Efforts to Improve Programmable Logic Controller Programming Competence and Its Application on Vocational High School

Tri Rijanto, Nurhayati Nurhayati(✉), Puput Wanarti Rusimamto, Agus Budi Santoso, and Agam Nizar Dwi Nur Fahmi

Department of Electrical Engineering, Universitas Negeri Surabaya, Surabaya, Indonesia
nurhayati@unesa.ac.id

Abstract. The industrial revolution has reached 4.0 by developing automation and cyber systems, but the use of automation in the industrial sector is still not accompanied by appropriate operators. Vocational High School (SMK) graduates who are ready to work to enter the industrial world still do not have the competencies expected by the industry. The required competence is the operation of the Programmable Logic Controller (PLC) at SMK YKP Magetan. With the competence of Industrial Electronics Engineering expertise, it is necessary to know the basics of PLC programming. This study aims to improve students' competence using learning media in the form of PLC trainers and determine the level of feasibility of PLC trainers as learning media. The method used in this research is a 4D development model. The stages of 4D development are as follows: (1) Define (Defining), (2) Design (Design), (3) Develop (Development), and Disseminate (Deployment). The research design that is used one group pretest-posttest using paired sample t-test. The test was carried out on students of class X TEI with a total of 35 students. Training at SMKN YKP Magetan which will provide material on PLC, introduction to Trainer KIT, programming, and assembly. Knowing the increase in students' understanding of PLC was given a pretest and posttest. The results showed that the PLC trainer learning media developed was categorized as suitable for use with an average value of 84.47% for media design, 84% for media material, 85.29% for media evaluation, and 84.41% of media motivation. Regarding the increase in competence using the paired sample t-test, a significance value of 0.00 was obtained which was smaller than the significance level of 5% (0.05) so it was stated that there was an effect of student competency signification after being given learning media in the form of class X TEI PLC trainer at SMK YKP Magetan.

Keywords: Programmable Logic Controller · Training kit · Student competence

1 Introduction

Programmable Logic Controllers (PLC) are an important part of industrial production processes [1]. Therefore, Vocational High Schools (SMK) play an important role in providing manpower for the industrial world. However, there are still many SMK graduates

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who are not ready to work. One of the contributing factors is the difference in competence between industrial needs and student competencies.Overcoming differences in competencies required by industry, learning facilities are needed to improve student competencies, one of which is by holding PLC programming training. [2].

PLC is an industrial computer consisting mostly of hardware and software used to control a machine or process. It is designed for multiple input/output (I/O) settings, extended temperature range, immunity to electrical noise, and resistance to vibration and impact. PLC is an example of a real time system because the output of the system controlled by the PLC depends on the input conditions. PLC devices have been at the heart of industrial automation and control systems since 1968. The PLC trainer is a prototype designed that allows beginners such as learners and experienced PLC users to connect, program and simulate real-time control processes. PLC trainer is a very useful tool for learning PLC hardware, software and programming yourself [3]. Some of the advantages of PLC over relay control logic are flexibility, higher reliability, communication possibilities, faster response times, and easier troubleshooting [4, 5].

The purpose of this research is to improve students' competence using PLC devices. We present basic PLC automatic operations such as locking and PLC component symbols with descriptions. To train students and people who are interested in the field of automatic control for industrial automation. The stages carried out by this research include designing, wiring, programming PLC using basic logic, downloading and uploading programs to the PLC via USB cable and testing on workstations [6].

With the advancement of research and technology, the programmable logic controller (PLC) is one of the most popular controllers in the manufacturing industry and will remain the leading controller type in the future. PLCs can be classified as digital computers used in various manufacturing industries. This is because of several beneficial advantages offered by PLCs such as cost-effective, flexible, reliable, and others.

PLC programs are usually written via ladder diagrams or other conventional programming methods which can be copied from a workstation (ie: computer or laptop) or even via a PLC handheld console via cable. Compact PLCs have a number of attached connecting terminals for input/output (I/O) connections and can be extended if the controller has insufficient I/O (for future expansion). In addition, the PLC can be reprogrammed to suit industrial needs [7].

The development of the automation and manufacturing industries causes a lot of demand for Programmable Logic Controller (PLC) training for the implementation of factory automation systems. Since the use of PLCs for industrial automation, factory technicians, engineers, and students have a challenge to increase their understanding of the use of PLC systems. The high cost of PLC training and the ever-changing changes and demands of the automation industry, companies and institutions find it difficult to provide the necessary training on PLC [8].

The work readiness of SMK graduates can be assessed from the competence of students, but the competence of students is still far from the expectations required by the industrial world. The reason for the distance of competence from industry needs is because the standards provided by the industry are too far from the competencies of students. Overcoming the differences in competencies required by industry, learning facilities are needed to improve student competencies, one of which is by holding PLC

trainer programming training. Trainers are equipment that is in a laboratory or workshop that is used as a learning medium. Learning media using trainers support the psychomotor abilities of students by learning by doing. The use of trainers with PLC material can be used to train students' competence skills starting from programming, designing, and assembling I/O on PLC trainers.

PLC is an industrial computer consisting mostly of hardware and software used to control a machine or process. PLCs are designed for multiple input/output (I/O) settings, immunity to electrical noise, and resistance to vibration and impact. PLC is an example of an automatic system that works according to the commands given in programming time. PLC devices have been at the heart of industrial automation and control systems since 1968. PLC trainers can help students connect, program, and simulate real-time control processes. Some of the advantages of PLC over relay control logic are flexibility, higher reliability, communication possibilities, faster response times, and easier troubleshooting. PLC programs are written via ladder diagrams or other conventional programming methods which can be copied from software (ie: computer or laptop) or even via the PLC handheld console via cable. Compact PLCs have several attached connecting terminals for input/output (I/O) connections and can be extended if the controller does not have enough I/O (for future expansion). In addition, the PLC can be reprogrammed to suit industrial needs.

Based on the several uses possessed by PLCs used in industry, it is necessary to be accompanied by operators who have the competence to do programming and assembly to handle maintenance on PLC devices. So SMK graduates need to be accustomed to knowing and learning by doing to have the competencies expected by the industry. The trainer is one of the steps that can be used to improve student competence in the field of PLC operation. So that the purpose of the study is to improve student competence after using PLC trainers and determine the feasibility of PLC trainers as learning media to improve the competence of students in class X TEI SMK YKP 1 Magetan.

2 Method

The research method used in this research is development research which refers to the 4D model (four-D model) which consists of 4 stages, namely Define, Design, Develop, and Disseminate. These stages can be seen in the Fig. 1.

At the definition stage, activities focus on analyzing the situation faced by the teacher, student characteristics, and the concepts to be taught. Because At this stage, the terms and conditions will be determined. Requirements for making interactive learning media, namely: by analyzing the objectives and limitations of the material being studied. The design phase aims to design a trainer learning media kit for competency standards for programming control system equipment. The design phase aims to design a learning media kit for control system equipment programming competency standards.

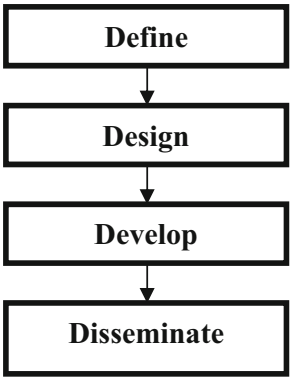

Fig. 1. Research Stage Model 4D.

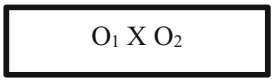

Fig. 2. Research design One Group Pretest Posttest.

This study uses materials in interactive learning media that are used referring to the curriculum used at SMK YKP Magetan on the competency standards for programming electronic control system equipment related to PLC and computer-assisted I/O which includes materials PLC basics, PLC programming technique, and study result test. The research design used to determine the increase in student competence using the One Group Pretest Posttest Design, with a sample of 35 students of class X TEI SMK YKP 1 Mageten [8]. The form of the research design is shown in Fig. 2.

Description:

O_1 = The pretest was conducted to determine the student's initial competence on the basics of PLC

X = Application of PLC trainer learning media to improve student competence in the field of PLC

O_2 = Posttest was carried out to determine the results of student competence after being given learning through learning media in the form of a PLC trainer.

The data collection technique was carried out to determine the increase in student competence using SPSS which was carried out by the t-test with the paired sample t-test technique. There are hypotheses given, namely:

H_1 = There are differences in student competencies after being given PLC trainer learning media to class X TEI students at SMK YKP Magetan

H_0 = There is no difference in student competence after being given PLC trainer learning media to class X TEI students at SMK YKP Magetan

In the feasibility test of learning media using data collection techniques using a questionnaire instrument there are 4 points, namely media design, media material, media evaluation, and media motivation. The criteria for the results of the assessment of the feasibility of learning media using Table 1.

Table 1. Media Eligibility Assessment Results Criteria

Evaluation	Presentation
Very Good	82%–100%
Good	63%–81%
Pretty good	44%–62%
Not Good	25%–43%

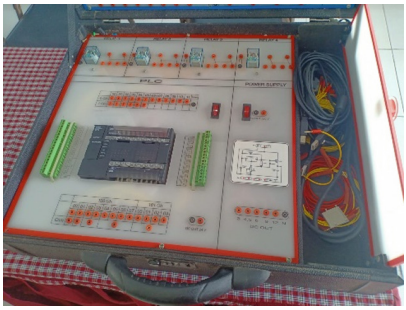

Fig. 3. LayoutTrainer PLC.

3 Results and Discussion

The media trainer used consists of four main components, namely input components, controllers, output components, and HMI. The input components consist of a push button, proximity switch, a tube sensor, and a reed switch. The output component consists of a relay, a DC motor, and a solenoid valve. Terminal blocks are used to place cable connections between input components and input terminals on PLCs and between output components and output terminals on PLCs. The terminal is used with the aim that students can connect input and output components to the PLC terminal using cables and screwdrivers. Trainers given to students can be changed according to their installation according to the commands given to the Ladsim program to control I/O on the trainers used. When the programming has been run according to the given simulation, then the program is uploaded to the trainer who has been strung together between I/O. The following on Fig. 3 is a display of the learning media in the form of a PLC trainer at SMK YKP Magetan.

Trainer programming using ladsim. Ladsim is software used to simulate the Ladder diagram programming language on a PLC (Programmable Logic Controller). Where this software is very suitable for basic training before entering PLC software products that are equipped with hardware to train logic and assemble logic circuits using PLC. The ladder simulator is equipped with a demo version, where in this demo version there is a PLC application in the form of several plants that are suitable for today's industrial needs. So after we make the program then we can simulate our circuit which refers to

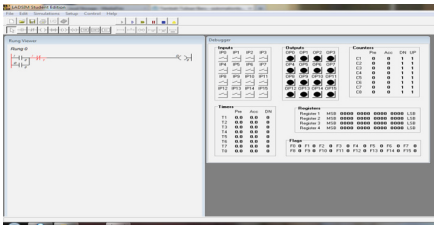

Fig. 4. Layout Software Ladsim.

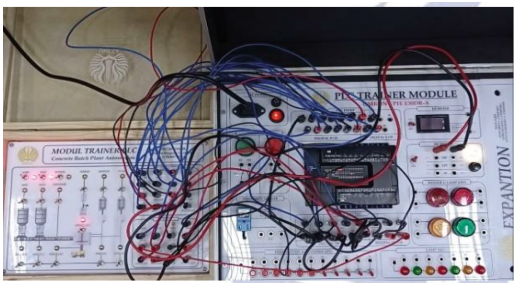

Fig. 5. DesignTrainer PLC.

the simulation in the demo version. If the simulation does not match the simulation in the demo then our logic circuit is wrong.

The available inputs and outputs are 12 pieces, 16 relays, 6 down timers, 6 up/down counters, and 4 register bits each. How to add a network/rung simply by clicking the Add Rung symbol or deleting Del Rung. To create a parallel connection, simply press the Add Branch symbol and navigate to the position we want, while to delete it, click the Del Branch symbol. To insert a rung simply click Insert Rung. The view of the ladsim software (Fig. 4).

Test this product to find out the function of the PLC trainer and the PLC Module can work properly. In CX-Programmer software, a timer circuit is needed as a simulation of the automatic working circuit of an automation system. in the real world, the automation system runs using all the complete functioning components, therefore it is not easy to reach the simulation level, therefore, the field conditions are likened to a timer [9, 10]. While the manual operation aims to signify the semi-automatic control system in the industry to students, which is where the semi-automatic production process is also widely applied in the industrial world. The following is the design and circuit used in the PLC trainer (Figs. 5 and 6).

The results of data collection regarding the pretest and post-test get learning outcomes with an average score of 78.80 for the pretest and 88.29 for the post-test. To find out if there are differences in student competence, the t-test test was carried out with the paired sample t-test technique. There are test requirements before the t-test is carried out, namely testing the normality of the data obtained in the study. The results obtained in the normality test are shown in Table 2.

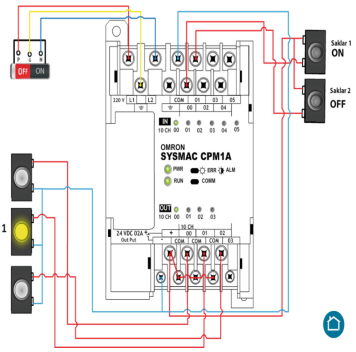

Fig. 6. PLC Circuit in Trainer Kit.

Table 2. Normality Test Results

Class	Data	Sig.	Description
X TEI	Pretest	0,200	Normal
	Posttest	0,200	Normal

Table 3. Test Results Paired Sample t Test

Aspect	Sig.
Student Competence	0,000

The results of the normality test on the pretest and posttest data showed a significance value of 0.200 > 0.05. Because the significance value is greater than 0.05, it is stated that the pretest and posttest data are normally distributed. The test was continued to find out the differences in student competence using the paired sample t-test technique. The results obtained are as in Table 3.

In the results of the paired sample t-test, a significance value of 0.00 was obtained. The basis for decision making is the paired sample t-test if the significance value is smaller than the significance level used, namely 5% (0.05), it is stated that there is a significant difference that occurs. So in this study hypothesis H1 is taken, namely, there are differences in student competencies after being given a PLC trainer.

The results of the student response questionnaire to PLC interactive learning media on competency standards for programming electronic control system equipment related to PLC and computer-assisted I/O in this study will be explained in Table 3. Aspects of this assessment consist of 1) Design of learning media, 2) Material of learning media, 3) Evaluation of learning media, and 4) Motivation of learning media.

Based on the results of the student response questionnaire as shown Fig. 7, several aspects were obtained, namely media design 84.47%, media material 84%, media evaluation 85.29%, and media motivation 84.41%. The results indicated that students'

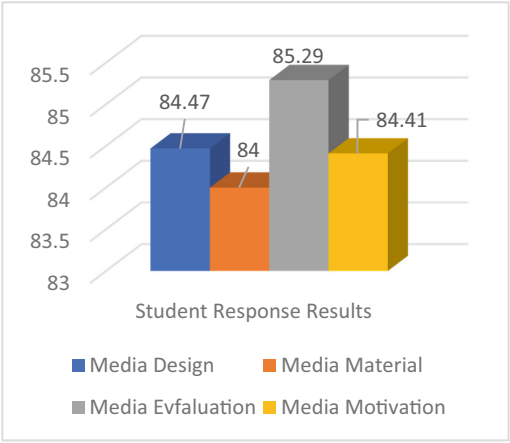

Fig. 7. Student Response Results

responses to the feasibility of learning media in the form of PLC trainers were in the very good category because the student response questionnaire scores were between 81% to 100%.

4 Conclusion

PLC trainers as learning media to improve student competence in terms of eligibility get very good scores because the questionnaire instrument given in 4 aspects contained in the trainers gets scores in the very good category. Based on the test using the paired sample t-test, it got a significance value of 0.00 so it took the H1 hypothesis, namely that there was a significant difference in the competence of class X TEI students at SMK YKP Magetan after being given a PLC trainer as a learning medium. The trainer can be used to continue students' competencies for getting used to the equipment that will be used while in the industrial world.

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