Development of a Programmable Logic Control Trainer as An Industrial Automation Learning Tool

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Abstract. The rapid advancement in industrial automation necessitates the development of effective learning tools to equip students and professionals with the required skills. This paper presents the design and implementation of a Programmable Logic Controller (PLC) trainer aimed at enhancing industrial automation education. The PLC trainer is developed to provide hands-on experience, simulating real-world industrial scenarios. It incorporates various input and output devices, sensors, and actuators, allowing users to program and control different automation processes. The trainer is designed with a user-friendly interface and comprehensive instructional materials to facilitate learning. The study evaluates the effectiveness of the PLC trainer through a series of tests and user feedback. Results indicate significant improvements in understanding PLC concepts and practical application skills among the participants. This PLC trainer serves as a valuable educational tool, bridging the gap between theoretical knowledge and practical implementation in industrial automation. Future developments will focus on integrating advanced features such as remote access and enhanced simulation capabilities to further enrich the learning experience.

Keywords: PLC, Trainer Module, Industrial Automation, Utility Model

1 Introduction

Modern technology is getting more complex, and industrial equipment is evolving quickly. such is the creation of control systems for the industrial sector. Up until now, control systems have been used in practically every aspect of the production process; they are used, for example, to regulate pressure, speed, and movement. There must be advancements in education to match the industrial world's rapid technological progress. A key component of developing human resource skills is education. The Practical Course on Setup & Using Electric Motors is one of the courses that demands students to grasp technological advancements. The automatic operation of electric motors will be studied in this course [1].

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The automatic operation of electric motors will be studied in this course. This is in accordance with the Decree of the Minister of Manpower Number 631 of 2016 issued by the Indonesian Government, which established the Indonesian National Work Competency Standards (SKKNI) necessary in industry, particularly in the field of industrial automation. The inclusion of competencies pertaining to the use of PLC in the manufacturing process is a crucial aspect of these competency standards. Given that PLC are still used in industry, it is crucial to have abilities connected to PLC[2].

Creating a PLC-based industrial automation system trainer for industrial automation education and electric motor practice. The construction of a PLC-based industrial automation system trainer, complete with a Jobsheet, comprises multiple elements: the trainer board, Automation Control apparatus, PLC, Contactor, Push Button, and Instrument in the case study. A jobsheet often includes assignments, practical steps, material details, and objectives. in creating an industrial automation system trainer that is PLC-based. It is intended that by using this PLC-based industrial automation system trainer, students studying Electrical Engineering Education at Medan State University's Faculty of Engineering will be able to learn more about indsutrial automation and develop their analytical skills.

2 Literature Review

A key element in raising the standard of education is learning media. This is a result of technology advancements in the field of education, which require efficacy and efficiency in the classroom. Reducing, if required, eliminating the dominance of verbalistic lesson delivery systems through the use of learning media is one of the efforts that must be made in order to attain optimal levels of efficiency and effectiveness Kristanto 2016 [3]. Learning media are used for two reasons: first, they are used out of need (demand). As life becomes more complex, learning becomes more complex as well, and learning itself becomes more complex as a result. In this case, the media can simplify difficult ideas so that they are easily understood. Second, due to advancements in technology across the board, there is a greater diversity in the media available today[4].

Media for learning can signify numerous things. Anything that can convey messages for meeting the five learning objectives is considered learning media. Improving learning outcomes and facilitating communication are the two main goals of utilizing learning media. To give a more thorough understanding, learning media can be thought of as any means of communicating ideas or information from source to recipient that can excite students' minds, spark their interest, and compel them to pay attention and learn in a way that will enable them to develop the attitudes, knowledge, or skills necessary to understand the information being presented. It is clear from the description and examples of learning media above that the primary objective of media is to disseminate ideas, facts, and resources to students. The most basic factor to take into account when selecting media is whether or not it can assist in meeting demands or achieving learning objectives; if it cannot meet these requirements, the media will not be employed [5].

3. Method

The Department of Electrical Engineering Education, Faculty of Engineering, Medan State University was the site of this study. A PLC-based industrial automation system trainer is the intended product being created as a tool for learning electric motor control. Using the Research and Development technique, research is being done on the creation of PLC-based industrial automation system trainer learning media as a means of developing electric motor control. Regarding the application of electric motor control competences in the educational field. Through the process of product creation, this research methodology seeks to create a product. Creation of instructional materials for trainers on PLC-based industrial automation systems.

The goal of developing electric motor control is to produce learning materials that are more relevant to the ability to operate and regulate electric motors. A PLC-based industrial automation system trainer will be the end result of the researchers' research and development efforts, serving as a tool for the advancement of electric motor control. An operation handbook, handouts, and work sheets are additional tools for improving electric motor control, together with a PLC-based industrial automation system trainer. The stages of the ADDIE model, as modified by Lee & Owens, served as the foundation for the development process used in this study.

3.2. Methods for gathering data

The following are the methods used in this study to acquire data:
1. Lecturers in the same Field Group in the Electrical Engineering Education Study Program were the subject of observations. This inspection covers the facilities, learning resources, student characteristics, and related curriculum.
2. Questionnaire: Give media experts and material specialists a questionnaire that evaluates the caliber of media and materials used to determine whether media and educational materials are appropriate. Subsequently, distribute a survey to ascertain the opinions of students regarding the media and the educational materials under development.

3.3 Methods of Data Analysis

Analyzing data using instrument validation: Sugiyono states that each test and non-test instrument is submitted for additional analysis utilizing item analysis after being tested with experts [6]. Next, the Kuder Richardson (KR21) technique was used to test the instrument's reliability [7]. Then, utilizing rating scale measurements as shown in Table 1, feasibility data analysis was performed.

4. Results and Discussion

The study was conducted in accordance with the phases of the ADDIE development model, which include analysis, design, development, implementation, and evaluation. The explanation that follows explains the steps involved in doing research and the outcomes of each stage of the investigation.

4.1 Analysis of Requirements

Technology investigation indicates that Omron, Schneider, and Siemens brands are the most commonly used PLC types in industry, while HMI is typically utilized as monitoring equipment. Ladder diagrams and instruction lists are two popular forms of programming languages. Other than that, it makes use of a number of parts, including several sensors and limit switches.

Based on observations of the skills of the Electrical Engineering major, a requirements analysis was developed, indicating the need for a trainer in the form of a PLC with buttons and lights. Moreover, HMI and PLC can be integrated. Also, you want to become knowledgeable about PLC troubleshooting programs and competencies**.** An Omron CP1E PLC with I/O 20 is utilized for the media analysis. Next, utilize the CX-Programmer software. With HMI, trainers can be mimicked. additionally furnished with a proximity sensor, contactor, limit switch, and push button. Furthermore, acrylic was used in the trainer's construction for ease of upkeep. acclimate to fundamental education.

With reference to the RPS practical course on the use and regulation of electric motors with SUB-CPMK (Final Capabilities for Each Learning Stage), specifically controlling electric motors with a PLC, an objective analysis was conducted to modify the teaching module. using control lessons that are preprogrammed. Following the needs analysis, a Focus Group Discussion (FGD) was conducted with the pertinent lecturers. A PLC trainer with 30 I/O units and RS232 and USB interface ports—the Omron CP1E—was used to model the technical specifications for the trainer. equipped with push buttons, sensors, and a number of input and output connector components.

4.2 Media Design

Based on the results of analysis and FGD for the design of a PLC-based automation control trainer with this design form as in Figure 1.

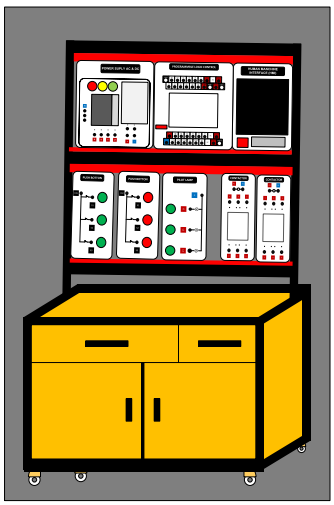

Fig. 1. PLC Based Automation Control Trainer Products.

Furthermore, the learning module is designed to support learning activities carried out using a Trainer according to the results of objective analysis. Where learning activities include 1) knowing and understanding the function of the components; 2) install PLC components; 3) programming the PLC; 4) carry out troubleshooting of PLC-based control systems.

4.3 Media Development

The creation of a training kit is done in three stages: preproduction, production, and postproduction. The process of preproduction involves getting supplies and tools ready. Program creation and component assembly make up the production process. The trainer's functional testing is the postproduction phase.

The initial stage of Pre-Production involves getting the materials and tools ready in accordance with the current design. Hand tools like hand drills, saws, pliers, screwdrivers, and electronics toolkits are among the equipment used. Components are assembled during production once the necessary materials are obtained. The process of assembly involves multiple stages: building the trainer frame, putting together the control and I/O boards, and lastly connecting the connections. The results of assembling the trainer components are shown in Figure 2.

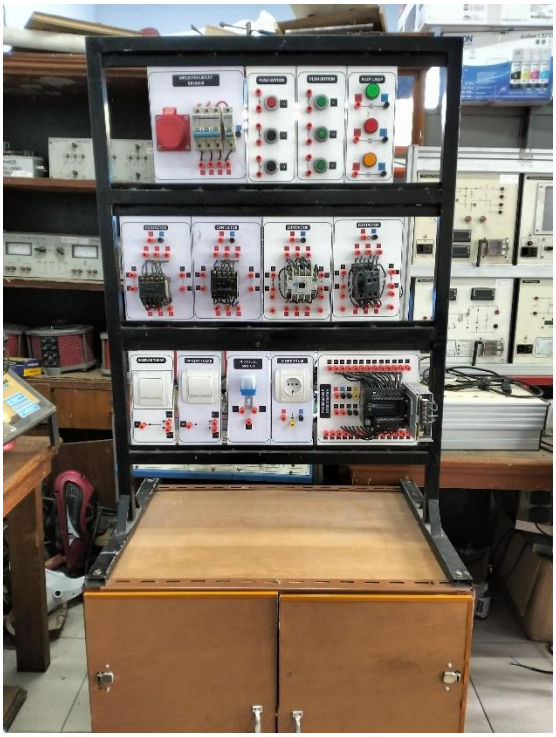

Fig. 2. PLC Trainer Display

The performance of the system as a whole as well as the functionality of each component of the trainer are tested. The process of evaluating each part's performance involves examining how well each installed component in the trainer works. Information on the outcomes of each component's functional testing that was done.

4.4 Implementation

Product evaluations are currently being done by media and material experts. This seeks to ascertain the viability of the project and offer recommendations for enhancing the product under development. According to the product being created, the evaluation is conducted using the Guttman scale with a 4-3-2-1 scale on the instrument's questions. The revised version will then be evaluated on actual users. Two lecturers from the Medan State University Faculty of Engineering, one of which was a material expert and the other a media expert, participated in the expert assessment, which was based on trials of trainer kits and learning modules.

The evaluation information provided by subject matter experts is comprised of eighteen statement items that reflect the two dimensions of content relevance and usefulness. The data used by media specialists to review the training kit product is comprised of 21 assertions that pertain to three key aspects: design, application, and usefulness. The application of a PLC trainer to Electrical Engineering majors was the next experiment. The PLC trainer's operation was briefly described and shown by the researcher. After that, students are given time to comprehend the content and attempt to complete practicums in accordance with the module. With a 4-3-2-1 scale on the instrument, students use the Guttman scale to offer assessments.

4.5 Material & Media Expert Assessment

With an average score of 3.61, material experts concluded that the training kit and learning modules' content fell into the extremely appropriate category. The material aspect and the usefulness aspect are the two categories into which the data from this assessment can be separated based on the instruments employed. Table 2 displays the average score for each aspect.

Table 1. Evaluation by subject-matter specialists

No	Aspects of member evaluation	question items	Total score	Avarage Score
1	Relevance of Material	5	18	3,60
2	Expediency	13	47	3,61
	Total	18	65	3.61

Material experts state that, based on this data, the content of the PLC Trainer and learning modules is very appropriate in terms of relevance and utility. The average score of 3.60 and 3.61 obtained for the relevance and usefulness aspects, respectively, demonstrate this. The trainer's and the learning modules' content, learning objectives, industry competency requirements, student needs, and student learning capacities are all considered aspects of relevance. The usefulness factor has to do with how well the content in the trainer and learning modules can boost students' enthusiasm and drive to learn, facilitate their comprehension of the subject matter, and broaden their understanding of programming, installing, and troubleshooting PLC systems. The suitability of the content in the training kit and learning modules to enhance students' abilities in programming, setting up and maintaining PLC systems, as well as enhancing work attitudes like innovative thinking, teamwork, and communication, is another factor that contributes to the usefulness of the material.

Three factors are considered when evaluating media experts: design, use, and usefulness. The training kit and learning modules that have been prepared have been rated by media professionals as very feasible, with an average score of 3.42, based on this data. When examining each component, the usefulness component has a mean score of 3.30 and the design component has a mean score of 3.71. With an average score of 3.25, the utilization aspect was rated the lowest. Table 3 displays the average score for each aspect.

Table 2. Evaluation by media specialists

No	Aspect	question items	Total score	Avarage Score
1	Design	7	26	3,71
2	Ultilization	4	13	3,25
3	Expediency	10	33	3,30
	Total	21	72	3,42

4.6 Qualifying Requirements

The table below displays the overall results of the training kit and learning module assessments for respondents who identified as material experts and media experts.

Table 3. Results of the training kit and learning module assessments

No	Respondent	Achievements	Criteria
1	Materials Expert	3,61	Very proper
2	Media Expert	3,42	Very proper
Avarage		3,52	Very proper

Based on this information, material specialists gave the research product—a training kit with learning modules—an evaluation of 3.61, placing it in the extremely feasible category. The training package and learning modules received a score of 3.42 from media experts, placing it in the very decent category as well. With an average achievement score of 3.52, all respondents provided a very acceptable assessment for the training kit and learning session. This demonstrates that the training manual and modules created may be applied as a hands-on educational resource in the Electrical Engineering Department's Practical Course on Setting Up and Operating Electric Motors.

5. Conclusion

The research yielded a solution in the form of a PLC-based Automation Control Trainer that complied with the competency requirements for Medan State University Electrical Engineering majors, according to the findings of the research and development. Technically speaking, this trainer is made up of an I/O board, a control board, and an HMI for monitoring and simulating production. It also has integrated PLC components. Every input and output component comes with fault switches to practice troubleshooting and auxiliary connections for wiring. This trainer's non-technical objectives include teaching four essential competencies: recognizing

PLCs and the parts that support them, conducting PLC system wiring, utilizing computers to program PLCs, and fixing PLC systems.

The PLC-based Automation Control Trainer with this learning module is very suitable for usage, according to the findings of the feasibility test. With a relevance aspect of 3.60 and a usefulness aspect of 3.61, material experts assigned an overall average score of 3.61. Media analysts assigned an overall score of 3.42, with 3.71 for design, 3.25 for usage, and 3.30 for usefulness. The evaluation falls into the very decent level in every way. Additionally, according to students, this trainer is excellent for use in classes on industrial automation.

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