AUTOMATION TRAINER FOR INDUSTRIAL CONTROL APPLICATIONS

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Abstract

This study presents the development and evaluation of a state-of-the-art Programmable Logic Controller (PLC) and human machine interface trainer specifically designed for instructional purposes. PLCs and HMIs are critical components in modern industrial automation, and their effective use demands a comprehensive understanding of their programming, operation, and troubleshooting. Therefore, this research aims to bridge the gap between theoretical knowledge and practical application by creating a versatile and interactive PLC and HMI training tool. The primary objective of this study is to design a PLC and HMI trainer that offers a user-friendly interface, comprehensive educational content, and real-world simulation capabilities. The study was conducted at Bohol Island State University (BISU) Main Campus, Tagbilaran City in the academic year 2020-2021. The study employed the experimental method of research in testing its effectiveness and descriptive design in determining the performance of the trainer. The performance of the trainer was evaluated by experts from the academe and private industry. The researcher used an observation guide to determine the functionality and the performance of the trainer. The results revealed that the trainer's performance was found to be functional and performs to its full potential and is an effective tool for instruction.

Keywords: automation, trainer, industrial control, plc, hmi.

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1. INTRODUCTION

The demand for technology in the manufacturing sector has always been strong. The industrial automation control system is the technology that is most frequently utilized in the manufacturing sector. Industrial automation is the use of control systems, like computers or robots, and information technology to manage various processes and machinery in an industry in order to replace the human workforce, which improves product quality, productivity, and manufacturing process flexibility.

With the use of modern equipment and devices, automation is performed to provide better and more efficient results. To run and manage the expansion of technology in the workplace, the sector needed qualified and knowledgeable workers. Students need to adapt and embrace the changes of technology associated with the new industrial revolution in order to bridge the gap between the industry standard and Bohol Island State University's mission to provide quality higher education and produce competent graduates in the arts, sciences, as well as in the professional and technological field. Additionally, the principal learning facilitators—teachers and instructors—should receive ongoing training to deal with the educational environment's continual change.

However, one of the challenges that the learning institution faces is the shortage of instructional materials specifically in the electrical shops. These aforementioned materials are very crucial channel of learning. It represents a range of materials, which can be used to extend the range of vicarious experience of learners in a teaching and learning situation.

Electrical technologist plays vital role in assembling and installing the aforementioned control system. To help the electrical technology students, the researcher formulated research in which students can apply their theories in actual work using automation control system through a device. The researcher concluded to produce a device called Automation trainer aided with programmable logic controller – human machine interface.

With this device, the Automation trainer for industrial control applications is developed; it is a mobile device that demonstrates the actual operation of an industrial automation control system using Programmable Logic Controller (PLC) as the main brain of the device and Human Machine Interface (HMI) as the user interface. A computer is also installed to aid the programming system of the trainer device. Through this device, students can apply their knowledge in automation control in actual work without the risks and waste of time, money and effort in practicing the process in installing, coding and programming of industrial automation control system. The device will be used as a trainer of the application namely; door shutter and liquid mixer.

Automation is a very complex term in the modern society, because it covers a lot of different ways of manufacturing processes differing in their conceptuality and logistics. In manufacturing there are so many definitions what automation is actually, according to Hubka and Eder (1988) automation is “the progressively transferring regulating and controlling functions from humans to technical systems”. High automated product is an important means for industry to meet the competitiveness arising from the low-cost countries, due to the high wages observed in the developed world. In that time of rapidly changing technologies and changing environment automation is the source for handling with competition. According to the area of the ongoing research we will define automation as a bonding sphere between mechanization and computerization together (Frohm, Linsdröm, Bellgran, 2005).

According to David Kolb`s (1984) Experiential Learning Theory, concrete learning is when a learner gets a new experience, or interprets a past experience in a new way. Reflective observation comes next, where the learner reflects on their experience personally. They use the lens of their experience and understanding to reflect on what this experience means.

According to the theory of John Dewey (1906), “Learning by Doing”, actual and practical approach contributes to the development off students’ skills and ideas. Electricity education needs demonstration of an actual device, such as instructional media to support and discussion for more effective teaching rather than verbal discussion only. Using conventional tool in teaching is much more accurate. With that, students can easily understand what the instructor is trying to explain or visualize.

Furthermore, Constructivist Learning Theory states that learning is an active process of creating meaning from different experiences. In other words, students learn best trying to make sense of something on their own with the teacher as a guide. The person receiving the stimuli organizes the sensory input. It cannot always be directly transferred from the teacher to the students. This means that the teacher cannot pour information into students' brain and always expect them to process it and apply it correctly later (Brooks, 1995).

In relation with this study, constructivism definitely signifies that using a device for instruction in teaching the students is a fruitful way to gain learning. Through the Automation Trainer, the students can interface the program in actual use then put it into action. With this, students can practice automation control. The researcher believes that developing the Automation Trainer covers the many learning requirements in the fields of industrial process control and automation.

2. METHODOLOGY

The study employed the experimental method of research in developing the trainer. To obtain the necessary data, the researcher made use of the observation guide as an instrument to determine capacity of the system to test its performance and functionality.

The researcher fifteen (15) technology and engineering experts from different learning institutions and private industries in the province of Bohol specifically at Bohol Island State University (BISU) - Main Campus, BISU Calape Campus, BISU Balilihan Campus, Bohol Light Company Incorporated and Coca-Cola Bottlers Incorporated to test the functionality and performance of the trainer.

3. RESULTS AND DISCUSSION

This presents the findings, analysis, interpretation and holistic project design of the study. It also presents the data gathered, collated, and tabulated in accordance to the appropriate statistical treatment. The construction of the Automation Trainer was based accordingly to its specified design.

Table 1 Functionality of the Automation Trainer in terms of PLC Input and Output Module

Input Devices	Input Address	Output Devices	Output Address	Operation	Observation	Remarks
Push Button	33000	Pilot Light	32000	pressing the push button	The pilot light had illuminated	Functional
	33001		32001			
	33002		32002			
	33003		32003			
	33004	Motor	32004	pressing and holding the button	The motor rotates counter-clockwise	Functional
	33005		32005			
	33006		32006			
	33007		32007			
Sensor	33008	Pilot Light	32008	swiping the upper part of the sensor	The pilot light had illuminated	Functional
	33009		32009			
	33010		32010			
	33011		32011			
	33012	Motor	32012	covering the upper part of the sensor	The motor rotates counter-clockwise	Functional
	33013		32013			
	33014		32014			
	33015		32015			

Table 1 shows the result of the Functionality of the Automation Trainer in terms of PLC Input and Output Module. The researcher tested the pushbuttons and sensors as an input device, the pilot lights and motors as an output device. Thus, the researcher conducted troubleshoot procedure during the testing. That pressing the Push button the pilot light will illuminates in the given program addresses. In terms of the Motor rotation, the researcher designated different kinds of rotation in every type of input devices, If the motor rotates in designated rotation it concludes that it was functional, and if the rotation of the motor did not follow the designated rotation it is interpreted that it is functional, possibly the two terminal of the motor was recently switched. The table depicts the test results being conducted in terms of the precision of the sensor. The proximity sensor has a 10-millimeter maximum detection range and is based on the number of trials conducted. Throughout the three trials, the precision of the sensor got a 100 percent rating, and the researcher's did not need to conduct troubleshooting procedures during the trials. It is not functional if something goes wrong with the input address of the program and can't detect the Motion of the sensor, it won't function so it needs to be check thoroughly and simulate it. The researcher tested the simulation of the input devices (push buttons, sensors) output devices (pilot light, motor) and it was successfully executed. The researcher conclude that the input and output devices are all functional and did not encounter any error.

Table 2Functionality of the Automation Trainer in terms of HMI Input and Output Module

Interface	Input Address	Output Devices	Output Address	Operation	Observation	Remarks
HMI	MR000	Pilot Light	32000	By pressing the push button in the screen	The pilot light had illuminated	Functional
	MR001		32001			
	MR002		32002			
	MR003		32003			
	MR004	Motor	32004	By pressing the push button in the screen	The motor rotates counter-clockwise	Functional
	MR005		32005			
	MR006		32006			
	MR007		32007			
	MR008	Pilot Light	32008	By pressing the push button in the screen	The pilot light had illuminated	Functional
	MR009		32009			
	MR010		32010			
	MR011		32011			
	MR012	Motor	32012	By pressing the push button in the screen	The motor rotates counter-clockwise	Functional
	MR013		32013			
	MR014		32014			
	MR015		32015			

Table 2 shows the result of the Functionality of the Automation Trainer in terms of HMI Input and Output Module. The researcher tested the HMI as an input device, the pilot lights and motors as an output device. The ladder diagram showed the functionality of the input and output devices in the trainer. The researcher tested a simulation of the input devices (push buttons) output devices (pilot light, motor) and it was successfully executed. The researcher conclude that the input and output devices are all functional. Thus, the researcher's need to conduct any troubleshoot procedure during the testing. That pressing in the HMI interface the pilot light will illuminates in the given program addresses. In terms of the Motor rotation, the researcher designated different kinds of rotation in every type of input devices, If the motor rotates in designated rotation it concludes that it was functional, and if the rotation of the motor did not follow the designated rotation it is interpreted that it is functional, possibly the two terminal of the motor was recently switched. The researcher tested a simulation of the input devices (HMI) output devices (pilot light, motor) and it was successfully. executed. The researcher conclude that the input and output devices are all functional did not encounter any error.

Table 3 Performance of the Automation Trainer in terms of Liquid Mixer Simulation

Level Sensors	Indicator Valve	Motor Operation	Observation
Low	Green	Motor 1 - Forward	The motor 1 and green light indication turn on as soon as the low-level sensor detects the liquid
			Sometimes the low-level sensor failed to detect, yet the motor 1 and green light indication energized
			The motor 1 and green light indication turn on as soon as the low-level sensor detects the liquid
Mid	Yellow	Motor 2 – Forward	Sometimes the low-level sensor failed to detect, yet the motor 2 and yellow light indication energized
			Sometimes the low-level sensor failed to detect, yet the motor 2 and yellow light indication energized
			The motor 2 and yellow light indication turn on as soon as the mid-level sensor detects the liquid
High	Red	Stop the motor 1 and 2	The motor 3 and red-light indication turn on as soon as the high-level sensor detects the liquid
			The motor 3 and red-light indication turn on as soon as the high-level sensor detects the liquid
			The motor 3 and red-light indication turn on as soon as the high-level sensor detects the liquid

Table 3 shows the performance of the liquid mixer. The researcher tested the simulation in the trainer by doing the actual work of simulating the program. In the first level of liquid mixer which is the low level. When the low level of liquid detected motor 1 – forward activated along with the green light indicator upon operation of simulation. Second is when the mid-level detected the liquid motor 2 – forward activated along with the yellow light indicator upon operation of simulation. The last level is the high level, when it detects the liquid, the motors stopped operating along with the red-light indicators. Therefore, the researcher concluded that the program simulation of the liquid mixer is all functional with the performance level of a very efficient and successfully executed.

Table 4 Performance of the Automation Trainer in terms of Door Shutter Simulation

Door Sensors	Indicator	Motor Operation	Observation
Close	Red	Motor 1 – clock wise rotation	Sometimes the closed sensor failed to detect, yet the motor 1 and red-light indication energized
			When the close sensor detects is start to run and the door shutter was fully closed the red-light indicator turns on
			When the close sensor detects is start to run and the door shutter was fully closed the red-light indicator turns on
	Yellow	Motor 1 -Stops	During the closing process the yellow light indicator turns on
			During the closing process the yellow light indicator turns on
			During the closing process the yellow light indicator turns on
	Green	Motor 2 – counter clock wise rotation	Sometimes the open sensor failed to detect, yet the motor 2 and green light indication energized
			Sometimes the open sensor failed to detect, yet the motor 2 and green light indication energized
			When the open sensor detects is start to run and the door shutter was fully closed the green-light indicator turns on

Open	Yellow	Motor 2 -Stops	During the opening process the yellow light indicator turns on
			During the opening process the yellow light indicator turns on
			During the opening process the yellow light indicator turns on

Table 4 shows the performance of the door shutter. The researcher tested the simulation in the trainer by doing the actual work of simulating the program. The door shutter has two functions the close and open. When the door shutter is fully close the red-light indicator turns on and the yellow light turns on upon operation started. When the door shutter is fully open the green light indicator turns on and the yellow light indicator turns on upon operation started. Therefore, researcher concluded that the program simulation of the door shutter is all functional with the performance level of a very efficient and was successfully executed.

4. CONCLUSION

After assessing the Automation Trainer for Industrial Control Applications, the researcher concluded that it is as an effective tool for instruction, it is evident that PLCs and HMIs offer numerous advantages and have proven to be highly effective in various applications. PLCs and HMIs are highly programmable and can be tailored to suit a wide range of applications and industries. Their flexibility allows for the creation of specific instructions and control algorithms that precisely match the requirements of the given task and capable of continuous operation without failure as show in the result of both functionality and performance test.

Recommendations

1. For Electrical Technology students, the trainer can be used for skill test, simulating and programmed a different application using Automation Trainer for Industrial Control Applications.
2. For the Electrical Technology Instructors, the trainer serves an additional instructional media that can be used in teaching the students in programming and simulating the trainer.
3. For the future researchers, innovations and upgrades of the instructional trainer shall be developed as an instructional media for Electrical Technology students of Bohol Island State University, Main Campus.

Since the trainer was made for simulation, the researcher recommends by adding alternative materials like sensors with different types and a push button for the input. Adding more motors and pilot light for the output will provide more demonstration of the simulation process.

5. REFERENCES

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