DESIGN OF PLC-BASED ELECTRIC MOTOR CONTROL TRAINER IN COURSES ELECTRIC MACHINERY CONTROL PRACTICE

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Abstract

PLC-based Electric Motor Control is one of the materials in the Electrical Machine Control Practicum course which requires a medium to make it easier for students during practicum. This trainer and practicum module were developed as a tool for teaching lecturers in explaining PLC-based electric motor control material. The PLC trainer in this study used the Zelio PLC module type SR2 B201FU. This study used the research & development method both in the design of the trainers and in the preparation of the PLC practicum modules. The research instrument carried out by the researcher was a media expert and material expert validation sheet to test the feasibility of the trainer to be applied in the Electrical Machine Control Practicum. The questionnaire was used to find out the respondents' responses regarding the importance of using trainers and PLC-based electric motor control practicum modules in the Electrical Machine Control Practicum course. The validation results of media experts and material experts prove that the trainer and PLC-based electric motor control practicum module are very feasible in terms of media and material. Based on the percentage of scores obtained from media experts, namely 91% and material experts obtaining a score of 98%, it is included in the very feasible category to be applied in the Electrical Machine Control Practicum course. The results of student respondents' responses related to the importance of using trainers and PLC modules obtained results of 87% included in the very important category to be applied in practicum.

Keywords: *Design, PLC, Trainer, Electric Motor Control, Practicum Module.*

1. Introduction

Education is a learning of skills, knowledge and habits of a group of people passed down from one generation to the next through a system of teaching, training or research. With the rapid development of technology at this time, various kinds of technologies have sprung up, starting from newly discovered technologies, to previous technological developments. Especially in the field of control of 1-phase and 3-phase electric motor controllers. At present the process in the control system is not only in the form of manual circuits, but many industries already use the PLC (Programmable Logic Controller) system and this control system is also implemented in the Electrical Machine Control Practicum course. PLC-based Electric Motor Control is one of the materials in the Electrical Machine Control Practicum course which requires a medium to make it easier for students during practicum. This trainer and practicum module were developed as a tool for teaching lecturers in explaining PLC-based electric motor control material [1].

Based on the results of initial observations, there were 54.5% of students in the 2019 Electrical Engineering Education Faculty of Tarbiyah and Teacher Training UIN Ar-Raniry Banda Aceh who had attended the Electrical Machine Control Practicum course said that material regarding PLCs was difficult to understand if they did not use a media trainer, while 45.5% said they did not understand at all starting from the delivery of the theory or during the monitoring. Given these problems, this research was made with the aim of designing trainers and compiling PLC-based electric motor control practicum modules and to test the feasibility of trainers as auxiliary media in the Electrical Machine Control Practicum course.

The research method used is the research & development method both in the design of trainers and the preparation of PLC practicum modules. Research and development is a process or research steps that are used to produce certain products as well as test the effectiveness of these products [2].

In designing this trainer using PLC Zelio SR2 B201FU. The wiring path from the PLC is connected directly to the banana port as the output from the PLC port itself. There are 14 ports connected to the PLC port with bananas [3]. The ports in question are L, N, I1 to I6 and Q1 to Q3, each of which has 2 switches. The results of the design can be seen in Figure 2 and Figure 3.

2. Method

This research uses the research and development (R&D) method. The instruments used to collect data in this study are validation sheets and questionnaires. To analyze the data resulting from validation, researchers use (1).[4]

$$\text{Percentage} = \frac{\text{Total Value Total}}{\text{Total Maximum Score}} \text{ X } 100 \qquad (1)$$

The stages used in this study are as follows:

1. Potential Problems

   Based on the results of observations made in the Electrical Machine Control Practicum course, students do not understand clearly about PLCs so that the learning process becomes less effective.

2. Collection of Information

   Trainers designed by researchers aim to help the learning process to be more effective. The tools and materials used are:

   a. PLC Zelio is the main component that will be used as the trainer
   b. Banana Plug Connector as port output.
   c. Test Pen is a tool to determine an electric voltage in a conductor, and as a tool to strengthen PLC port bolts.
   d. Combination pliers as a tool that can hold, grip and twist and cut wires and other objects.
   e. Plus screwdriver equipped with a rubber coated handle or insulator to keep it safe while working.
   f. NYAF cable 0.75 mm as a conductor of voltage and electric current.
   g. Solder and tin to attach the NYAF cable to the banana connector inductor plate.
   h. Plywood measuring 23 x 30 cm as a trainer cover.
   i. 14 mm drill and drill bit.

3. Trainer Design

   Before designing it into a real form, first design a sketch of the trainer using

Microsoft Visio 2016 software. The researcher designed this trainer by placing the Zelio PLC on plywood measuring 23 x 30 cm (the front cover of the trainer) which has been given space to show the PLC screen and buttons as well as banana connectors that are attached to each PLC port with a size of 14mm as output from each port, namely L/N, I1 to I6 and Q1 to Q2 (switch 1 and switch 2) on the PLC. The design of the trainer and its description can be seen in Figure 1 [5].

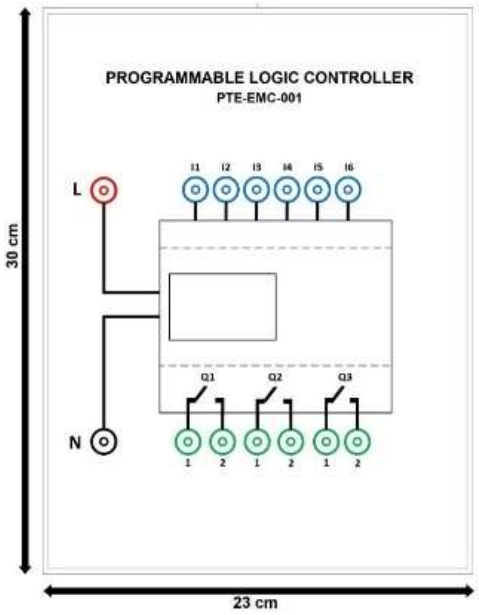

Figure. 1. PLC trainer design.

4. Validation of Trainers

Validation of trainers and practicum modules is carried out by validation of material experts and media experts to see the feasibility of trainers and practicum modules [6].

5. Trial of Trainers

Trials of trainers and practicum modules were carried out by 13 students as respondents in response to the use of trainers and practicum modules.

3. Literature Study

Literature study contains a description of the results of previous research on issues to be studied as an accurate source to guide research writing.

a. Hesti Istiqlaliyah, with the title "Analysis of the Effects of Using a Star Delta System with Manual and PLC Circuits on 3 Phase Electric Motors" in 2017. This research used the Research and Development (R&D) method. The results of his research prove that there are several differences in the use of circuits between PLC systems and manual systems, namely the PLC system is more practical, simple, reliable, easy to program, but quite expensive and more difficult to maintain.
b. Hariyanto, Didik Aribowo and Mohammad Fatkhurrokhman, with the title "Development of 3 Phase Motor Control Kit Trainer Learning Media in Electric Motor Installation Subjects at SMKN 4 Serang City" in 2020. This research used

the Research and Development (R&D) method. The results of his research prove that the effectiveness of the trainer kit learning media for controlling 3-phase motors and electric motor installation jobsheets results in a pre-test value of 56.73 and a post-test value of 87.82, so there is an increase in learning outcomes after using learning media with n-gain obtained 0.73 which fall into the category of "high effectiveness".

4. Result and Discussion

a. Research Results

1). Results of Trainer Design

In designing this trainer using PLC Zelio SR2 B201FU. The wiring path from the PLC is connected directly to the banana port as the output from the PLC port itself. There are 14 ports connected to the PLC port with bananas [7]. The ports in question are L, N, I1 to I6 and Q1 to Q3, each of which has 2 switches. The results of the design can be seen in Figure 2 and Figure 3.

The operation of the PLC trainer requires a guide in the form of a module that contains code and programming methods so that the PLC can carry out commands according to the desired program. Some of the material contained in the PLC practicum module contains material on electric motor control, namely PLC-based Direct On Line starting, PLC-based automatic alternating live load circuits, PLC-based interlocking circuits and PLC-based forward reverse circuits.[4] The practicum module is also equipped with how to install the PLC onto an electric motor, how to operate the PLC to be programmed, and the PLC program code with a ladder diagram language type [8].

Figure 2. Front view of PLC trainer design results.

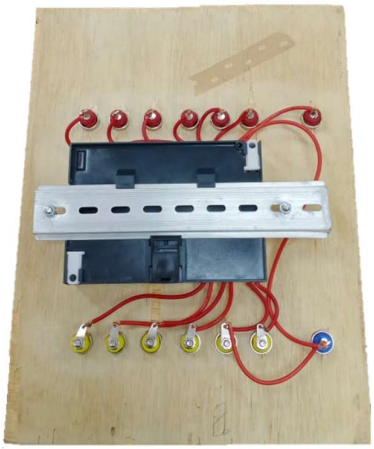

Figure. 3. PLC Wiring Line to Banana port from behind.

2). Results of Validation

The validation results were obtained based on the validation instruments of material experts and media experts which were given to two validators. Based on the results of media validation, the total score is 32 with a maximum value of 35 and the eligibility percentage results are 91% with the category "Very Eligible" for use in the Electrical Machine Control Practicum course.

Based on the results of the material validation, it was obtained that the total score was 44 with a maximum total value of 45 and obtained a feasibility percentage of 98% with the "Very Eligible" category.

3). Results of Trial of Trainers and Practical Modules for PLC-Based Electric Motor Control

Trials were conducted to see responses from respondents on the importance of using trainers and practicum modules. The respondents in the PLC trainer trial and practicum module were students in semester VII who had taken the practicum course on controlling electrical machines in the Electrical Engineering Education Study Program, Faculty of Tarbiyah and Teacher Training, UIN Ar-Raniry Banda Aceh, totaling 13 students. Based on the results of respondents' responses per indicator regarding the importance of using trainers and PLC-based electric motor control practicum modules, a total score of 624 was obtained from 13 respondents with a maximum value of 715 and the percentage value obtained was 87% with the "Very True" category. To be used as one of the materials that can be applied in the Electrical Machine Control Practicum course.

Based on the results of individual respondents' responses regarding the importance of using trainers and PLC-based electric motor control practicum modules in the Electrical Machine Control Practical course, the total score was 624 out of 13 respondents and the maximum total score was 715 with a percentage value of 87% with category "Very True".

b. Discussion

Based on the results of the media validation test, it obtained a percentage value of 91%, while the results of the material validation obtained a percentage value of 98%. So in terms of media and material, the feasibility of the Trainer and the PLC-Based

Electric Motor Control Practicum Module received the "Very Eligible" category to be applied to the Electrical Machine Control Practicum Course. The graph can be seen from Figure 4.

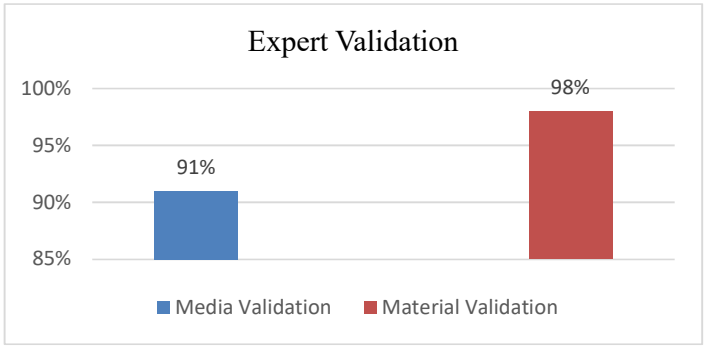

Figure. 4. Graph of Media Expert and Material Expert Validation Results.

From the results of the respondents' responses which had been processed by the researchers, they obtained different percentage results for each indicator. If you look more closely, the time efficiency indicator is at a lower percentage level of 85% compared to the material presentation indicator of 87%, learning outcomes of 88%, and benefits of 88%. The graph can be seen from Figure 5.

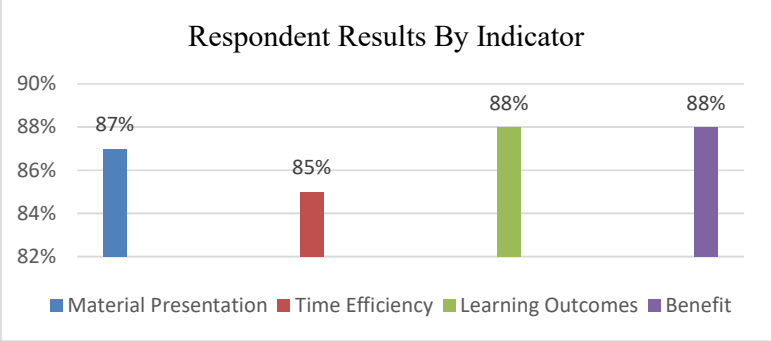

Figure. 5. Graph of Respondent Results by Indicator.

Media validation results give a value with a total score obtained is 32 with a maximum total score of 35 and obtains a feasibility percentage of 91% based on the calculation formula. the category of trainer eligibility percentage level indicates that the PLC trainer gets the “Very Eligible” category for use in the Electrical Machine Control Practicum Course. For details of validation can be seen in table 1.

TABLE 1 MEDIA VALIDATION TEST RESULTS

Indicator	Statement item	Value Criteria
General View	Statement 1	4
	Statement 2	4
	Statement 3	5
Practical	Statement 4	5
	Statement 5	5

Quality	Statement 6	4
	Statement 7	5
	Total Score	32
	Percentage	91%

The results of the material validation the validator gives a value with a total score obtained is 44 with a maximum total value of 45 obtaining a feasibility percentage of 98% based on the calculation formula. then the results of the material validation test showed that the trainer and the PLC-based electric motor control practicum module received the "Very Eligible" category to be applied to the Electrical Machine Control Practicum course. For details of validation can be seen in table 2.

TABLE 2 MATERIAL VALIDATION TEST RESULTS

Indicator	Statement item	Value Criteria
Material	Statement 1	5
	Statement 2	4
	Statement 3	5
Time	Statement 4	5
Purpose	Statement 5	5
	Statement 6	5
	Statement 7	5
Benefit	Statement 8	5
	Statement 9	5
	Total Score	44
	Percentage	98%

The results of respondents' responses based on indicators related to the importance of using trainers and PLC-based electric motor control practicum modules obtained a total score of 624 out of 13 respondents with a maximum value of 715 and the percentage value obtained was 87% and was in the "Very important" category to be used as one of the material and applied when the practicum course is carried out. For details of the responses can be seen in table 3.

TABLE 3 RESPONDENT RESULTS BY INDICATOR

Indicator	Item Number	Value Criteria					Total	Percentage by Item	Percentage by Indicator
		1	2	3	4	5			
Material Presentation	1	0	0	0	7	6	58	89%	87%
	2	0	0	1	8	4	55	85%	
Time Efficiency	3	0	0	1	8	4	55	85%	85%
	4	0	0	0	9	4	56	86%	
Purpose	5	0	0	1	5	7	58	89%	88%
	6	0	0	1	8	4	55	85%	
	7	0	0	1	3	9	69	92%	
	8	0	0	2	6	5	55	85%	
Benefit	9	0	0	0	8	5	57	88%	88%
	10	0	0	2	5	6	56	86%	
	11	0	0	0	6	7	59	91%	
Total Score and Total Percentage							624		87%

The results of individual respondents' responses also obtained the same results as the calculation results and the total score obtained was 624 out of 13 respondents and the maximum total score was 715 with a percentage value of 87% and was in the

"Very Important" category. For individual details can be seen in table 4

TABLE 4 RESPONDENT RESULTS BY INDIVIDUAL

Name	Total Value Criteria	Percentage
Respondent 1	48	87%
Respondent 2	43	78%
Respondent 3	44	80%
Respondent 4	50	91%
Respondent 5	44	80%
Respondent 6	52	95%
Respondent 7	52	95%
Respondent 8	52	95%
Respondent 9	46	84%
Respondent 10	49	89%
Respondent 11	46	84%
Respondent 12	46	84%
Respondent 13	52	95%
Total Score and Total Percentage	624	87%

5. Conclusion

This study aims to produce modules and trainers that can assist the learning process. The validation results of media experts obtained a percentage of 91% and material experts obtained a percentage of 98%. Based on the results of the validation by media experts and material experts, it was shown that the PLC trainer and practicum module were "Very Eligible" applied to the Electrical Machine Control Practicum course.

The results of the respondents' responses from 13 students obtained a percentage of all indicators of 87%, so the respondents' responses stated that the PLC trainer and practicum module were "Very important" to be used in the Electrical Machine Control Practicum course.

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