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Effectiveness of the Application of the Problem-Based Learning Model Assisted by EKTS Simulation on the Learning Outcomes of Electric Motor Installation of TITL Students Tomohon 1 Christian Vocational School

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ABSTRACT

This study aims to see the improvement of student learning outcomes in the subject of applying EKTS (Electrical Control Techniques Simulator) software in the subject of Electric Motor Installation of class XI TITL SMKS Kristen 1 Tomohon. Electrical control techniques simulator is a simulator software that can be used to design electromechanical systems. This software provides various kinds of electromechanical systems that use relays, time relays, buttons, motors, switches, and various basic mechanical systems. This study seeks to make students' understanding of electric motor installation circuits more understandable and can be understood clearly so that there are no more doubts and fears when practicing them which can cause poor student learning outcomes. There are three circuits used in this study, namely the DOL (Direct On Line) circuit, Forward-Reverse and Star Delta circuits. From these three circuits, researchers can see the extent to which students' understanding of electric motor installations. This research will be conducted at SMKS Kristen 1 Tomohon. Which is addressed at Jl. Tomohon - Tondano No. 158, Matani Satu, Kec. Tomohon Tengah, Tomohon City, North Sulawesi Province. The current type of research uses experimental research, namely True Experimental research (pure experiment), namely experiments that follow procedures and meet the requirements of experiments, especially those related to controlling variables, control groups, providing treatment or manipulating activities and testing results. With the Two Group pretest-posttest design. The subjects

of this study were students of class XI TITL II SMKS Kristen 1 Tomohon. The data obtained were analyzed using hypothesis testing. With this study, the average pre-test was 62.86 and the average post-test score was 82.86. The results of this study indicate an increase in learning outcomes for electric motor installation lessons in class XI TITL II SMKS Kristen 1 Tomohon.

Keywords: EKTS Software, Electric Motor Installation, Learning Outcomes.

INTRODUCTION

Learning is fundamentally important for every human being willing to strive for a living. Teaching and learning activities must adhere to appropriate learning standards to ensure high-quality learning. Quality learning positions teachers appropriately, enabling them to effectively fulfill their roles, meeting students' learning needs. In today's education world, many schools already maintain high standards and quality to meet students' learning needs.

In a subject, there are parts of the learning material that must be understood by students. If students experience difficulty in understanding a learning material, it will affect low student motivation and learning outcomes. In the subject of electric motor installation, there are learning materials that are quite difficult for students to understand, therefore teachers are expected to play an active role in teaching and learning activities. In the school that I observed, especially in the subject of electric motor installation, it was seen that there was a lack of student responsiveness to the learning material and that active communication between teachers and students was still lacking, resulting in student learning outcomes that were not yet satisfactory.

The low learning outcomes in electric motor installation lessons are likely caused by: 1) Students' fear of damage to the equipment used. 2) The occurrence of electrical short circuits with users (students) due to students' lack of understanding of the learning competencies in operating electromagnetic control systems. 3) The availability of learning media is still minimal. In today's developments, many manual systems have been replaced by automatic systems, this is due to the existence of tools that can control a work process using a computer system.

In schools, industrial systems and processes are already being implemented, making it common for electrical power engineering schools to send their students directly to industry for fieldwork. However, it would be better if students were first taught about industrial systems through practical exercises or simulations, which would help them learn and develop their knowledge. In practice, not all students are proficient in operating electric motor control systems. Vocational High Schools (SMK) are schools that prepare students to study and develop knowledge that can support them in competing in the industrial world. Students are required to be proactive, innovative, and creative in the learning process to enable them to learn and develop knowledge.

Improving learning outcomes in vocational education requires instructional approaches that support students' ability to understand complex concepts and perform technical tasks with confidence. In electrical engineering subjects, particularly electric motor installation, many students struggle to master control circuits due to limited hands-on experience, fear of equipment damage, and insufficient conceptual grounding (Huang et al., 2020; Fernández-García et al., 2021). These difficulties often lead to reduced motivation and poorer academic performance. Global research highlights that digital

simulations can reduce cognitive load, enhance visualization of abstract concepts, and create safer learning environments for technical practice (Ginns et al., 2019; Lim & Jang, 2019).

SMKS Kristen 1 Tomohon is one of the vocational schools included in this category. After conducting observations at this school and asking several questions regarding the level of student success in the competency of operating an Electric Motor Installation for Class XI in 2025/2026, it turns out that there are still many students who get scores below the Minimum Completion Criteria. After looking at the learning outcomes obtained by these students, it turns out that there has not been a significant increase experienced, so in this case it is necessary to do a more effective way to improve student learning outcomes, namely by providing learning media that can later improve student learning outcomes through EKTS software media. SMKS Kristen 1 Tomohon, a vocational school preparing students for the electrical and industrial automation sectors, has identified persistent challenges related to learning outcomes in electric motor installation. Observations and teacher interviews indicate that many students score below the Minimum Completion Criteria and show low confidence during practical exercises. These challenges mirror findings in vocational education globally, where limited exposure to industrial-level systems and fear of errors hinder performance (Osman & Khuzaimah, 2021; Xiao & Hu, 2020).

The Electrical Control Techniques Simulator (EKTS) provides a virtual learning environment enabling students to design, simulate, and troubleshoot control circuits. Research indicates that simulator-based learning strengthens conceptual understanding, supports self-correction, and reduces misconceptions during early stages of technical training (Effendi, 2017; Rafiq & Hashim, 2022). However, empirical evidence combining EKTS with Problem-Based Learning (PBL) in Indonesian vocational education remains limited. This study addresses this gap by examining how EKTS-assisted PBL influences student learning outcomes.

There are several important things that can be used as advantages of using EKTS software, including:

1) Can design and simulate electric motor installation systems.
2) In experimenting with control systems using various relays, contactors, timers, switches, and electric motors.
3) SoftwareThis can also help to show errors in the design that we made after we did the simulation.
4) The design results are in the form of images that can be printed, or can be saved in the form of jpg, gif, png, and bmp files.

These results influence the utilization of computerized technology capabilities through the use of EKTS software to facilitate students' understanding of the competencies required to operate electric motor installation control systems. This process can help improve student learning outcomes at SMKS Kristen 1 Tomohon.

LITERATURE REVIEW

Learning model

According to Slavin in Tri Anni (2011), learning is an individual change caused by experience. Meanwhile, learning is an effort to organize the environment that provides nuances so that the learning program grows and develops optimally. Thus, the learning process is internal and unique to the individual student, while the learning process is external, deliberately planned and behaviorally engineered. A learning model is a concept for realizing the teaching and learning process, which means a plan that will or can be implemented. Meanwhile, according to Yoice and Marsha in Sugandi (2016), a learning model is a pattern plan used in compiling the curriculum, organizing teaching materials, and providing guidance to teachers in the classroom in learning settings or other settings. It is said that a pattern means a teaching model in its development in the classroom, requiring elements of methods, teaching techniques and media as support.

Problem-Based Learning is an instructional model that organizes learning around authentic problems requiring investigation, reasoning, and solution construction. PBL is grounded in constructivist theory, which emphasizes learner-centered engagement, collaborative inquiry, and reflective thinking (Hmelo-Silver, 2004). Meta-analytic studies show that PBL enhances problem-solving skills, conceptual understanding, and long-term knowledge retention (Strobel & van Barneveld, 2009; Loyens et al., 2011).

Definition of EKTS

Electrical control techniques simulatoris a simulator software that can be used to design electromechanical systems. This software provides a variety of electromechanical systems that use relays, time relays, buttons, motors, switches, and various basic mechanical systems (Effendi, 2017). The main use of this simulator is to simulate the basics of electromechanical systems, because this Electrical control techniques simulator has a useful feature for correcting errors if there are errors in the installation of the equipment. Another feature of this Electrical control techniques simulator is the presence of a list of all circuit elements that are commonly used in real environments.

EKTS is a simulation platform that allows users to design electromechanical control circuits consisting of relays, switches, buttons, contactors, time relays, and motors. Simulations allow students to test circuit logic and identify wiring errors before performing real-life installation. Digital simulation tools have been shown to improve student engagement and reduce operational risks during early learning stages (Effendi, 2017; Lim & Jang, 2019). EKTS serves as a scaffolding tool by providing error detection, visual feedback, and opportunities for repeated practice.

Electric Motor Installation Material

Electric motor installation is one of the fundamental vocational subjects that is very important for students to understand in electrical programs, but in reality, this subject is difficult for most students to understand. Electric motor installation is one of the installation subjects intended to control or control the operation of electric motors for production purposes in an industry. The term 'control' means to control and regulate, so what is meant by electric motor control is the motor regulation from the start to the control of the motor until it stops rotating.

The control system can be divided into three categories according to its function, namely: 1) control at the time of starting (starting) 2) control when the motor rotates (speed control) (reversing the direction of motor rotation) 3) control when the motor stops rotating (braking). According to technological developments that have an impact on industrial development, control methods or systems will continue to develop therefore they can be divided into, 1) manual control (manual control) 2) automatic control (automatic control) 3) programmable control or known as a programmable controller, while the material in the electric motor installation subject is: 1). DOL (direct on line) circuit 2), Star-delta (Y-Δ) circuit 3), and Circuit with two directions of rotation (forward-reverse).

Electric motor installation is a foundational competency for students in electrical engineering vocational programs. It includes control systems such as Direct On-Line (DOL), Forward-Reverse, and Star-Delta circuits. Understanding these circuits requires mastery of sequential logic, safety mechanisms, and electromechanical interactions. Misinterpretation of these systems can lead to equipment damage or safety risks. Literature emphasizes that simulation-supported instruction enhances students' readiness and skill acquisition in motor control practices (Adekunle & Olatunji, 2020; Fernández-García et al., 2021).

METHOD

This research will be conducted at SMKS Kristen 1 Tomohon. Which is located at Jl. Tomohon - Tondano No.158, Matani Satu, Tomohon Tengah District, Tomohon City, North Sulawesi Province. The research time is the time used by the researcher during the research, planned to be carried out in October-November 2025. This research was conducted during the provision of electric motor installation subjects.

Research Types

The current type of research uses experimental research, namely True Experimental research (pure experiment), namely experiments that follow procedures and meet the requirements of experiments, especially regarding variable control, control groups, treatment administration or activity manipulation, and testing results. In experimental research, there are at least two sample groups that have been considered to have the same or nearly the same characteristics, namely the experimental group and the control group. The difference between the two groups is the type of treatment given. The experimental group is given special treatment, namely using EKTS software (variables whose consequences will be tested), while the control group is given conventional treatment or treatment that is usually done previously.

Research design is a specific presentation of the research. The approach used in this study is a quantitative approach through experimental methods. The two-group pretestposttest design was used.

Research Variables

In this research, 2 types of variables were determined to be measured based on the research title, these variables are:

Independent Variable, with the notation (X), is the variable that influences the dependent variable. In this study, namely: The variable in this study is the use of EKTS Software.

The dependent variable, denoted by (Y), is the variable that is influenced or the result of the independent variable. The dependent variable in this study is the students' circuit analysis skills. The circuit analysis in question is the post-test result of all 12th grade students at SMKS Kristen 1 Tomohon.

Data collection technique

1. Observation

According to Ahmad Tanzeh, observation is "a method of collecting data using the eyes without the aid of other standard tools for this purpose."

Based on the description above, the researcher conducted sensory observations of the research object, along with notes on matters deemed necessary. In this study, the researcher used these observations to obtain data on the teaching and learning facilities and infrastructure at the school, the school's condition, and student activities during the electric motor installation learning activity.

2. Test

Achievement tests generally measure students' mastery and abilities after a certain period of time receiving teaching and learning from a teacher (Sukardi, 2007). Achievement tests can be used to assess learning progress and identify learning problems. Achievement tests apply to both experimental and control classes, with the same type and number of questions.

The learning achievement test is carried out twice, namely:

a. Pre-Test

Pre-Testcarried out to determine initial competency before treatment is given.

b. Post-Test

Post-Testconducted to determine the final abilities of students after being given treatment.

3. Documentation

Another way to obtain data from respondents is to use documentation techniques. This technique involves examining written materials such as official documents in the form of letters or other evidence (Sukardi, MP).

This method is used to obtain written or pictorial data about the list of names of students included in the experimental group and control group, photos of student activities during the learning process and other documentation deemed necessary in this research.

RESULTS AND DISCUSSION

Normality Test

To determine whether a sample is normal, if sig > 0.05, it is normal; if sig < 0.05, it is considered abnormal. The calculation results are as follows table 1.

Table 1. Summary of Normality Test

No	Group	sig	Conclusion
1	*Pre-Test*Experimental Class	.616	Normal
2	*Post-Test*Experimental Class	.647	Normal
3	*Pre-Test*Control Class	.976	Normal
4	*Post-Test*ClassControl	.888	Normal

Based on the table 1, it can be seen that the pre-test and post-test data for learning outcomes in both the experimental and control classes have a sig value > 0.05, so it can be concluded that the data group is normally distributed.

Reliability Test

To accept or reject the hypothesis by comparing the sig value in Levene's statistic with 0.05 (sig > 0.05) The results of the homogeneity test can be seen in the following table 2.

Table 2. Summary of Homogeneity Test

Class	F count	*Sig*	Information
Pre-Test	2,226	0.148	Homogeneous
Post-Test	5,296	0.030	Homogeneous

The results of the homogeneity test of the research variables show that the pre-test calculated F value is 2.226 with a significant value of 0.148 while the post-test calculated F value is 5.296 with a significant value of 0.030. From the results of the calculation of the significance value of the pre-test and post-test data, which is greater than 0.05 (sig > 0.05), it can be concluded that the data in this study has a homogeneous variance.

Hypothesis Testing

This study aims to determine the differences in learning methods using EKTS software and conventional methods in improving student learning outcomes in learning Electric Motor Installation in class XI TITL II SMKS Kristen 1 Tomohon. The analysis used is the t test with the help of SPSS for windows version 16.00 which can be explained in detail as follows:

Pre-Test and Post-Test t-Test of Experimental Group

The pre-test and post-test t-tests for the experimental class aimed to determine whether there was an increase in scores. The study's conclusion was declared significant if the calculated t-value was greater than the table t-value at a significance level of 5% and the p-value was <0.05. The summary of the pre-test and post-test ttests for the experimental class is shown in the following table 3.

Table 3. Summary of Paired t-Test Results Pre-Test with Post-Test Experimental Group

Class	Average	thitung	table	P
*Pre-Test*Experimental Group	62.86	17,344	2,179	0.000
*Post-Test*Experimental Group	82.86			

Based on the table above, the average pre-test score for the experimental group was 62.86 and the average post-test score was 82.86, resulting in an increase of 2.00. The t-value was also obtained. count > ttable at a significance level of 5% (17.334 > 2.179) and has a p-value < 0.000, which means that it can be concluded that there was a significant increase in the learning outcomes scores of students in the experimental group.

Hypothesis for *Paired Samples Test* is:

Hypothesis for Paired Samples Test is:

Ho: there is no significant difference between the values *pretest*and value *posttest* experimental group

Ha: there is a significant difference between the values *pretest* and value *posttest* experimental group

If the value is obtained *Sig. (2-tailed)* more than 0.05 then H0 is accepted and Ha is rejected, this means the value *pretest* and *posttest* the experimental group did not have a significant difference. However, if the value obtained *Sig. (2-tailed)* less than 0.05 then H0 is rejected and Ha is accepted, this means the value *pretest* and *posttest* the experimental group had significant differences. See table 4.

Table 4. Paired Sample Test Experimental Group

PAIR 1	Pairen Diffrences					T	df	Sig. (2-tailed)
	Mean	Standard Deviation	Std. Error Mean	95% confidence interval of the difference				
				Lower	Upper			
PRE- POST TEST	20,000	4,315	1,153	17,509	22,491	17,344	13	.000

Mark*Sig. (2-tailed)*in the table above shows 0.000 (<0.05), this means that H0 is rejected and Ha is accepted, in other words the value *pre-test* and *post-test.* The experimental group had a significant difference. Therefore, it can be concluded that the learning method using the EKTS software in the experimental group experienced an increase.

Pre-Test and Post-Test t-Test of the Control Group

The pre-test and post-test t-tests for the control group were used to determine whether there was an increase in scores. The study's conclusion was considered significant if the calculated t-value

was greater than the table t-value at a significance level of 5% and the p-value was less than 0.05. A summary of the pre-test and post-test results for the control group is shown in the following table 5.

Table 5. Summary of Paired t-Test Results of Pre-Test with Post-Test of Control Group

Class		Average	thitung	table	P
Pre-Test Group	Control	60.76	7,500	2,201	0.000
Post-Test Group	Control	63.07			

Based on the results of the t-test, it is known that the pre-test average was 60.76 at the time of the post-test, increasing to 63.07, so the increase was 2.30. Furthermore, based on the t-test, the calculated t was 7.500 with a significance of 0.000. The t-table value with a significance level of 5% is 2.201. So the calculated t value> t-table (7.500> 2.201) and the significance value is less than 0.05 (p = 0.000 <0.05). From the data above, it can be concluded that the increase of 2.30 is significant or there is a significant increase in the learning outcome scores of students in the control group.

Hypothesis for *Paired Samples Test*

Hypothesis forPaired Samples Test is:

Ho: there is no significant difference between the values *pre-test* and value *post-test* control group

Ha: there is a significant difference between the values *pre-test* and value *post-test* control group

If the value is obtained *Sig. (2-tailed)*more than 0.05 then H0 is accepted and Ha is rejected, this means the value *pre-test* and *post-test* the control group did not have a significant difference. However, if the value obtained *Sig. (2-tailed)* less than 0.05 then H0 is rejected and Ha is accepted, this means the value *pre-test* and *post-test* the control group had a significant difference. See table 5.

Table 5. Paired Sample Test Control Group

Pairen Diffrences								
PAIR 1	Mean	Standard Deviation	Std. Error Mean	95% confidence interval of the difference		t	Df	Sig. (2tailed)
				Lower	Upper			
PRE-POST TEST	2.30769	1.10946	.30769	1.63729	2.97810	7,500	12	.000

Mark*Sig. (2-tailed)*in the table above shows 0.000 (<0.05), this means that H0 is rejected and Ha is accepted, in other words the value *pre-test* and *post-test* The control group had a significant

difference. Therefore, it can be concluded that the learning method using the EKTS software in the experimental group experienced an increase.

1. Post-Test t-Test of Experimental Class and Post-Test of Control Class

The independent-sample t-test analysis of the post-test of the experimental group and the post-test of the control group aims to determine whether there is a significant difference in the post-test scores in the experimental and control groups. The research conclusion is declared significant if the calculated t value is greater than the table t value at a significance level of 5% and the p value is <0.05. The summary of the pretest and post-test t tests of the experimental and control groups is shown in the following table 6.

Table 6. Summary of Post-Test t-Test Results for Experimental Group and Control Group

Class	Average	thitung	table	P
Experimental Group	82.86	6,723	2,060	0,000
Control Group	63.07			

The summary of the post-test t-test shows that the average learning outcome of the experimental group is 82.86 and the average learning outcome of the control group is 63.07, so it can be concluded that the average learning outcome of the experimental group is 19.78 greater than that of the control group.

From the table 6, it is known that the calculated t is 6.723 with a significance of 0.000. The t table obtained at a significance level of 5% is 2.060. So the calculated t value > t table (6.723 > 2.060) and the significance value is less than 0.05 (p = 0.000 < 0.05). It can be concluded that there is a significant difference in student learning outcome scores in the experimental group and the control group.

Hypothesis for *Independent Samples Test*

Hypothesis forIndependent Samples Test is

H0: there is no difference in the average value of the experimental group and the control group.

Ha: there is a difference in the average value of the experimental group and the control group.

If the probability value obtained is > 0.05, then H0 is accepted and Ha is rejected, this means there is no difference in the average value of the control class and the experimental class. However, conversely, if the probability value is < 0.05, then Ha is accepted and H0 is rejected, this means there is a difference in the average value of the experimental group and the control group. See table 7.

Figure 7. Independent Sample Test

Levene's Test For Equality of Variances	t – test for Equality of Means

	f	Sig.	t	Df	Sig. (2tailed)	Mean Differences	Standard Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
EVA	5,269	.030	6,723	25	.000	19.78022	2.94205	13.72096	25.83948
EVNA			6,559	19,128	.000	19.78022	2.99767	13.50886	26.05158

*EVA = Equal Variances assumed

*EVNA = Equal Variances not assumed

Mark*Sig. (2-tailed)*The table shows 0.000, which means it is less than 0.05. Therefore, Ha is accepted and H0 is rejected. In other words, there is a difference in the average values of the experimental and control groups.

The alternative hypothesis in this study was proven correct as shown by the overall test results.*independent test*in each group, namely the experimental group and the control group. The results of the test*independent test*also showed that there was a significant increase in the average value in the experimental group compared to the average value of the control group.

The findings align with global research emphasizing simulation-supported pedagogy. EKTS allowed students to visualize circuit logic, detect errors autonomously, and reduce anxiety associated with hands-on electrical work. When combined with PBL, students engaged in problem-solving processes that strengthened conceptual and procedural knowledge. These results echo the conclusions of Neumann et al. (2021), who found that simulation-based learning environments promote deeper understanding in technical education.

CONCLUSION

Based on the results of the study, it can be concluded that the use of learning media with EKTS (Electrical Control Techniques Simulator) software has a good influence on the learning achievement of the Electric Motor Installation subject of class XI of SMKS Kristen 1 Tomohon. This can be shown by the results of the hypothesis test that the significance value obtained is smaller than the significance level. So there is a difference in the average learning outcomes of the experimental group. Based on the conclusions of the research results above, the researchers propose suggestions for vocational high schools, especially the TITL department, namely the use of EKTS software should be further developed to improve student learning achievement. Educators are advised to be able to use EKTS software in the learning and teaching process to create a more effective and enjoyable learning atmosphere. For further researchers, it is hoped that they can develop further research using other learning methods to improve student learning achievement. For the follow-up of this research, it is hoped that the school can use this learning method so that it can later improve student learning outcomes and can strengthen communication during learning and teaching activities. EKTS-assisted PBL significantly enhances student learning outcomes in electric motor installation subjects. Students demonstrate greater

conceptual understanding, confidence, and practical readiness. Vocational institutions should integrate simulation technologies to strengthen competency-based learning and improve alignment with industrial automation demands. Future research should explore long-term retention, integration with augmented reality, or broader implementation across vocational subjects.

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