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Design and Development of an Automated PLC Electropneumatic Conveyor System Apparatus: An Industrial Process Simulator for Teaching Electrical/Electronics Technology Courses

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ABSTRACT: The study was focused on the design and development of An Industrial Process Simulator for Teaching Electrical/ElectronicTechnology Courses . This project development research tried to achieve the following objectives: (1. To design and construct a valuable, innovative and inexpensive prototype for electrical and electronics instructional equipment; 2. Test the performance of the developed prototype in conformity to its design parameters and operational limitations; and 3. To determine the acceptability of the developed prototypes in terms of its functionality, aesthetics, economy, workability, durability, safety and instructional applicability).

The five-point Likert's scale was used to determine the descriptive meaning of the indicators of the variables used. Furthermore, the Weighted Average Mean (WAM) was used to interpret the equivalent meaning of the data gathered.

Evaluation result shows that the project obtained an overall mean of 4.72 which means that the completed project is "HIGHLY ACCEPTABLE" to the evaluators based on the criteria of functionality, aesthetics, durability,workability economy, safety and instructional applicability.

INTRODUCTION

One important dimension in teacher education is related to the use of *Instructional Materials* like laboratory equipment, Manual of Activities and many others specifically for those teaching Electronics and Electrical technology courses. In order to attain more effective and meaningful teaching-learning activities is to expose the students in practical activities. This for the fact that laboratory facilities enhance, facilitate and make teaching-learning process easy, lively and real. Instructional materials are the devices developed or acquired to assist or to facilitate in transmitting an organized knowledge, skills and attitudes to the learners within an instructional situation. To be precise, instructional materials are necessary. These are educational resources used for illustrating the content of instruction, thereby making learning more tangible and effective. The sequence in which learners encounter materials has direct effect on the achievement of the task. In providing the closer experience to real situation, instructional materials enhance acquisition and retention of factual information. Instructional materials not only provide the necessary concrete experience but also help student integrate prior experience.

For those schools offering technology courses like electronics and electrical technology are the very important for today's millennial times. The school need to produce competent graduates equipped with standard skills needed for employment. So, these technical and vocational schools should provide adequate laboratory facilities, to enhance learning activities and technical trainings for the students.

The researcher strongly believes that with the construction of ***An Industrial Process Simulator*** the teaching-learning process is improved. This apparatus can provide laboratory activities for the students to enhance their understanding of the different principles of electronic industry.

OBJECTIVES OF THE STUDY

The study aims to achieve the following objectives:

1. design and construct a valuable, innovative and inexpensive prototype for electrical and electronics instructional equipment;
2. Test the performance of the developed prototype in conformity to its design parameters and operational limitations;
3. determine the acceptability of the developed prototypes in terms of its functionality, aesthetics, economy, workability, durability, safety and instructional applicability.

RESEARCH METHODOLOGY

This research used *Project Development Method* (PDM), wherein the researchers conceptualized the design and specifications of the trainer. The project was constructed and assembled in conformity with the design. Hence, revisions were made for any observed and found defects and reassemble the device until it can be seen functional, acceptable and for better improvement.

The descriptive-evaluative research design was also applied to evaluate the apparatus along the identified variables. Furthermore, the main data gathering instruments used were sets of questionnaire-checklist supplemented by unstructured interviews and observation.

This study will be conducted at the Isabela State University Ilagan Campus. The respondents of the study were selected technology instructors from the College of Education and from Industrial Technology Department, Engineering instructors/professors from Electrical Engineering Department and students from electronics, electrical technology, and electrical engineering of Isabela State University-Ilagan Campus and other campuses preferably that offers technology courses. Also included as respondents were teachers from technical and vocational schools, TESDA, Electronic technicians and electricians from different electronics shops and centers and in the locality were also invited by the researchers to evaluate their work.

General methods and activities are as follows:

1) Designing and constructing of Electrical and Electronics Technology Instructional Trainer;
2) Testing the operation of the Constructed Trainer; and
3) Determining the acceptability of the trainer in terms of its functionality, aesthetics, economy, workability, durability, safety and instructional applicability with activity manual.

RESULTS AND DISCUSSION

a. Project Description. The Automated PLC Electropneumatic Conveyor System Apparatus: An Industrial Process Simulator for Teaching Electrical/Electronic Technology Courses can perform numerous activities relating to programming. It also represents as a miniature of an equipment that uses in different industry plants. This project designed and constructed for the purpose of teaching the students in electrical, electronics technology and engineering for them to experience and learn how different automated machines work in industry plants. The major function of this project is to separate the plastic bottles and metals. It uses two proximity sensors to sense object that pass through the conveyor and cylinders to actuate and push the object in their respective container.

b. Project Design and Components. In order to perform the research properly, the construction procedure of the trainer was followed consistently according to its project design. The project composed of different components. It has a panel board made of acrylic plastic, mini conveyor, compressor, cylinders, proximity sensors, Siemen 7 for programming, FLR, tank reservoir, swiches and terminals blacks. Below shows the actual design of the project.

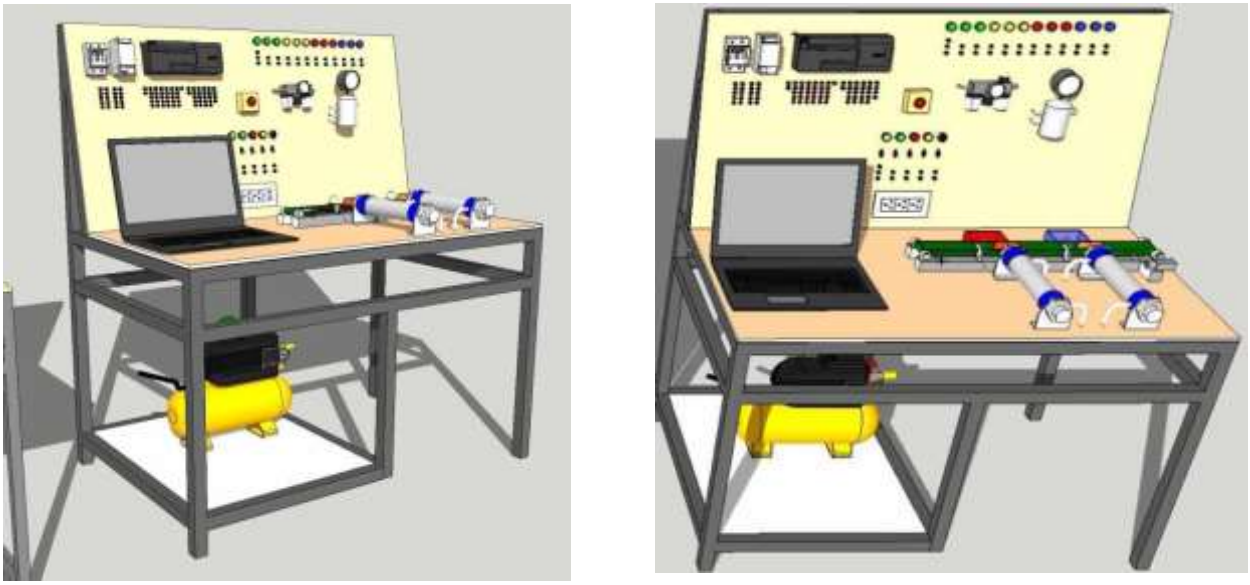

Figure 1. Illustration of the Project

c. Project capabilities and Limitations. After all the major components were placed in their respective places, the project was subjected to testing and evaluation.

Capabilities

The project capability is to illustrate separation of non-metal and metal objects. It uses as an instructional device for installing the parts and to visualizing the action of what had the PLC programmed. Enhance teaching and learning process to become more lively and actively participation by the students.

Limitations

- Intended for teaching only.
- It does not for production system.
- Only to perform the task in the program but to programmed.
- It illustrates a separation of non-metal and metal objects in linear motion not in robotic form.

d. Project Evaluation. In order to determine the general acceptability of the project in terms of functionality, aesthetics, economy, workability, durability, safety and instructional applicability.Tables below present the data of interest.

1. Acceptability of the developed trainer in terms of different criteria.

Table 1. Level of Acceptability of the Completed Project According to Functionality

Statement	WEIGHTED MEAN	INTERPRETATION RATE
1. The device is operative and design for instructional purpose	**4.67**	**Highly Acceptable (HA)**
2. The trainer is easy to use because of its organized components.	**4.73**	**Highly Acceptable (HA)**
3. The trainer series its purpose similar on what existing on the market.	**4.80**	**Highly Acceptable (HA)**
4. The fully constructed trainer serve its purpose effectively and efficiently.	**4.60**	**Highly Acceptable (HA)**
5. The electro pneumatic trainer can serve as instruments in learning.	**4.80**	**Highly Acceptable (HA)**
Mean Average:	**4.72**	**Highly Acceptable (HA)**

Table 1 shows the level of acceptability of the completed project in terms of functionality. As reflected on the post-survey for the operative and designed for instructional purpose got a mean of 4.67 which describes as highly acceptable (HA). Students nowadays learn not just through knowledge but experience and demonstrations. The result for the trainer is easy to use for it has organized components and easy to manipulate got a mean of 4.80 “Highly acceptable”. For the effectivity and efficiency got a mean of 4.60 which describes a as “Highly acceptable (HA)”. The machine itself also serves as an instrument in learning for students may use it as an actual experience as reflected on its weighted mean of 4.80 “Highly acceptable (HA).” The respondents rated the functionality of the trainer as “highly acceptable” with a grand mean of 4.72

Table 2. Level of Acceptability of the Completed Project According to Aesthetics

Statement	WEIGHTED MEAN	INTERPRETATION RATE
1. The design and Construction of Electro Pneumatic System Trainer is unique.	**4.80**	**Highly Acceptable (HA)**
2. The components parts of the trainer are firmly attached.	**4.67**	**Highly Acceptable (HA)**
3. The design and construction of Electro Pneumatic Trainer is pleasing to the eye.	**4.87**	**Highly Acceptable (HA)**
4.The design and construction of Electro Pneumatic Trainer	**4.80**	**Highly Acceptable (HA)**
5. The design and construction of Electro Pneumatic Trainer Strategically assemble to the layout.	**4.67**	**Highly Acceptable (HA)**
Mean Average:	**4.76**	**Highly Acceptable (HA)**

As to aesthetics of the trainer, the respondents gave a rating of "highly acceptable" with a grand mean of 4.76. As to the design, It indicates that the project has a unique design as reflected with a weighted mean of 4.80 with an interpretation of "Highly acceptable (HA)". Furthermore, it also interprets that the components parts of the trainer are firmly attached which means it has a stable and durable materials as reflected in the weighted mean of 4.67 which would mean "Highly acceptable (HA)". The design and construction of the project is pleasing to the eye because it replicates real machine based on its weighted mean of 4.87 "Highly acceptable." Moreover, the design and construction of the project has 4.80 weighted mean with a description of "Highly acceptable." Sorting out, the design and construction of the said machine was strategized and assembled to layout as reflect in the weighted mean of 4.67 "Highly acceptable (HA)."

Table 3. Level of Acceptability of Completed Project According to Durability

Durability	**Mean**	**Remark**
1. Quality of materials.	4.87	Highly Acceptable
2. Resistance to stress.	4.69	Highly Acceptable
3. Resistance to deformation.	4.77	Highly Acceptable
Grand Mean	**4.77**	**Highly Acceptable**

Table 3 reflects the acceptability level of the developed projectr as per durability. When it comes to the quality of materials (4.86), resistance to stress (4.68) and resistance to deformation (4.77), the trainer was rated "highly acceptable". In general, with a grand mean of 4.77 the trainer was rated "highly acceptable". This implies that the project is long-lasting and can resist any shock. To support this finding, Bakshi et al., (2014) stressed in their article that a durable project is long-lasting. This mean that if the project is properly designed and constructed, it is durable.

Table 4. Level of Acceptability of Completed Project According to Workability

Statement	**WEIGHTED MEAN**	**INTERPRETATION RATE**
1. The constructed trainer is easy to used or operate.	**4.67**	**Highly Acceptable (HA)**
2. The trainer can be used by single or multiple person without the assistance of somebody.	**4.73**	**Highly Acceptable (HA)**
3. The different components can easily identified	**4.60**	**Highly Acceptable (HA)**
4. The terminals and components are well labeled for care of performing a task (job).	**4.80**	**Highly Acceptable (HA)**
Mean Average:	**4.55**	**Highly Acceptable (HA)**

Table 4 shows the evaluation of the project in terms of workability as reflected on the post-survey was the constructed trainer is easy to used or to operate because of its built and structure. There are guide for every terminal for its use and got a weighted mean of 4.67 describes as "Highly Acceptable (HA)". Moreover the trainer can be use by single or multiple person without the assistance of somebody because of its guides and pictorial diagram and got a "Highly Acceptable with a mean of 4.73. For the different components can easily identified because of its labeled names with a weighted mean of 4.60 with an interpretation of "Highly acceptable (HA)". In addition, the terminals and components are well labeled for care of performing a task which can help the person to easily identify and understand the use of each components with a weighted mean of 4.80 with and interpretation of "Highly acceptable (HA). The respondents found out that the workability of the project was "Highly Acceptable" with a mean of 4.55.

Table 5. Level of Acceptability of Completed Project According to Safety

Statement	**WEIGHTED MEAN**	**INTERPRETATION RATE**
1. Other accessories properly installed.	**5**	**Highly Acceptable (HA)**
2. The trainer has no sharp object that can cause injury.	**4.60**	**Highly Acceptable (HA)**
3. The wire connection minimized short circuits and electrocutions	**4.93**	**Highly Acceptable (HA)**
4. Components are mounted on a non-conductor material.	**4.67**	**Highly Acceptable (HA)**
5. The trainer is stable during operation because of its durable and strength frame/base.	**4.93**	**Highly Acceptable (HA)**
Mean Average:	**4.82**	**Highly Acceptable (HA)**

As to the level of acceptability of the developed project in terms of safety, the project is safe to be used with an over all mean of 4.82 which means a "Highly Acceptable. It shows that the other accessories are properly installed as reflected with weighted mean of 5 with an interpretation of "Highly acceptable (HA)" and it also shows that the trainer has no sharp object that can cause injuries and harm to human environment as reflected with weighted mean of 4.60 with an interpretation of "Highly acceptable (HA)". On top of that, the components are mounted on a non-conductor materials which prevents short circuit and fire hazards as reflected with weighted mean of 4.67 with an interpretation of "Highly Acceptable (HA)". Over and above, for the stable during operation because of its durable and strength frame/base which can prevent damaging the machine got a weighted mean of 4.93 with an interpretation of "Highly acceptable (HA).

Table 6. Level of Acceptability of Completed Project According to Economy

Economy	**Mean**	**Remark**
1. Economy in terms of materials needed.	4.61	Highly Acceptable
2. Economy in terms of time/labor spent.	4.61	Highly Acceptable
3. Economy in terms of machine/s required.	4.75	Highly Acceptable
Grand Mean	**4.65**	**Highly Acceptable**

Table 6 reveals the acceptability level of the developed trainer as per economy. In terms of (1) materials needed; (2) time/labor spent; and (3) machine required, trainer was rated "highly acceptable" with means of 4.611, 4.61 and 4.75, respectively. The grand mean of 4.65 shows that overall the trainer was "highly acceptable" among the respondents. This goes to show that the project is inexpensive in nature. Tuller et.al (2014) confirmed the findings of the researcher that the acceptability can be evaluated in its economical aspect. The project should be economical in all aspects of functionality. As the project functions there must not be much consumption occurred.

Table 7. As to the level of acceptability of the developed trainer in terms of Instructional Applicability

Statement	**WEIGHTED MEAN**	**INTERPRETATION RATE**
1. The trainer when used can demonstrate the intended purpose	**4.80**	**Highly Acceptable (HA)**
2. The design and construction of Electro Pneumatic Trainer helps to enhance students engagement.	**4.87**	**Highly Acceptable (HA)**
3. The constructed trainer provides hands on activities for electrical students	**4.73**	**Highly Acceptable (HA)**
4. The trainer work evitable in electrical wiring for teaching and learning process.	**4.73**	**Highly Acceptable (HA)**
5. The design and construction of Electro Pneumatic Trainer increases skills and competencies in electrical technology	**4.73**	**Highly Acceptable (HA)**
Mean Average:	**4.77**	**Highly Acceptable (HA)**

Along the level of acceptability of the developed trainer as per instructional applicability, items 1 and 2 were rated "highly acceptable" by the respondents with means of 4.80 and 4.87 and items 3, 4 and 5 were rated "Highly Acceptable with the mean of 4.73.4, respectively. Overall, the project was "highly acceptable" with a grand mean of 4.88. This implies that the trainer is highly relevant in shopwork instruction along electronics and electricity.

Summary of the Ratings Given by Respondents on the General Acceptability of the Completed Project

Table 8. The General Level of Acceptability of the Completed Project

Statement	**WEIGHTED MEAN**	**INTERPRETATION RATE**
FUNCTIONALY	**4.72**	**Highly Acceptable (HA)**
AESTHETICS	**4.76**	**Highly Acceptable (HA)**
DURABILITY	**4.77**	**Highly Acceptable (HA)**

WORKABILITY	**4.55**	**Highly Acceptable (HA)**
SAFETY	**4.82**	**Highly Acceptable (HA)**
ECONOMY	**4.65**	**Highly Acceptable (HA)**
INSTRUCTIONAL APPLICABILITY	**4.77**	**Highly Acceptable (HA)**
OVER ALL MEAN	**4.72**	**Highly Acceptable (HA)**

As shown in Table 7, the completed **Industrial Process Simulator for TeachingElectrical/Electronic Technology Courses** received mean ratings of 4.72, 4.76, 4.77, 4.55, 4.82, 4.65 and 4.77 for its functionality, aesthetics, durability, workability, safety, economy, and instructional applicability, respectively. The instructional device was perceived to be highly acceptable by the respondents in all criteria presented. The computed overall mean was 4.72 which suggests that the project is "highly acceptable". This implies that the electrical trainer is highly suitable for electronics and electrical activities specifically in programable and logic controls.

Summary of Findings Conclusions and Recommendations of the Study

The following were the significant findings of the study:

1. The project design is *good*. It is *functional*, *durable*, *economical* and *safety*.
2. It is highly acceptable as an instructional device in teaching electrical and electronics technology courses.
3. The project helps the students develop their skills and boost awareness in different automated machines.
4. It is user friendly.

CONCLUSIONS

In light of the aforementioned findings, the study concludes that an Automated PLC Electropneumatic Conveyor System Apparatus: An Industrial Process Simulator for Teaching Electrical/Electronic Technology Courses can be developed using resources and materials available in the local market. The developed device is functional, aesthetic, workable, durable, safe, economical and with instructional applicability. It is very useful as instructional device that facilitates teaching and learning in electronics and electrical subjects.

RECOMMENDATIONS

Based from the given conclusions, the following recommendations are hereby given:

1. The apparatus should be patented prior to its commercialization.
2. Other trainers in Electronics and Electrical should be developed to provide a wider coverage of teaching the course.
3. Minor revisions of the design should be done for better performance.
4. Further studies should be conducted to come up with other useful features of the project.

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