Advanced Development of PLC Trainer Products as Facilities in the Control Engineering Laboratory

Gitud Sudarto[1](✉), Minnar Titis Santoso[2], and Hikmat Oka Kusuma[1]

[1] Electrical Engineering Department, Universitas Negeri Surabaya, Surabaya, Indonesia
gitudsudarto@unesa.ac.id

[2] Family Welfare Education Department, Universitas Negeri Surabaya, Surabaya, Indonesia

Abstract. The rapid development of technology in the industrial world must also be accompanied by the development of the world of education, therefore the bachelor of Electrical Engineering Study Program, Surabaya State University provides automation control systems courses to bridge students to study control systems Automation. However, in the implementation of the teaching and learning process based on the results of researchers' observations through an open questionnaire to automation assistants and students, it can be concluded that the teaching and learning process lacks visualization tools. Seeing these conditions, the researcher who is also a member of the laboratory technicians aims to design an automation system tool that combines a Programmable Logic Controllers (PLC) control system and a Pneumatic system using *the reverse engineering* method. Based on the calculation results using the likert scale, a score of 3.8 was obtained for product validation testing by experts, which means that trainers are worthy of use for practicum.

Keywords: PLC CP2E · HMI · Control Engineering

1 Introduction

The rapid development of technology in the industrial world must also be accompanied by the development of the world of education, education has the main factor in improving HR skills, therefore graduates of students of the bachelor degree Electrical Engineering Study Program, Universitas Negeri Surabaya are expected to have the ability to design, plan, install, and improve industrial systems, in order to keep pace with current technological advances. One of the competencies of Electrical Engineering graduates related to *the update* above is being able to master automation control systems, the basics in understanding automation control systems have been studied in the automation control system course and facilitated with the industrial automation community 3 in the Engineering Laboratory Control. However, there is still a lack of equipment as *a visualization* in the learning process, so far in the learning process using PLC and Pneumatics, but all of them are only in the form of a *trainer kit*. These limitations make students feel bored and a little difficult to understand the concept of industrial automation.

S. Setiawan et al. (Eds.): IJCAH 2022, ASSEHR 724, pp. 1072–1079, 2023.
https://doi.org/10.2991/978-2-38476-008-4_114

Seeing these conditions, the researcher intends to design an automation system that combines a Programmable Logic Controllers (PLC) control system and a Pneumatic system using *reverse engineering* methods in making the design a learning medium at the Control Engineering Laboratory of Universitas Negeri Surabaya and analyze the results of the design are on the learning process of the Automation Control System course of the S1 Electrical Engineering Study Program, Universitas Negeri Surabaya. Programmable Logic Controllers (PLC) is a digital electronic device that uses programmable memory as an *internal* store of a set of instructions by implementing certain functions of functions, such as logic, *sequential*, timing, calculation, and arithmetic to control various types of machines or processes through digital and or analog I/O modules [1]. Programmable Logic Controllers (PLC) is widely used in industrial applications, for example in beverage factories, paper mills, and so on. In other words, almost all applications require electrical or other electronic control. Programmable Logic Controllers is a major component in the *Computer Integrated Manufacturing* (CIM) environment [2].

Programmable Logic Controllers (PLC) can create a real time/real environment where all information is stored. Information such as targets, *reject* results, operating status, test results can be directly viewed from the computer. Programmable Logic Controllers (PLC) is an electronic computer that can perform various control functions at complex levels [3]. Programmable Logic Controllers (PLC) can be programmed, controlled and operated by the operator in operating the computer. Programmable Logic Controllers (PLC) is generally depicted with lines and equipment on a *ladder diagram* [3]. The resulting image on the computer illustrates *the wiring*/relationships required for a process. The Programmable Logic Controllers (PLC) will operate all systems that have an output whether it should be *on* or *off*. It can also be operated a system with varying outputs. PLC can be operated with inputs in the form of *on/off* or variable input equipment. Programmable Logic Controllers (PLC) works based on existing inputs and depends on the circumstances at a certain time which will then ON or OFF the outputs. Logic 1 indicates that the expected state is met whereas logic 0 means that the expected state is not met. Programmable Logic Controllers (PLC) can also be applied for the control of systems that have multiple outputs. In a PLC there are parts consisting of the CPU (*Central Processing Unit*) which is the main part and is the brain of a Programmable Logic Controllers (PLC) [4, 5]. This CPU serves to retrieve instructions from memory then encode and execute those instructions.

2 Methods

This research applied the basic method of research step. The first step (1) analysis, to find out what is lacking from previous research and what will be needed by the research target, (2) design, tool design in accordance with the data that has been analyzed (3) Understanding, to understand and correct the designs that have been made to avoid errors in the implementation process, (4) implementation, and (5) evaluation [6, 7]. This step is implemented continuously until the ideal design and implementation is found. Place and time of this research is in Universitas Negeri Surabaya which located on A8 Building at Control Engineering Laboratory Electrical Department from June until November 2022. Here is a flow chart of the research design (Fig. 1).

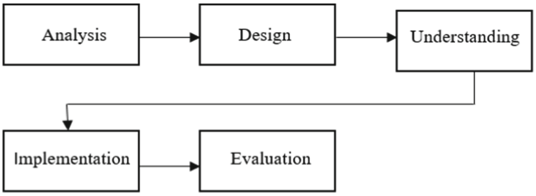

Fig. 1. Flowchart of the research

At the stage of preliminary study, it is divided into 2 forms, namely literature and field studies. Based on the analysis of data from the preliminary study obtained, the next stage is to compile a simulation while the frame work of the automation control trainer tool includes design planning, needs analysis, *hardware* planning and tool testing. The development stage is the process of manufacturing and developing products. At this stage, the development of modules is carried out according to the design. After that, the trainer tool is validated by experts. The next stage is reverse engineering activities starting from *Disassembly Product* At this stage the researcher studies the working principle of the Programmable Logic Controllers (PLC trainer tool, Assembling Components At this stage the researcher analyzes the ease of disassembly, *Benchmarking* At this stage comparing components and working principles of similar products, then determining the components to be adopted, Conducting New Product Design At this stage the researcher makes design of industrial automation trainer tools with new systems with the advantages of new products. The final stage in the use of *the reverse engineering* method is the tool making phase, where in this phase the researcher realizes the design of the industrial automation trainer tool in real and actual form in accordance with the concept that has been made [8]. At this stage, researchers test the product using the *trial error* method, each component is tested to find out whether it is running or moving properly and at the same time to detect if something goes wrong before the product enters the limited class simulation stage. Simulations are carried out to determine the performance and feasibility of industrial automation trainer tools by collecting students, then respondents will be given an explanation and try directly the operation of the trainer tool. Product analysis is carried out to find out whether the feasibility of industrial automation trainer tools as a learning medium in the automation control system course of the S1 Electrical Engineering Study Program, Surabaya State University. The analysis is carried out based on the questionnaire data that has been obtained. The validation process of the analysis results will be evaluated by the validator [9]. If the evaluation process does not find any problems, then proceed with the implementation of the tool, otherwise, return to the revision process. The implementation stage is the process of applying the trainer module as learning material. This stage of the module is applied to the target, namely PLC practicum students in the electrical engineering department. The last stage is the evaluation stage. This stage is a stage to evaluate the process of developing a trainer module according to the model used. The results of the evaluation are used to correct the shortcomings [10]. Revisions were made so that the trainer module could be said to be feasible and used for learning resources for students. The next step is the collection of quality and quantitative data using instruments in the form of questionnaire sheets.

Table 1. Calculation of CP2E Trainer Validation Result Score

Criterion	Value/Score
Excellent	4
Good	3
Enough	2
Bad	1

After obtaining research data, the next procedure is data analysis. The data analysis technique used for this study is a percentage technique obtained based on the calculation of scores according to the Likert scale on each research instrument result. The following is a table of calculating the score result of the trainer design validation shown in Table 1.

$$\text{Mean Value} = \frac{\sum v}{\sum p} \tag{1}$$

Description:
V = Σ Validator's answer
P =Σ Validator × Σ item

Then the data of the questionnaire results are analyzed with the following formula. The recapitulation of the results of the Trainer validation assessment is shown in Table 2.

3 Results and Discussion

The result of this study is the CP2E PLC Trainer which is the next generation of previous trainer project. Omron CP2E PLC Trainer with extra addition of Output that includes the relay, Timer, DC motor, 24V DC LED. PLC CP2E Trainer size of 49 cm × 46 cm arranged on an acrylic board. In the second design, in the PLC CP2E trainer consists of 8 LED indicator lamp consisting of 2 red LED, 24 yellow LED, 2 green and white LED; one HMI and a timer; 6 button switches; and one PLC CP2E with 19 DC inputs and 17 relay outputs. Based on the results of expert validation, in the aspect of media conformity with the curriculum, it gets a score of 4 which means it is very good. In terms of appearance and media quality, it gets a score range of 3 to 4 which means it is good to very good. Meanwhile, in the aspect of media compatibility with the workbook, it gets a score of 4 which means it is very good. In the design trainer indicator, the expert validation results got a score of 3 which means it is good. Components added to support trainer performance include 24 V DC LED lights, 12 V DC relays, 24 V DC motors, timer and Human Machine Interface (HMI).

The type of relationship that is taking place in a series by Indicator lights. LED indicator lamp used to represent as a working load from the simulation. Relays and timers are used to add a motor performance system so that they can turn back right and left. HMI is used to control the working system of the tool. However, an update of the touchscreen HMI screen is needed to make it easier to control the tool's work system.

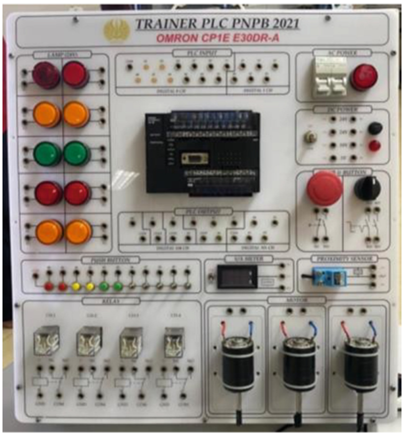

Fig. 2. Trainer PLC Omron CP1E

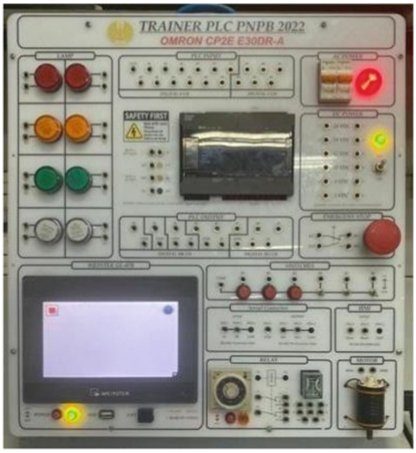

Fig. 3. Trainer PLC Omron CP2E

Here is what the Omron CP1E PLC Trainer looks like. Before it was developed is shown in Fig. 2.

After going through the research process, the Omron CP1E PLC Trainer was then developed into the Omron CP2E PLC Trainer. Here is the display of CP2E PLC products in Fig. 3.

There are three aspects with total 15 sections details assessed by validators, there are Media Conformity with the Curriculum, Media Appearance and Quality, Media Conformity with practicum modules. Based on the results of expert validation, in the aspect of media conformity with the curriculum, it gets a score of 4, In terms of appearance and media quality, it gets a score range of 3 to 4 which means it is good to very good. Meanwhile, in the aspect of media compatibility with the workbook, it gets a score of 4.

Table 2. Trainer validation assessment

No	Rated Aspect	Evaluation				∑
		1	2	3	4	
Media Compatibility Curriculum						
1	Linearity of Trainer media to the course material given.				1	4
2	Making trainer media helps to understand the material presented				1	4
Display and Media Quality						
1	Trainer media Design				1	4
2	Trainer media frame box suitability with the series				1	4
3	Component layout design aesthetics			1		3
4	Clarity of drawings/circuit schematics on the trainer			1		3
5	The writing on trainer media is legible				1	4
6	Wiring-point layout accuracy			1		3
7	Connector cable length according to needs			1		3
8	Ease of connecting jumper cables on the trainer media				1	4
9	Ease of access on each network				1	4
10	Trainer performance			1		3
11	Ease of operation use of trainer				1	4
Media Compatibility with the Workbook						
1	Linearity of the trainer media with the module material in the workbook				1	4
2	Linearity of the Practicum activities accordance with those contained in the workbook				1	4
	Total					54

Based on the calculation results using the Likert scale, a score of 3.8 was obtained for product validation testing by experts.

4 Conclusion and Suggestion

Results of the final design OMRON CP2E PLC trainer media in comparation to the previous one is the next level step to make the trainer media simpler, thus can make exponentially better understanding to the student. Second, with the addition of HMI can be used to control the plant or as we know as *Automation System* environment. Based on the validation assessment results, there are some suggestions to reduce the number of indicator lights or the switch aiming that can be a space to another *Automation System* component, the development of this tool based on inspiration to make a good learning media thus can achieve efficient way better understanding to the course given by the lecturer, positive support always needed to run this development project with minimum obstacle.

Acknowledgment. The author would like to thank to Research and Community Service Institute of Universitas Negeri Surabaya and my colleagues who have support resources for this article.

Authors' Contributions. All authors contributed, Gitud writing, Minnar collecting data anda Hikmat editing this article.

References

1. Kalpana Bhise, Sharwari Amte M.Tech. NIELIT, Embedded PLC Trainer Kit with Industry Application, NIELIT, Aurangabad, Maharashtra, India, ISSN: 2319- 5967 ISO 9001:2008 Certified International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 4, Issue 3, May 2015
2. Wawan Muliawan, 2018, Teknik Laboraturium, Lombok Timur: Universitas Hamzanwadi.
3. Akparibo Awingot,,Development of a Programmable Logic Controller Training Platform for the Industrial Control of Processes,, American Scientific Research Journal for Engineering, Technology, and Sciences 15(1):186–196 · January 2016
4. E S Maarifand Suhartinah Compact Portable Industrial Automation Kit for Vocational School and Industrial Training, Industrial Automation Laboratory, Astra Manufacturing Polytechnic,Jakarta, Indonesia, International Symposium on Materials and Electrical Engineering (ISMEE) 2017
5. R. Susanti et., all, 2021. Teknik Pengelolaan Laboraturium, Yogyakarta: Penerbit Andi.
6. Erwin Normanyo, Francis Husinu, Ofosu Robert Agyare Developing a Human Machine Interface (HMI) for Industrial Automated Systems using Siemens Simatic WinCC Flexible Advanced Software, Department of Electrical and Electronic Engineering, Faculty of Engineering, University of Mines and Technology, Tarkwa, Ghana 2 Accra Brewery Limited, Accra, Ghana, Journal of Emerging Trends in Computing and Information Sciences ©2009-2014 CIS Journal. All rightsreserve
7. Sulistyani Puteri, 2020, Pengelolaan Laboraturium, Depok: YRF.
8. Weni Puspita, 2020, Manajemen Laboratorium Untuk Mahasiswa Dan Umum, Sleman: Deepublish.
9. Priyambodo, 2017, Mengenal Jenis, Fungsi dan Prinsip Pengelolaan Laboraturium, Lampung: Universitas Lampung.
10. Hoetary, TA, 2017, Manajemen pengelolaan laboraturium, Palembang: Noer Fikri Offset.