Demonstration Trainer for Instrumentation Device with Programmable Logic Controller

Jessie Nigparanon, PhD

Bohol Island State University- Main Campus

Abstract

Introduction: This research focuses on the development of a demonstration trainer designed to simulate and teach the operation of instrumentation devices integrated with a Programmable Logic Controller (PLC). The trainer aims to provide hands-on experience and enhance understanding of industrial automation systems, particularly in monitoring and control applications.

Objectives: The primary objective of this study was to evaluate the trainer's performance and assess its effectiveness as a learning tool for instruction.

Methods: The study employed the experimental design, particularly the one group competency skill test design; a type of experimental study in which only one group receives a treatment and is then measured in a post skill test. In this design, there is no control group or baseline condition to compare with.

Results: The results show that the trainer is an effective and user-friendly tool for both teaching and learning, with students demonstrating strong performance and improved competencies in PLC programming and troubleshooting.

Conclusions: The study concludes by highlighting the trainer's effectiveness as a hands-on instructional tool, contributing valuable insights to the field of industrial automation and PLC-based instrumentation device applications.

Keywords: demonstration, trainer, instrumentation, device, plc

1. Introduction

Automation is the continuous and coordinated operation of a production system that uses electronic or mechanical equipment to regulate both the quantity and quality of output (Gates, 2012) [1]. Over the past century, automation has significantly improved the manufacturing industry, boosting productivity, efficiency, and overall profitability.

Today, automation is an essential part of industrial operations. One key technology behind this progress is the Programmable Logic Controller (PLC), which is known for its ability to operate reliably in harsh industrial environments. PLCs help streamline processes, reduce downtime, cut operational costs, and speed up production.

A PLC is designed to automate machines and processes by handling three core functions: input, processing, and output. For it to effectively monitor and control variables in a system, it must be able to sense its environment. This is where sensors or instrumentation devices come in. These instrumentation devices or commonly known as electronic sensors, detect changes in conditions such as position, distance, temperature, and flow, providing critical input to PLC-controlled systems (Kandray, 201o) [2].

From the smallest gadgets to the most complex machines, electronics plays a key role in shaping modern life. Features like automatic lighting, smart appliances, and sensor-driven safety systems show how automation has quietly become part of our daily routines (Leelaarporn, et.al., 2021) [3].

These innovations rely on sensors, which come in many forms and serve various purposes. They can detect the presence or absence of objects, temperature variations, proximity, chemical presence, and more (Schulman & Shah, 2000) [6]. In industrial settings, these sensors are commonly paired with PLCs to enable responsive and automated control systems (Low, et.al., 2005) [4].

Because sensors are widely used in both residential and industrial applications especially in alarm systems and safety circuits—understanding how they work is crucial for students in technology and engineering. To support this learning, the researcher developed an instructional tool designed to help students grasp the theories, operations, and real-world applications of instrumentation device.

The Demonstration Trainer for Instrumentation Device with Programmable Logic Controller integrates several common sensor types, all connected to a PLC in a mock-up training unit. This device addresses the lack of hands-on training tools in many schools, especially for sensor-related studies. Instructors can use it for simulations and skills assessments, allowing students to design and test their own circuit diagrams. Users can choose to activate one sensor or a combination of sensors to control a common output, represented by LED lights. These LEDs light up when a sensor is "on" and remain off when it is not active.

This project was inspired by the need to improve the quality of instructional materials available for sensor education. It aims to enhance students' knowledge and skills in automation, especially in technology and engineering. As part of Bohol Island State University's commitment to producing skilled and competitive graduates, this tool serves as a valuable medium to support that mission.

2. Objectives

This study set out to construct and create a Demonstration Trainer for an Instrumentation Device interfaced with a Programmable Logic Controller. This trainer was created for the purpose of equipping learners with practical skills on how automation sensors and PLCs function in modern technological systems. The study also sought to assess the trainer's overall performance. Most importantly, it aimed to investigate the effectiveness of this device as a teaching aid—facilitating industrial automation concepts, sensor technologies, and PLC programming through active learning experiences.

3. Methods

This study implemented an experimental research design using a one-group competency skill test method. This method relies on one group receiving the instruction through the Demonstration Trainer, which was then followed by a post-skill assessment to evaluate learning and trainer effectiveness. In this design, there is no control group or baseline condition to compare with. The research setting was Bohol Island State University – Main Campus located in Tagbilaran City. This institution was selected for the study as it had technical courses along with Programming subjects offered in technology and engineering, equipping students with relevant practical knowledge of sensor systems and their applications.

The researcher chose fifty (50) respondents, with twenty (20) technology experts coming from the campus to validate the performance level of the trainer. Fifteen (15) respondents came from the computer engineering third year students and fifteen (15) students, from the electrical technology who undertook the skill test of the trainer.

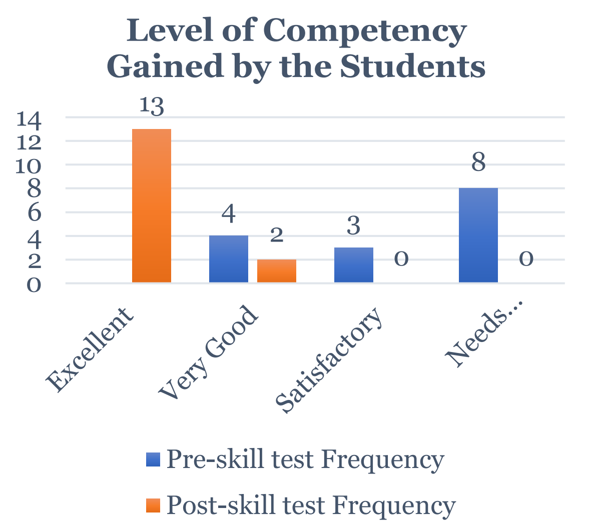
Data were collected using two main tools: an observation guide and a competency skill test. The observation guide included a series of descriptive statements designed to assess the trainer's efficiency and effectiveness as an instructional tool. The competency skill test measured the learners' ability to apply what they had learned using the trainer. These tools were based on literature, expert consultation, and aligned with the objectives of the study.

4. Results

Response Range Analysis of the Demonstration Trainer for Instrumentation Device with PLC

Instrumentation Device	Operation / Condition	Response	Description
Motion Sensor	Object at 1 meter	Sensor triggered	Detected object at close range
	Object at 6 meters	Sensor detected object.	Detected object at mid-range
	Object at 7 meters	The object was not detected.	Out of detection range
Light Sensitive Sensor	Light source turned off	Sensor activated	Detected absence of light
Proximity Sensor	Object at 1mm	Sensor detected object	High sensitivity at close range
	Object at 3mm	Sensor detected object	Maintained detection at short distance
	Object at 6mm	The object was not	Detection range exceeded

		detected.	
Smoke Sensor (distance in meter and time in sec. to trigger)	3 sec. in 1 meter	Sensor detected object	Responsive at close range and short duration
	6 sec. in 2 meters	Sensor detected object	Detection still effective at mid-range
	9 sec. in 3 meters	The smoke was not detected.	Smoke not detected beyond optimal range
Twin Photo Beam Sensor	Beam interrupted	The sensor detects the object.	Accurate detection upon signal obstruction
Infrared (IR) Sensor	object at 20 cm	Sensor detected object	Reliable detection at near range
	object at 50 cm	Sensor detected object	Effective mid-range detection
	60 cm	The sensor does not detect the object	Beyond sensor's maximum range



5.

6. Discussion

Response Range Analysis of the Demonstration Trainer for Instrumentation Device with PLC shows the detection range of the sensors. The motion sensor can detect a moving object up to a maximum distance of 6 meters. However, when the object is 7 meters away, the sensor can no longer detect it.

For the photoelectric sensor, there is no specific detection range since it operates based on the presence or absence of a light source.

The proximity sensor has a maximum detection range of 3mm, beyond which it fails to detect objects.

Meanwhile, the infrared (IR) sensor detects objects as long as they pass through its invisible beam. The sensor converts the change in incoming infrared radiation into a corresponding change in output voltage, which then triggers detection (Scheible et al., 2004) [5].

Finally, the twin photo beam sensor identifies an object when it interrupts or blocks the beam signal.

Overall, the demonstration trainer effectively highlighted each sensor’s detection range and behaviour under different conditions, making it a valuable tool for hands-on learning in automation and electronics.

Meanwhile, the bar graph shows a notable shift in the students’ competency levels before and after using the trainer. Initially, a large portion of students—8 out of 15—were in the "Needs Improvement" category, with only a few achieving higher scores. However, after engaging with the trainer, the majority of students—13 out of 15—moved into the "Excellent" category, and none remained in the lowest bracket. This striking improvement demonstrates the effectiveness of the trainer in enhancing students’ knowledge and skills in sensor applications and PLC programming through hands-on, practical experience.

7. Recommendation

As a result of the findings, there are specific suggestions to enhance the effectiveness and functionality of the Demonstration Trainer for Instrumentation Device with PLC. Firstly, hands-on exercises addressing the detection range for each sensor should be improved so that learners appreciate how sensors operate at different distances and under varying conditions. Secondly, tasks such as automatic doors or light-activated systems should be included to illustrate reallife applications to automation using sensors. Lastly, an introduction of other types of sensors used in industry, like analog sensors, will help broaden students' industrial exposure. Improvement on these areas will enhance student learning together with the quality of instruction facilitated by the training device.

References

[1] Gates, E. (2012). Electronics an introduction, six edition. Pasig City, Philippines. Raffles Corporate Center.

[2] Kandray, D. (2010). Programmable automation technologies: an introduction to CNC, robotics and PLCs. Industrial Press.

[3] Leelaarporn, P., Wachiraphan, P., Kaewlee, T., Udsa, T., Chaisaen, R., Choksatchawathi, T., ... & Wilaiprasitporn, T. (2021). Sensor-driven achieving of smart living: A review. IEEE Sensors Journal, 21(9), 10369-10391.

[4] Low, K. S., Win, W. N. N., & Er, M. J. (2005, November). Wireless sensor networks for industrial environments. In International Conference on Computational Intelligence for Modelling, Control and Automation and International Conference on Intelligent Agents, Web Technologies and Internet Commerce (CIMCA-IAWTIC'06) (Vol. 2, pp. 271-276). IEEE.

[5] Scheible, G., Smailus, B., Klaus, M., Garrels, K., & Heinemann, L. (2004). U.S. Patent No.6,749,119. Washington, DC: U.S. Patent and Trademark Office.

[6] Schulman, J. H., & Shah, R. (2000). Basic application of a sensor.U.S.Patent No. 6,088,608. Washington, DC: U.S. Patent and Trademark Office.