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Design And Development of PLC Trainer Kit For Inductive and Resistive Load

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Abstract

The design and development of a PLC Trainer Kit for Inductive and Resistive Load was developed for the enhancement of training and instruction about automation in electrical and electronics classes. This trainer kit was made portable for use in instruction.

The trainer kit consists of five (5) sections namely: PLC section features PLC as control unit of the trainer; overcurrent protective device and power supply section; input devices section; output devices section includes inductive loads and resistive loads; and input disconnecting switches.

In order to create the trainer kit, the researcher adhered to the study's conceptual model. The first step is to collect and evaluate relevant literature and studies. Second is to create the training board according to the design. Supplies, tools, and equipment that are needed were prepared. To make the project presentable, the materials were assembled, installed, and finished according to measurement. After the trainer kit was completed, it will be subjected to examination and assessment by teachers, students and experts in the field.

The researcher asked for the assistance of ten electrical technology experts, ten teachers, and ten students to assess the project's acceptability. The criteria used to assess the project's acceptability are its functionality, workability, durability, safety, and instructional applicability; these criteria have three distinct indicators that will be rated on a Likert scale of 1 to 5, with 5 representing the highest rating, or Outstanding, and 1 representing the lowest rating, or Poor. The qualitative method will be used to analyze the data gathered from the various evaluators.

The trainer kit obtained a GRAND MEAN of 4.66 which is equivalent to the description of “OUTSTANDING”. This reveals that trainer kit served its purpose according to the design fabrication and function which suits the current trend in Electrical field. It was found that the situational and multipurpose exercises that may be controlled using the training board, along with a laboratory and user manual, are effective ways to improve higher order thinking skills. The functioning criterion fulfilled its main objective of portability. Its stand-alone designed with transportable housing assembly adds to the project's durability, and the safety features which are crucial because electricity is a constant hazard were commended for being very satisfactory.

Keywords: *PLC trainer kit, inductive load, resistive load, instructional device, automation*

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INTRODUCTION

Technology transforms our world and impacts our daily lives. It plays a significant part in making our tasks uncomplicated and fast-moving.

In industry, the major contribution of technology for manufacturing different products can be seen clearly. It is a fact that before the production was labor intensive and slow. But nowadays, the industrial process seems easier and faster using various machines with the application of automation and the employment of industrial robots which are programmed and manipulated by skilled personnel. The demand for skilled and knowledgeable workforce to utilize this new technology increases. With this demand, the education sector needs to update in terms of training to cope up with the industrial needs.

According to Dizon, et al. (2019), K to 12 program implementations in the Philippines is aimed at producing more skilled students with basic skills for lifelong learning and employment. It can help students master the skills and learn the fundamental competencies which are necessary to meet the demands of the global industries. Under these K to 12 programs is the Technical-Vocational-Livelihood Track.

In Technical-Vocational-Livelihood Track, instructional devices are extremely beneficial for the learning process of students. As stated by Muraina (2015), instructional devices can be utilized to alleviate, enhance, and stimulate teaching and learning activities. An instance of this is utilizing programmable logic controller (PLC) trainer boards in electrical and electronics subjects. Teachers should be able to deliver the lesson effectively to the students through hands-on activities with the use of PLC trainer boards.

As stated by Moon (2013), experiential learning is the strategic, active engagement of students in opportunities to learn through doing, and reflection on those activities, which empowers them to apply their theoretical knowledge to practical endeavors in a multitude of settings inside and outside of the classroom. Therefore, hands-on activities utilizing PLC trainer boards are very essential to the electrical and electronics students to attain familiarization and mastery involving mechatronics devices. Likewise, it allows students to see and experience some of the industrial works in the field of technology that requires automation.

Unfortunately, most of the public secondary schools do not have the capacity to produce trainer kits that can be used to impart such knowledge and skills due to lack of materials and inadequate budget of the school. With this, it limits the capabilities of the students to learn and perform the target competency.

Moreover, majority of the available PLC trainer kits are large and occupy huge space of teaching area. It is difficult for the teachers to utilize these boards particularly in limited classroom setting and extension programs. Thus, teachers conduct hands-on activities in a certain location only.

From the stated problems, the researcher aims to design and develop a (Programmable Logic Controller) PLC Trainer Kit for Inductive and Resistive Load. It will help the students to familiarize the operation and control of different mechatronics devices such as cylinder, dc motor, sensor, and electrical loads. The trainer consists of input and output devices that are found in the workplace.

Additionally, the trainer kit intended to use locally available materials for low cost and design the project to be portable so that the teachers can easily conduct classes regardless of classroom size or location. The researcher is optimistic that the learning process can be facilitated through this project and the lessons can be made more understandable to the students.

The general objective of the study is to design and develop a programmable logic controller trainer kit for inductive and resistive load that would benefit the end users mostly in the TVL track of senior high school.

Specifically, the study aims to:

1. Design and develop a programmable logic controller trainer kit for the inductive and resistive load as instructional device with the following features:
    a. Electrical/mechatronics input and output devices;
    b. Compact;
    c. Overcurrent protective device and power supply; and
    d. Input disconnecting switches.

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2. Fabricate the trainer kit according to the design.
3. Test the trainer kit in conformity with the design parameters.
4. Evaluate the acceptability of the trainer kit in terms of the following criteria:
    a. Functionality
    b. Workability
    c. Durability
    d. Safety
    e. Instructional Applicability

The project is focused on the design and development of a Programmable Logic Controller Trainer Kit for Inductive and Resistive Load for the enhancement of training and instruction in automation in electrical and electronics classes. The trainer kit features a power supply and overcurrent protective device. It is limited to using a PLC controlling inductive and resistive loads. The input devices for PLC consist of push buttons, proximity sensor, photoelectric sensor, and limit switch. On the other hand, output devices are comprised of resistive and inductive loads such as incandescent bulbs, DC motor, relay, solenoid valve and air cylinder. These features can provide a venue for the students to familiarize themselves with the function and operation of these electrical and mechatronics devices for their practical activities. The respondents of the project were composed of (10) electrical students, ten (10) instructors from the field of electrical technology, and 10 electrical experts from the industry. Moreover, the beneficiaries of the project are TVL senior high school students of Dasmariñas Integrated High School.

METHODOLOGY

Project Design

The PLC trainer kit for inductive and resistive load is designed for the familiarization of students with the operation and control of electrical and mechatronics devices. The trainer consists of five (5) sections namely: PLC section features PLC as control unit of the trainer; overcurrent protective device and power supply section as the source of 220V AC and 24V DC; input devices section comprises of push buttons (normally close and normally open), proximity sensor, photoelectric sensor, and limit switch; output devices section includes inductive loads and resistive loads; and input disconnecting switches.

Different industrial devices were combined in this project to make it compact and to help teachers facilitate hands-on activities in their class.

Figure 1. Actual Picture of the Project

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Figure 2. Project for Transport

The project's transportability is shown in Figure 2 for use as an instructional material for community training on PLC wiring tasks.

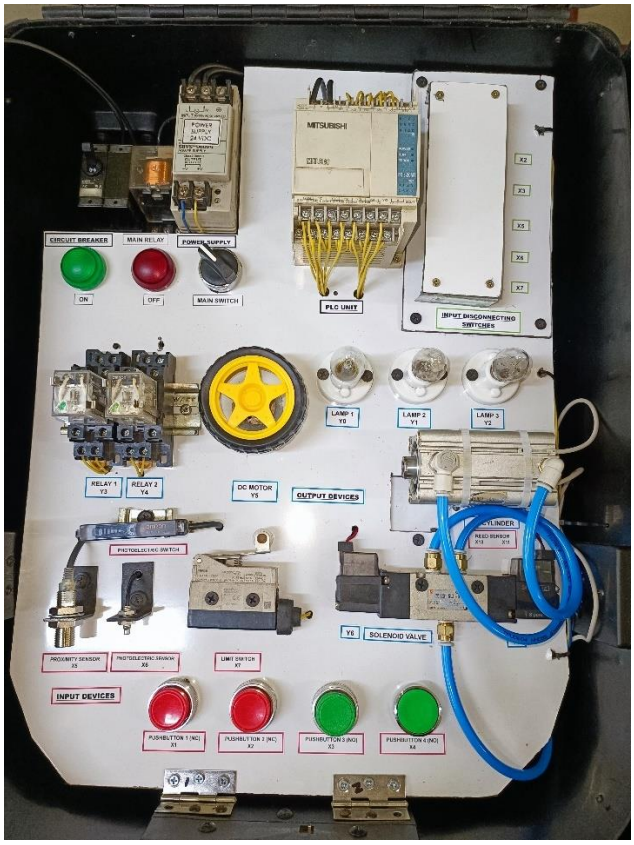

Figure 3. Actual Picture of the Project Containing the Devices

Figure 3 shows the picture of the actual project containing the devices. In order to operate and demonstrate the various mechatronic devices, the project provides a PLC trainer board with inductive and

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resistive loads. The project consists of five (5) sections namely: PLC section; overcurrent protective device and power supply section; input devices section; output devices section; and input disconnecting switches section.

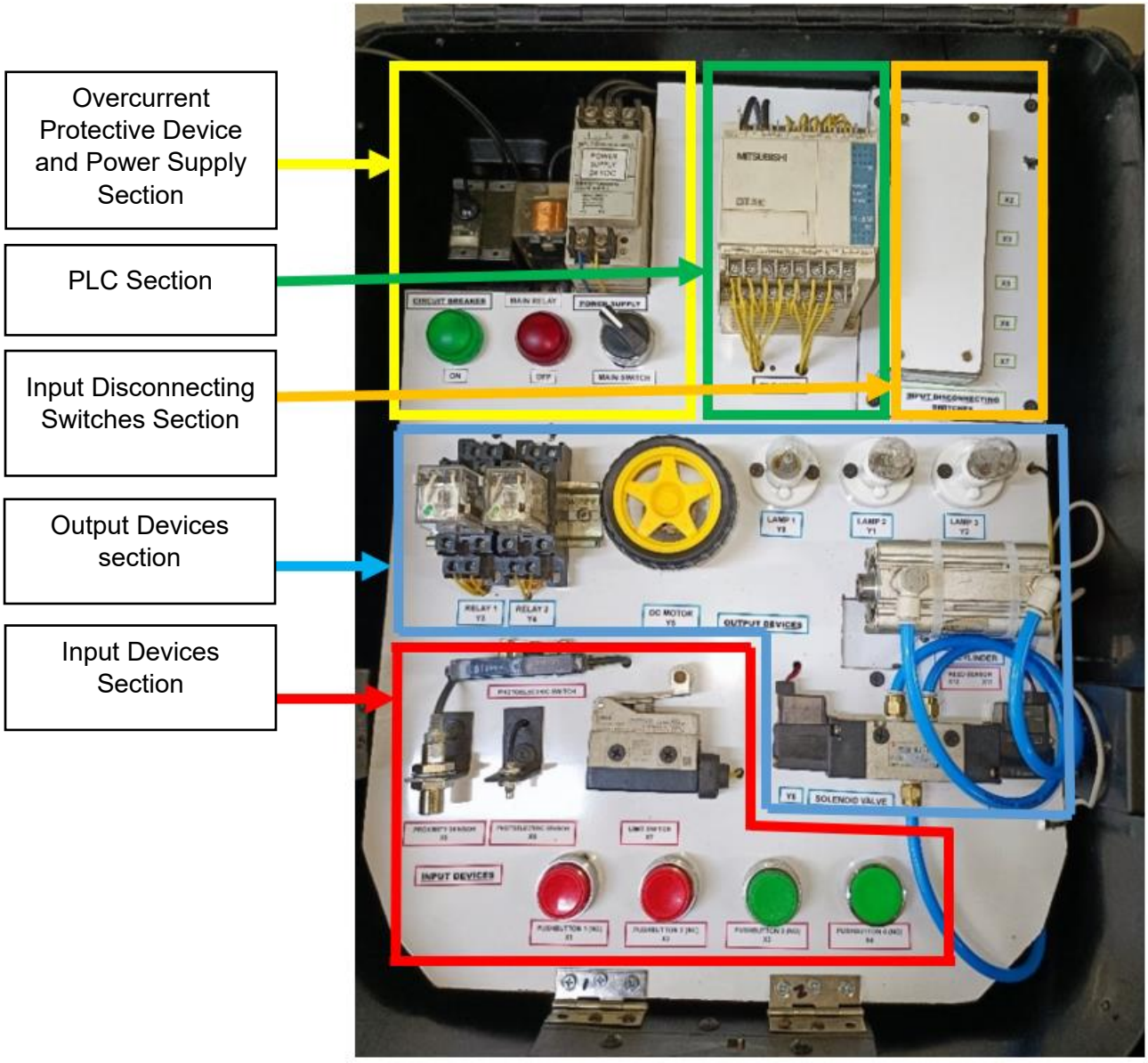

Figure 4. Five Sections of the Project

PLC Section

Due to the demand for automation in the industry, the main device of the trainer kit is programmable logic controller (PLC) that serves as the control unit. PLC section features the main device of the project which is Mitsubishi Melsec FX1s with specifications of 12 inputs and 8 outputs. It is the type of PLC that will be used to control inductive and resistive loads of the trainer.

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Overcurrent Protective Device and Power Supply Section

The project uses a circuit breaker 5A Fuji Electric as overcurrent protective device with light indicators that signify that voltage is supplied on the trainer. It will help to secure the function of the trainer and to ensure that safety of end users during operation. Moreover, the different voltage requirements of the devices require two different voltages from the power supply for the project to operate. A power supply was included to provide 24V DC source for DC devices.

Input Devices Section

Input devices section transmit signal to plc to conduct such operation of output devices. It includes the following devices: four (4) push buttons (normally close and normally open), proximity sensor, photoelectric sensor, and limit switch.

Output Devices Section

Output devices receive the signal and the result of conditions. This section includes inductive loads such as two (2) relays, dc motor, solenoid valve and three (3) incandescent lamps as resistive loads.

Input Disconnecting Switches Section

The input disconnecting switches section is also included in the project. It consists of five (5) DC on/off mini switches which are connected to input devices that cause open circuits and task the students to conduct troubleshooting activity.

The evaluation was conducted through a survey to determine the acceptability of the trainer kit. In the process, a survey on the functionality, workability, durability, safety, and instructional applicability of the project will be gathered based on the format of the evaluation criteria for the prototype adopted by the College of Industrial Technology. Each criterion was determined by a set of three indicators rated on a scale of 1 to 5, where 1 is the lowest and 5 is the highest.

The respondents were composed of (10) electrical students, ten (10) instructors from the field of electrical technology, and 10 electrical experts from the industry.

The data gathered were collected, recorded, and computed for the means using the formula below to interpret the result which will determine the acceptability of the training board.

$$x = \frac{\Sigma x}{n}$$

Where: x = mean

Σx = sum of the scores; and

N = the number of respondents

As shown in Table 2, the respondents used the Likert scale to describe how acceptable the training board is to them. The Likert scale is in numerical value which was described as outstanding with the highest acceptability and numbered as 5 while poor as the lowest acceptability and numbered as 1.

Table 2. Likert Scale to Describe the Training Board

Numerical Scale	Descriptive Rating
4.51 – 5.00	Outstanding
3.51 – 4.50	Very Satisfactory
2.51 – 3.50	Satisfactory
1-51 – 2.50	Fair
1.00 – 1.50	Poor

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RESULTS AND DISCUSSION

The design and development of PLC trainer kit for the inductive and resistive load is designed for the familiarization of students with the operation and control of electrical and mechatronics devices. To ensure the functionality of each device, the project testing was conducted. Each device passed functional testing resulting in what was the expected output. Circuit breaker and power supply delivered the expected voltage reading of 220V to 230V and 24V. The PLC power indicator turned ON as testing procedure was conducted in PLC unit. Input devices correspond with PLC input power indicator as well as output devices. Input disconnecting switches worked correctly as the input disconnecting switch is ON or OFF, the PLC input and output power indicator responds to the input and output devices.

Criteria and Indicators	Mean			
	Teachers/ Experts	Student	Weighted	Descriptive Rating
1. Functionality	4.80	4.70	4.75	**Outstanding**
2. Workability	4.77	4.67	4.72	**Outstanding**
3. Durability	4.67	4.60	4.63	**Outstanding**
4. Safety	4.55	4.43	4.49	**Very Satisfactory**
5. Instructional Applicability	4.65	4.77	4.71	**Outstanding**
OVER-ALL MEAN	**4.69**	**4.63**	**4.66**	**Outstanding**

Table 1. Summary Evaluation Results for Acceptability of the Project

Summary of the evaluation for the acceptability of the project on five criteria is presented as follows:

On functionality, the evaluators gave a descriptive rating of outstanding with an average mean of 4.75. This shows that the project can be easily operated.

On workability of the project, the evaluators rated the project outstanding with the mean 4.72. The evaluators confirmed that the project is not hard to fabricate due to availability of materials, tools and technical expertise.

On durability, the project was rated outstanding with a mean score of 4.63 which means that the project was found sturdy and well-built.

On the safety of the project, it was rated very satisfactory with a mean score of 4.49 which indicates that the project is safe to use and poses no danger to the user.

In terms of instructional applicability, the evaluators rated the prototype outstanding with the mean of 4.71. The results showed that this project is recommended as an instructional device for teachers in the field of electrical technology.

The trainer kit obtained a GRAND MEAN of 4.66 which is equivalent to the description of "OUTSTANDING". This reveals that trainer kit served its purpose according to the design fabrication and function which suits the current trend in Electrical field.

Conclusions

Based on the set objectives of the study and results of the evaluation conducted, the following conclusions were formulated:

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1. The trainer kit was fabricated utilizing locally accessible materials in accordance with the plan, design, and function.
2. The trainer kit served its purpose as an instructional training device especially, since it is also transportable.
3. Upon testing and evaluation, the trainer kit is said to be "Outstanding" and highly acceptable in terms of functionality, workability, durability, safety and suitability as an instructional training board.

Recommendations

Based on the results of the study, below are the recommendations and suggestions to enhance the PLC trainer kit for the inductive and resistive load:

1. The trainer kit is rated as Outstanding and can be used as an instructional material in the Division of Dasmariñas.
2. Administrators and program experts should support educators in creating locally available resources to improve their approach in the delivery of lessons while saving time, money, and effort.
3. The trainer kit can be utilized in outreach initiatives like barangay and/or extension programs for those with limited resources, considering its portability.
4. The trainer kit must be reproduced for use by other trainers and trainees.
5. Future researchers can include miniature compressor in the trainer kit.

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