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The effectiveness of the kit portable PLC on electrical motors course among vocational school students in Aceh, Indonesia

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ABSTRACT

This research aims to test the effect of the kit Programmable Logic Controller (PLC) on the achievement of vocational school students' competencies in electrical motor control courses for form 3 students in Aceh, Indonesia. Constructivist theory and Bloom's Taxonomy are referenced in this study in relation to learning. While the ADDIE model is used in relation to product development. This study used a quasi-experimental design with pre- and post-tests. The population (N = 333) in this study was level 3 vocational students in Aceh, Indonesia. The number of samples was 98 people, consisting of the experimental group (n = 50) and the control group (n = 48) selected by cluster random technique. The instruments used in this study included pre- and post-test interview protocols. The values of the KR20 reliability coefficient of the question items on the knowledge aspect were 0.97 and 0.81 on the skills aspect. The results of the descriptive analysis found that the experimental group (mean = 64.08; SD = 4.548) showed better competency achievement than the control group (mean = 63.06; SD = 5.487). The result of hypothesis test using Mann Whitney test is [Asymp. Sig. (2-tailed) = .000, p < 0.05] which means that the teaching aids developed have successfully had a positive effect in improving the achievement of student competencies. The implications of this study have produced a teaching aid that can be used as a template by teachers to build teaching aids that are more affordable, easy and safe to use so that they can be motivated to innovate in learning and become a new career opportunity. Given that the Covid-19 epidemic has affected face-to-face learning, the proposal for further research is the need to integrate logic control programming (PLC) learning aids into a technology-based learning trend. Researchers, on the other hand, suggest a broader scope of study whether teachers and students in a wider area and other fields of knowledge related to the utilization of PLC programming.

Keywords: effectiveness, teaching aid, programmable logic controller, motor electric installation, vocational schools.

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Introduction

Vocational education is an education that trains graduates with employment skills. Entering the era the needs of the industry. The Indonesian industrial world needs high-quality human resources. Graduates of vocational schools with skills can meet the needs of Indonesian industry. Thus, graduates of vocational schools that suit the

of Industrial Revolution 4.0, the skills needs of all walks of life and workers have undergone remarkable changes [1]. The skills possessed by graduates of vocational schools must correspond to industrial world can reduce the unemployment rate in Indonesia [2]. With the government's policy through the Ministry of National Education, it is expected that the number of vocational schools will exceed public schools in the next 10 years at 70%

compared to 30%. Given that Indonesia needs a large number of mid-level skilled workers to meet the needs of the world of employment and industry, this consideration seems logical.

However, it is certainly not easy to realize this hope, needed the support of all sectors of society, the business community, and industry [3]. Currently, there is an impression that the skills of vocational school graduates are not good enough, and they are worried about losing competition with existing foreign workers. With good quality of graduates of vocational schools, it is hoped that they will not only work in their home countries, but are also expected to compete with the foreign workforce globally [4]. It is often heard that on the one hand, there are a large number of graduates from vocational schools, but on the other, there are still very few (limited) graduates who are able to work independently and according to their capabilities [5].

Certain factors that can influence the achievement of students in this programming topic have also been identified. Among them are the factors of knowledge, skills and interests of the students themselves. Thus, the use of teaching aids is expected to have an influence in the learning process. There is a lot of talk about the use of teaching aids for teachers in teaching and learning activities. Some of the obstacles or constraints faced by teachers in the implementation and provision of teaching kit in the teaching and learning process include insufficient teaching materials, heavy teaching burden, lack of time, impracticality, inability to write teaching materials on their own, and insufficient funds [6].

According to Mohd Yasin et al [7], the use of teaching aids in teaching and learning activities in vocational schools has not reached satisfactory and inadequate levels, especially involving the use of the latest technical skills. Facilities in the process of inadequate teaching and learning are one of the factors that hinder the implementation of the vocational school curriculum. The next factor is due to the knowledge, skills and attitude of the teacher himself, if laboratory facilities are insufficient for practical training, no steps will be taken [8]. According to Pheng [9], teachers do not have enough time to provide teaching and learning equipment and perform system maintenance on practical equipment. Moreover, the old method of using blackboards by teachers is boring and less effective in giving students understanding. This can lead to a lack of teaching growth in institutions and an inability to consistently coordinate to support

learning in a more complex and challenging teaching environment.

Based on the initial studies conducted in learning the topic of logical control programming (PLC) in the electrical machine installation course, it was found that there are weaknesses in the practical teaching process due to various factors, among which is that the absence of teaching aids is enough to cause students to lack understanding of the teaching and learning process. Existing teaching aids are very simple and will not encourage students to think creatively about programming system solutions. In addition, simply applying theoretical concepts to practical activities will not directly affect the performance of students. In addition, insufficient funding, teachers with no experience, inexperienced management staff and lack of materials in the library [8]. Therefore, portable PLC kit, It is hoped that it will help the teaching and learning process as a training media in vocational schools.

The objective of this study is to test the effect of portable teaching aids programming logic control (PLC) for electric motor control courses among students of form 3 vocational school in Aceh, Indonesia.

The research question of study: What is the effect of teaching portable PLC kit on student competency achievement for electric motor control courses among students of form 3 vocational schools in Aceh, Indonesia?

A hypothesis should be built to answer the questions studied to find out the impact of portable PLC teaching aids in learning electric motor control in students. Here are the hypotheses in this study: Ho = There is no difference in the effect of portable PLC kit for electric motor control courses among students of form 3 vocational school in Aceh, Indonesia; Ha = There is a difference in the effect of portable PLC kit on electric motor control courses among students of form 3 vocational school in Aceh, Indonesia.

Theoretical Framework

In this study, researchers used the theory of Constructivism founded by Vygotsky, Piaget and Bruner. This Constructivism Theory was also co-adapted with the ADDIE development model by Branch [10] and Dick & Carey [11].

Constructivist learning theory is one of the learning methods based on the student's experience related to existing knowledge. This theory emphasizes student activity. The learning process is

not only dominated by the teacher but the student is also active in it. One of the learning strategies that actively involves students is constructivism. The method of constructivism places students in the main role in the student centered process [12].

In the context of constructivism learning related to assists in the learning process, students are required to be actively involved and interact to make learning more meaningful. One of the challenges teachers face in applying constructivism methods is adapting and changing instructional design strategies to enable students to actively participate in effective project activities and assignments, thus encouraging students to explore, test, build, collaborate, and reflect on what is being studied [13].

It is believed that constructivist learning related to the use of teaching aids can help students solve problems more quickly, since this process emphasizes aspects of group thinking and discussion, and can establish bilateral communication between students and teachers, students and students [14].

Referring to Bloom's Taxonomy theory, general instruments, competencies are divided into three parts: attitude, knowledge, and skills. Taxonomy Bloom is one of the development of cognitive theory, usually associated with problems setting learning goals and standard problems assessing or measuring learning outcomes, as curriculum development [15].

The attitude aspect covers all things related to emotions, such as feelings, values, appreciations, passions, interests, motivations and attitudes. According to Gunawan & Palupi [16], the aspect of attitudes related to a student's attitude and interest towards subjects among them is receiving attitude,

which is related to the sensitivity of students in receiving external stimuli in either in the form of problems or specific conditions. Feedback, is a reaction to the stimulus given from the external one. Assessing (valuing), this has to do with value or belief in a stimulus. Organization, that is, the attitude of aligning values into an organization. The characteristics of values that are the integration of the values that a person possesses are reflected in attitude and personality.

Cognitive aspects are a field that deals with the purpose of learning that deals with mental processes that begin at the level of knowledge up to the evaluation stage [17]. Knowledge level is a person's skill in recalling terms, formulas, names and so on

The psychomotor aspect is a student's skill in acting related to physics skills including a physical movement and coordination to achieve learning outcomes [18]. Psychomotor aspects include physical mobility and coordination, practical skills and physical skills. These skills can be measured in terms of speed, accuracy, distance, method/implementation technology. In PLC programming competencies, the psychomotor aspect can be interpreted as a student's skill in applying PLC programming that covers practical knowledge and skills.

The level of teaching aids is to refer to the ADDIE model. This stage includes the design and development of PLC teaching aids [19]. While the evaluation section is to test the usability and impact of PLC teaching aids on students' competency achievement through expert assessment and post-testing. The resulting PLC teaching aids are expected to have a positive impact on teachers and students during the teaching and learning process. Figure 1 shows the theoretical framework of the study.

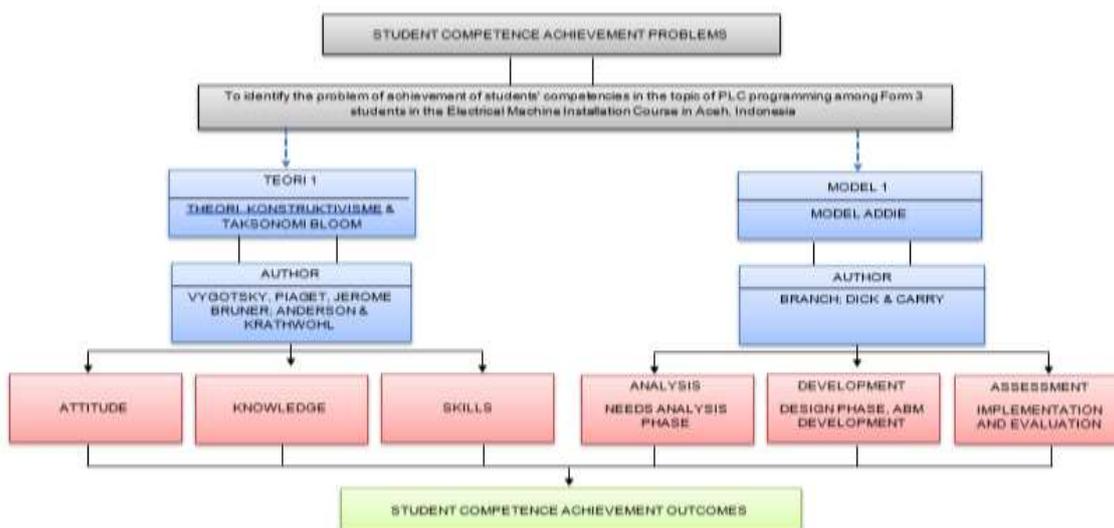
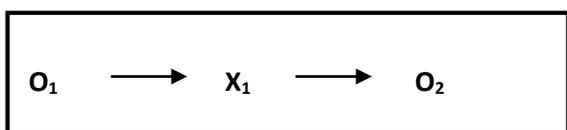


Figure 1 - Study theory framework

Research Methodology

Study Design. The study used quasi-experimental design through quantitative approach. Quantitative approaches are used because this study requires data in the form of figures. Sang [20] believes that the use of quantitative approaches can demonstrate the discovery of comprehensive information, differences and consequences. This study aims to study the impact of the development of portable PLC kit on the achievement of student competencies on electrical machine installation courses for form three students of vocational schools in Aceh area, Indonesia. Figure 2 is a flow chart from this study.



Note:
 O1 = Pre-Test
 X1 = Learning through experience
 O2 = Post Test

Figure 2 - Study framework. Adapted from Hastjarjo in Chook & Campbell [21]

Population. Based on the data obtained from the database of institutions that manage the vocational school data, the number of form 3 students in electrical engineering of vocational schools in Aceh area, Indonesia is 539 people. The number of schools identified is 16 schools which in turn are categorised as urban and rural schools to focus on the selection of sample studies. The determination of the urban or rural school category is based on the geographical position of the school. Referring to Table 1 below, there are 6 schools that fall into the rural school category in the field of electrical engineering. The total number of students in rural schools is 126. Table 1 shows data on the number of schools and students categorised as rural schools in the field of electrical engineering in Aceh, Indonesia.

Table 1 - Data of students and vocational schools in the field of electrical engineering in Aceh rural area

No	School Name	Area	Number of Student
1	Lhok Nga Aceh Besar Vocational School	Rural	5 Student
2	Darul Kamal Aceh Besar Vocational School	Rural	22 Student

3	Tanah Luas Vocational School No. 1	Rural	9 Student
4	Bener Meriah Vocational School No. 1	Rural	28 Student
5	Bener Meriah Vocational School No. 2	Rural	9 Student
6	Abdya Vocational School No. 1	Rural	32 Student
7	Sinabang Vocational School No. 2	Rural	21 Student
Total			126 Student

Source: Ditpsmk, 2020.
<http://peta.ditpsmk.net/peta2/index.php/chome/pencariansekolah/>

Based on Table 2 below, there are 9 schools that fall into the urban area school category. The total number of students in schools in the urban area is 413. But the actual number was 333 people who went on to become the population in this study.

Table 2 - Data of students and vocational schools in the field of electrical engineering in the Aceh urban area

Bill	School Name	Area	Number of Student
1	Banda Aceh Vocational School No. 2	Urban	48 Student
2	Sigli Vocational School No.2	Urban	50 Student
3	Bireuen Vocational School No.1	Urban	51 Student
4	Lhokseumawe Vocational School No.5	Urban	15 Student
5	Langsa Vocational School No.2	Urban	100 Student
6	Karang Baru Aceh Tamiang Vocational School No.2	Urban	54 Student
7	Takengon Middle Aceh Vocational School No. 2	Urban	28 Student
8	Peureulak East Aceh Vocational School No.2	Urban	23 Student
9	Meulaboh West Aceh Barat Vocational School No.2	Urban	44 Student
Total			413 Student

Source: Ditpsmk, 2020.
<http://peta.ditpsmk.net/peta2/index.php/chome/pencariansekolah/>

Based on the two tables above, researchers chose urban area schools as the place where the study was conducted as it was easily accessible thus minimizing the production of study costs. In addition, the number of urban school students has more students than the number of students in rural schools. Therefore, researchers only need to choose the two schools that are the place of study until the implementation of the study becomes simpler, simpler and time-saving.

Sample. The samples in this study consist of form 3 students from electrical engineering vocational school who took courses in electrical motor courses. Refers to school and student data of designated urban areas. Next, out of the 9 schools in the city area, researchers selected the schools that were used as study places by randomly selecting using cluster sampling techniques. From the 9 schools in the town area, one school was chosen randomly by voting method, until it was found Peureulak East Aceh Vocational School No.2. The purpose of this school selection is to be used as a school for pilot studies to carry out the analysis of the needs of kit development and testing of research instruments [22]. According to Panahbehagh [23], this technique is used when the population is not made up of individuals, but consists of groups or groups of individuals or clusters. District sampling techniques are used to determine samples when objects to be studied or data sources are very extensive [24]. Figure 3 shows a map of population dissemination and samples of studies.

When it was obtained from the school used as a place of study, researchers selected two schools that were used as places of study. Out of the remaining 8 urban schools, researchers selected two schools using the voting method until 2 schools, namely Banda Aceh Vocational School No. 2 and Karang Baru Aceh Tamiang Vocational School No.2. But, as early as 2020, almost the entire country was faced with a Covid-19 pandemic. Indonesia is one of the countries affected by the Covid-19 pandemic. The spread of covid-19 has rapidly spread throughout the 34 existing areas, not to mention the westernmost area of Aceh.

Banda Aceh as an area city and being one of the places to conduct this study itself has a fairly high number of covid-19 positive cases compared to other districts in Aceh area. The area has been designated as a red zone for the spread of covid-19 with the number of victims continuing to increase, until the local government designates the area as an area that applies social blocking, this includes the blocking of teaching and learning activities in schools [25]. Therefore, researchers made changes by aborting Banda Aceh Vocational School No.2 as one of the places to conduct studies and replace them with other urban area schools whose rate of spread of Covid-19 was lower. Thus, the remaining 6 schools were re-elected by voting for a replacement school that had been dropped previously, hence found Langsa Vocational School No. 2 as a replacement school. It is one of the urban schools that is still implementing the teaching and learning process during the Covid-19 pandemic. Figure 4 is the sampling technique in this study.

Based on Figure 4, Langsa Vocational School No.2 was selected as an experiment group, while Karang Baru Aceh Tamiang Vocational School No.2 was selected as the control group. As for the purpose of selection of the two schools, it is to avoid internal threats to the validity of the study. The 3 table below shows that the samples were 98 people comprising 48 students of control school and 50 students from experiment school. The number of non-permanent students per semester makes it difficult to accurately state the number of students. In addition, the Covid-19 pandemic has an impact on the number of students who are following the teaching and learning process.

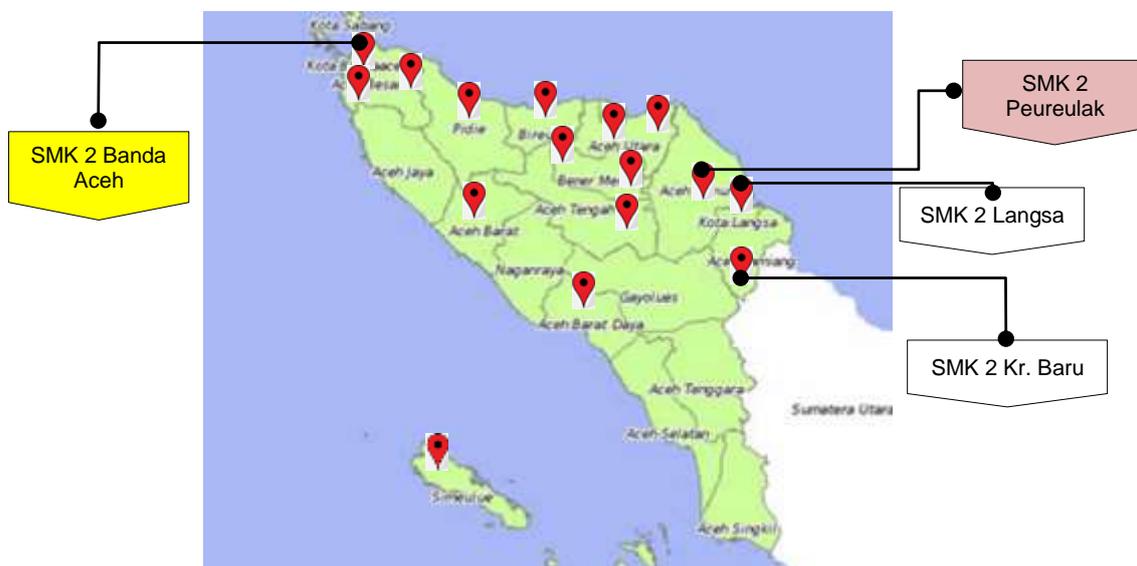


Figure 3 - Population dissemination study

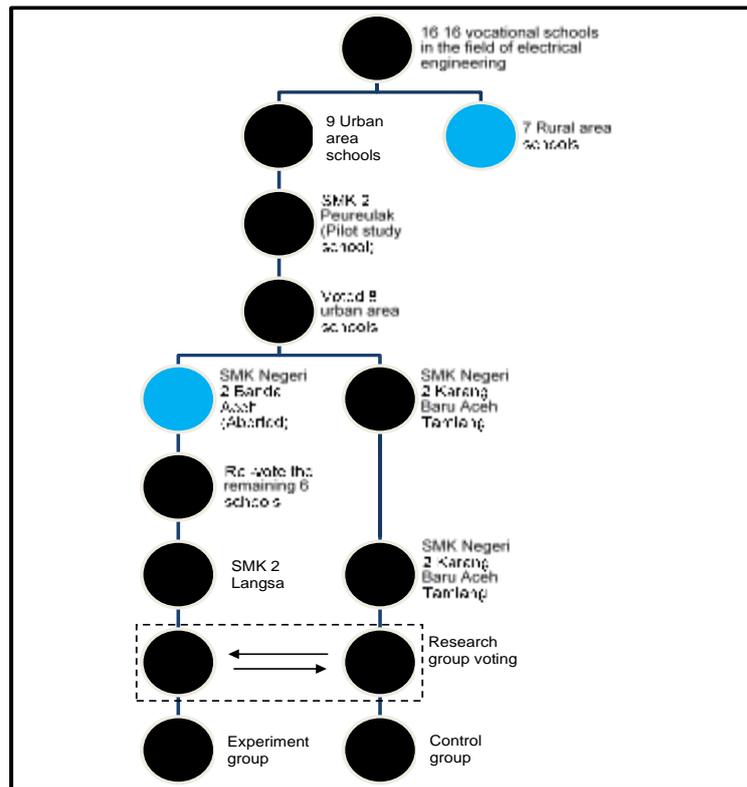


Figure 4 - Sampling technique

The characteristics of the subject in the population are inaccurate, the population can be considered as an abstract element as well as difficult or unquantifiable or accurately calculated [26]. According to Table 3, the sample number is 154 students. But the number of samples during the study was 98 students only. The number is based on the attendance list of students owned by the teacher who teaches at the course

Table 3 - Number of study samples

School	Class A	Class B	Total
Karang Baru Aceh Tamiang Vocational School No.2 (control)	24 Student	24 Student	48 Student
Langsa Vocational School No.2 (Experiment)	26 Student	24 Student	50 Student
			98 Student

Instruments. The study used pre-tests and post-tests. Testing is a measurement tool with objective standards, so it has multiple uses and can be used to measure and compare the behavior of an individual or group. Pre- and post-test tests are used to measure students' competency achievement before and after using developed teaching aids. Pre- and post-test tests are conducted in the form of

written tests, since written tests are a common way to test students' cognitive abilities [27].

The preparation of pre-test and post-test questions is aimed at seeing the extent of the impact of portable plc teaching aids on the achievement of students' competencies through the use of such teaching aids. These questions are first tested through a pilot study test before doing an actual study. Students are given 30 minutes to answer the pre-test. Then at other sessions the student conducts a 4-hour laboratory session. As for the post-test session, students are given 30 minutes to answer all questions. In the actual test, the answer paper was reviewed by 3 experts in the field based on the schemes provided to ensure the reliability of the results obtained.

The instruments that have been constructed have been reviewed by three experts comprising vocational teachers in electrical engineering in Aceh and senior lecturers of the Sultan Idris Education University of Malaysia with experience teaching over 10 years. The instrument of the test question item also tested its validity and reliability.

The validity and reliability of the instrument is important to ensure that the results obtained are reliable and indisputable [28]. The value of the test item is calculated using the Kuder-Richardson 20 formula (K-R20). According to Yap et al. [29], the Kuder-Richardson formula is used to avoid giving

tests twice and avoiding problems dividing tests into two parts. This formula can be used for homogeneous tests where each test item measures the same factors of general or personality abilities. According to him, the Kuder-Richardson formula depends on the consistency of individual performance of an item by item based on the standard deviation of the test. The value of KR_{20} is between zero (0) and 1.00, although a negative value is possible. A high KR_{20} value indicates that the test has internal consistency. For Carey [30], a value above 0.90 showed very high reliability. The coefficient value of reliability is .974 on the knowledge aspect and .811 on the skills aspect. According to Ghafar [31], in case the coefficient value is high (0.8 and above), it can be concluded that the test set has high reliability.

Besides, researchers also use protocol instruments. The interview protocol in this study is also an in-depth source of data on the most important teaching practices. Through the interview method, researchers were able to meet several key conditions, which involve students' knowledge of motor installation based on PLC programming. The interview method can also make it easier for researchers to conduct deeper exploration, since new information obtained can only be known through students' experiences, opinions, feelings and ideas about motor control systems and PLC programming knowledge. In addition, the interviews carried out can provide new information to researchers, especially information related to the practice of using teaching aids in programming learning. Researchers were also able to explore important information of a subjective nature to understand situations and things that are not directly visible.

Researchers also used the technique of dissenting in conducting interviews so that the respondent can give a complete opinion, explain and elaborate each question asked. Researchers will minimize questions so that the respondent can explain further the answers stated. Additionally, researchers will avoid asking questions by giving respondents a shadow of answers to avoid the researchers' biases.

Data Analysis

The findings were analyzed using *statistical package for social science (SPSS) ver. 23.0*. Researchers used descriptive statistics to illustrate the study data that covered the amount of data,

maximum value, minimum value, mean value and so on. The researchers will then test the normality of the data to find out whether the data obtained is scattered normally or not. If the study data is found to be normal, researchers will use the Parametric t-test while if the data is abnormal, researchers will use the Non-Parametric Wilcoxon and Mann Whitney tests.

To analyze the results of the interview protocol, researcher begin writing the transcription of the interview immediately after the interview session. Researchers also examined and referenced field notes to help parse data, such as feelings, thoughts and intentions that cannot be measured.

Document Analysis. According to Bungin [32], document analysis is one of the methods of data collection used to search historical data in social study methodologies. Guba and Lincoln in Moleong [33], explain the difference between document and record terms. A record definition is any written statement provided by an individual/organization to test an event. Documents are data sources for additional research, including written material, films, drawings, and monumental works, all of which provide information for the research process. Documents can be used to analyze values and track what can be obtained in one document [34]. Through document analysis, researchers were able to identify the extent to which the learning on the Electrical Machine Installation course on the topic of logical control programming (PLC) had an impact on the achievement of students' competencies.

Pre and Post Test Tests. Assessments were conducted to test the impact of PLC teaching aids on students' academic achievements that can be measured through pre-tests and post-tests. This test method is used to assess students' level of understanding, mastery and skills. Pre-tests are used to obtain data showing students' weaknesses so that these vulnerabilities can be detected and early assistance can be planned. The post-test is aimed at looking at progress and weakness after carrying out interventions. The set of questions for pre-tests and tests are the same set of questions.

Video and Picture Documentation. Researchers used photo and video recordings for the purpose of observing the implementation of teaching. The use of photo and video recordings can make it easier for researchers to record each teaching execution activity more accurately. The use of these two audio visual materials is to reduce any possibility of important data dropped throughout the observation. The use of photo and video recordings

is a very suitable way to gather information in the form of voice and movement and can overcome the weaknesses of researchers who are only able to record a portion of the observations from the entire findings [35].

Research Results

Research Question: What is the effect of kit portable PLC on the achievement of student competency for electric motor courses among students of form 3 vocational school in Aceh, Indonesia?

Prior to the introduction of the programming topic, a Pre Test was administered to 98 students to see the students' existing knowledge on the subtopic installation of electrical machines based on PLC programming as well as to see the equivalence of both groups. Table 4 shows the results of the Pre Test score for the electrical machine assembly course obtained by the experimental group respondents and the control group respondents.

Based on the results of the pre-test results, it was found that the students who obtained the pre-test score at a weak level (50-59) for the experimental group of 5 people (10%), whereas the control group was 8 (16.67%). The students who scored moderately (60-69) in the experimental group were 35 students (70%) and for the control group 32 students (66.67%). Next, the number of students who obtained the pre-test scores with satisfactory levels (70-80) in the experimental group was 10 students (20%), while the number of students in the control group was 8 (16.67). At the level of excellence (81-100), there were no students who scored at excellent levels in both groups, thus it was concluded that both groups of students had the equivalent of pre-test scores.

Table 4 - Pre-test score

Level	Experiment Group (n = 50)		Control Group (n = 48)	
	f	(%)	f	(%)
Excellent (81-100)	0	0	0	0
Satisfactory (70-80)	10	20	8	16.67
Medium (60-69)	35	70	32	66.67
Weak (50-59)	5	10	8	16.67
Very Weak (0-49)	0	0	0	0
Total	50	100	48	100

To determine the equality of both groups, a descriptive analysis to compare the mean values is

performed. Table 5 below shows a comparison of the mean values of Pre Test. The mean value of the control group was 63.06 while the mean value of the segment group was 64.08. Both mean values are in the weak level category by reference to Table 5. Therefore, it can be concluded that both groups in terms of pre-test scores are equivalent.

Table 5 - Comparison of Pre Test Mean Values

	n	Min	S. D	S. D Error
Control Group Pre-Test	48	63.06	5.487	.792
Experimental Group Pre-Tests	50	64.08	4.548	.643

Researchers have statistically descriptive data such as Table 6 below to reflect the study data that includes the amount of data, maximum value, minimum value, mean value and so on. The researchers then performed normality tests on all data obtained through the research instruments (Pre Test, Post Test) used to ensure that the data were normally buried.

Table 6 - Descriptive Data Analysis

	n	Min	Max	Mean	S.D
Control Group Pre-Test	48	50	70	63.06	5.487
Experimental Group Pre-Tests	50	50	70	64.08	4.548
Control Group Post-Test	48	60	78	71.02	3.987
Experimental Post-Test Group	50	65	85	80.56	3.477
Number of valid Samples	48				

Table 7 below shows the findings from the Data Normality Test. From data normality analysis, significant value (Sig) for Kolmogorov-Smirnov test and Shapiro-Wilk test, it was found that three of them were less than 0.05 (<0.05). This can be concluded that the data obtained is not normally sown. To that end, the data needs to be analyzed with non-parametric statistics using the Mann-Whitney Test.

Table 7 - Data Normality Test

Class	Kolmogorov-Smirnov	Shapiro-Wilk
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	Statistics	df	Sig.	Statistics	df	Sig.
Pre-Experimental Test	.140	50	.015	.919	50	.002
Post-Experimental Test	.171	50	.001	.844	50	.000
Pre-Control Test	.201	48	.000	.898	48	.001
Post-Control Test	.170	48	.001	.958	48	.086

Note: df = degree of freedom, Significant at level $p < 0.05$.

Study Hypothesis. Researchers conducted the Mann-Whitney Test because the number of samples for both groups was not the same as the control group of 48 people and the experimental group of 50 people. The hypothesis that was constructed in this study is: H_0 = There is no difference in the effect of portable PLC kit for electrical motor control courses among students of form 3 vocational school in Aceh, Indonesia; and H_a = There are differences in the effect of the portable PLC kit on electrical motor control courses among vocational student's form 3 in Aceh, Indonesia compared to students who follow conventional learning methods. This hypothesis will be accepted if the Asymp.Sig value is less than 0.05 (< 0.05), while if the Asymp.Sig value is more than 0.05 (> 0.05), then the study hypothesis is rejected.

Table 8 and Table 9 show findings from the Mann-Whitney Test. The statistics showed that the value of Asymp.Sig (2-tailed) was .000, and that it was less than 0.05 (< 0.05). Then it can be proved that the hypothesis is accepted. Thus, it can be concluded that there is a difference in the outcome of students' competency achievements in the Electrical Machine Installation Course between form 3 vocational students who follow the learning method using portable PLC kit and students who follow conventional learning methods.

Table 8 - Mann-Whitney Test (Rank)

Group		n	Min Rank	Total Rank
Student Competency Achievement	Control Group	48	25.91	1243.50
	Experiment Group	50	72.15	3607.50
	Total	98		

Table 9 - Mann-Whitney Test (Statistical Test^a)

	Student Competency Achievement
Mann-Witney Test	67.500
Wilcoxon W Test	1243.500

Z Test	-8.076
Asymp. Sig. (2-tailed)	.000
Exact Sig. [2*(1-tailed Sig.)]	.000b

Note: a = the variables grouped: group, b = not corrected for bonding.

Discussion

A total of 50 students of the experimental class were exposed to learning that took advantage of portable PLC kit to test the usability of the device and to see the impact of learning on the electrical motor control course among of vocational schools form 3 in Aceh, Indonesia. Meanwhile, the other 48 students who are the control class group are implemented using conventional learning methods. Both groups were given tests both before and after the learning activities were carried out to see the comparative results of students' achievements.

The results of the analysis of the mean value of the tests before the study was carried out as in Table 5.2 are equivalent. Both groups are categorised as having weak mean values. Meanwhile, the results of the descriptive data analysis on Table 5.3 showed significant results at the mean value of the experimental group test after the study was performed compared to the experimental group. The gap between the mean values before and after treatment was carried out in the experimental group was 16.48. Meanwhile, the gap in the value of the mean before and after the study activities carried out on the control group was 7.96. The mean value gap between the two groups was 9.54. So it can be concluded that significant differences occurred in the experimental group treated with portable PLC kit. On the other hand, on the control group, the value of the difference did not show a significant increase.

The hypothetical test results based on a nominee (Rank) referring to Table 5.5 showed significant differences in mean values between the two groups after the study was conducted. The experimental group had a higher mean value of 72.15, compared to the control group (25.91), the difference in the mean values between the two groups was 36.24. This illustrates that there has been a significant improvement in the outcome of the competency of experimental group students after being given treatment with learning that benefited portable PLC kit compared to before being given treatment. The control group, with conventional learning, did not show the results of competency achievements that were significant both before and after the study.

Next, the statistical test results of the hypothesis of the study as shown in Table 5.6, the value of Asymp.Sig (2-tailed) is .000, and it is less than 0.05 (<0.05). It can then be explained that Ha's hypothesis that there is a difference in the effect of using portable PLC kit on the electrical motor control course among students of form 3 vocational school in Aceh, Indonesia is accepted. This means that the use of portable PLC kit has been effective in improving the outcome of the competency of experimental group students as opposed to the achievements of control groups that implement conventional learning.

In addition, portable PLC kit has been developed to provide understanding and thus improve students' academic achievement in related topics. Through portable PLC's kit utilization of practical learning activities, students can gain a fun new experience as they learn programming topics. Overall, it has successfully produced interventions that positively impact learning and teaching for the topics learned.

The developed tool teaches portable PLC kit equipped with electrical circuits using plug and unplug wiring systems. According to Intan study [36], the effect of using teaching aids with plug and unplug systems is higher compared to using conventional wiring systems. In line with a study conducted by Zahri and Osman [37], they argue that teaching aids that use plug-in components make it easier for students to process circuits for understanding purposes. The use of teaching aids can also increase the level of understanding of students and thus improve the number of scores obtained. In addition, the amount of time in practical activities can also be reduced and thus provides an opportunity for students to try practically repeatedly. This teaching aid can also make it easier for teachers to stage demonstrations and in turn spark students' interest in practical practice in the laboratory.

The portable PLC kit were developed with the aim of wanting students to know and understand the application of PLC programming-based electrical machine control systems in the industry. This can stimulate students' learning motivation in following the teaching and learning process and is very supportive of students' competencies before entering the world of work [38]. PLC programming competencies are indispensable in the industry. PLC has been successfully applied to every industry segment, including steel mills, paper mills, food processing plants, chemical plants and power plants. PLC performs a variety of regulatory tasks, from

recurring on/off settings from simple machines to sophisticated manufacturing and process settings. Automation systems in the industry include operations such as processing, installation, inspection and handling of materials, in many cases solving more than one of these operations in the same system. Figure 5 shows the activities of students doing programming the motor control system with the portable PLC kit.



Figure 5 - Students do programming of motor control systems on computer software and PLC teaching aids

Meanwhile Rowe et al. [39] has successfully created a kit to guide PLC hands-on learning in undergraduate engineering education at the University of Colorado Boulder. As a result, students provided positive feedback on the use of teaching aids in merging theoretical learning in classes and practicality into PLC programming activities. Based on the results of Suparta's [40] study, it was found that PLC teaching aids can be used as learning media to improve students' learning outcomes. In addition, the use of PLC teaching aids as a learning media in creating electrical machine control wiring systems has had a positive impact in improving students' learning outcomes.

Such portable PLC kit can be highlighted to be a trend of hands-on knowledge delivery besides practicing active learning pedagogy, and also, engineering subjects [[41], [42]]. Teachers from other technical and vocational schools can take this idea to be applied to their learning and teaching delivery process so that the level of mastery of basic programming concepts for technical and vocational school students especially in the field of electrical engineering increases and thus helps the students when pursuing work in the industry and or furthering their studies at Polytechnics or Universitas.

Conclusions

Overall, this study was successfully conducted to see the impact of PLC portable kits on electric motor courses especially on

programming topics among vocational school students in Aceh, Indonesia. The PLC portable kit has also tested its usability on students, where the use of portable PLC kit has achieved the objectives of the study that the researchers have built and has a positive impact whether in terms of academic achievement, interest and motivation of students in studying programming topics. Through this study, researchers are directly or indirectly able to support the government's idea of a teaching factory by motivating teachers to be more creative and innovative in producing business-based learning that refers to the standards and

procedures that occur in the industrial world in real terms by producing marketable kit products. This creates a new job opportunity that has the potential to reduce the unemployment rate which is more dominated by graduates of vocational schools.

Conflict of interests. On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Ачех кәсіптік-техникалық училищесінің (Индонезия) оқушыларына арналған «Электр қозғалтқыштағы портативті БЛК-ның тиімділігі» курсы

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ТҮЙІНДЕМЕ

Бұл зерттеу Индонезияның Ачех қаласындағы 3 курс студенттеріне арналған электр қозғалтқышын басқару пәні бойынша кәсіптік-техникалық училище оқушыларын оқыту үшін бағдарламаланатын логикалық контроллер (БЛК) жинағының әсерін тексеруге бағытталған. Бұл зерттеуде конструктивизм теориясы мен Блум таксономиясы туралы айтылады. ADDIE моделі өнімді әзірлеуге қатысты қолданылады. Бұл зерттеуде алдын ала және тесттен кейінгі сынақтармен квазиэксперименттік дизайн қолданылды. Осы зерттеуге Индонезияның Ачех қаласындағы кәсіптік білім беретін 3-деңгейдегі студенттер (N = 333) қатысты. Таңдалынған адамдар кездейсоқ кластерлік іріктеу әдісімен таңдалған эксперименттік топтан (n = 50) және бақылау тобынан (n = 48) тұратын 98 адамды құрады. Бұл зерттеуде пайдаланылған құралдарға тестілеуге дейінгі және кейінгі сұхбат хаттамалары кірді. Сұрақтардың KR20 сенімділік коэффициентінің мәндері – білім аспектісі бойынша 0,97 және дағдылар аспектісі үшін 0,81 болды. Сипаттамалық талдау нәтижелері эксперименттік топтың (орта = 64,08; SD = 4,548) бақылау тобына қарағанда (орта = 63,06; SD = 5,487) жақсы құзыреттілікке қол жеткізгенін көрсетті. Манн-Уитни сынағы арқылы гипотезаны тексеру нәтижесі: [Асимп. Sig. (Екі жақты) = 0,000, p < 0,05], яғни әзірленген оқу құралдары оқушылардың оқу үлгерімін арттыруға сәтті әсер етті. Бұл зерттеудің нәтижелері мұғалімдерге оқудағы инновацияларға ынталандыру және жаңа мансаптық мүмкіндіктерді ашу үшін қол жетімді, қарапайым және қауіпсіз оқыту құралдарын жасау үшін үлгі ретінде пайдалануға болатын оқыту құралын жасауға мүмкіндік берді. Ковид-19 эпидемиясының бетпе-бет оқытуға әсер еткенін ескере отырып, бағдарламалатын логикалық бақылау (БЛК) оқулықтарын біріктіру қажеттілігіне қатысты қосымша зерттеулер ұсынылады. Зерттеушілер, сонымен қатар зерттеулердің қосымша кең ауқымын ұсынады.

Түйін сөздер: эффектілер, ПЛК оқулықтары, қосымша ақпарат, электр машиналарын орнату курсының құзыреттіліктері.

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АННОТАЦИЯ

Это исследование направлено на проверку влияния комплекта программируемого логического контроллера (ПЛК) для обучения учащихся профессиональных технических училищ по дисциплине управление электродвигателями для студентов 3-го курса в Ачехе, Индонезия. Теория конструктивизма и Таксономия Блума упоминаются в этом исследовании. Модель ADDIE используется в отношении разработки продукта. В этом исследовании использовался квазиэкспериментальный план с предварительными и последующими тестами. Население (N=333), участвовавшее в этом исследовании, были студентами профессионального образования 3 уровня в Ачехе, Индонезия. Количество выборок составило 98 человек, состоящих из экспериментальной группы (n=50) и контрольной группы (n=48), выбранных методом случайного кластерного отбора. Инструменты, использованные в этом исследовании, включали протоколы интервью до и после тестирования. Значения коэффициента достоверности KR20 вопросов по аспекту знаний составили 0,97 и 0,81 по аспекту навыков. Результаты описательного анализа показали, что экспериментальная группа (среднее=64,08; SD=4,548) показала лучшее достижение компетентности, чем контрольная группа (среднее=63,06; SD=5,487). Результат проверки гипотезы с использованием критерия Манна-Уитни: [Асимп. Sig. (Двусторонний) = 0,000, p < 0,05] означает, что разработанные учебные пособия успешно оказали положительное влияние на повышение уровня успеваемости учащихся. Результаты этого исследования привели к созданию учебного пособия, которое учителя могут использовать в качестве шаблона для создания более доступных, простых и безопасных учебных пособий, чтобы они могли быть мотивированы на инновации в обучении и открывать новые возможности для карьерного роста. Учитывая, что эпидемия Covid-19 повлияла на очное обучение, предлагается провести дальнейшие исследования в связи с необходимостью интеграции учебных пособий по программированию логического управления (ПЛК). Исследователи, с другой стороны, предлагают более широкий круг изучения вопроса.

Ключевые слова: эффекты, учебные пособия по ПЛК, дополнительная информация, компетенции курса по установке электрических машин.

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