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Design and Development Power Generation Mock-UP Trainer

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Abstract: *This study aims to design and develop a Power Generation Mock-Up Trainer for educational purposes at Surigao del Norte State University (SNSU) and other State Universities and Colleges (SUCs) and training centers in the Philippines. The trainer enhances electrical students' cognitive and tactile skills, addressing challenges faced by automotive technology students in wiring and connecting actual electrical circuits. The Power Generation Mock-Up Trainer simulates real-world scenarios, allowing students to work with realistic components and systems to develop competency and practical analytical skills. The revised trainer improves upon the existing alternator model by directly coupling the battery to the alternator, with the engine operating at variable speeds during battery charging. This design adjusts the direct current voltage output based on data from the battery management system. The product design and development process includes data collection, design, testing, and revisions, culminating in the final product. Test results show that the trainer is 94% effective in simulating industrial electrical installations (Elfizon, et al., 2019). By providing a versatile and durable learning tool, the trainer helps students understand power generation and battery management in dynamic conditions. This innovation bridges the gap between theoretical knowledge and practical application, preparing students for industry demands and enhancing learning outcomes.*

Keywords: Power Generation, Mock-up Trainer, Prototype

I. INTRODUCTION

In recent years, the landscape of education is constantly evolving, and equipping students with essential design and development skills is crucial for success in the 21st century. The era of the 21st century is often regarded as an era of technology (NAGASUBRAMANI,ET AL.,2018). The alternating mock-up trainer for power generation would be addressed The Alternating mock-up trainer for power generation serves as a bridge between theoretical knowledge and analyzing application, providing students with a simulated environment to explore and master the intricacies of alternating operation and analyzing. One of the ways in which the Alternating mock-up Trainer for power generation shapes students is by fostering a practical analyzing and experiential learning approach. By engaging with the Alternating mock-up trainer for power generation, students can actively participate in hands-on activities, allowing them to develop critical thinking by analyzing components connection, problem-solving, and decision-making skills. This immersive learning experience not only enhances their technical competence but also instills a sense of confidence and self-reliance. Thus, the propose of this research is for power generation proves to be highly useful in education by providing a safe and controlled environment for students to explore and experiment. It eliminates the risks associated with working on actual electrical systems, ensuring that students can learn without the fear of causing damage or harm. This controlled setting allows students to make mistakes, learn from them, and refine their skills in a supportive and guided manner.

II. REVIEW OF LITERATURE

The use of mock-up trainer as an instructional material is very significant in the cycle of teaching-learning in developing technical skills and exercises, certainly in building and residential wiring installation and maintenance to

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guarantee the learners quality education in an industrial-like scenario. This study employed a descriptive method of research by determining the trainers' acceptability using the variables–functionality, usefulness, safety, and maintenance, and it is technical feasibly using the variables – validity, reliability, and replicability by the electrical experts from the academic and the industry. After series of demonstrations and technology assessments of the respondents, the said trainer was rated by both experts from the academe particularly teaching electrical technology and engineering, and the electrical industry acceptable and technical feasible on all the criteria in the given instrument. With this trainer present in the shop-laboratory, learners can develop their expertise by accomplishing such tasks because it is along-side the real market of building and industrial wiring installation and maintenance (Pereyras J, et.al 2017).

Considering the widespread use of alternators in various industries and the importance of hands-on experience in understanding their operation and maintenance, the odds are favorable for the alternator trainer. If the target audience includes individuals pursuing careers or studies related to electrical maintenance, power generation, or similar fields, the alternator trainer can provide valuable practical skills and knowledge. So, the odds are fairly high, for the alternator trainer being a beneficial and effective learning tool in such contexts, It also has wheels/rollers for easier transfer from one place to another without carrying the prototype (Rey G. GavicaJr.,et al.,2022) .

This device allows for a focused study on the principles, operation, and maintenance of alternators, which are essential components in electrical systems, particularly in automotive, aerospace, and power generation industries. The battery energy storage is been developed, addressing its key technical characteristics, lifespan, and operational efficiency (T. P. Teixeira, C. L. T. Borges,et al.,2021). The model includes representations of batteries and operational strategies, and is integrated with a composite reliability assessment model to evaluate the impact of the integrated batteries on trainer performance. Power generation mock-up trainers typically provide hands-on experience in assembling, disassembling, and troubleshooting alternators, which can enhance practical skills and deepen understanding compared to theoretical learning alone. Alternating trainers often simulate real-world scenarios, enabling learners to apply theoretical knowledge to practical situations, such as diagnosing faults, testing performance, and optimizing efficiency. For students or professionals aiming to work in fields where alternators are widely used, electrical maintenance, or renewable energy systems, an alternating trainer offers directly applicable skills and knowledge. Alternating trainers may cover various aspects, including electrical principles, mechanical components, voltage regulation, and control systems, providing a comprehensive understanding of alternating operation and integration into larger electrical systems.

III. CONCEPTUAL FRAMEWORK

The material inputs for this innovation are carefully planned, selected, designed, constructed, tested and evaluated to ensure the efficiency and effectiveness of the device.

Figure 1: Conceptual Model of the Study

First box represents the input of the study. This entails the first step in developing all the concepts in order to materialized the project. It also implicates on how the proposed project being weighed. The second box entails the designing and development of the project. The third box complies with the output of the device.

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It is understood that in this stage the device is now on its completion and undergoing already series of tests. This area discusses the whole design of the project, its diagram and the connection point. Base on the materials gathered fabrication stage will follow by following the procedural design of the project.

In this paper, we present our work, which is doing an energy audit on the alternator's current output and battery's voltage based on alternator speed. As technology advances, more and more electrical devices are produced and being installed in vehicles. To cope with the demand, an alternator has been designed and modified so that it can produce enough power. (Rozdman K. Mazlan et al., 2017).

Objectives of the Study

The main objective of the study is to design and develop of alternating mock up trainer for power generation. Specifically, the study aims to:

1. Developed device known as an alternator system for mock-up trainer power generation.
    1.1 Technical description
    1.2 Cost
2. To established the procedural steps are processes in the development of the device.
3. Evaluate the respondents' level of the proposed device in terms of the following aspects:
    3.1 Analyze
    3.2 Design
    3.3 Develop
    3.4 Durability
    3.5 Summary and Evaluate

Implement And Evaluate

4. Scientific Data of the performance of the device.
5. Develop user's manual.

Significance of the Study

This research project shall be valuable to the following individuals:

Faculty. This system provides students in electrical engineering, power systems, and related fields with valuable hands-on learning experience.

Future Researchers. This provides valuable insights, opportunities, and challenges for future researchers seeking to advance knowledge, innovation, and education in the field of electrical engineering and related disciplines.

Scope and Limitations

The primary focus of this research is to design and develop an alternating mock-up trainer for power generation, which involves the creation of a functional prototype. The production of this kind of project should not be limited to SNSU electrical student SUC'S and training centers in Surigao City but also to other provinces in the Philippines. The conduct of the project will be made by the researchers with the aid of relevant knowledgeable people. However, the innovative ideas of the researchers shall still be followed.

Definition of Terms

Mock-up trainer - Is for educational tool for students that help them understands the process of generating and distributing electricity using key components like an alternator, battery, and power inverter. It provides hands-on training for understanding device operation, circuit design and troubleshooting in a safe and controlled environment.

Power Generation - Is the process of converting energy from the battery into electricity for consumption.

Prototype - Is a preliminary device design to operate and evaluate the functionality,efficiency and safety of a power generation.

Alternator - It is an eletrical machine that converts mechanical energy to electrical energy also generates dc power and charges the battery.

Motor - It drives the alternator to supply energy back to battery.

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Circuit Breaker - Safety device designed to protect the prototype from damage caused by current in excess of that which the equipment can safely carry overcurrent.

12V Battery - A 12V battery serves as a power source for the alternating trainer. It provides the necessary electrical energy to operate the trainer and simulates real-world conditions where alternator charges a battery then store dc power.

Digital volt-amp meter - The voltmeter measure voltage, whereas ammeters measure current.

Power inverter - Is a device that changes direct current (DC) to alternating current (AC). The resulting AC frequency obtained depends on the particular device employed. Inverters do the opposite of rectifier's which were originally large electromechanical devices converting AC to DC.

Omron Relay With Socket - Is a device used to control electrical circuits by opening and closing contacts in response to an electrical signal.

Start button - Is the control input and to activate specific functions of the device. They allow users to interact with the system and demonstrate its operation features, also to start the motor.

Stop button - Define as a safety control mechanism utilized in various systems and equipment to immediately halt the operation in emergencies or to prevent damage, ensuring safety and system integrity.

Receptacle - Providing a place in a wiring system where current can be taken to run electrical devices**.**

Ac bulb - Is a electrical component that emits light when an alternating current passes through its filament.

Wire - Is used to connect various components within the alternating trainer. They facilitate the flow of electrical current between different parts of the alternating mock-up trainer for power generation and ensure proper functioning.

Exhaust fan 12V DC - Is a ventilation device powered by a 12-volt direct current power source. It's designed to expel stale air or unwanted odors from enclosed spaces of device.

LED - Is a semiconductor device that emits light when an electric current is passed through it.

Project Design

Below is the architectural design of the research device (Power generation mock-up trainer), included the labeled parts of the research project.

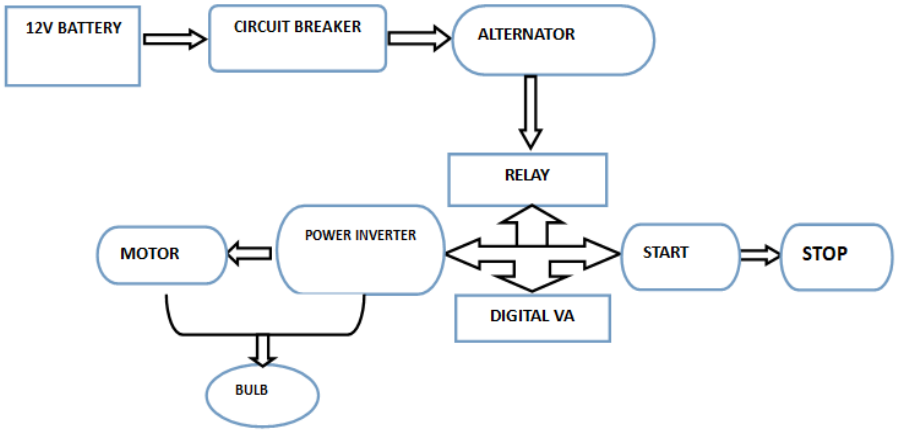

Figure 2: Block Diagram

Project Development

The following are the procedural steps for completing the project.

1. Research Design
2. Research Environment
3. Research Respondents
4. Data Gathering procedures

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5. Data Analysis
6. Ensure that all devices to be used are functional and not defective.
7. Connect all wiring, starting from the battery to the other components.
8. Verify that all wiring components are correctly connected to the appropriate parts.
9. Test each component to ensure it is functioning properly.
10. Test the completed product (alternating mock-up trainer for power generation) to confirm that all components are working correctly.
11. Finalize the setup by securing the components onto plywood and arranging them in their proper positions.
12. Once all components are set up and wiring connections are checked, the alternating mock-up trainer for power generation is ready for use.

Operation Procedure

In determining the performance of the device, the following procedure was followed:
1. Start/Stop procedure.
a. To start the power generation trainer:
Ensure all components are properly installed.
Press the green button to activate the power generation trainer.
b. To stop the power generation trainer:
Press the red button to deactivate the trainer's operation.
2. Inspect wiring connections that would possibly make up accidents.
3.Observe proper or correct installation.

Testing Procedure

In order to assure that every part of the device is working properly, the following test procedure should be done:

1. Check every part of the device.
2. Testing the alternating mock-up trainer for power generation.
3. Check each connection points.
4. Test the device and conduct an assessment and efficiency on it..

Evaluation Procedures

Evaluation is a way to determine the acceptability of the proposed project. Selected people were asked to rate the performance of the device. These respondents were composed of selected residents in Surigao City who have specialized on the field. Prior to the actual demonstration/evaluation of the device, the researcher explained the function of the device as well as its specification of the prototype. Before the evaluation sheet was given to the respondents, its content was discussed by the researchers. When the evaluation has been accomplished, the result was tabulated and computed to find the mean of every criterion as well as the overall mean.The respondents will then evaluate the said proposed project based on usability, quality of design, functionality, safety, and efficiency. The evaluation sheet is provided where respondents can write their comments and suggestions for further improvement of the device.

V. RESULTS AND DISCUSSIONS

This chapter presents the project description, capabilities and limitations, project test results, and the final evaluation.

Criteria and Statement	Mean	Qualitative Description
A. Functionality		
Function of the device is meet as it expected.	4.25	**Excellent**
The device performs the task effectively.	4.32	**Excellent**
The device has a minimal error.	4.25	**Excellent**
The device can be enhanced or updated.	4.45	**Excellent**

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The quality and consistency of the device's outputs	4.45	**Excellent**
Average Mean	4.34	**Excellent**

Acceptability of the device in terms of Functionality

The table assesses the "Functionality" criterion using five different claims regarding the device's performance and functionality. Every claim describes a distinct aspect of the device's functionality. The "Mean" column displays the average ratings or scores given to each statement. For example, Statement 1 received an average score of 4.25, Statement 2 received an average score of 4.32, and so forth. The mean score is the overall assessment of each statement's functionality. The "Qualitative Description" column provides a qualitative assessment or description of each statement based on its mean score. In this case, Statements 1 through 5 received the rating of "Excellent," indicating that they were well-reviewed and produced excellent work. According to this data, the device's functionality was evaluated favorably. For statements 1 through 5, which speak to the equipment's ability to fulfill tasks effectively and satisfy expectations, the device received an "Excellent" grade.

Acceptability of the device in terms of Applicability

D. Durability	Mean	Qualitative Description
The device withstands physical forces, including compression, tension, and torsion.	4.50	Excellent
The device's performance under various environmental stresses, such as temperature extremes, humidity, dust exposure, and water resistance.	4.45	Excellent
The materials used in the prototype behave under repeated use over time, which may include abrasion resistance and wear testing.	4.35	Excellent
Device performance under high and low temperature conditions.	4.50	Excellent
Device longevity and performance of the battery under typical usage conditions, including charge/discharge cycles.	4.50	Excellent
Average Mean	4.46	Excellent

The respondents' opinions, which evaluate the "Applicability" criterion based on five different claims on the device's suitability and adaptability to different applications and user needs, are shown in the table. The "Mean" column displays the average ratings or scores given to each statement. For example, the average score for Statement 1 was 4.52, the average score for Statement 2 was 4.60, the average score for Statement 3 was 4.45, the average score for Statement 4 was 4.35, and the average score for Statement 5 was 4.45. The mean score is the overall assessment of each statement's applicability. The "Qualitative Description" column provides a qualitative assessment or description of each statement based on its mean score. In this case, statements 1 through 5 were both rated as "Excellent," indicating that they were exceptional and either met or exceeded safety standards. According to this table, the applicability of the gadget was deemed favorable. Statement 1 claims that the device works well in a certain real-world setting or application. received an "Excellent" grade, meaning it is appropriate for a certain use or function. According to Statement 2, the gadget satisfies the demands of the target user group and was given an "Excellent" grade, indicating that it can meet the needs and preferences of its users. The remaining criteria for the gadget were rated as outstanding, indicating that it meets all expectations for application.

Acceptability of the device in terms of Durability

B. Applicability	Mean	Qualitative Description
The device's effectiveness in specific real-world applications or environment.	4.52	Excellent
The device meets the needs of intended user group.	4.60	Excellent
The device withstands the specific environmental and usage conditions of its intended application.	4.45	Excellent

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Measure how quickly and easily users can adopt the device, considering factors like training requirements and the user interface's intuitiveness.	4.35	Excellent
Level of maintenance required for the device and the availability of user support and resources.	4.45	Excellent
Average Mean	4.47	Excellent

Five different claims on the unit's capacity to tolerate high temperatures, resist deformation, and be well-designed are used in the table to assess the "durability" criterion. The "Mean" column displays the average ratings or scores given to each statement. For example, both Statements 1 and 5 received outstanding results. These demonstrate how each assertion's device durability is assessed generally and is shown by the mean score. The "Qualitative Description" column provides a qualitative assessment or description of each statement according to its mean score. In this case. Statements 1 through 5 were rated as "Excellent," indicating that they were highly acclaimed and had the best possible design. Based on the data in this table, it was concluded that the device's durability was favorable. Statements 1 through 5 focus on the device's ability to withstand physical forces like compression, tension, and torsion; its performance under different environmental stresses; how the prototype behaves under repeated use over time, including wear testing and abrasion resistance; and the battery's longevity and performance under typical usage conditions, such as charge/discharge cycles. The device received an "Excellent" rating, meaning that it showed the best resilience and maintained its shape under a variety of conditions.

Acceptability of the device in terms of Safety E. Safety	Mean	Qualitative Description
1. The device has an emergency shutoff mechanism, warning indicators, and user manuals for safety usage.	4.15	Very Good
2. Device absence from harmful substances, such as battery leaks or toxic materials.	4.20	Very Good
3. The physical design of the device to identify sharp edges, pinch points, or moving parts that could pose risks during use.	4.15	Very Good
4. The device potential electrical hazards, including short circuits, overloads, and proper grounding.	4.30	Excellent
5. The device's ability to manage heat during operation.	4.15	Very Good
Average Mean	4.19	Very Good

Three particular claims are used in the table to assess the "Safety" criterion: the device has an emergency shutoff mechanism, there are no toxic substances present, and protection is provided. Mean: The "Mean" column displays the average rating or score for each statement. For example, the average score for Statement 1 was 4.15, the average score for Statement 2 was 4.20, and the average score for Statement 3 was 4.15. Statement 5 received a score of 4.15, whereas Statement 4 received an average score of 4.30. The mean score is the overall assessment of the safety of each statement. Qualitative Description: The "Qualitative Description" column provides a qualitative assessment or description of each statement based on its mean score. In this case, all five of the statements received the rating "Very Good," meaning that they were well-reviewed and believed to contain adequate safety measures. Based on the information in this table, it was determined that the gadget was sufficiently safe. Statement 1: The product was rated as "Very Good" and features an emergency shutoff mechanism. This indicates that an automated shutdown mechanism built into the equipment would immediately stop it if it met any issues while in use. This is supported by Statement 2, which was rated as "Very Good" as well. The device's lack of dangerous components and battery leakage demonstrates that every aspect of safety was carefully taken into account during development to guarantee that the user would not suffer any harm. Statement 3 states that any moving parts, pinch points, or sharp edges that could be hazardous to use are identified by the device's physical design. This demonstrates the device's degree of safety as well as its ease of use. Statement 4 demonstrates how potential electrical hazards to the device, including overloads, short circuits, and proper grounding, are taken into account during the fabrication process. Making the device safer to use is

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one of the main objectives. Finally, the device's ability to regulate heat during operation is taken into account during the manufacturing process (statement 5). This will include the device's ability to withstand any room temperature and to continue to perform without worry in the event that it breaks or malfunctions.

Overall Acceptability

Criteria	Mean	Rank	Qualitative Description
A. Functionality	4.34	**4**	**Excellent**
B. Applicability	4.47	**4**	**Excellent**
D. Durability	4.46	**4**	**Excellent**
E. Safety	4.19	**3**	Very Good
Grand Mean	4.49		**Excellent**

The table presents an evaluation of a power generation mock-up trainer based on several key criteria, including Functionality, Applicability, Durability, and Safety. The criteria are assessed based on mean scores, rankings, and qualitative descriptions. Each criterion has been assigned a mean score reflecting its performance. For example, the mean score for functionality was 4.15, while applicability scored 4.23, indicating its slightly higher performance. The ranking of each criterion is shown in the "Rank" column, with applicability receiving the highest rank (1), signifying its strongest performance among all criteria. Durability and safety ranked second and third, respectively. In the "Qualitative Description" column, all criteria are rated as "Very Good," signifying that each one performed admirably and met all the required standards. The "Grand Mean," calculated by averaging all the mean scores, is 4.17, which reflects an overall evaluation of "Very Good" for the trainer's acceptability. Based on the table, it can be concluded that the trainer performed excellently across all categories, with applicability taking the top rank followed by durability and safety. Overall, the evaluation indicates that the power generation mock-up trainer meets the desired standards and performs well in all aspects, ensuring its effectiveness as an educational tool.

VI. SUMMARY

This study aimed to evaluate the effectiveness of the proposed project, which is a alternator mock-up trainer for power generation. It focuses on the primary usage, functionality, applicability, durability and safety aspects of the project, as well as how it effectively assists people through innovative means.

The project is tested out of 10 respondents that has knowledge regarding electricity, enough to understand the flow of the project its material used, functions, usage and how it works.

VII. FINDINGS

Based on the comprehensive evaluation of the "Alternating mock-up trainer for power generation," the following key findings have emerged:

1. Functionality Excellence:

The prototype exhibited exceptional functionality, earning an excellent rating. This indicates a high level of effectiveness in providing free energy and a reliable mock-up trainer for power generation.

2. Applicability Across Diverse Settings:

The device exhibits versatility and adaptability, receiving high ratings for both residential and commercial applications. It effectively addresses specific needs, accommodates user requirements, and provides a safe and practical learning experience in the field of alternating current mock-up trainers for power generation.

3. Workability and Accessibility:

The tool was well-agreed by users, who were satisfied with its workability and the availability of expertise, materials, tools, and support resources. While the tool's ability to provide valuable educational experiences received a slightly lower score, it presents an opportunity for further improvement.

4. Durability:

The tool was highly regarded by users for its durability, demonstrating strong resistance to deformation, high temperatures, and environmental factors. This resilient framework ensures the tool's longevity, making it suitable for long-term educational use.

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5. Safety User:

The tool was highly regarded by users for its emphasis on safety. By eliminating sharp edges, avoiding toxic materials, and incorporating safety features like adequate protection and clear instructions, the device prioritizes user well-being, making it suitable for educational environments.

VIII. CONCLUSION

Alternating current mock-up trainers for power generation provide students with hands-on experience in electrical and control systems, enhancing their learning and developing essential skills for careers in engineering and technology. Additionally, they promote understanding of sustainable practices.

In conclusion "Power generation mock-up trainers " serve as essential tools for students, providing hands-on experience and practical knowledge in electrical and control systems. By providing a safe space for experimentation and troubleshooting, these trainers significantly enhance the learning experience. When Engaging with these trainers fosters essential skills that are crucial for future careers in engineering and technology. Through practical engagement with the trainers, students build a solid understanding of the alternating mock-up trainer for power generation concepts. Interaction with motor control trainers also promotes a deeper understanding of sustainable practices within the industry.

IX. RECOMMENDATIONS

Active Participation, students are encouraged to actively participate in hands-on exercises, collaborate with peers during troubleshooting activities, and enhance problem-solving skills by gaining diverse perspectives. **Regular Practice,** Regular practice sessions will help solidify concepts and improve technical skills. **IMPACT: hands-On Exploration,** students should actively explore the various functionalities of the alternating mock-up trainer for power generation to deepen their comprehension. **Learning c**ollaborating with classmates on projects can enhance learning through the exchange of ideas and troubleshooting strategies. **Practical Experience p**articipating in hands-on simulations will provide practical experience, which is essential for mastering theoretical concepts. **Review and Discussion,** Regularly reviewing and discussing the outcomes of experiments will reinforce understanding and retention of key principles. Future researchers are encouraged to conduct studies similar to this idea for further improvements.

LIMITATIONS: Base on our study this project only operates for 5 minutes because the energy provided by the alternator to the battery is insufficient. The powers the trainer, which demonstrates how power is generated.

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