PLC Automatic Control Module Development Using ADDIE Models

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Abstract. The modern industrial era, commonly known as the 4.0 has encouraged the industry to utilize advanced technology to meet the needs of companies such as Programmable Logic Controller (PLC). To produce graduates as expected, learning media must also have reliability in supporting the learning process. The purpose of this research is to develop a learning module for automatic control using PLC. The design of this study is based on research and development methodology (RnD). Then the product is verified by experts and after revising the product it is tested on students to get the best product. The ADDIE model was used in the product development process of this study. The instrument used in this study was a media feasibility assessment form for validators that involved media experts and material experts. a simple qualitative descriptive is used for data analysis technique.

Keywords: ADDIE, Module, Control, Automatic, PLC.

1 Introduction

The modern industrial era 4.0 encourages many industries to use automatic machines and equipment that are effective and efficient. Many industries utilize advanced technology to meet company needs such as control system needs, worker safety, security and product quality. For industry, the use of technology can make work easier and increase production results, because the machines or automatic tools used are able to work effectively and efficiently. One of the automatic control device technologies that is widely used in industry is the Programmable Logic Controller (PLC)[1].

The development of PLC-based control technology has become increasingly widespread in all industrial sectors today. So one of the industrial job markets in the industrial revolution 4.0 era is mastering PLC-based industrial control technology that is connected to a web-based network or HMI (Human Machine Interface). In fact, this industrial control technology is not only applied in the production process industry, but in all sectors such as smart homes, control and monitoring of traffic activities, control and monitoring of electrical energy use, and other controls. The importance of the ability to master PLC-based control technology in the

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industrial world is so great that higher education institutions must create graduates with the competency to master PLC technology[2].

The Programmable Logic Controller is a central control unit for an industry or a production process. If it is programmed correctly, efficient operation and safety aspects of the process can be met. This technical article provides a quick comparison of current automation systems and past technologies to understand and explore the potential of PLCs in any process. Previously, smart relay and Relay Logic Controller was used in a traditional manner, requiring human intervention and error. However, with the advantage and use of microprocessor or microcontrollers, as well as new specific tools like PLC, SCADA and DCS, precision, accuracy and productivity have increased. These automatic systems can increase flexibility in the control of the process and reduce human intervention[3].

As the demand for automation increases, the control system must be easy to program, executable, reliable, resilient and cost-effective. This technical paper reviews the application of PLC in the current market. We will also look at the applications of the PLC in control engineering studies, energy research and industrial control applications as well as monitoring of plants. Although the PLC has its limitations, we believe that it has more benefits than limitations[4].

The entire automation revolution makes The Programmable Logical Controller (PLC) has been the backbone of industrial control systems, where the low level regulatory feedback loops has primarily been controled by the PLC. Despite recent advancements in automation technology through the Industry 4.0 (hyperconnected ecosystem) paradigm, PLCs still lack modern versions that focus on the functionality needed for industry revolution 4.0 focused in automatic control systems. A new PLC for industry revolution 4.0 was create an IoT-PLC in designed and prototyped product. IoT PLCs function as containerized devices where all functionality is packaged into containers. It features regulatory control capabilities as well as fog computing capabilities (filtering and field data storage) and multiple radio interfaces that can be independently managed. Additionally, IoT-PLC uses virtual device models as an abstraction method to represent real-world entities, allowing IoT-PLC apps to transparently and easily interact with upper cloud layers. The live migration feature allows you to reconfigure loops without restarting the controller, giving you more flexibility[5].

The German Government has launched Industry 4.0 as a high-level technology strategy to maintain Germany's position as a world market leader in the manufacturing sector, while at the same time addressing challenges in the energy and aging sectors. Germany proposed an Industry 4.0 reference architecture model based on regulations published by the IEC. Achieving Industry 4.0 can be achieved through the digitalization of factories. By standardizing the factory environment and improving the operating environment for human-machine interaction, manufacturing productivity and quality can be significantly improved. PLCs allow you to analyze intelligent platforms while meeting Industry 4.0 standards[6].

There were repetitive tasks in every process industry. Therefore, we are integrating an automation system into a industrial process in order to increase productivity in a short period of time with less chance of error. Traditional methods of filling various types of liquid in a fixed percentage in various containers or bottles require manual processes. In the current trends of an automation systems, such as Industry Revolution 4.0, manual processes are being replaced by fully or semi-automated reconfigurable processes by incorporating advanced

technologies. This manual process will reduces production rate and product consistency in some cases because of error and human intervention[7].

Industrial Automation (IA) significantly reduces human senses, human labor and costs. In line with the fast development of control systems, automation and sensors technologies, many control systems like PLC and SCADA are playing an important role in automation of industries using hardware and software tools. This paper will focus on automation of industrial system using a few tools like PLC, LAB VIEW, internet and etc. This proposed system implemented the control method using PLC. The system can maintain water levels and temperatures in four different tanks by automatically controlling the on/off switch of a connected heating mixer. This system provides a more convenient and efficient solution for manufacturing industries to move from manual to automatic[8].

The development of industrial science and technology is currently experiencing very rapid progress, for this reason it is necessary to require professional experts in their fields. On the other hand, this is a challenge to always improve the capabilities of human resources (HR), so that they can become reliable and competitive resources. The increasingly rapid development of technology causes industries to compete to improve the quality of the products or services produced[9].

Industry is one of the stakeholders for Electrical Engineering undergraduates, Faculty of Engineering, Medan State University. Based on observations made on students from the Electrical Engineering Bachelor's study program, Faculty of Engineering, Medan State University who have completed industrial practical work, many students do not understand the use of PLC technology in the industrial world. Students are not permitted to practice or take part in work in this section. This will certainly reduce the interest of the industrial world in providing job opportunities for graduates of Electrical Engineering degrees[10].

To produce graduates as expected, of course learning facilities other than presentation are also adequate in the learning process. Due to the very expensive price per PLC unit, the ratio of adequacy between practicum equipment and the number of students participating in practicum is felt to be very low [2]. So learning support media are needed that are more practical, low cost and effective. Therefore, the development and use of learning media is urgently needed. Electrical engineering study program students must have practical skills through learning experiences during their education[11].

Media is a component that carries messages or news between the communicator and the communicant. This means that the media is a relationship between two parties who want to convey information. So learning is a link in conveying messages between lecturers and students[12]. PLC module for learning media can make it easy for students to learn about developments in control technology in industry. With this learning media, students can carry out simulations, so that the theories and concepts that have been obtained through lecturers can be understood well. The PLC Trainer is a simulator module that is capable of simulating the work system of a system's work process[10].

When learning theoretical content, some students are not very active in group discussions and class discussions, and students' ability to organize and conduct experiments is also not very creative[13]. Nor the student will be able to apply the functionality of PLC to industrial equipments. Students' analytical skills regarding PLC topics and automatic control systems are

also not optimal yet. Therefore, the learning outcomes are still unsatisfactory due to the low ability of students to apply the learned theory to the industry in real situations.

Because of the issues raised, some efforts can be made to increase the effectiveness of the learning process through the use of innovative modules and interesting teaching materials. A good module will be packaged in a thematically appealing way and include images, instructions, illustrations, case studies or situational cases, and sufficient laboratory equipment to support the course learning outcomes. Therefore, it is necessary to develop an automatic control learning module using PLC to improve students' theoretical and practical skills.

2 Method

Learning modules function as tools or media to facilitate the transfer and distribution of material from educators to students. Learning media that is complete, systematic, clear, interesting and appropriate will facilitate the acceptance of the learning material given to students. If students easily accept and master the material provided, then learning objectives will be achieved optimally so as to produce students who have high creativity[15].

The study used research and development (RnD) design. Research to create or develop product designs. The product is tested, revised and then verified by experts and got trial tested on students. Several development methods are proposed by multiple experts. One of these is the research and development method which is proposed by Mr. Sugiyono. Based on Sugiyono's theory, the steps to manufacture a product include potential and problem phases, data collection, product design, design validation, product design modification, product testing, product modification, application trials, and product Includes modifications and mass production[16].

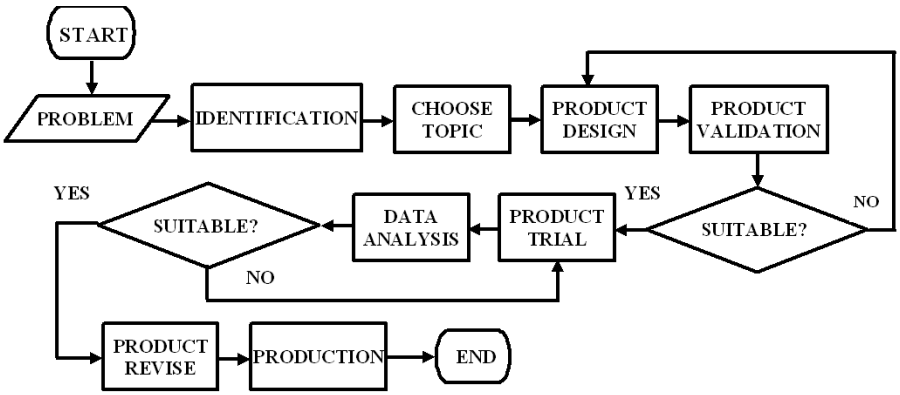

Fig. 2. Research Flowchart

The learning device development procedure used in this research was adapted from ADDIE model which is developed by Dick and Carry. There are ADDIE model consists of Analysis, Design, Development, Implementation, and Evaluation[17]. This model is selected based on the theoretical foundations of learning design and based on the consideration that this model has been developed systematically. The stages of the ADDIE model can be seen in Figure 3.

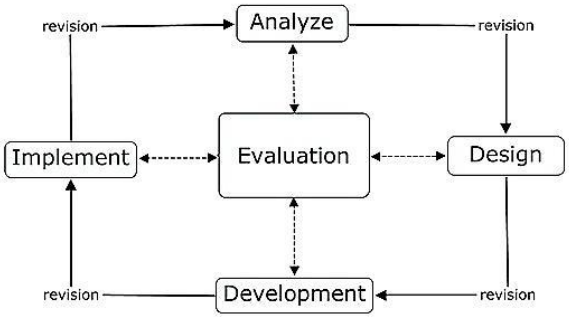

Fig. 3. ADDIE model development step

3 Results and Discussion

This research produces a PLC learning module to support the competencies that students must achieve in course learning outcomes. The resulting PLC learning module contains Introductory PLC Theory, PLC OMRON, CX Programmer Software, PLC Programming, AND and OR Logic Control, Sequential and Latching Control, Timer, Counter, Differential Up and Down, Shift Register, Add and Subtract, Data Communication and Human Machine Interface. To support the learning module that has been developed, a PLC control trainer is needed that is appropriate to the learning material. This research uses a PLC control trainer available at the Electrical Power Network and Installation Laboratory. The PLC control trainer used can be seen in Figure 4.

Fig. 4. Programmable Logic Controller Panel

In this research, data collection was carried out by providing media suitability assessment instruments and learning material suitability assessment instruments. The assessment was given by four media experts and four material experts. This assessment aims to validate and

test the feasibility of the learning modules that have been developed. Apart from that, the data collected is an assessment of the feasibility of the learning module from users, namely students. Data collection from students is carried out by providing instruments for assessing the suitability of learning media and learning materials. User assessments were carried out by twenty students who took the Automatic Control and PLC course. The results of data collection can be seen in table 1, table 2 and table 3.

Table 1. Media Expert Validation Results

No	Instrument	Media Experts				Average	Percentage (%)	Category
		I	II	III	IV			
1	Graphic Eligibility	4	5	4	5	4,5	90%	Very Eligible
2	Safety Eligibility	5	5	4	4	4,5	90%	Very Eligible
3	Language Eligibility	5	4	5	5	4,75	95%	Very Eligible
4	Pedagogy Eligibility	5	5	5	5	5	100%	Very Eligible

Tabel 2. Material Expert Validation Results

No	Instrument	Material Experts				Average	Percentage (%)	Category
		I	II	III	IV			
1	Content Eligibility	5	5	5	4	4,75	95%	Very Eligible
2	Serving Eligibility	4	5	4	5	4,5	90%	Very Eligible
3	Language Eligibility	5	5	5	4	4,75	95%	Very Eligible
4	Contextual Assessment	5	4	5	5	4,75	95%	Very Eligible

Table 3. User trials results

Users	Indicators						
	Material	Information	Pedagogy	Learnability	Design	Robustness	Affective
1	92	89	88	91	92	88	92
2	89	93	95	88	95	89	93
3	88	86	94	93	87	93	90
4	88	87	93	91	88	87	92
5	92	90	93	88	93	95	91
6	95	95	92	89	88	93	88
7	93	95	90	91	90	90	90
8	88	93	86	93	88	87	87
9	93	95	86	88	92	92	86
10	86	87	87	90	90	93	93
Average	90	91	90	90	90	91	90

The result of this research is an automatic control learning module using a PLC. The result of learning module has been assessed by four learning media experts and four learning material experts. Based on the assessment results of four learning media experts, it can be concluded that the PLC automatic control learning module is very suitable for use as supporting media in the learning process. Based on the assessment results of four material experts in the field of electrical engineering, it can be concluded that the material in the PLC automatic control learning module is very appropriate and in accordance with the learning outcomes of the course. Based on assessments from experts, it can be concluded that the learning module

developed is very feasible and suitable for implementation in the learning process for industrial automatic control courses.

Data from the validation assessment from four media experts is shown in table 1. The results obtained were an average pecentage score of 94% in the very feasible category. This shows that the learning modules developed can be used in the learning process to achieve course learning objectives through learning media. Based on data from the validation assessment results from four material experts, it is shown in table 2. The results obtained were an average percentage score of 94% in the very feasible category. The results of this assessment show that the learning material in the automatic control module using a PLC is very suitable and can be applied to the industrial automatic control learning process.

Next, a trial of the automatic control module using a PLC was carried out on twenty students who taught industrial automatic control courses. The student assessment results data after testing the automatic control learning module using a PLC is shown in table 3. Based on the student assessment results data, an average score of 90 was obtained. These results indicate that the learning module developed is very feasible and can help students understand the learning material.

4 Conclusion

Based on research data, the automatic control learning module using a PLC is in the very feasible category. The results of the learning media expert assessment and material expert assessment show that the product developed can be applied to the learning process to support learning outcomes in industrial automatic control courses. Based on the results of trials using the automatic control learning module using PLC on students, an average score of 90 was obtained which shows that the learning module developed is very suitable and can support the student learning process in industrial automatic control courses.

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