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Development and Usage of Refrigeration and Air Conditioning Trainer for Beginners

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Abstract: *This study aimed to evaluate the effectiveness of the developed trainer for refrigeration, which is constructed through the specifications of the users. It focuses on the primary usage, functionality, applicability, and safety aspects of the project, as well as how it effectively assists people through innovative means. The project is tested out of 15 respondents that has knowledge regarding refrigeration and air-conditioning, enough to understand the flow of the project its material used, functions, usage and how it works. Based on the comprehensive evaluation the following key findings have emerged. Functionality Excellence, The prototype trainer demonstrates exceptional functionality, achieving an excellent rating. This indicates a high level of effectiveness in performing various task/activity in refrigeration works. Applicability of the device exhibits versatility with high ratings. Its adaptability to diverse environments underscores its broad applicability.User safety of The trainer dependability is further enhanced by the removal of potentially hazardous materials and the addition of overload protection.*

Keywords: Trainer, Refrigeration and Air-Conditioning, Development and Usage, Prototype

I. INTRODUCTION

Industrial air conditioning has been utilized for drying, controlling humidity, and reducing smoke and dust for more than a century. Its most well-known use is to provide a comfortable working atmosphere for employees in offices, retail establishments, and industrial facilities in order to boost their comfort and productivity. The process of treating and distributing air to regulate certain areas' temperature, humidity, and air quality is known as air conditioning. Air is circulated over heated or chilled coils and/or a temperature-controlled water spray to regulate humidity and temperature. Odors and dust are also eliminated by direct water sprays. Aside from mechanical separation, adhesion, screening, filtration, or static attraction, other air cleaning systems could involve other methods based on the kind of air contaminants and acceptable air quality. Lowering a substance's temperature below that of its surroundings is known as refrigeration, and it involves the process of producing cooled water for use in process or air conditioning applications. The temperature range of chilled water used for air conditioning may overlap with that of chilled water required for procedures like injection molding. In order to produce cooled antifreeze solutions (brines) at temperatures below the freezing point of water, refrigeration systems are also utilized (Sumalpong, Jr 2020.)

Cool water can be utilized as spray water or in closed coils for air washers. For closed systems and standalone spray water systems, chilled water can also be utilized. To create and distribute cold air, numerous techniques are employed. Via coils that are chilled by water, brine, or the direct expansion of a volatile refrigerant, air is circulated through central air conditioning systems. After cooling, the air is dispersed by ducting. Air washers, closed or open chilled water systems, and open recirculating cooling are the three broad categories into which the water systems related to air conditioning can be divided. Open recirculating cooling systems and open chilled water systems are comparable in water treatment applications.

II. REVIEW OF LITERATURE

One teaching strategy to improve knowledge and technical skill acquisition is the use of educational trainer devices. This solves a common problem with the traditional teaching methodology that prevents pupils from remembering and retaining what they have learned in the classroom. With trainer devices, students may engage directly with the hardware and software, giving them a concrete, hands-on experience. This hands-on experience strengthens theoretical ideas and

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advances knowledge of how technological systems function in practical settings. Because these mimic real-world systems, students can experiment and make mistakes without worrying about endangering the genuine systems. Building expertise and confidence in this regulated setting is crucial, particularly when working with sophisticated or costly technology (Jambari 2018.)

Technical skill development trainers encourage active learning, in which students interact with the technology directly as opposed to passively taking in knowledge(Koumparaki 2023.) Due to the fact that students are more likely to remember information and build technical competencies through practice, this hands-on method greatly improves skill learning.Working with this trainer promotes problem-solving and critical thinking. The ability to identify problems, troubleshoot issues, and develop solutions are essential for those working in technical fields(Lahwal 2022). This procedure aids in the development of a methodical approach to problem-solving that may be applied in real-world job settings. To become proficient in technology, theoretical knowledge is frequently insufficient on its own. By giving students a platform to apply theoretical knowledge to real-world situations, device trainers aid in closing this knowledge gap by strengthening learning and expanding comprehension(Zhang 2022).Numerous system trainers can be customized or programmed to replicate various scenarios or conditions, meeting the unique learning requirements of people or groups. This adaptability makes it possible to create a more customized learning environment that can meet different skill levels and learning styles(Haleem,2022).

With the use of these tools, students can apply their academic knowledge in real-world problems. This kind of application is essential to technical education because it makes the material more relatable to students and shows them how it works in real-world settings. Trainer gadgets help people retain knowledge better over the long run because they offer a hands-on, practical experience(McKernon, 2022). When students actively interact with technology instead of merely learning about it in theory, they are more likely to retain the tasks and solutions they need to solve.Students can hone their skills through repeated use of trainer gadgets. Repetition is essential for learning complex technical skills because it helps pupils develop muscle memory and self-confidence. Numerous training tools offer instantaneous performance feedback, enabling learners to promptly recognize and rectify errors. This immediate feedback loop is crucial for learning because it enables students to comprehend the effects of their actions and make the required corrections in the moment(Wekerle 2022).

III. CONCEPTUAL FRAMEWORK

With the intention of creating a trainer for air conditioning and refrigeration that will serve as a teaching tool to expose pupils to real-world refrigeration scenarios. The project's safety and functionality are attained by meticulous planning, design, testing, and evaluation of the inputs. Figure 1. embodied the idea of our research. It displays the study's flow. The input used to create the project is represented by the first box. Such as relevant research that provides us with ideas for this project, expertise and abilities, materials and equipment used in assembly, and, ultimately, the processes that must be followed for the project to be completed. A strong materials and methods section will allow readers to assess the research conducted and, if necessary, duplicate the study, claim Ng KH and Peh WC (2008). The planning and design of the circuits is contained in the second box. After that, the materials and components are fabricated and assembled, and the device is tested and evaluated. A methodical and impartial appraisal of a project, whether it is ongoing or finished, is called project evaluation. Determining the project's relevance and degree of accomplishment as well as its development effectiveness, efficiency, impact, and sustainability are the goals (Haque, 2019). The third box represents the output, or the finish product made by the team which is the Solar Powered Smart Emergency light with fire detection and alarm system.

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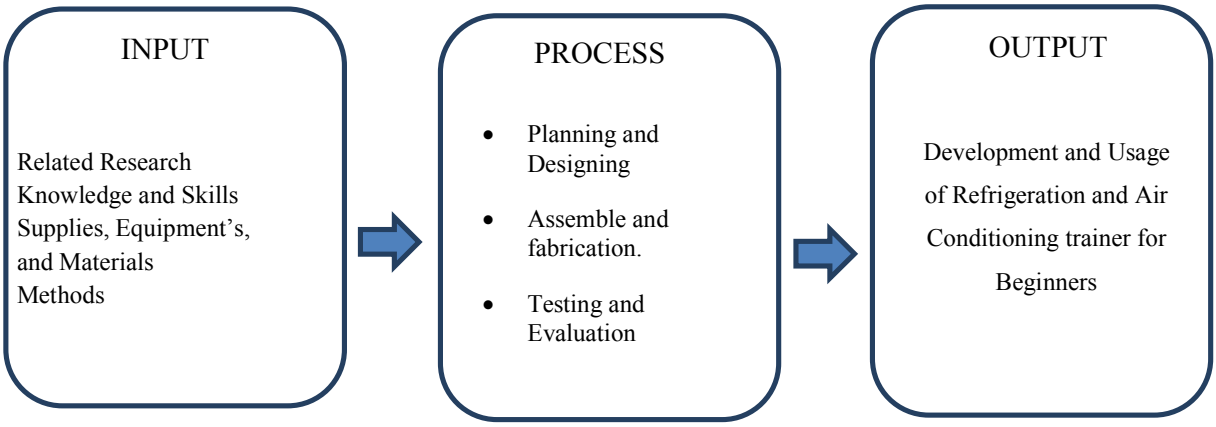

Figure 1: Research Diagram

Objectives of the Study

The main goal of this study is to design and develop a Refrigeration and Air Conditioning trainer for Beginners. This will help students and faculty to understand deeply in doing air conditioning repair works and able to grasp concept upon doint it.

Specifically, this study aimed to achieve the following objectives:

1) To developa refrigeration and air conditioning trainer for beginners..
2) Integrate the said trainers in teraching system of faculty.
3) Determine the acceptability of the device in terms of:
   - Functionality
   - Applicability
   - Workability
   - Economy
   - Safety

Significance of the Study

This study aims to design and develop a refrigeration and air conditioning trainer for beginners. It specifically focuses on enhancing instructors capability in teaching students the concept of refrigeration and how to manage trouble work in dealing different air conditioning units.

The following are the beneficiaries of the study to be conducted by the researchers:

- **Students**. This study will enable students understand more in handling air conditioning works. This also help them to master each points in troubleshooting and observing running condition of every unit.
- **Fellow Faculties**. This work will help also co-faculties to enhance more there knowledge in transmitting quality learning to students .
- **Future Researchers**. This study serves as valuable reference for future researchers, providing insights and inspiration for new studies.

Scope and limitations

This study will be conducted in selected areas in Surigao City. The main focus of this study is to develop a trainer to be used in training or teaching beginners taking up refrigerationg and air conditioning courses. This work aims to boost knowledge of students to understand more in refrigeration related works so that they will be equipped of necessary information while on the course.

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IV. METHODS

Below is the block diagram of the research, this includes the flow on how students can grasp their knowledge upon taking the course.

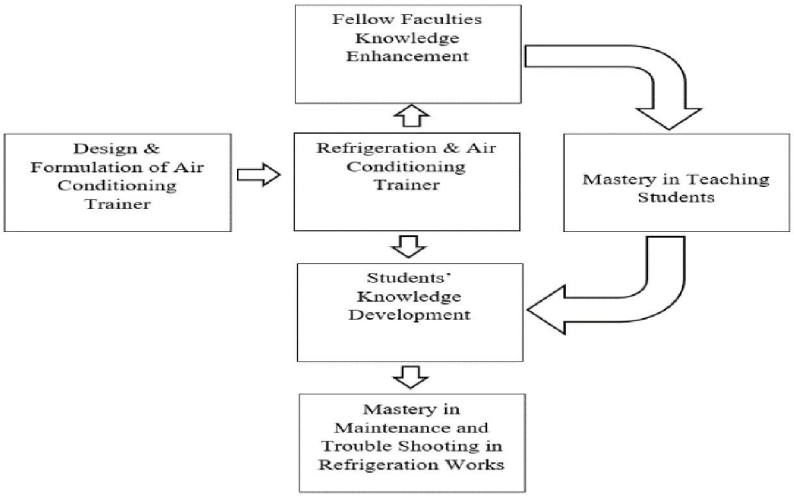

Figure 2: Block Diagram

Project Development

The steps for creating the project are listed below.

- Gather all the materials required in making the project.
- Check and test all the devices to be use is working and not defective.
- Assemble the frame where all components will be attached
- Secure the components by bolting to the frame to prevent it from falling
- Review all the wiring components specially the controller if it is properly connected.
- After assembling all the components and checking the proper wiring connections, now the device is ready to use.

Operational Procedure

1. Preliminary Checks

Visual Inspection:

- Inspect all components for visible damage or loose connections.
- Ensure all wiring and connections are secure and properly insulated.
- Ensure that fan/blower blades are not loose.
- Ensure that the belts are intact and not loose.

Safety Verification:

- Verify that the work area is clear and that all safety measures are in place.
- Ensure all safety guards and covers are in position.

2. Electrical Testing

Voltage Check:

- Use a multimeter to verify that the 3-phase, 220V AC power supply is available.
- Check the output of the step-down transformer to ensure it provides 12V DC.

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Continuity Testing:

- Perform continuity tests on the electrical wiring to ensure there are no open circuits.
- Verify the continuity of the control circuit connections.

3. Component Functionality Testing

Induction Motor:

- Test the induction motor separately by briefly turning it on and off to ensure it starts and runs smoothly.
- Listen for any unusual noises or vibrations.

Compressor:

- With the induction motor running, ensure the compressor is engaging and compressing the refrigerant properly.
- Check for any unusual noises or excessive vibrations.

Control Circuit:

- Test the thermostat and other control switches to ensure they are functioning correctly.
- Verify that the control circuit responds to inputs and activates the compressor and blower fan as expected.

4. System Performance Testing

Temperature Testing:

- Set the thermostat to a specific temperature and measure the air temperature at the vents using a digital thermometer.
- Ensure the temperature drops to the desired level within a reasonable time frame.

Pressure Testing:

- Connect pressure gauges to the refrigerant lines to measure the high and low side pressures.
- Verify that the pressures are within the manufacturer's specified ranges for normal operation.

Airflow Testing:

- Measure the airflow at the vents using an anemometer.
- Ensure the airflow is consistent and meets the expected values for the set blower fan speed.

5. Leak Testing

Visual Inspection:

- Inspect all refrigerant lines, fittings, and connections for signs of oil or refrigerant leaks.

Electronic Leak Detector:

- Use an electronic leak detector to check for any refrigerant leaks in the system.
- Focus on joints, connections, and components prone to leakage.

Soap Solution Test:

- Apply a soap solution to suspected leak areas and watch for bubbles, which indicate a leak.

6. Operational Testing

Full System Operation:

- Run the entire system continuously for an extended period (e.g., 30 minutes) to ensure stable operation.
- Monitor temperature, pressure, and airflow to confirm the system is operating within normal parameters.

Response to Control Inputs:

- Adjust the thermostat and blower fan speed settings to test the system's responsiveness.
- Ensure the system adjusts the temperature and airflow according to the control inputs.

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7. Final Checks and Documentation

Post-Operation Inspection:

- After the test run, inspect all components for any signs of overheating, wear, or damage.
- Check the electrical connections and refrigerant lines again for any issues.

Documentation:

- Record all test results, including temperature readings, pressure values, airflow measurements, and any anomalies observed.
- Document any issues found and the actions taken to resolve them.

Feedback and Improvements:

- Gather feedback from students and instructors on the system's performance and usability.
- Note any areas for improvement or further testing needed.

Evaluation Procedure

One way to assess a prospective project's viability is to evaluate it. We use surveys as part of our research process to gather data. We seek the assistance of statisticians who use exacting computational methods to guarantee the precision and dependability of the data that has been gathered. Their participation confirms the accuracy of the data and helps to reduce biases, giving our study findings a strong foundation. A group of people were asked to evaluate the project's performance. Selected electrical professionals from Surigao Del Norte State University comprised this group of responders. The device's operation and the project specifications were explained by the researcher prior to the device's real presentation and evaluation. Before giving the evaluation form to the responders, the researchers went over its contents. Following the assessment, the information was gathered and processed to ascertain the overall mean and the means for every criterion. The primary evaluation criteria are economy, safety, workability, application, and functionality. Consequently, participants are able to offer their feedback, recommendations, and concepts to further improve and develop the gadget.

V. RESULTS AND DISCUSSIONS

Project Description

Students can do a rudimentary investigation into air conditioning using this training unit. P-H and psychrometric charts can be used by students to calculate and find the enthalpy change. The unit has an evaporator inside an air duct that is coupled to an air-cooled condenser unit. On both sides of the evaporator, the air duct has temperature and relative humidity sensors. Air travels down the duct via a tiny manually-adjustable fan. A pressure switch, sight glass, filter dryer, TEV valve, high- and low-pressure gauges, and a pressure switch are all part of the refrigeration circuit. In addition, pressure transducers that link to the instrumentation are part of the circuit.

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VI. EVALUATION RESULT

Table 1. Acceptability of the trainer in terms of Functionality

Functionality	Median	Rank	Description	Interpretation
1. The trainer device performs exactly as the intended usage	5	1	Excellent	Very Highly Acceptable
2. The induction motor runs smoothly without any noise and vibrations	5	1	Excellent	Very Highly Acceptable
3. The compressor is engaging and compressing the refrigerant properly.	5	1	Excellent	Very Highly Acceptable

Legend:5-Excellent, 4-Very Good, 3-Good, 2-Fair, 1-Poor

Table 1 assesses the acceptability of the trainer in terms of functionality, focusing on specific aspects related to its performance. All three categories are rated “Excellent” which indicates that the trainer performs outstandingly as it’s expected. This also means that the trainer meets the targeted working conditions that able to be use in various activity in beneficial for students and faculty.

Table 2. Acceptability of the trainer in terms of Applicability

Applicability	Median	Rank	Description	Interpretation
1. The trainer can performs different task that simulate same as the actual work	4	3	Very Good	Highly Acceptable
2. The device accommodates the specific needs of its users	5	1	Excellent	Very Highly Acceptable
3. The device meets the safety standard	5	1	Excellent	Very Highly Acceptable

Legend:5-Excellent, 4-Very Good, 3-Good, 2-Fair, 1-Poor

Table 2 evaluates the device's acceptability in terms of application, emphasizing factors such as its adaptability to different environments, ability to meet user needs, and compliance with safety regulations. The trainer's applicability to perform various tasks that simulate the same as the actual work is rated as "Very Good." This indicates that it can be used in a range of environments, but it might be improved to make it even more versatile or setting-specific.This shows that the trainer was made with preferences of its targetedusers. This is a sign that user-centered design is working well. When a trainer has a "Excellent" grade for meeting safety criteria, it means that it meets or surpasses accepted safety standards. This is an essential component, particularly for safety equipment, since it guarantees the device's dependability and safety when used in different environments. In conclusion, Table 2 indicates that the device's applicability is quite good. The trainer is excellent at meeting the unique demands of users and satisfies or surpasses safety requirements, even though there may be some areas for development in terms of its application to various contexts. The "Excellent" ratings in the latter two categories indicate a strong alignment between the trainer’s design and user requirements, as well as a commitment to safety, making it a versatile and reliable choice across various environments.

Table 3. Acceptability of the trainer in terms of Safety

Legend:5-Excellent, 4-Very Good, 3-Good, 2-Fair, 1-Poor

Safety	Median	Rank	Description	Interpretation
User’s safety	5	1	Excellent	Very Highly Acceptable
Absence of harmful materials	4	3	Very Good	Highly Acceptable
Overload/Short circuit protection are applied	5	1	Excellent	Very Highly Acceptable

Table 3 evaluates the device's acceptability in terms of safety, emphasizing elements pertaining to human safety, the lack of hazardous materials, and the usage of overload/short circuit protection. The user’s safety is evaluated as

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"Excellent," indicating that great care was taken in the design of the item to ensure the protection of users when they are using it. A device that has a "Excellent" grade in this category is likely safe and dependable. We rank the lack of hazardous items as "Very Good." This suggests that the materials used in the device's design present little chance of harming consumers. Although excellent, there might be some space for material safety enhancements or improvements. Interpretation: The device's application of overload/short circuit protection has been assessed as "Excellent," indicating that it has protective mechanisms in place to keep overloads and short circuits from happening, thus increasing safety. Robust safety features are positively correlated with a "Excellent" ranking in this category. Taken together, Table 3 shows that the device operates with remarkable safety. A significant commitment to guaranteeing user safety throughout operation is indicated by the "Excellent" ratings for overload/short circuit protection and user safety. Although the equipment is deemed safe overall, there may be room for improvement in terms of material safety, as indicated by the "Very Good" grade for the lack of hazardous materials. With an emphasis on shielding users from potential risks, the gadget seems to be extremely acceptable and safe to use overall.

Summary

This study aimed to evaluate the effectiveness of the developed trainer for refrigeration, which is constructed through the specifications of the users. It focuses on the primary usage, functionality, applicability, and safety aspects of the project, as well as how it effectively assists people through innovative means. The project is tested out of 15 respondents that has knowledge regarding refrigeration and air-conditioning, enough to understand the flow of the project its material used, functions, usage and how it works.

Findings

Based on the comprehensive evaluation the following key findings have emerged:

1. Functionality Excellence: The prototype trainer demonstrates exceptional functionality, achieving an excellent rating. This indicates a high level of effectiveness in performing various task/activity in refrigeration works.

2. Applicability: The device exhibits versatility with high ratings. Its adaptability to diverse environments underscores its broad applicability.

3. User safety and Material Considerations: The device's dependability is further enhanced by the removal of potentially hazardous materials and the addition of overload protection.

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