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The Effectiveness of Outseal Programmable Logic Controller-based Training Kit to Improve Vocational High School Students' Control System Skills

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ABSTRAK

Permasalahan dalam penelitian ini adalah masih banyaknya siswa yang belum menguasai keterampilan sistem kendali berbasis PLC sesuai dengan tujuan pembelajaran. Hal ini dikarenakan media pembelajaran yang digunakan hanya berupa simulasi dengan menggunakan tombol dan lampu pilot tanpa menggunakan komponen aslinya. Tujuan dari penelitian ini adalah untuk mengkaji dan mengungkap keefektifan training kit PLC *berbasis* PLC outseal *dalam meningkatkan keterampilan praktik siswa pada sistem kendali berbasis PLC. Metodologi penelitian yang digunakan dalam penelitian ini adalah* pre-experiment one group pre-test and post-test, *dengan sampel penelitian sebanyak 32 siswa SMK jurusan teknik instalasi tenaga listrik. Data penelitian dikumpulkan dengan menggunakan kuesioner penilaian keterampilan dan dianalisis dengan teknik analisis* paired sample t-test *dan* effect size test. *Hasil penelitian menunjukkan bahwa nilai t-hitung yang diperoleh sebesar 7,915 dengan signifikansi 0,000 dan nilai d = 1,701. Hasil tersebut menunjukkan adanya perbedaan keterampilan siswa setelah dan sebelum menggunakan training kit yang diterapkan dan terbukti dapat meningkatkan keterampilan siswa secara signifikan. Dengan demikian, terbukti bahwa training kit ini efektif meningkatkan keterampilan siswa SMK. Berdasarkan hasil penelitian ini, diharapkan SMK dapat menerapkan training kit ini untuk memudahkan pembelajaran dan meningkatkan keterampilan siswa dalam penerapan sistem kendali berbasis PLC.*

ABSTRACT

The problem in this study is that many students still have not mastered the skills of PLC-based control systems in accordance with the learning objectives. This is because the learning media is only a simulation using buttons and pilot lights without using the original components. The aims of this study is to examine and reveal the effectiveness of the outseal PLC-based PLC training kit in improving students' practical skills in PLC-based control systems. Pre-experiment one group pre-test and post-test is the research methodology used in this study, with a research sample of 32 students from the electrical power installation engineering department vocational school. The research data were collected using a skill assessment questionnaire and analyzed using paired sample t-test analysis technique and effect size test. The results revealed that the t-value obtained was 7.915 with a significance of 0.000 and a value of d = 1.701. These results show differences in students' skills after and before using the training kit that is applied and proven to improve student skills significantly. Thus, it is proven that this training kit effectively improves vocational students' skills. Based on these results, vocational high schools are expected to apply this training kit to facilitate learning and improve students' PLC-based control system skills.

1. INTRODUCTION

The development of Industry 4.0 has brought enormous changes in manufacturing, one of which is making production machines that can work automatically and independently. To create systems like this in the industry, a programmable logic controller (PLC)- based control system is used to create machine logic algorithms that can work automatically (Alshammari, 2023; Anthwal et al., 2024). PLC plays a significant role in industrial machine automation, making machines work more precisely, efficiently, and flexibly for

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various production processes. Along with technology development today, PLCs are used as essential logic processors in machines and integrated with advanced technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and big data cloud computing. This integration allows data collection and analysis in real time and can accelerate responses to changes in operational conditions (Jie & Jiahui, 2023; Samigulina & Samigulina, 2023). In addition, PLC-based control systems can create communication lines between production machines in the industry to produce a more synchronized and well-coordinated production system. Thus, the application of PLC to control machines plays a significant role in increasing productivity and industrial flexibility (Haleem et al., 2024; Iyer et al., 2024). This change not only increases company productivity competitiveness but also prepares the industry for more adaptive and innovative technological developments.

Along with this technological advancement, the industry is also looking for experts in the field of PLC-based industrial control systems to develop industrial machines owned by a company. However, at this time, the industry still has difficulty finding workers who are experts in industrial-based control systems. So, for every problem in the industry, the company always hires a consultant to fix it, thus adding to the more significant operational costs (Cheong et al., 2023; Mo et al., 2023; Salkic et al., 2022). Thus, industry today needs skilled labor in the field of PLC-based industrial control systems. Currently, there are also agencies that aim to prepare a workforce of experts in this field, one of which is a vocational high school. As explained by previous study vocational schools aim to improve students' intelligence, knowledge, moral character, disposition, and skills to equip them with the necessary skills to live independently and pursue careers in their fields (Choi, 2021; Zeng et al., 2022). In-depth vocational high school also prepares students with good communication skills and a strong work ethic, indispensable in the current era of industrial development 4.0 (Cahuc & Hervelin, 2024). One of the departments in a vocational high school that produces skilled workers in the field of PLC-based control systems is the Department of Electrical Power Installation Engineering (EPIE). This has been emphasized in the EPIE department curriculum, where one of the competencies of graduates is being an expert in the field of PLC-based control systems.

The achievement of competencies that students must master is inseparable from the effectiveness of learning carried out by students. One of the things that significantly affects the effectiveness of learning applied in vocational high schools is the technology/learning media used during the learning process. Because vocational high schools majoring in EPIE are always related to the technology used by industry, the learning process should use the same technology used by industry to create meaningful learning for students and students master skills according to industry needs (Aswardi et al., 2023). However, not all vocational high schools can make learning more meaningful and meet industry needs. This is based on the problem of limited competence possessed by educators of the latest technology used by industry. In addition, the problem of limited practicum equipment and learning technology is an obstacle that vocational high schools often face (Artiyasa et al., 2020; Puput Wanarti Rusimamto et al., 2021). This problem is also experienced by SMK Negeri 1 Padang in the EPIE department. Based on observations made at SMK Negeri 1 Padang, many students still have not thoroughly mastered PLC-based control system skills. This is because the learning is still a simulation of an industrial-based control system, which only uses button components as control system inputs and lam pilots as control system outputs (indicators). In learning PLC-based control systems, students must be able to use sensors, buttons, and other components widely used in PLC-based control systems in industry. Both components control the industry's electrical machines, electro-pneumatic controls, and automatic lighting systems.

Meanwhile, so far, the learning has only been carried out in the form of simulators, so the competence of current graduates is still not by the established curriculum standards. The impact concluded at this time is that students cannot operate PLC-based control system components such as sensors, contactors, and relays, which are widely used to operate machines in industry today. Therefore, this problem must be addressed firmly by educators because it will impact the lack of relevance of competencies mastered by students to industry needs and reduce the skills of graduates of students majoring in electrical power installation engineering in the field of PLC-based control systems. As stated by previous study learning objectives will be achieved correctly and according to competence if the work carries out learning in the industry (Abdullah et al., 2021).

To overcome this problem, innovative learning media are needed through the development of industrial technology and make students directly involved in the learning process so that the skills acquired by students are more attached (Prasetyo, 2021; Pratama et al., 2022). Learning media that can involve students directly in the learning process is a training kit. Thus, this research applies a PLC training kit based on outseal PLC to the learning process. This training kit is a learning media that involves students directly in making PLC-based control systems. So, this study aims to determine the effectiveness of the PLC training kit based on outseal PLC in improving students' PLC-based control system skills. Outseal PLC is used as the PLC in this training kit and does not use ordinary PLCs with well-known brands such as Omron, Siemens, Mitsubishi, or Schneider because teachers themselves cannot make them; schools must buy them directly. Unlike the outseal PLC, the advantage is that the hardware is open source, meaning that educators can make it themselves (Artiyasa et al., 2020; Risfendra et al., 2020). The main component uses Arduino, and the supporting components are optocouplers, transistors, regulator ICs, capacitors, and resistors that are easily found on the market. Because of these advantages, Outseal PLC is the latest technology educators can use in the learning process of PLC-based control systems.

This research is also based on previous research, which states that PLC training kits can improve student learning outcomes regarding student knowledge (Artiyasa et al., 2020). The training kit he developed is a simulation of buttons and pilot lights that have not been integrated with other components, such as sensors and contactors. The PLC he uses in making training kits is a commonly used PLC, namely Omron PLC, which has the disadvantage that it cannot be made by educators themselves. Research conducted by other study developed a PLC training kit using an outseal PLC (Risfendra et al., 2023). However, their research only examined the practicality and validity of the PLC training kit without revealing its impact on students' knowledge or skills. More specific research was conducted by other study which revealed that implementing PLC training kits in the learning process can improve students' PLC programming skills (P.W. Rusimamto et al., 2023). Based on previous research, there is still no research examining how the effect of PLC training kits on improving the practical skills of vocational students' PLC-based control systems. So, the novelty of this study is the application of an outseal PLC-based training kit that is integrated with more control system components such as contactor sensors and other supporting components. The aims of this study is to examine and reveal the effectiveness of the outseal PLC-based PLC training kit in improving students' practical skills in PLC-based control systems. This will be a new finding, as well as the impact of using an outseal PLC-based PLC training kit on students' practical skills.

2. METHOD

The research methodology used is a pre-experimental study using a one-group pre-test and post-test strategy. By using this method, pre-experiment research involves only one class, namely the experimental class, and does not involve a comparison or control group class. Only the baseline and final tests of the experimental class were used to collect research data (Setyawan et al., 2024). The pre-experiment research steps used are shown in Figure 1.

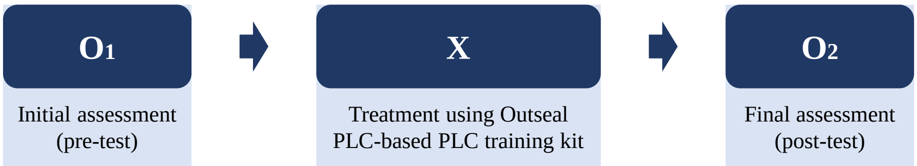

Figure 1. Pre-Experiment Research Design with One Group Pre-Test and Post-Test Approach

Figure 1 shows that the O_1 variable is an initial assessment using an outseal PLC-based PLC training kit before learning. The next stage is to complete treatment (X), namely applying the PLC training kit based on the PLC outseal in the learning process of PLC-based control systems. This treatment was carried out for six meetings in learning PLC-based control systems. After these six meetings, a final assessment was conducted to determine the students' PLC-based control system skills after using the PLC training kit based on the PLC outseal. This assessment is called the post-test assessment (O_2) (Aswardi et al., 2023). The research sample used in this study was 32 class XII students majoring in electrical power installation engineering who were studying PLC-based control systems at SMK Negeri 1 Padang. All students were involved in testing the effectiveness of the Outseal PLC-based PLC training kit to improve students' control system skills. A total of 32 students were included in the experimental class and given treatment using the Outseal PLC-based PLC training kit in control system learning in order to determine changes in PLC-based control system skills that students have mastered.

PLC-based control system learning is learning that trains students' skills in using PLC to control machines in the industry. Therefore, the use of PLC is so extensive that there is no standardised instrument used to measure students' skills in using PLC as a control system. Therefore, in this study, the instrument used is a questionnaire, which is compiled based on the learning outcomes of PLC-based control systems in the Department of Electrical Power Installation Engineering at vocational high schools. The statement items in the questionnaire will be assessed using a Likert scale, which has five scoring options. This instrument will be used in research to gain a thorough understanding of how much the Outseal PLC-based PLC training kit can improve the PLC-based control system skills of students majoring in electrical power installation engineering at vocational high schools. Table 1 show the lattice of instruments used to assess students' PLC-based control system skills.

Table 1. PLC-Based Control System Skill Assessment Questionnaire Grid

No	Skill Aspect		Assessment Indicator	R-value
1.	Work preparation	1.	Students can prepare the tools and materials needed to create a PLC-based control system.	0.947
		2.	Students can prepare the wiring diagram of the PLC control installation.	0.901
		3.	Students can make PLC programme design correctly either in the form of flowcharts/time diagrams/in the form of words.	0.744
2.	PLC Input Device Installation	4.	Students can select the input components used to create a PLC-based control system in accordance with its purpose.	0.887
		5.	Students can read the wiring diagram of the PLC input installation.	0.824
		6.	Students can connect the button input device to the PLC correctly.	0.928
		7.	Students can connect the proximity sensor input device to the PLC correctly.	0.904
3.	PLC Output Device Installation	8.	Students can select the output components used to make PLC-based control systems in accordance with their objectives.	0.936
		9.	Students can read the wiring diagram of the PLC output installation.	0.754
		10.	Students can connect DC and AC output components to the PLC correctly (pilot lamp/solenoid/contactor).	0.900
4.	PLC Programming	11.	Students can communicate PLC with a computer/laptop.	0.955
		12.	Students can create a basic PLC logic programme (AND, OR, NOT) correctly.	0.803
		13.	Students can implement a timer and counter instructions in PLC programming.	0.900
		14.	Students can create PLC ladder programmes according to the work instructions given.	0.888
		15	Students can transfer the ladder programme from the computer to PLC.	0.766
5.	Commissioning of PLC Control System	16.	Students can complete the PLC-based control system project according to the time given.	0.888
		17.	Students can operate the PLC-based control system according to its function.	0.907
		18	The PLC-based control system made by students can work according to its function.	0.832
		19.	Students are able to correct errors that arise when testing PLC-based control systems.	0.858

This study's student performance assessment instrument also underwent validity and reliability tests. The validity test aims to determine whether student skills can be assessed using the student performance assessment instrument. At the same time, reliability testing aims to determine the consistency of the instruments used to assess students' industrial control system skills. Validity testing uses the Pearson moment product correlation equation with 32 students as respondents. The calculation results are shown in Table 1, which shows that the R-value obtained on all assessment items is greater than the R-table value (0.349). So, the performance assessment instrument is valid for assessing students' industrial control system skills. Furthermore, reliability testing is carried out using the Cronbach's Alpha equation. The Cronbach's Alpha value obtained is 0.979, which means that the performance assessment instrument consistently assesses students' industrial control system skills (Alqahtani & Alsalem, 2023; Candra et al., 2023). Based on the results of these two tests, the student performance assessment instrument can be used to assess students' industrial control system skills validly and consistently.

This study used parametric data analysis techniques to analyze the data. The experimental class used as the research subject provided two sets of data: pre-test and post-test. Therefore, both data sets must undergo a prerequisite, namely the data normality test. The prerequisite test used was only the normality test because the class used in the study was only one class, namely the experimental class, so the data homogeneity test was not carried out. The data normality analysis technique uses the Kolmogorov-Smirnov Z data analysis technique. After verifying that the pre-test and post-test data are normal, the data will be analyzed using paired sample t-test and effect size analysis techniques. The paired sample t-test data analysis technique is used to determine the difference in student PLC-based control system skills before and after using the Outseal PLC-based PLC training kit. The effect size data analysis technique is used to determine the extent of the impact of the Outseal PLC-based PLC training kit to improve students' PLC-based control system skills (Aswardi et al., 2023; Sukardi et al., 2020). Based on Cohen's d theory, the effect size results will be divided into three categories to determine the impact criteria of the effect size calculation, as shown in Table 2.

Table 2. Effect Size Criteria Cohen's d

No	Effect Size Value	Criteria
1	$0.8 \leq d \leq 2.0$	Big
2	$0.5 \leq d < 0.8$	Medium
3	$0.2 \leq d < 0.5$	Small

3. RESULT AND DISCUSSION

Result

This research applies the Outseal PLC-based PLC training kit to help students improve their PLC-based control system skills. Outseal PLC-based PLC training kit is made to give students hands-on experience in using PLC as a control system in the industry. The primary purpose of this kit is to help students become more proficient in making PLC-based control systems, which is very important for students to master in the development of industrial control. Students can investigate and practice various PLC functions with the Outseal PLC-based PLC training kit, such as programming, setting control parameters, manipulating buttons and controls, and decomposing PLC-based electric motor control systems. Because contractors for 3-phase induction motor control are included in this training kit, the Outseal PLC-based PLC training kit is integrated with other control system components, such as limit switch sensors, push buttons, contactors, thermal overload relays, MCB (miniature circuit breaker), and pilot lights, so that the skills obtained by students are by the learning objectives of PLC-based control systems. The Outseal PLC-based PLC training kit teaches students how to effectively integrate PLC control with these components to develop a comprehensive PLC-based control system. Figure 2 shows the appearance of the Outseal PLC-based PLC training kit applied in learning PLC-based control systems.

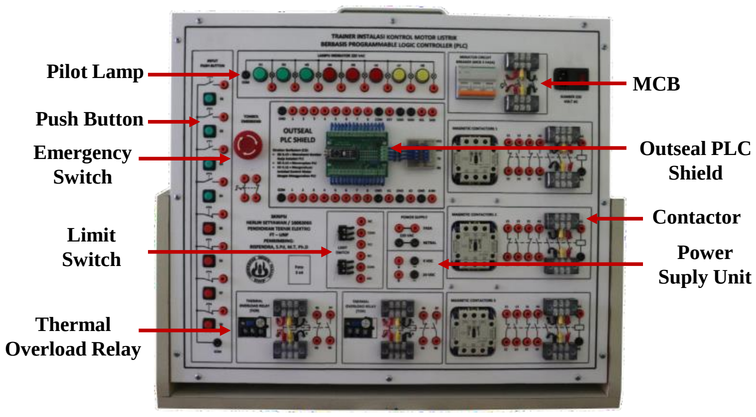

Figure 2. PLC Training Kit Based On Outseal PLC

In To assess the extent of the improvement of students' PLC-based control system skills, two data types were taken in this study: pre-test value data and student post-test data. Students' pre-test scores were taken before applying the Outseal PLC-based PLC training kit, and post-test scores were taken after applying the Outseal PLC-based PLC training kit in the PLC-based control system learning process. The pre-test and post-test data need to be checked for data normalcy before being processed. Table 3 displays the test findings.

Table 3. Effect Size Criteria Cohen's d

Deskripsi		**Pre-test**	**Post-test**
N		32	32
Normal Parameters[a,b]	Mean	60.500	81.688
	Std. Deviation	12.454	10.117
Most Extreme Differences	Absolute	0.078	0.067
	Positive	0.064	0.055
	Negative	-0.078	-0.067
Test Statistic		0.078	0.067
Asymp. Sig. (2-tailed)		0.200[c,d]	0.200[c,d]

Description: a: Test distribution is normal, b: Test distribution is normal, c: Lilliefors significance Correction, d: This is a lower bound of the true significance

The pre-test data has a 2-tailed significance value of 0.200, according to the results of the data normality test in Table 3. The significance value obtained (α = 0.200 > 0.05) exceeds the standard significance criterion of alpha 0.05. Therefore, it can be concluded that the pre-test results are normally distributed and suitable for use in additional statistical analysis. In addition, the reader should be aware of many other essential details of the normality testing. In this study, thirty-two students completed the initial assessment (pre-test) with a mean score of 60.500 and a standard deviation 12.454. The normality test was also conducted on the post-test data, with a 2-tailed significant result of 0.200. The significance value of the normality of the post-test data (α = 0.200 > 0.05) is higher than the commonly used alpha 0.05 significance threshold. Thus, it can be concluded that the post-test data collected was also regularly distributed and suitable for additional statistical analysis. On the post-test assessment, the thirty-two students had a mean score of 81.688, with a standard deviation 10.117. Thus, effect size analysis and paired sample t-tests can be concluded using pre-test and post-test data sets where the data are normally distributed. To help readers see the pre-test and post-test data distribution and better understand their normality, the data are also presented in histogram form with data normality curves. The Higrogman pre-test data is shown in Figure 3, and the Higrogman post-test data is shown in Figure 4.

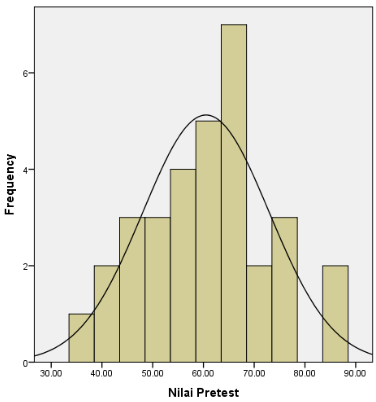

Figure 3. Histogram and Normality Curve of Pre-Test Data

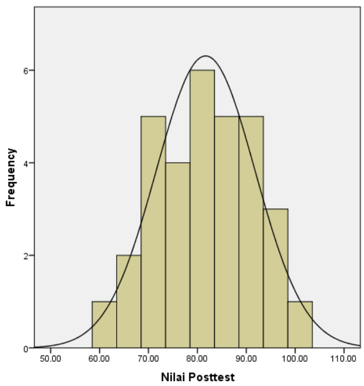

Figure 4. Histogram and Normality Curve of Post-Test Data

After the pre-test and post-test data are declared customarily distributed, they are analyzed with data analysis techniques to answer this research question. The first test carried out is paired sample t-test testing. This test aims to determine the difference in students' PLC-based control system skills before and after using the PLC training kit based on outseal PLC. The paired sample t-test data analysis results are shown in Table 4.

Table 4. Effect Size Criteria Cohen's d

	M	**SD**	**SE**	**CI = 95 %**		**t**	**df**	**Sig. (2-tailed)**
				Lower	**Upper**			
Posttest - Pretest	21.188	15.143	2.677	15.728	26.647	7.915	31	0.000

Description: M: Mean, SD: Standard deviation, SE: Standard error mean, t: t-value, df: Degrees of freedom, CI: confidence interval

Base on Table 4, the calculated t-value is 7.915 with a 2-tailed significance value of 0.000. While 2.0395 is the t table value obtained, the t table value obtained with df 31. From these results, it can be seen that the 2-tailed significance value achieved is smaller than the standard significance value of 0.05 (0.000 < 0.05), and the calculated t value obtained is greater than the t table value (7.915 > 2.0395). This finding shows a difference in students' PLC-based control system skills before (pre-test) using the outseal PLC-based PLC training kit and after (post-test) using the outseal PLC-based PLC training kit. By using the PLC training kit based on the PLC outseal, there is a real improvement in students' skills in the field of PLC-based control systems.

The second data analysis is to analyze the impact of using a PLC outseal-based training kit in the learning process on improving students' PLC-based control system skills using the effect size data analysis technique. Table 5 displays the results of the effect size analysis obtained.

Table 5. Effect Size Criteria Cohen's d

Value	Mean Value	Standard Deviation	Effect Size Value	Criteria
Pretest	60.500	12.454	1.701	Large
Posttest	81.688	10.117		

The effect size value obtained from the analysis is 1.701; this value is included in the large category when classified according to Cohen's d effect size criteria shown in Table 5. Thus, these results can be used to conclude that the PLC training kit based on overseas PLC significantly improves students' PLC-based control system skills. The average value of students on the pre-test and post-test assessments, which amounted to 60.500 and 81.688, respectively, on the assessment of PLC-based control system skills, is evidence that supports these findings. This value reinforces that by using an outseal PLC-based PLC training kit in the learning process, all skills have reached the threshold value and are declared to have mastered the skills of a PLC-based control system.

Discussion

Outseal PLC-based PLC training kit is a set of practicum props to train students' PLC-based control system skills. The offshore PLC-based PLC training kit is designed according to the PLC-based control system learning needs. The Outseal PLC-based PLC training kit can train students directly on the circuit and programming of PLC-based control systems widely used in industry today. Outseal PLC-based PLC training kits are integrated with other control system components, such as limit switch sensors, push buttons, contactors, thermal overload relays, MCB, and pilot lights, so that the skills gained by students are by the learning objectives of PLC-based control systems. Thus, the Outseal PLC-based PLC training kit that is applied in learning can train student-based control system skills using the skills required by the industry (Mo et al., 2023; Rijanto et al., 2022). This statement is that if the school carries out learning by the equipment in the industry, the skills obtained by students while at school will be the same as the needs needed by the industry. Thus, learning carried out in vocational high schools is expected to resemble or be the same as what students will do in the industry (Abdul Rahman et al., 2020; Simelane et al., 2018).

Based on the results of the data analysis of the paired sample t-test obtained, it can be seen that there are significant differences in students' PLC-based control system skills before and after using the outseal PLC-based PLC trainer kit. Students' skills are improved after utilizing the outseal PLC-based PLC trainer kit. These findings suggest that students' skills can improve using the outseal PLC Shield-based PLC training kit to learn PLC-based control systems. The findings of this study support previous research on PLC-based automation system skills, which shows that using training materials based on learning objectives can significantly improve students' academic performance and learning outcomes (Aswardi et al., 2023; Pratama et al., 2022). In addition, there are also previous studies that support the success of this study, which state that if a lesson uses the same components used as those in the industry, the success in school learning will be high. The skills obtained by students will be relevant to what is needed by industry or the world of work.

The results of the second data analysis technique using the effect size criticized using Cohen's d criteria also show positive results. The results of the analysis show that using an outseal PLC-based PLC trainer kit in the PLC-based control system learning process significantly improves students' PLC-based control system skills. This conclusion is evidenced by the effect size value obtained, which is 1.701 (Kicklighter, 2021). Using an outseal PLC-based PLC trainer kit in the learning process will provide better student understanding and facilitate students in mastering PLC-based control system skills. Using a PLC training kit based on outseal PLC in the learning process will involve students directly in the learning process. In addition, using a training kit, students are trained directly to use each component of a PLC-based control system to make learning more meaningful and attached to students. As stated by previous study states that learning by involving students directly in the learning process and involving students directly to complete the practicum they do, the learning process will have a significant impact on improving student skills (Bitetti et al., 2018). By applying student learning as the center of learning supported by learning technology and learning objectives, schools will produce competent graduates in their respective fields (Kuo, 2008; Praveena et al., 2023).

This research will develop a new understanding and innovation of PLC training kits for learning PLC-based control systems in vocational high schools' electric power installation engineering departments. This research is also analyzed from previous research to produce novelty in research, like those conducted who developed a PLC training kit that uses an Omron branded PLC that is widely used by industry (Artiyasa et al., 2020). The training kit they developed only contains PLC and simulation of PLC usage using a pilot lamp without using sensors or contactors that are widely applied in industry. So, the learning is only a simulation, not a natural or similar project carried out in industrial work. Previous researchers also developed a PLC training kit conducted which uses outseal PLC as a PLC in a PLC training kit and uses a human-machine interface (HMI) as a machine interface with humans—in this study using these two components and lamps as indicators of simulation projects that are done (Abdullah et al., 2021; Arowolo et al., 2020).

Thus, the novelty of the research conducted is that first, the PLC training kit developed and implemented in this study already contains relevant and widely used industrial components such as sensors, contactors, MCBs, TORs, and other supporting components. The main components that make up this training kit are outseal PLCs. The advantage of using PLC Outseal is that the teacher can make the PLC hardware because the hardware and the application used to program it are open source, meaning that anyone can make it. The problem of the lack of learning media owned by schools can be overcome because the usual manufacture of PLC outseal is relatively cheap, and the components are readily available (Risfendra et al., 2020). The study results show that, based on the data analysis of paired sample T-tests and effect size, the application of PLC training kits in the learning process proved effective in improving student skills (Setyawan et al., 2024). The effectiveness of this PLC training kit is also supported by the concept and purpose of making this training kit, where the learning carried out will involve students directly in working on projects/practicums. This is also supported by previous research where students' practical skills can be improved if they work directly on a project/practicum (Sudarto et al., 2023).

The second novelty in the research is to examine the effectiveness of using PLC training kits to improve students' practical skills. Previous research has examined how much it impacts students' knowledge and programming skills. So, the results of this study will provide more knowledge about the impact of PLC training kits that can be used to improve students' practical skills. Applying an outseal PLC-based training kit in the control system learning process can improve the quality of learning and help achieve learning objectives well. Research can provide readers with an understanding of the effectiveness of outseal PLC-based PLC training kits to improve students' PLC-based control system skills. This research can provide references to readers about technology that can be applied to the control system learning process to improve the effectiveness of the learning process. Therefore, to improve the learning process and student competence in the field of PLC-based control systems, vocational high school educational institutions, especially the electric power installation engineering department, can utilize the results of this research.

4. CONCLUSION

Based on the research results, after using the Outseal PLC-based PLC training kit in the learning process, there are significant differences in student skills; this result refers to the research findings and the results of the Paired Sample T-test analysis. In addition, the results of the data analysis show an impact on the extensive criteria for using outseal PLC-based PLC training kits to improve students' PLC-based control system skills, as shown by the results of the second data analysis, namely the effect size test. Based on these two findings, it is evident that integrating PLC training kits into the learning process effectively improves students' PLC-based control system skills, maximizing the achievement of this study's objectives. Based on these results, it is hoped that vocational schools majoring in electrical power installation engineering can use this training kit in the classroom to make it easier for students to understand and improve PLC-based control system skills to produce graduates who are competent in PLC-based control systems.

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