wjert, 2022, Vol. 8, Issue 5, 287-297. *Original Article* **ISSN 2454-695X**

World Journal of Engineering Research and Technology

WJERT

www.wjert.org **SJIF Impact Factor: 5.924**

PLC-BASED DUMBWAITER SIMULATOR

[1]Ribomapil D. Nacorda, PhD.TM, [2]Jessie Nigparanon, PhD.TM, *[3]Evangelita A. Anino, MSIT

[1,2]Bohol Island State University Main Campus, Tagbilaran City

[3]Bohol Island State University Calape Campus, Calape, Bohol.

Article Received on 20/03/2022 **Article Revised on 10/04/2022** **Article Accepted on 30/04/2022**

***Corresponding Author**
Evangelita A. Anino, MSIT
Bohol Island State University Calape Campus, Calape, Bohol.

ABSTRACT

This study was conducted primarily to assemble and assess the performance level of the PLC-Based Dumbwaiter Simulator, determine the level of effectiveness of the simulator as an instructional device, and determines if there is a significant difference in the results of pre-skill test and post-skill test rating of the students using the instructional device. This was conducted on the two campuses of Bohol Island State University namely: Main and Calape Campus in the Academic Year 2018-2019 for the improvement of instruction in electrical technology and electrical engineering courses. The respondents of the study were ten (10) third-year Electrical Technology students, twenty (20) fourth-year Electrical Engineering students and five (5) technical experts from BISU system. This study made use of experimental methods of research in the assembly of the device. A one group pre-skill test-post-skill test was employed for testing of its effectiveness in enhancing the technical skills of the students. The results of the study revealed that students' performance using the device was increased by 49.30%. The result showed that the device is suitable to be utilized in the electrical technology and electrical engineering laboratory as a tool for instruction. The researchers highly recommend utilizing the simulator as a tool for instruction in electrical technology and electrical engineering laboratories.

KEYWORD: Electrical Technology, Electrical Engineering, PLC, Dumbwaiter, Simulator Effectiveness.

INTRODUCTION

Life would be comfortable and easy through technology. Technology is a product and process used to accomplish and simplify various tasks in daily lives (Ramey, 2013). It is from simple or manual into automatic and complicated processes. Knowledge and technology transfer is the way to improve technology capability (Handoko, 2016). With the knowledge of intelligent human lead the way for technological innovation providing boundless advancement to everyone. One important product of innovation is the Programmable Logic Controller (PLC). It is a solid-state member of the computer family, using integrated circuits instead of electromechanical devices that are capable of storing instructions, such as sequencing, timing, counting, arithmetic, data manipulation, and communication to control industrial machines and processes (Bedi et al., 2015). Programmable Logic Controller (PLC) helps automation by lowering the amount of power consumed by working machines, controlling systems via proper keeping of records and reducing required manpower via the supply of manpower (Chavre, 2017). Aside from that, using PLC will shorten the time consumed in hard wirings of control. Due to the broad application of PLC, the industrial sector widely adopts which creates a great challenge to the technician.

Operation of the Programmable Logic Controller (PLC) is complex which needs a skillful and technically-knowledgeable person. Therefore, in-depth training of the technician is required to adhere to the requirements of the industry. The said training is a great challenge for the institution since they have a big role in enhancing the skills and knowledge of the students. However, the learning of the students will depend on the quality of education inputted to them. One factor that largely contributes to the learning of the students is the availability of instructional devices that help them to provide the theoretical input and experience the real world of work. However, as observed, the institution had experienced inadequacy of the said devices, particularly on the programmable logic controller.

According to Thangeda et al., (2016) the transition in the teaching system offered in educational institutions and the introduction of technology in educational institutions are a clear indication that education has to be of a certain quality to meet certain standards in the market. Therefore, it is relevant to train and equip individuals within the tertiary institutions with quality skills to attain sustainability. Therefore, the institution has to provide quality education by upgrading the instructional apparatuses and facilities to cope with the technological advances in their field of specialization to sustain the need of the industry.

Through the instructional devices in electrical laboratories, the students were exposed to the current set-up of the industry.

According to Friedrich Froebel's theory which emphasizes that learning comes through self-activity (Curtis, 2015). It is a great and fundamental principle in education that would allow the students an opportunity to engage in an actual operation that would result in the acquisition of knowledge through self- activity and actual hands-on activities. Through the inevitable process of trial and error, individuals begin to internalize the lessons learned and produce adaptive strategies to take further action (Walton et al.. 2014). Using technology devices in teaching has been proven to be an effective tool in conceptualizing ideas through demonstration of the actual process. Moreover, giving instruction would be more convenient with the aid of the instructional device because it will be easier to explain the topic if done through actual hands-on.

In response to the given statements, the researchers intend to design, assemble and assess the performance of the PLC-Based Dumbwaiter Simulator. This apparatus is integrated with computer unit, Programmable Logic Controller (PLC) unit, transformer, relay, push-button switches, limit switches, light indicators, 7 segment display, wiper motor, and fabricated dumbwaiter prototype.

The researchers believe that the assembly of PLC-Based Dumbwaiter Simulator will be of great contribution to the development of the students' competencies. This will able the students to be exposed to control automation, utilizing the dumbwaiter prototype as an output that will function as long as the correct program design inputted into the system. Aside from designing, the device allows the students to enhance the ability of plc program troubleshooting, as well as the installation of device components.

METHODOLOGY

The study made use of experimental methods of research in the assembly and assessing the performance of the device. A one-group pre skill test – post skill test design was employed for testing of its effectiveness in enhancing the technical skills of the students. The study was conducted at Bohol Island State University-Main and Calape Campus. The two campuses offer electrical courses in which PLC designing is part of the topic. There were 35 respondents in the study which includes 20 (twenty) 4th-year students of Bachelor of Science in Electrical Engineering, 10 (ten) 3rd-year students of Bachelor of Science in Industrial Technology, major in electrical technology and 5 technology experts from BISU system.

The instruments used in the study were the observation guide, pre-skill test and post-skill test, and scoring rubrics.

The pre-skill test and post-skill test experiment was conducted to check the improvement of the respondents' skills with the use of the simulator. The pre skill test was given to the students before any discussion and after the assembly of the PLC-Based Dumbwaiter Simulator, while the post skill test was given after the discussion and hands-on activities. Both pre-skill test and post-skill test administration were utilizing the same content scoring rubrics as the basis of the students' rating. The result of the post skill test was the basis in determining the degree of effectiveness of the simulator.

The observation guide was utilized to measure the performance level of the Electromechanical Sequence Control for 3-Phase AC Induction Motor Trainer. It also includes the details on how the simulator works.

The design weighed the effectiveness and amount of learning a student has acquired through the use of Interactive Control of Robotic Arm. The experimental design was complemented with a descriptive method to find the acceptability of the Interactive Control of Robotic Arm with instructors.

The researcher utilized questionnaire for the experts. To acquire the necessary information on the acceptability level of the Interactive Control of Robotic Arm, the researcher conducted observations for the Interactive Control of Robotic Arm.

RESULTS AND DISCUSSION

Data were gathered and tabulated which was supported with tables that illustrate the responses in the performance of the PLC-Based Dumbwaiter Simulator and the effectiveness of the simulator as an instructional device. The construction of the PLC-Based Dumbwaiter Simulator was based on the specified design.

The block diagram (Figure 1) of the PLC-Based Dumbwaiter Simulator is a representation of the components and system process.

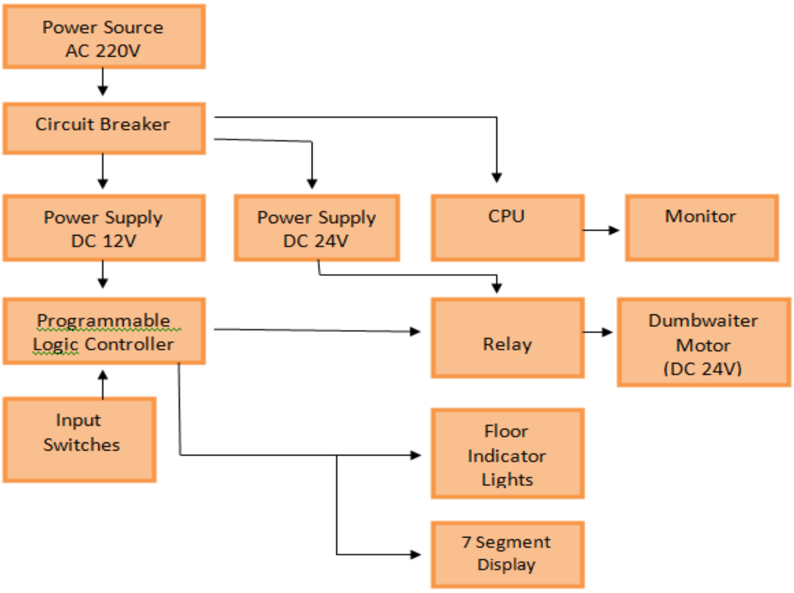

Figure 1: Block Diagram of PLC-Based Dumbwaiter Simulator.

The schematic diagram (Figure 2) of the PLC-Based Dumbwaiter Simulator is a representation of the power circuit. It indicates the wiring connections between the devices and the dumbwaiter motor.

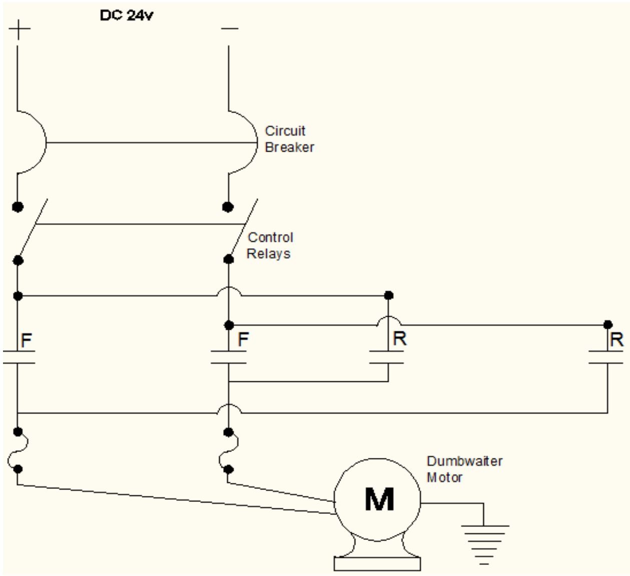

Figure 2: Power Circuit Schematic Diagram of the PLC-Based Dumbwaiter Simulator.

The schematic diagram (Figure 3) of the PLC-Based Dumbwaiter Simulator is a representation of the power supply. It indicates the wiring connections going to the dumbwaiter motor and PLC.

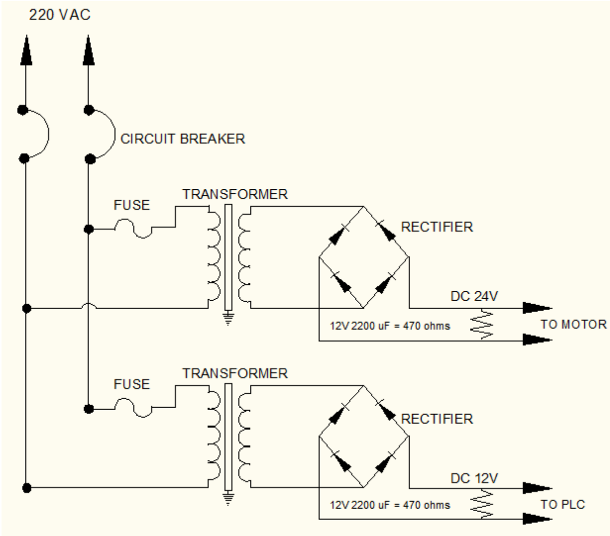

Figure 3: Power Supply Schematic Diagram of the PLC-Based Dumbwaiter Simulator.

Table 1: Performance Level of PLC-Based Dumbwaiter Simulator in terms of Accuracy in Stopping every Floor Level.

Direction	**Floor Level**	**Trials**			**Description**
		1	**2**	**3**	
Upward	1st to 2nd	Car stopped on the 2nd floor	Car stopped on the 2nd floor	Car stopped on the 2nd floor	Functional
	2nd to 3rd	Car stopped on the 3rd floor	Car stopped on the 3rd floor	Car stopped on the 3rd floor	Functional
	1st to 3rd	Car stopped on the 3rd floor	Car stopped on the 3rd floor	Car stopped on the 3rd floor	Functional
Downward	3rd to 2nd	Car stopped on the 2nd floor	Car stopped on the 2nd floor	Car stopped on the 2nd floor	Functional
	2nd to 1st	Car stopped on the 1st floor	Car stopped on the 1st floor	Car stopped on the 1st floor	Functional
	3rd to 1st	Car stopped on the 1st floor	Car stopped on the 1st floor	Car stopped on the 1st floor	Functional

Table 1 shows the accuracy of operation particularly the stopping of the dumbwaiter car at every floor level. The researchers tested the movement of the dumbwaiter car if it is functioning. In every trial, switches on every floor of the dumbwaiter were tested if the car moves and stops at the desired floor. Every switch had an assigned task particularly to command the car where to go.

The switches on every floor of the dumbwaiter functioned or triggered once the dumbwaiter car arrived on a particular floor. The limit switches installed were functional that triggered to stop the dumbwaiter car as arrived at the desired floor. Besides, an emergency stop button was installed in the device in case of dumbwaiter car malfunctioning. Based on the result, the

PLC-Based Dumbwaiter Simulator was 100% functional and able to stop the car on the desired floor.

Table 2: Performance Level of the PLC-Based Dumbwaiter Simulator in terms of Accuracy in Floor Level and 7-Segment Display.

Operation	Trials	Results		
		Floor Level	**7- Segment**	**Description**
Pressing 1st floor switch	1	Car stopped on the first floor	Display Number 1	Functional
	2	Car stopped on the first floor	Display Number 1	Functional
	3	Car stopped on the first floor	Display Number 1	Functional
Pressing 2nd floor up	1	Car stopped on the 2nd floor	Display Number 2	Functional
	2	Car stopped on the 2nd floor	Display Number 2	Functional
	3	Car stopped on the 2nd floor	Display Number 2	Functional
Pressing 3rd floor	1	Car stopped on the 3rd floor	Display Number 3	Functional
	2	Car stopped on the 3rd floor	Display Number 3	Functional
	3	Car stopped on the 3rd floor	Display Number 3	Functional
Pressing 2nd floor down	1	Car stopped on the 2nd floor	Display Number 2	Functional
	2	Car stopped on the 2nd floor	Display Number 2	Functional
	3	Car stopped on the 2nd floor	Display Number 2	Functional

The 7- Segment Display installed in PLC-Based Dumbwaiter Simulator was also functional and able to display the correct numerical number indicating the exact location of the dumbwaiter car. Pressing the 1st-floor switch the dumbwaiter car moves going to the first floor, as the car stopped on the said floor numerical number 1 was displayed on the segment. The same case when pressing the 2nd floor switch, the dumbwaiter car moves going to 2nd floor, as the car stopped the numerical number 2 was displayed in the segment, and also pressing the 3rd floor switch the dumbwaiter car moves going to 3rd floor and as the car stopped in said floor the numerical number 3 was also displayed in the segment.

The dumbwaiter car was operated by a DC motor to moves up and down. To prevent the motor from reversing while in the forward state, the researchers made sure that an internal interlocking of the program was properly employed.

Table 3: Performance Level of the PLC-Based Dumbwaiter Simulator in terms of Program Output Response.

Direction	Floor level	trial	Result in Time Response (Seconds)				Description
			Motor	Segment Display	Run Light	Floor Level Indicator	
Upward	1st to 2nd	1	4.19 sec	4.04 sec	4.24 sec	4.08 sec	Functional
		2	4.19 sec	4.04 sec	4.24 sec	4.08 sec	Functional
		3	4.19 sec	4.04 sec	4.24 sec	4.08 sec	Functional
	2nd to 3rd	1	4.29 sec	4.29 sec	4.34 sec.	4.26 sec	Functional
		2	4.29 sec	4.29 sec	4.34 sec.	4.26 sec	Functional
		3	4.29 sec	4.29 sec	4.34 sec.	4.26 sec	Functional
	1st to 3rd	1	8.33 sec	8.35 sec	8.35 sec.	8.16 sec	Functional
		2	8.33 sec	8.35 sec	8.35 sec.	8.16 sec	Functional
		3	8.33 sec	8.35 sec	8.35 sec.	8.16 sec	Functional
Downward	3rd to 2nd	1	4.23 sec	4.06 sec	4.20 sec	4.19 sec	Functional
		2	4.23 sec	4.06 sec	4.20 sec	4.19 sec	Functional
		3	4.23 sec	4.06 sec	4.20 sec	4.19 sec	Functional
	2nd to 1st	1	4.79 sec	4.19 sec	4.80 sec	4.14 sec	Functional
		2	4.79 sec	4.19 sec	4.80 sec	4.14 sec	Functional
		3	4.79 sec	4.19 sec	4.80 sec	4.14 sec	Functional
	3rd to 1st	1	8.54 sec	8.16 sec	8.58 sec	8.21 sec	Functional
		2	8.54 sec	8.16 sec	8.58 sec	8.21 sec	Functional
		3	8.54 sec	8.16 sec	8.58 sec	8.21 sec	Functional

Table 3 shows the functionality of the program output response of the PLC-Based Dumbwaiter Simulator. The travel time of dumbwaiter car and run light indicator from one floor to another were tested. Also, the time of 7-segment held the display and the time floor level indicator held the light was tested. Based on the result, the program outputs were functional and responded according to the requirement.

Table 4: Pre-Skill Test and Post-Skill Test Result of the Students N=30.

Range	Description	Pre skill Test			Post Skill Test		
		f	%	Rank	f	%	Rank
3.25 – 4.00	Very Good	0	00.00%		27	90.00%	1
2.50 – 3.24	Good	1	3.33%	3	3	10.00%	2
1.75 – 2.49	Fair	15	50.00%	1	0	00.00%	
1.00 – 1.74	Poor	14	46.67%	2	0	00.00%	
Average Rating		**1.80 Fair**			**3.55 Very Good**		

The table shows the frequency and percentage of the students' performance on the pre-skill test and post-skill test in using the PLC-Based Dumbwaiter Simulator. The result of the pre-skill test obtained the average rating of 1.80 which described as Fair while the average rating of the post-skill test is 3.55 which described as very good. The result revealed that the device is an effective tool for the acquisition of learning competencies in electrical laboratories and essential in improving the skills of the students

Table 5: Difference between the Pre-Skill Test and Post-Skill Test Results of the Students.

Difference	t computed value	t tabular value	Description	Interpretation
	at 0.05 level of significance, df 29			
Pretest and Posttest	- 10	±2.045	Significant	Reject Null Hypothesis

Table 5 presents the difference between the pre skill test and post skill test of the students. The data illustrated that students got a higher rating on the post-skill test than of the pre-skill test. The computed t-value was -10, with an absolute tabular value of ± 2.045 at 0.05 level of significance. It showed that there was a significant difference in the performance of the students taking pre skill test and post skill test. Thus, the null hypothesis was rejected. This proved that the use of the PLC-Based Dumbwaiter Simulator is essential for the improvement of the students' skills and retention of knowledge.

This is supported by the Experiential Learning Theory of John Dewey, which states that "Education must be conceived as a continuing reconstruction of experience; the process and goal of education are one and the same thing" (Kolb et al.,2005). The apparatus offered hands-on experience of the students on designing control application in PLC programming using ladder logic and troubleshooting thus, providing them retention of knowledge and skills improvement. It will also increase the self-confidence of the students and strengthen the interest in the course leading to consciously and willingly participate in laboratory and industrial studies (Erdal et al., 2008).

CONCLUSION

The PLC-Based Dumbwaiter Simulator serves as an effective tool for delivering instruction in electrical laboratories and provides the students with an in-depth understanding of the automated control system of dumbwaiter using the programmable logic controller (PLC). Moreover, the device can operate to its highest level of efficiency with guaranteed safety to the students.

Recommendations

Based on the data and findings, the researcher offers the following recommendation:

Utilize the PLC-Based Dumbwaiter Simulator in delivering the instruction on PLC programming and troubleshooting topic; upgrade the simulator by using sensors, instead of limit switches; construct additional PLC-Based instructional apparatuses that can imitate the actual functions in the industry; and recommend the study to be patented for its protection.

REFERENCES

1. Bedi, H.S., Verma, S., Sharma, Rk., Singh, B. The concept of programmable logic controllers. Retrieved September 12, 2017 from https://www.researchgate.net/ publication/319123482 The Concept of Programmable Logic Controllers and its role in Automation, 2015.
2. Chavre, V.M. The role of PLC in automation and industrial applications. Retrieve December 5, 2017 from https://www.academia.edu/35039152/ The Role of PLC in Automation and Industrial Applications, 2017.
3. Curtiz, S.J. Biography. Retrieved December 10, 2017 from http://www.britannica.com/biography/Friedrich-Froebel, 2015.
4. Erdal, H., Halliyev, V. Electro-mechanical control systems simulator (ECSS) with multi-language support, Istanbul, Turkey. Faculty of Technical Education, Marmara University Institute of the Philippines, Inc. The Philippine electrical code (1980). España Street, Manila, 2008.
5. Handoko, F. The role of tacit and codified knowledge within technology transfer program on technology adaptation. Retrieved October 21, 2017 from https://www.researchgate.net/publication/301824193_The_role_of_tacit_and_codified knowledge_within_technology_transfer_program_on_technology_adaptation, 2016.
6. Kolb, D. and Kolb A. Academy of management learning & education. Cleveland, Ohio: Experience Based Learning Systems, Inc., 2005.
7. Ramey, K. What is technology-meaning of technology and its use. Retrieve September 10, 2017 from https://www.useoftechnology.com/what-is-technology, 2013.
8. Tangeda, A. Education for sustainability: quality education is a necessity in modern day. Retreived September 19, 2017 from https://files.eric.ed.gov/fulltext/EJ1089752.pdf, 2016.
9. Walton, J. and Valentin, C. Human resource development: practices and orthodoxies. Retrieved October 10, 2017 from https://books.google.com.ph/books?id=rEodBQAAQBAJ&pg=PA34&lpg=PA34&dq=Through+trial+and+error,+students+begin+to+internalize+the+lessons+learned+and+produce+adaptive+strategies+to+take+further+action&source=bl&ots=97NbVvrftF&sig=ACfU

3U2AbsheUONjkTHJF5B8nS-fYuOomg&hl=en&sa=X&ved=2ahUKEwjJ-fLrtrPjAhWi3mEKHcFCAQ8Q6AEwAXoECAkQAQ#v=onepage&q=Through%20trial%20and%20error%2C%20students%20begin%20to%20internalize%20the%20lessons%20learned%20and%20produce%20adaptive%20strategies%20to%20take%20further%20action&f=false, 2014.