Educational Administration: Theory and Practice
2024, 30(2), 446
e-ISSN: 2148-2403
https://kuey.net/

Research Article

Effectiveness of the EPI Electrical Media to Electrical Diagram Read Ability

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Citation: Komarudin, Marji, Sutadji, E., Widiyanti. (2024). Effectiveness of the EPI Electrical Media to Electrical Diagram Read Ability. *Educational Administration: Theory and Practice*, *30*(3), 17-27. doi: 10.52152/kuey.v30i3.446

ARTICLE INFO

Received: 10 Jul 2023
Accepted: 22 Sep 2023

ABSTRACT

Training is a form of vocational education that is the choice of the younger generation. Training prepares graduates in order able work in the fields studied. EPI (Electronic Petroleum Injection) electrical media is a learning tool that helps students read EPI electrical diagrams. The purpose of this study is to assess the effectiveness of the EPI electrical media on the ability to read electrical diagrams. This study applies a quasi-experimental non-equivalent pretest-post-test. The population are the automotive training participants at the Malang State University. The sample is 80 participants was divided into two groups, namely the experimental and control groups. Research data were collected using written tests, interviews, and observations. The written test data were tested for normality, homogeneity, and ANOVA test. The results revealed that there were differences in the ability to read electrical diagrams between the control class and the experimental class. Efficient electrical media to improve the ability to read electrical diagrams. EPI electrical media can be applied in automotive training.

Keywords: Automotive Training, Electronic Petroleum Injection, Electrical Diagram, Read Ability, Vocational Education.

INTRODUCTION

The productivity level of the workforce in Indonesia was below the average of the Association of Southeast Asian Nations (ASEAN), which is 78.2 per cent (Azizah, 2020). The vice president expressed the same opinion that the quality of Indonesia's workforce is not the best in ASEAN (Purnamasari, 2020). One way to improve the quality of the workforce is training (Putri, 2021). Many types of training are conducted to improve the quality of the workforce (Edelia & Aslami, 2022).

One type of training is the Malang State University Automotive Training (PUSDIKLAT-UM). Pusdiklat is an automotive training institution that prepares prospective technicians for Suzuki workshops. Pusdiklat participants were scattered throughout Suzuki workshops. The results of interviews with teachers showed that Pusdiklat participants could not read electrical diagrams. (Fauzan, Hamidah, & Sriyono, 2019) who said that many students on campus cannot read electrical diagrams. The results of Kusari (2011) research show the students' electrical competence abilities were low. This condition will be a loss for them when working in a car repair shop. The current automotive development focuses on the electrical field without neglecting the mechanical field. Now, many car factories are producing electric cars (Nugrahadi, 2021). Pusdiklat participants must master electrical skills to work well in a car repair shop.

The ability to read electrical diagrams was a basic knowledge (prior knowledge) for the next learning process. Training participants who cannot read electrical diagrams will have difficulty understanding the electrical materials for the anti-lock brake system, electric power steering, and automatic transmission. Prior knowledge is the knowledge of participants when entering relevant learning situations to obtain new information (Hailikari, Katajavuori, & Lindblom-Ylanne, 2008; Liu, Lin, & Paas, 2014). Meanwhile, (Roschelle, 1995) stated prior knowledge is knowledge mastered by students and personal knowledge when learning new material. According to

(Song, Kalet, & Plass., 2014) and (Amadieu & Tricot, 2009) prior knowledge is a basic scheme in learning. Prior knowledge determines the quality of learners to acquire new information (Mcnamara, Kintsch, Songer, & Kintsch, 1996).

According to Febriyono, Widjanarko, (2014) and Kusari (2011), the problem in teaching electricity was the unavailability of learning media that can help students master electrical competence. This condition was similar to the results of observations at Pusdiklat-UM. That condition causes a low ability to read electrical diagrams. The reading electrical diagrams ability was generally taught using modules, manual books, and presentations. The results of observations at the Education and Training Center showed that electrical diagrams were taught using manual books and presentations. However, learning electrical diagrams using manual books and presentations is still not effective. Electrical diagrams must be displayed clearly so the material presented can be received well. Maximum electrical learning outcomes require electrical media (Widjanarko, Sofyan, & Surjono, 2016). The right learning media can help trainees master the ability to read electrical diagrams (Komarudin & Mukhadis, 2020b). Therefore, this research uses EPI electrical media which is equipped with electrical diagrams, manual books, and worksheets. This media makes it easier for trainees to read the diagrams that connect the components of the EPI. The purpose of this study was to measure the effectiveness of the EPI electrical media on the ability to read electrical diagrams.

LITERATURE REVIEW

The Importance of Reading Electrical Diagrams

Many trainees, including participants of PUSDIKLAT-UM and students on campus, lack the necessary skills to read electrical diagrams effectively (Fauzan et al., 2019; Kusari, 2011). The inability to read electrical diagrams can lead to difficulties in understanding complex electrical systems in automotive repair and maintenance. Deficiencies in this fundamental skill can hinder trainees' ability to troubleshoot electrical issues and accurately interpret circuit connections, resulting in ineffective repairs.

Inadequate skills in reading electrical diagrams can lead to errors and safety hazards in automotive repair, as misinterpreting circuit connections can result in faulty repairs or improper installations (B. Moeller & J. Moeller, 1994). The lack of proficiency in understanding electrical diagrams can lead to delays and inefficiencies in diagnosing and resolving electrical issues, impacting the overall productivity and quality of work in car repair shops. Trainees with deficiencies in this skill may struggle to keep up with advancements in automotive technology, such as electric vehicles, where a strong understanding of electrical systems is crucial.

Prior knowledge serves as a foundation for learning new information. In the context of reading electrical diagrams, trainees' existing knowledge and understanding of electrical principles, components, and circuitry shape their ability to comprehend and interpret diagrams effectively (Bayer, Zadeh, Schröder, & Dengel, 2022). A strong base of prior knowledge in electrical systems can facilitate the acquisition of new information, allowing trainees to build upon existing mental schemas and effectively integrate new concepts. Recognizing and addressing gaps in prior knowledge is essential for designing effective training programs that aim to improve trainees' skills in reading electrical diagrams.

Challenges in Teaching Electrical Competence

One of the challenges in teaching electrical competence is the absence of appropriate learning media that can effectively support the acquisition of electrical skills. Traditional teaching materials, such as modules, manuals, and presentations, may not adequately engage trainees or facilitate the development of practical skills in reading electrical diagrams. The lack of specific learning media designed for teaching electrical competence can hinder trainees' ability to grasp complex electrical concepts and effectively apply them in real-world scenarios. Developing and implementing specialized learning media, such as EPI Electrical Media, can address this challenge by providing targeted resources that enhance trainees' understanding of electrical diagrams and related competencies.

Traditional teaching approaches, such as relying solely on modules, manual books, and presentations, may not sufficiently engage trainees or cater to their diverse learning needs. Trainees may struggle to fully comprehend complex electrical concepts solely through passive learning methods, resulting in limited practical skills and retention. Active learning methodologies, including interactive discussions, hands-on activities, and visual aids, are often more effective in promoting deeper understanding and skill development in electrical competence. Integrating innovative teaching strategies and utilizing specialized learning media, like EPI Electrical Media, can

enhance the effectiveness of training programs in teaching electrical competence.

Clear and comprehensive electrical diagrams are essential for effective teaching of electrical competence. Ambiguous or poorly designed diagrams can create confusion and hinder trainees' ability to accurately interpret circuit connections and understand electrical systems. Detailed and well-organized diagrams that clearly illustrate component layouts, wiring connections, and system functionalities are crucial for trainees to develop a strong foundation in reading electrical diagrams. Using clear and comprehensive electrical diagrams ensures that trainees acquire accurate mental models of electrical systems, facilitating their ability to troubleshoot and repair electrical issues effectively (Yasak, 2020).

EPI Electrical Media

EPI (Electronic Petroleum Injection) electrical media is a specialized learning tool designed to assist trainees in reading electrical diagrams effectively. The components of EPI Electrical Media typically include electrical diagrams, manual books, and worksheets. Electrical diagrams within the EPI Electrical Media provide visual representations of circuit connections, component layouts, and electrical system configurations (Gusnusa & Myori, 2022). The manual books provide additional explanations, guidance, and reference materials related to electrical systems and their corresponding diagrams. Worksheets offer practical exercises and activities to reinforce trainees' understanding and application of electrical diagram reading skills.

EPI Electrical Media enhances the learning experience by providing a comprehensive and interactive approach to teaching electrical diagram reading. Visual representations in the form of electrical diagrams enable trainees to grasp complex circuit connections more effectively than traditional teaching methods. The combination of diagrams, manual books, and worksheets in EPI Electrical Media caters to different learning styles, promoting a more inclusive and engaging training environment. The interactive nature of EPI Electrical Media encourages active participation, problem-solving, and critical thinking, fostering a deeper understanding of electrical systems and their corresponding diagrams (Carpenter, Mayo, Wagner, & Yelvington, 2016). Using EPI Electrical Media can improve trainees' ability to read electrical diagrams accurately and efficiently, enhancing their overall performance in diagnosing and repairing electrical issues in automotive settings.

Evaluating the effectiveness of EPI Electrical Media involves conducting empirical studies or experiments to measure its impact on trainees' learning outcomes, specifically in reading electrical diagrams. Assessment methods may include pre-and post-tests to measure improvements in trainees' diagram reading skills after using EPI Electrical Media. Other evaluation techniques could involve collecting qualitative data through surveys, interviews, or observations to gather trainees' feedback on the usability, effectiveness, and overall satisfaction with EPI Electrical Media. The assessment should focus on key aspects, such as trainees' comprehension, accuracy, speed, and confidence in reading electrical diagrams, to provide a comprehensive understanding of the effectiveness of EPI Electrical Media as a training tool.

METHODOLOGY

Design

This research is implemented on EPI electrical material with the topic of electrical components, component symbols, cable color symbols, and reading electrical diagrams. This material is useful for trainees while working in a car repair shop. PUSDIKLAT participants are prospective car technicians who will repair the electrical system. The ability to read diagrams and solve electrical problems is an important competency to master. This study applied a quasi-experimental pretest-post-test with 80 participants (Bizimana, Mutangana, & Mwesigye, 2022) (**Table 1**).

Table 1. Quasi Experiment with Pre-Test Post-Test Control Group Design

Pre-test	Treatment	Post-test
Pre-test scores	Used manual book and presentation	Post-test scores
Pre-test scores	Used manual book and EPI electrical media	Post-test scores

The learning stages in both classes are the same, the difference is the use of EPI electrical media in the experimental class. The learning stages consist of opening, core activities, and closing. **Table 2** shows the learning activities of the control class and the experimental class.

Table 2. Learning Stages of the Lecturing Model

No	Phase	Activity	Control class	Experiment class
1	Introduction	The teacher begins the class, checks students, and does the pretest	Equal	Equal
2	Core activities	The teacher conveyed the material component names, and cable colors, and read electrical diagrams.	Used PowerPoint, manual book, and textbook	Used PowerPoint, textbook, manual book dan EPI electrical media.
3	Closing	The teacher concluded the materials and did the post-test	Equal	Equal

Population and Sample

The population and sample in this study were 80 participants in the automotive training at the State University of Malang (PUSDIKLAT-UM). The population and sample were then divided into a control class and an experimental class. Indicators of the ability to read electrical diagrams include mentioning the name of the components, mentioning the color of the wires; read electrical diagrams.

Procedure

The teacher gave a pretest at the beginning of the implementation. The pretest-post-test indicators include: mentioning the name of the electrical components, mentioning the color of the cable, and reading electrical diagrams. After doing the pretest, the teacher continued to deliver the material on the name of the component. That knowledge is a component of the ability to read electrical diagrams. The material for the name of the component is conveyed using the media of an electrical diagram. This media helps teachers teach the names of electrical components. Teachers can point directly to the components. In the control class, the teacher uses a manual book and PowerPoint so that he cannot show the components directly. The teacher may occasionally appoint one of the trainees to show the components of an electrical diagram. Next, the teacher conveys the cable color material. The color of the EPI electrical cable has a distinctive color pattern. This material needs to be delivered so that the trainees memorize the cable colors. Each cable color has its character, for example, the orange wire color is used for the Engine Control Module (ECM) ground. Teachers can directly indicate the color of the cable, for example, the color of the red wire, the white line is coded with "Red/White". The previous two materials became the basis for reading electrical diagrams. The teacher can immediately point to the relationship between components and the color of the wires. Electrical media can be used as an assessment instrument during learning. Teachers can ask trainees to read pictures on electrical media. The teacher can immediately point to the relationship between components and the color of the wires. Electrical media can be used as an assessment instrument during learning. Teachers can ask trainees to read pictures on electrical media. The teacher can immediately point to the relationship between components and the color of the wires. Electrical media can be used as an assessment instrument during learning. Teachers can ask trainees to read pictures on electrical media.

The EPI electrical media displays the EPI electrical components and diagrams on a flat surface so that teachers can easily convey the relationship between the sensor and the ECM. Researchers made observations during the process of delivering material. At the end of the delivery of the material, a post-test is given, and the indicators asked are the same as the pretest. The results of the pretest and post-test were then tested for normality, and homogeneity followed by the One Way ANOVA test. ANOVA test results include the difference in the mean, median, minimum value, and maximum value. The results of the analysis are then used as the basis for selecting interview informants. Interview indicators include post-test indicators and several questions about the experience of using EPI electricity media.

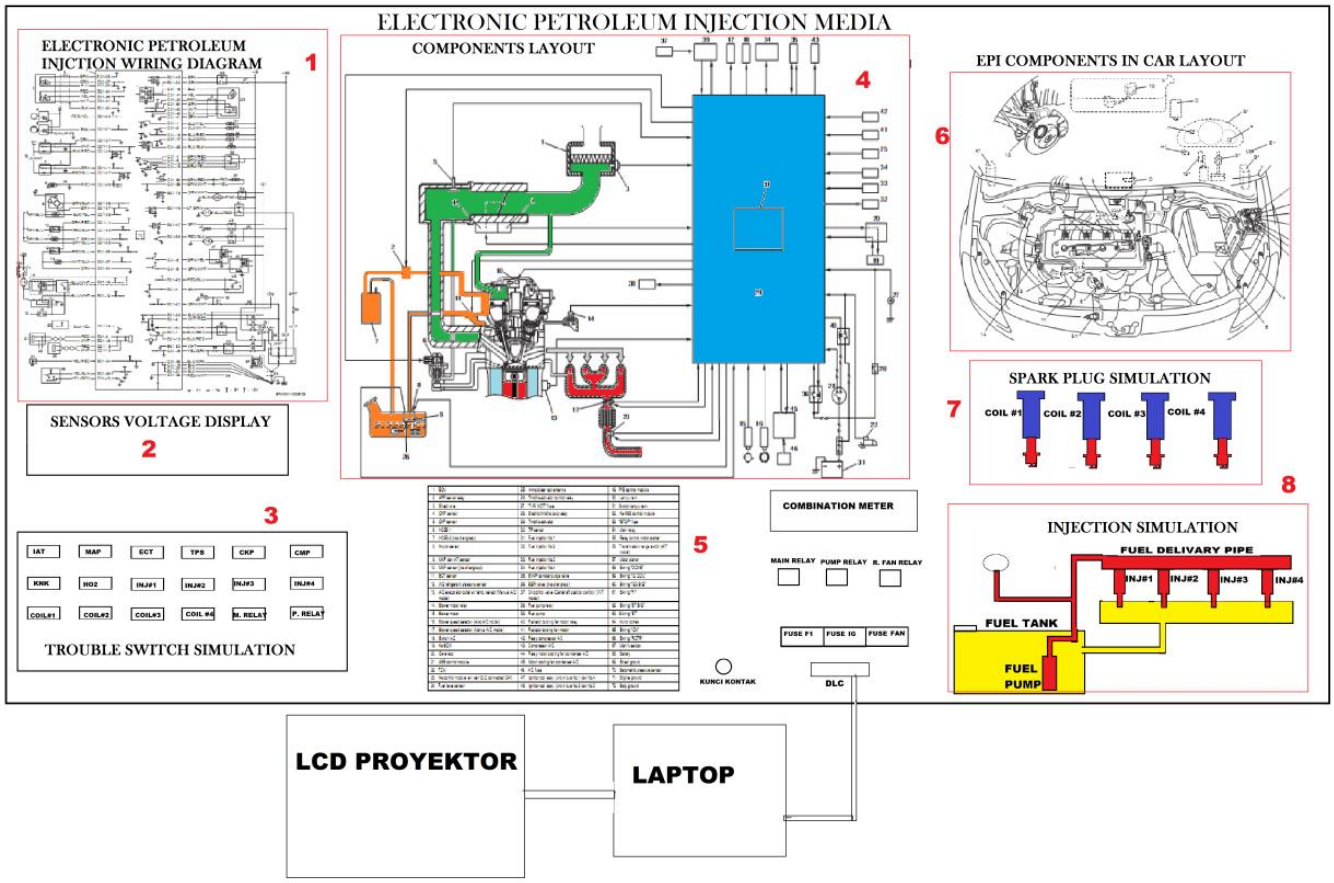

Figure 1. Electrical Media Layout

The EPI electrical media in **Figure 1** has several components including electrical diagram images used to read the circuit, sensor voltage display to view voltage changes, troubleshooting buttons for problem simulation, layout plans to show component locations and distinguish sensors and actuators based on arrow directions, component names to show the identity of the components, the layout of the components in the car to help visualize the location of the components, simulation of ignition to help visualize the shape and speed of spark plugs, simulation of spraying to describe the shape of the spray.

Instrument

Research data were collected using tests, observations, and interviews. The written test consists of a pretest and a post-test. The pretest and post-test instruments are the same. Interviews were conducted after the implementation process to measure the trainees' ability orally. Observations are done during learning, the expected information is the interaction between the teacher and the training participants. **Table 3** shows the electrical reading indicators.

Table 3. Electrical Reading Indicators

No	Indicator	Written test	Interview
1	Mentioning Name of the electrical components	Question in the form of multiple choice.	The training participants were asked to name the electrical components orally
2	Mentioning electrical symbols	Question in the form of multiple choice.	The teacher instructs the participants to say the symbols on the electrical media or the machine
3	Mentioning the color of the cable	Question in the form of multiple choice.	The teacher asks participants to name the color of the wires.
4	Reading electrical diagrams	The question is a sequence of reading electrical diagrams	The teacher asks the participants to read the electrical diagram

Analysis

The test results were tested for normality and then analyzed using ANOVA. Observations were made to determine learning activities. Interviews were conducted after the learning activities. The questions posed to the informants were the materials tested on the written test, and experiences after using the EPI electrical media.

RESULTS

One indicator of the success of automotive training was the ability to read electrical diagrams. This ability is obtained when using the right media and methods. The results of the pretest-post-test are shown in **Table 4.**

Table 4. Description of Research Data

	Experiment class			Control class		
	Pretest	post-test	Improvement	Pretest	post-test	Improvement
Mean	44.73	70.92	26.19	42	46	4
Median	42.11	71	28.89	36.84	47.37	10.53
Minimum	31	52	21	21	21	0
Maximum	68	89	21	63	68	5
Range	37	37		42	47	

The average pretest of the experimental class in **Table 4** was (44.73) and the control class was (42), there was a small difference between the two classes. This means that the control class and the experimental class have the same character. While the post-test average of the experimental class was (70.92) and the control class was (46), there was a difference of 29.92, and there was a significant difference between the two classes. The average pretest of the experimental class with the average post-test is also different, there is an increase of (26.19). While the control class has an average increase of (4). There is a difference in the increase of 22.19. Generally, the class average is used as a comparison for the success of the learning process. Based on the average of the two classes, it can be concluded that the experimental class is better than the control class. The minimum pretest value of the experimental class (31) and the control class (21), there is a difference but not significant. In the control class, there was no difference in the minimum score between the pretest and post-test. This condition is possible because of monotonous learning. Based on the results of interviews with Pusdiklat participants they had studied electrical diagrams in SMK, but because they did not like it, they were not interested in learning. Unlike the experimental class, there is an increase in the minimum score of (21).

Based on the results of interviews with participants, information was obtained that by using electrical media the training participants were easier to understand the material presented. The maximum value of the experimental class increased by (21), while the maximum value of the control class increased by (5). The use of EPI electrical media had a significant impact on the ability to read electricity. The results of this quantitative study are in line with the results of observations which show that experimental class participants find it easier to complete work during practice. The learning process uses active electrical media. The teacher can ask participants to actively name components, and mention component symbols, and cable colors that have an impact on the ability to read electrical diagrams.

Table 5. ANOVA Test Result

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2170.278	1	2170.278	7.150	.009
Within Groups	23675.984	78	303.538		
Total	25846.262	79			

This research is useful for improving the ability to read electrical diagrams. **Table 5** shows the results of the ANOVA test between the control class and the experimental class. The results of the ANOVA analysis showed a significance of 0.09. The rule on the ANOVA test is if the significance of the ANOVA test is less than 0.05, then it is declared significant. This means that there is a difference between the control class and the experimental class.

This study aims to measure the effectiveness of the EPI electrical media. The results of data analysis in this study were analyzed using the ANOVA test in Table 5, the probability value was smaller than 0.05, so it was concluded that there was a difference in the ability to read electrical diagrams for the control class and the experimental class. The ability to read electrical diagrams is basic knowledge in the automotive field. The results

of this study are in line with research by (Song et al., 2015) and (Teoh & Neo, 2007) which states that media have a direct impact on prior knowledge. EPI electrical media is a combination of several media so that it is rich in information. Prior knowledge is explicit knowledge, conceptual knowledge, and meta-cognitive that students master when entering relevant learning situations to get new information (Liu et al., 2014). Knowledge of reading electricity can be the foundation for subsequent knowledge. For example, studying the anti-lock brake system (ABS) requires knowledge of reading electrical diagrams to understand the relationship between components. Table 1 shows that there is a difference in the maximum value between the control class and the experimental class which can be used as a basis that there is an influence of electrical media on the ability to read electrical diagrams. Media can improve basic skills (Kalyuga, 2013; E. J. Wamalwa & W. Wamalwa, 2014). Research by Rias and Zaman, (2013) concluded that prior knowledge ability is an important component of learning that must be improved through the use of media. The trainees in the experimental class find it easier to identify components, cable colors, and component symbols, and read electrical diagrams. Automotive electrical media such as the engine management system has a strong influence on the ability to read electricity (Marji, 2020; Sukardi, Sunardi, & Sampe, 2015).

The results of the interviews showed the low ability to read electrical diagrams of automotive training participants. This condition is in line with the (Nozomi, & Hamzah, 2018) research results. Many factors influence this condition, one of which is the availability of appropriate learning media. The results of the quantitative research show that there are differences in the average results of the control class and the experimental class. This condition can be used as evidence that learning media is one of the keys to the success of the learning process. The results of this study are in line with (Mujianto, 2011) which showed an increase in the average score of D3 participants in mechanical engineering settings using electric power steering demonstration media.

DISCUSSION

Teachers in the experimental class find it easier to show electrical components and practice reading electrical diagrams. Electrical media helps participants to visualize how to read electricity. Teachers can actively deliver electrical material. Participants can find out the relationship between electrical components easily. Media helps to convey abstract material (Sukiyasa & Sukoco, 2013; EmaWulansari, & Puyada, 2017). **Table 4** shows an increase in the average, minimum, and maximum values in the experimental class, after receiving treatment using EPI electrical media. The increase in the average control class with the experimental class has a significant difference. One of the keys to successful learning in research was the use of EPI electrical media.

The ability to read electricity is a mandatory skill for automotive training participants. A study by Amadieu and Tricot, (2009) highlights that the provision of comprehensive information had an impact on the ability of prior knowledge. The EPI electrical media had comprehensive information. This media is equipped with component names, component symbols, cable colors, and electrical diagrams as shown in **Figure 1**. Learning activities are a knowledge transfer process, there needs to be a minimum capital that students must have, namely prior knowledge. Media is used in building prior knowledge in course venues (Bennett & Brennan, 1993). According to (Bodemer & Ploetzner, 2005) using interactive visualization can reduce the lack of prior knowledge abilities. Visualization is the main key to providing in-depth understanding to participants (Shabiralyani, Hasan, Hamad, & Iqbal, 2015).

The ability to read electrical diagrams was a prerequisite for mastering the next competency (Komarudin, 2018). This competence was very important in solving electrical problems in vehicles (Komarudin, Marji, Sutadji, & Widiyanti, 2020a). Electrical capability can be improved by using visual media. The media helps the trainees to master the components of the ability to read electrical diagrams. Participants said that the EPI electrical media helped to memorize component names, component symbols, and cable colors and read electrical diagrams. Media helped students master electrical skills (Nopilar, 2011). Electrical demonstration media provides benefits in increasing the final ability of electricity learning (Tahroni & Widjanarko, 2014). EPI electrical media was a teaching medium when teaching material on component names, component symbols, cable colors and how to read electrical diagrams. **Table 4** is a description of the final results of the control class with the experiment. Overall, there are significant differences between the two classes. the difference is due to differences in the mastery of EPI's electrical materials. The results of the interview showed that the experimental class participants more easily mastered the indicators of the ability to read electrical diagrams in **Table 2**. Learning media had a better impact than existing learning (Mayilshami & Pandian, 2018; Olayinka, 2016).

The use of electric media based on engine petroleum injection provides several advantages, namely making it easier for participants to know the names and locations of EPI components, memorize electrical symbols, memorize cable colors and read electrical diagrams. These advantages can make it easier for trainees to solve

electrical problems.

CONCLUSION

The EPI electrical media was created to improve the ability to read electrical diagrams for automotive training participants. This media must be equipped with a detailed job sheet, a module that helps participants during the learning process, the most important thing is a teacher who masters the EPI material well. The utilization of electrical media can increase competencies that support the ability to read electrical diagrams including mentioning names of electrical components, mentioning electrical symbols, and mentioning cable colors and their symbols. EPI electrical media is efficient in improving the ability to read electrical diagrams.

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