrial Revolution 4.0.

In general, the teaching staff at Vocational College still use teaching aids which is not up to date with a modern world, resulting in time constraints. Students will also lose focus due to the lack of interest in teaching and learning sessions (Makeline, 2014). This study aims to discuss the development of the Refrigeration Simulation System teaching aids for the DMC 4323 (Commercial Refrigeration System) subject.

According to Arora (2011), cooling is a process of removing heat from one location to another through flow of material to reduce temperature. In other words, heat transfer involves four main components namely condenser, metering device, evaporator and compressor. According to Zhang, et al. (2012), the flow of refrigerant will undergo a phase change from liquid to vapor and have a decrease and rise in heat and temperature.

The refrigeration system is the same as that used by refrigerators as it remains in a same refrigeration cycle. Rodolfo (2011), defrost is a refrigerator that conceptualizes continuous cooling which results in the production of ice in the refrigerator. According to Trott (2000), there are 4 main components in the cooling system namely expansion valve, evaporator coil, compressor and condenser. Figure 1 shows basic refrigeration cycle.

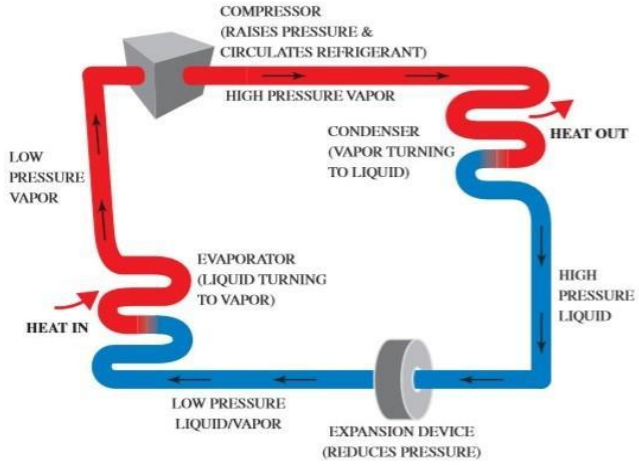


Figure 1: The basic refrigeration cycle - Fundamental of HVACR (2013)

Technical learning in the field of refrigeration requires the use of teachings aids. The use of teaching aids is one of the most popular approaches among technical teachers (Hanif, 2016). This is in line with what has stated by Widiyatmoko (2013), Teaching Aids is defined as a method to ensure students understand basic concepts and can be produced by teachers using basic materials. The use of teaching aids can also help technical teachers to explain something and the concept of learning content more accurately than verbal description (Azman, 2014).

In the era of modern education, as stated by Rahman & Hashim (2011), learning methods using wireless devices enable learning to happen anytime, especially in Technical and Vocational education. The Industrial Revolution 4.0 which emphasized the use of the Internet of Things enabled teaching aids upgrade to be more efficient. According to the statement provided by Wortmann & Fluchter (2015), the impact of the Internet of Things technology at this time is not limited to its use on individual products alone, but can be extended to the public as long as they can access the product to become part of the IoT system. This is supported by Wang et al. (2013), IoT operates by collecting raw data from the analyst signal and then processing it into information that moves the electronic hardware according to the programmed efficiency.

2. Research Objectives

The purpose of this study is to produce a teaching aids that will solve the following problems which are high level of dependence on textbooks, less interesting learning due to the use of conventional methods as well as low quality of several teaching aids to subject of Commercial Refrigeration Systems. This study will enhance the quality of teaching and learning for students and teachers in the Vocational College of Air conditioning and Refrigeration program. The objectives of this study as below.

- To design the *Refrigeration Simulation Systems (RSS)* that improve students understanding based on 21st century learning style using Internet of Things (IoT).
- To developed *Refrigeration Simulation Systems (RSS)* that improve teacher efficiency in terms of time for teaching and learning sessions.
- To test the functionality of *Refrigeration Simulation Systems (RSS)* in terms of reading measurements.

3. Methodology

Methodology is a technique and method that often to be used to achieve the objectives and objectives of the study. The design of this study is product development using ADDIE model as development guidelines. The development process of this product is based on 5 phases outlined through the ADDIE Model.

The teaching aids product, Refrigeration Simulation System (RSS) is developed as a product development by using the ADDIE Model as guideline. The ADDIE model is used due to the instructional model that researchers often use to develop more effective product designs. The ADDIE model is an acronym that shows every step in designing and developing a product. The first phase is the Analyse phase and followed by the Design phase as the second phase. The third phase is the Development phase and the fourth phase is Implementation. The fifth and final phase is the Evaluation phase.

3.1 Analyse

In this phase, the researcher begins the study by analysing the source of the problem and giving an overview of the product being developed. The results show that most vocational colleges still use conventional teaching aids such as books to explain Mollier Chart and conventional temperature and pressure measurements. Therefore, researchers use the analysis necessary to open a view at the use of materials, components and equipment and previous studies to be used in a developing a product. The researcher has reviewed the previous product and has chosen to develop a simulated product that is accessible to the involved parties. For this phase, the researcher emphasized the simulated and wireless access aspects of the product to perform temperature and pressure measurements for teaching and learning sessions. Analysis of existing products is shown in Table 1.

Table 1: Existing product analysis

Item	Product 1	Product 2	Requirements for product development
Structure of temperature and pressure sensors	Complex	Simple	Complex structures are difficult to do but give more accurate reading.
Effectiveness of temperature and pressure measurement	Good	Moderate	The efficiency of measuring temperature will affect the readings recorded.
Room temperature and pressure sensor assembly	Limited	Broad	The limited installation space limits the movement of temperature sensors.
Safety	Good	Moderate	Safety should be modeled and improved for users and.
Cost of installation of temperature and pressure	High	Low	The costs of installing temperature and pressure sensors should be considered and include maintenance costs.

3.2 Design

Design phase is the phase that gives the product design an overview. In this phase, the researcher emphasizes the aspects of component layout, temperature sensing and pressure and the application of the Internet of Things into the product. Based on these aspects, important factors such as safety, functionality and development that the researcher can implement are emphasized. This phase is done by drawing on three design drawings as a design proposal to be developed and given to expertise. The result of the discussion on the design proposal with the parties involved resulted in a complete sketch of the product with complete design. The final design that had been choosen by researcher is shown by Figure 2.

The operating system of this product has a complete basic cycle equipped with internet access to transmit temperature and pressure displays. Temperature and pressure sensors are placed into the cycle system for each component. Once the temperature and pressure readings are detected, they are processed by an Arduino board located in the control box and sent to the cloud so they can be connected to an internet-enabled smartphone to access the server and subsequently display the temperature and pressure readings on the Blynk application.

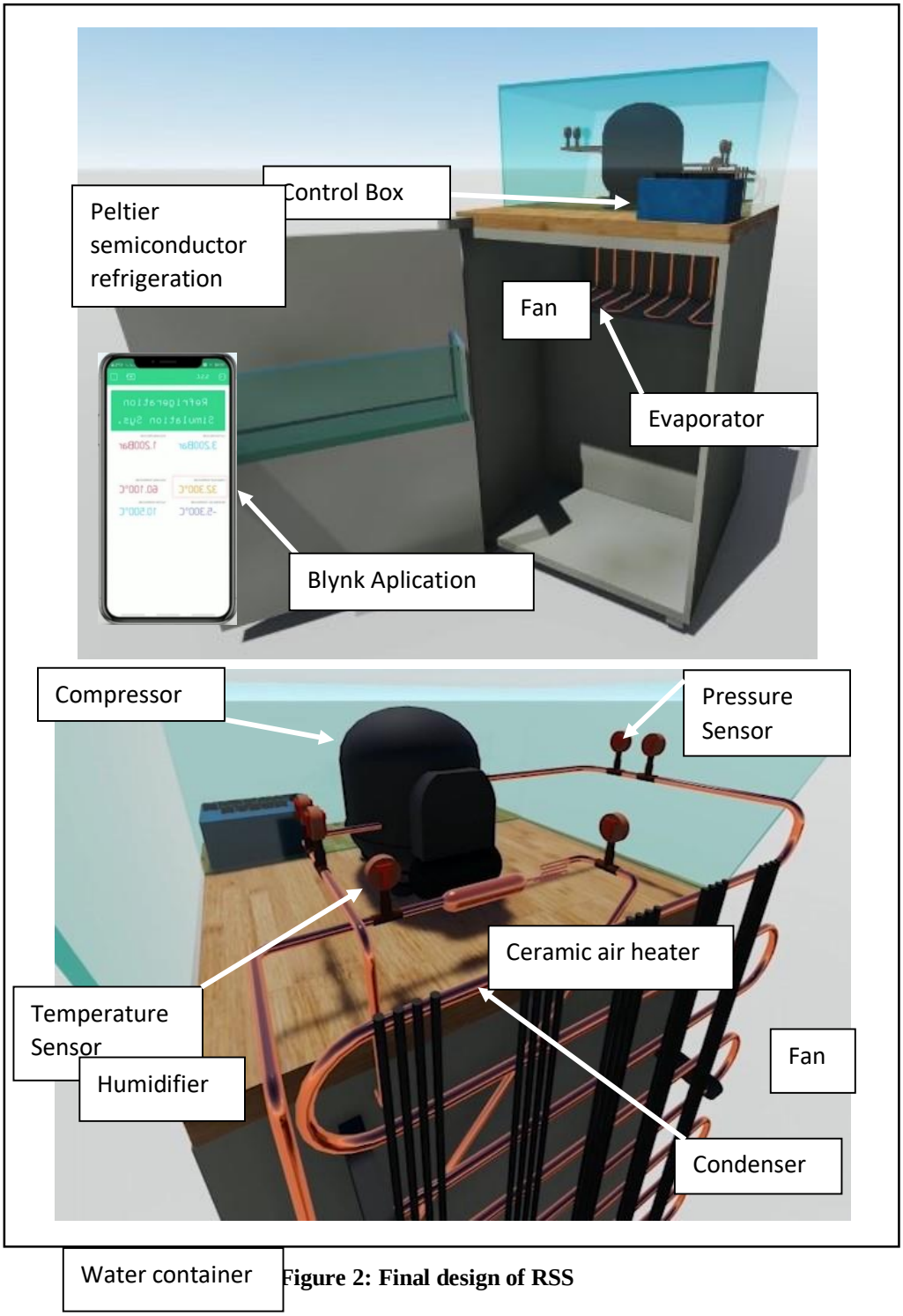


Figure 2: Final design of RSS

3.3 Development

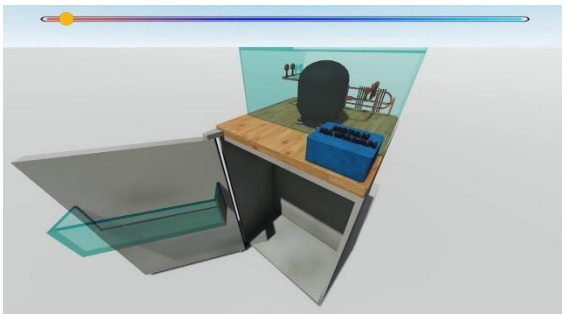
The beginning of the development phase is done by dividing the development of mechanical, electrical and IoT parts. The mechanical parts are initiated to obtain the final design by assembling and connecting the main components namely compressor, condenser, capillary tube and evaporator. Assemble and connect the main components namely compressor, condenser, capillary tube and evaporator. Sensor installation is also included in the development of mechanical parts. Then, the IoT programming section was developed using the Arduino Ide for coding on sensors and control boards. Eventually, the circuit was connected to complete the product assembly. Figure 3 shows Blynk Application equipped with IoT.

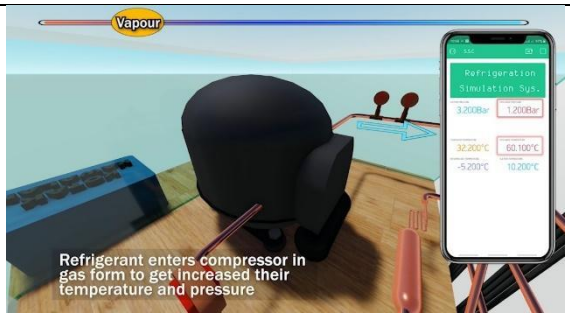
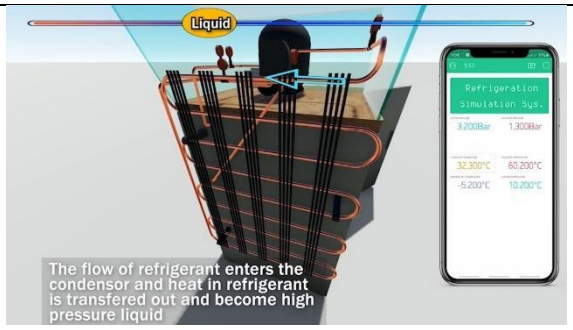
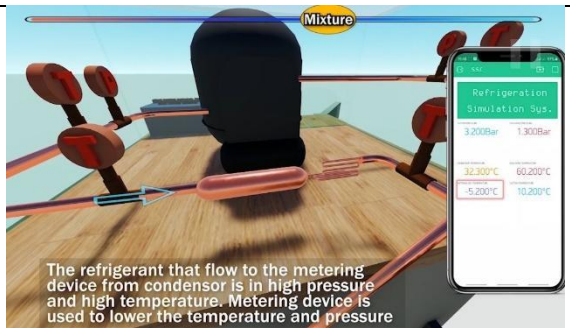
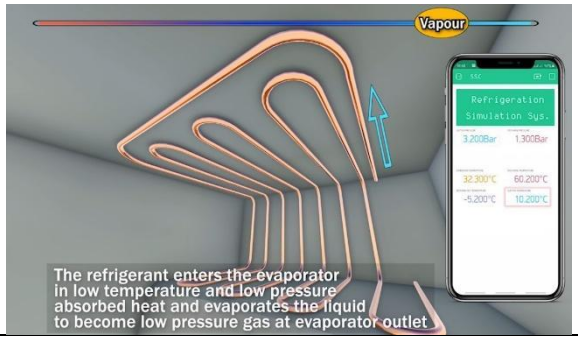
Figure 3: Blynk Application equipped with Internet of Things

3.4 Implementation

The fourth phase, which is the implementation phase is to test the product in aspect of design and functionality of the product. Product design is tested to get the same specifications as planned in the design phase such as the security factor working well. Functionality testing of this product is tested in terms of temperature and pressure measurement using internet access to display on the smartphone screen. Detail for the product implementations shown in Table 2.

Table 2: Product Implementation

No	Diagram	Work Operation
1		Testing is done by turning on the refrigeration cycle cooling system.

2		The refrigerant passes through the compressor and subsequently detects by temperature and pressure sensor placed after the compressor. Temperature and pressure readings will be recorded and displayed on the smartphone.
3		Next, a test is performed on the condenser, which is a temperature detector that detects the temperature after passing through the condenser and readings are also displayed on the smartphone.
4		At the capillary tube section, the temperature will be recorded by the temperature sensor and displayed on the smartphone as well.
5		Finally, forcing is carried out on the evaporator. The temperature and pressure will be recorded and displayed on the smartphone.

3.5 Evaluation

Evaluation of this product is done in a quantitative form which is a questionnaire distributed to 3 experts in the field of refrigeration and air conditioning. Distribution of questionnaire was in Google Form type was given to a technician of University Tun Hussein Onn Malaysia, a lecturer of Batu Pahat Community College and teacher of Vocational College. The questionnaire covers aspects of demographics, design, development, functionality and product improvement recommendations. These aspects all have questions that require specialists to respond "yes" or "no" except aspects for improvement suggestions that provide space for experts to comment on the product being developed.

4. Results

All three experts provided feedback based on the questionnaire form provided by the researcher. Each item of the question was analysed by the researcher to obtain the level of design, development and functionality of the product. Based on Table 3, it can be said that all three experts agree that the material used is appropriate, safe and easy to handle while also attracting students' attention and focus during the class. In addition, the component layouts developed also have the three experts agree that the layout is in good condition. For a user-friendly set of icons as well as apps that provide convenience to teachers, the three experts agreed.

Table 3: Design and Development Analysis

NO	ITEMS	YES	NO
1	Do RSS design can attract students in learning session?	3	
2	Is the material used to develop the RSS is suitable?	3	
3	Do RSS design is it safe to use?	3	
4	Do RSS design easy to handle?	3	
5	Are RSS components layout being neat?	3	
6	Is the icon layout and reading on the user-friendly smartphone display?	3	
7	Will this application provide convenience for students and teachers?	3	

Table 4 shows 2/3 experts agree that this product has good functionality. The researcher also estimates the product's temperature and pressure measurements and produces a graph showing the Coefficient of Performance of the product.

Table 4: Functionality Analysis

NO	Question	Yes	No
1	Will RSS be able to display temperature readings of outputs on condensers, evaporators, metering devices and compressors simulated on smartphone applications?	2	1
2	Will RSS be able to display pressure readings on outputs and simulated compressor inputs on smartphone applications?	2	1
3	Are the IoT applications displayed on smartphones communicate well between temperature and pressure sensors?	3	
5	Do all the buttons / icons in this application work well?	2	1

Figure 5 shows the Coefficient of Performance of the product being developed. The marking of these reference points is the result of the temperature and pressure estimates on the Mollier Chart. Based on the Mollier Chart, the enthalpy readings are taken, and the Coefficient of Performance calculations are performed to develop the graph.

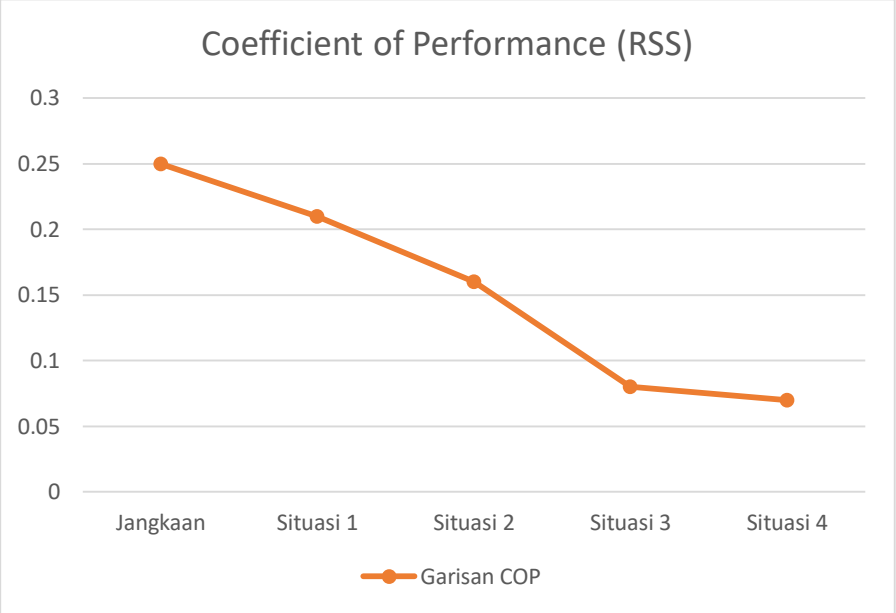


Figure 5: Coefficient of Performance of Product

5. Discussion

The discussion on this study follows three things namely design, functionality and suggestions for improvement. Researchers emphasize these three things because the objectives of the study and the research questions are based on them. The first discussion is about product design.

In developing this product, the emphasis on product design is related to component layout and temperature and pressure detector layout. In the selection of layouts, the researcher considers the aspects that will be used by the student and the teaching staff during the teaching and learning sessions. Therefore, the researcher ensures that the layout of the components is visible and does not pose a risk to the user. In addition, the researcher also conducted the selection of components by ensuring that the components were able to provide high levels of functionality to the product such as the use of capillary tubes which could reduce pressure and temperature compared to the TXV meter.

From a functional aspect, the researcher ensures that the product can detect temperature and pressure to be processed and displayed on the smartphone screen. Therefore, researchers connect temperature and pressure sensors to a control box that has an Arduino Wemos conceptual IoT circuitry programmed using the Arduino Ide. Next, researchers use a cloud-enabled Blynk application that stores processed temperature and pressure readings by accessing the cloud server.

For the product improvement aspect, the researcher has provided a questionnaire to experts with a background in refrigeration and air conditioning. Some of the suggested improvements are related to adding accessories to the product so that students have additional knowledge in the subject being studied. Experts also recommend that each of these components be labelled with a barcode with the aim of giving students the opportunity to find extra information related to the component when the barcode is scanned using a smartphone. Lastly. researchers also take expert views to improve the applications used so that the icons and displays shown are added to obtain readings other than temperature and pressure such as direct enthalpy calculations.

6. Conclusion

The In conclusion, the Refrigeration Simulation System is one of the teaching aids that incorporates the concept of technology in keeping with the development of modern technology to become a competitive product for facilitating teaching and learning sessions for students and teachers especially

at Vocational College who follow the subject of Commercial Refrigeration System. By making some improvements as suggested, this product may be indirectly used by other institutions that have a subject that touches the features of this product. Easy-to-develop specifications and easy-to-use products allow this product to be developed by highly skilled and widely used people. Overall, this product can make a positive impact on its use in many respects, especially for educational systems aimed at producing highly skilled professionals in the fields of refrigeration and air conditioning.

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