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AUTOMOTIVE CIRCUIT SIMULATION: IMPROVING PRIOR KNOWLEDGE ABILITY AND PRACTICAL SKILL ACQUISITION IN THE VEHICLE BODY ELECTRICAL SYSTEM

Susi Tri Umaroh*[1)], Sudirman Rizki Ariyanto[2)], Warju[3)]
1. Automotive Engineering Technology, Faculty of Vocational Studies, Universitas Negeri Surabaya, Indonesia
2. Automotive Engineering Technology, Faculty of Vocational Studies, Universitas Negeri Surabaya, Indonesia
3. Automotive Engineering Technology, Faculty of Vocational Studies, Universitas Negeri Surabaya, Indonesia

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* Corresponding author.
Corresponding Author
E-mail address:
susiumaroh@unesa.ac.id

ABSTRACT
This research aims to analyze the improvement of cognitive and psychomotor abilities by integrating ACS (Automotive Circuit Simulation) in learning about vehicle body electrical systems. This research is quantitative research with a quasi-experimental design with two groups, namely an experimental group and a control group. The data collected was analyzed using quantitative descriptive. The results of this research indicate that there are differences in prior knowledge and the acquisition of practical skills among students who utilize ACS media as a learning tool for vehicle body electrical systems. Recommendations from this research include further integrating ACS into the curriculum, increasing the availability of digital learning resources, and providing additional training for educators to optimize the potential for independent and interactive learning for students through simulation. Thus, this article proposes an innovative solution to effectively support the development of students' knowledge and skills in the field of vehicle body electrical systems.

I. INTRODUCTION

Currently, the education sector is supported by information and communication technology (ICT) in the learning and teaching process [1]. According to UNESCO, vocational learning (TVET) must be transformed into digital trends that involve technology for the teaching and learning process [2]. Apart from that, the challenges of the Industrial Revolution 4.0 are an era that demands significant changes in education, especially in the automotive sector. With developments in the field of technology, there are many applications of Android technology for mobile learning which can increase the effectiveness and efficiency of learning.

Education is one of the main pillars in achieving Sustainable Development Goals (SDGs), which are listed in SDGs 4. One of the key indicators in achieving SDG 4 goals is improving the quality of education at various levels, including secondary education, such as Vocational High Schools (VHS). Vocational Schools play an important role in ensuring that students acquire practical competencies that are relevant to the needs of the world of work so that they are ready to enter the labor market. Providing quality education at the vocational school level is the key to achieving SDG 4, which emphasizes the importance of equitable, relevant, and quality access to education. Vocational Schools, as educational institutions, have a strategic role in preparing the young generation with the skills and knowledge needed in the 21st-century world of work. One of the study programs at Vocational Schools that is closely related to industry is the Motorcycle Engineering and Business Study Program (TBSM). This program equips students with knowledge of the motorcycle body electrical system, which is a key component in the automotive industry. To improve students' understanding and skills regarding motorcycle body electrical systems, effective learning media is very important. Currently, the teaching media is generally manuals and trainers which involve direct practice in workshops. However, these methods often have limitations in providing in-depth understanding to students. This can hinder students' ability to solve problems that may arise in the world of work.

Apart from that, there are obstacles in conventional learning methods where students have little opportunity to practice directly according to real situations because there are limited learning media available at school. This has an impact on not maximizing the development of the knowledge and skills required by students. Therefore, a more effective alternative is needed to provide relevant understanding and skills in the TBSM Study Program. The

limitations of practicum activities also show that students are not facilitated with digital learning media as a substitute for practicum equipment. This can also mean that students do not have other supporting tools to study outside of school time to improve basic practical skills. Therefore, one strategy in learning that can improve skills is to combine practical activities with learning media [3][4].

Motorcycle body electricity is a sub-section of material that automotive engineering vocational students must master. Where electricity often becomes an obstacle for students when doing practice because they don't understand the concept of knowledge so in practicums in trainers, problems often occur. To solve this problem, technology must be addressed in the learning media used. Learning media that can be used by teachers to enrich classroom learning, namely: audio narratives, illustrations or pictures, videos or animations, simulations, or a combination of all media is called learning multimedia. One interesting alternative in studying electrical systems and as a security solution to prevent short circuits is the use of digital simulation-based learning media[5]. The use of this media utilizes technology to provide a more in-depth experience in understanding the motorcycle body's electrical system. Implementation of media-based learning Digital simulation has great potential to stimulate students' interest so that they can build their prior knowledge about complex concepts and practical skill acquisition [6], [7], [8], [9].

Prior knowledge or initial knowledge is a combination of experience, knowledge, attitudes, and even beliefs that an individual has acquired from experience throughout his life which will construct new knowledge and experiences[10]. In learning, prior knowledge has an important role. Student learning achievement, especially in vocational education, is known from 3 aspects, namely knowledge, attitudes, and skills. Practical skill acquisition can be obtained when students often receive training and teaching through demonstration strategies.

Previous research has investigated various aspects related to the effectiveness of digital simulation-based learning in an educational context. Al-Elq (2010) found that students who used digital simulations in medical vocational learning experienced significant increases in academic achievement in both knowledge and practice[11]. Research by Campos et al. (2020) also shows that digital simulations can help students develop problem-solving abilities in the context of science and also as a support for online learning[12]. Meanwhile, in the context of engineering education, research by Landau & Levin (2023) revealed the benefits of using digital simulations in increasing students' understanding of mechanical systems [13]. Although there is some evidence showing the benefits of digital simulation-based learning in education, there is a lack of knowledge that needs further research. This research aims to determine the impact of increasing initial knowledge and gaining practical skills on motorcycle body electrical material by integrating ACS into learning. This material provides provisions for students to understand the body's electrical system on a motorcycle, therefore understanding the circuit in concept and initial knowledge determines their ability to practice the circuit correctly to avoid short circuits in electrical components. The following research questions were investigated.

1. Is there a significant difference in the prior knowledge and practical skills of students who study with ACS and those who study using manual book wiring diagrams in vehicle body electrical material?

II. METHOD

A. Research Design

This research uses a quasi-experimental quantitative approach with an equivalent control group pretest and posttest design to analyze the effectiveness of ACS on students' prior knowledge and practical skills. Students were selected from several Vocational High Schools (VHS) in Indonesia which opened collaboration classes with industry, in this case, Honda. The survey method was used to collect initial data from respondents to ensure that the VHS involved met the expected criteria. This study used ACS-supported learning experience criteria to determine the research group. Implementation of ACS is by the class XI curriculum, using the ACS application. Students were categorized into two groups (the experimental group (ACS) and the control group).

To control extraneous variables that could threaten internal validity, such as teacher competency, school facilities, and student background, several measures were taken. First, schools were selected from a pool that had established collaboration classes with Honda, ensuring a baseline standard of facilities and industry-relevant curriculum. Second, teacher experience was controlled for by selecting schools where instructors had undergone similar training programs provided by the industry partner. Finally, the use of a pretest helped account for initial differences in students' prior knowledge, allowing the posttest results to reflect the effect of the intervention itself more accurately.

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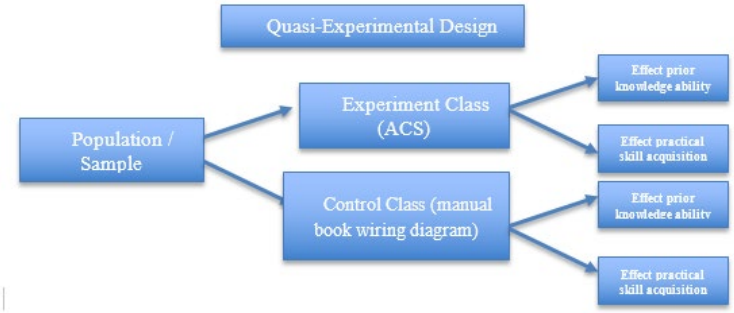

Fig. 1 Research Design Quasi-Experimental Design

B. Research Setting and Sampling

The population of this study includes 34 Motorcycle Engineering and Business VHS (TBSM) under PT. Mitra Pinastika Mulia (MPM) Honda East Java Indonesia. The sampling technique used was proportional stratified random sampling. This technique was chosen to ensure that the sample was representative of the entire population of partnered VHS schools, reducing selection bias and increasing the generalizability of the findings. The research sample was determined using the Slovin Equation at an error tolerance level of 20%, resulting in 15 VHS. From this sample, 7 VHS (50%) were selected as the experimental group which were taught using ACS, and another 7 VHS (50%) were taught using manual book wiring diagrams (control group). The remaining 1 VHS was used for a pilot study to test the instruments and procedures.

C. Data Analyst

This research implemented a normality test using the one-sample Kolmogorov-Smirnov test as a prerequisite for statistical analysis. The criteria for considering data to be normally distributed is when the significance value is > 0.05; conversely, if the significance value is <0.05, it can be considered that the data is not normally distributed. The homogeneity test is carried out to assess whether the variants from each class have homogeneity of variance. If a variant is categorized as homogeneous and there are two or more groups of variants, the homogeneity test is considered to meet the criteria if the significance value is > 0.05.

The justification for the chosen statistical tests is as follows: The independent samples t-test was selected for hypothesis testing because the study design involves comparing the mean scores of two distinct, independent groups (ACS vs. control) on a continuous dependent variable (post-tests scores). This test is robust and appropriate for measuring the difference between two groups when the assumptions of normality and homogeneity of variances are met. A significance level (alpha) of 0.05 was chosen as it is a conventional and widely accepted threshold in social science and educational research, representing a 5% risk of concluding that a difference exists when there is none (Type I error).

If the analysis prerequisites (normality and homogeneity) are met, the next step is to continue with hypothesis testing using the T-test (independent sample t-test) with a significance level of 0.05 [3]. In more detail, the hypothesis in this research is formulated as follows.

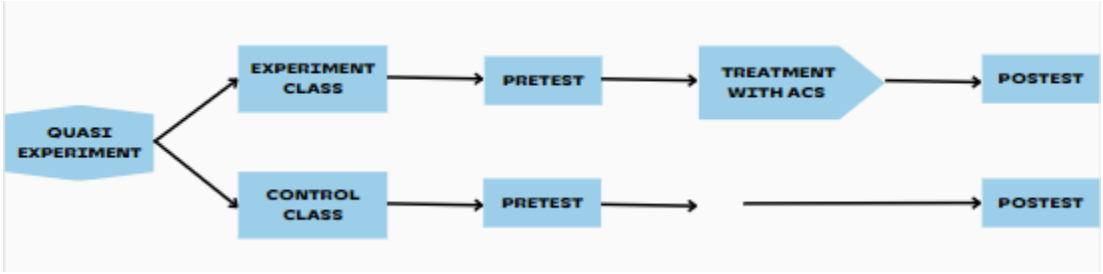

Fig. 2 Research Design An Equivalent Control Group Pretest And Posttest Design

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H0: There is no significant difference in the prior knowledge and practical skills of students who study with ACS and manual books in learning material for motorbike body electrical systems.

H1: There is a significant difference in the prior knowledge and practical skills of students who study with ACS and manual books in learning material for motorbike body electrical systems.

III. Result and Discussions

A. Result

Examination of the level of normality of the distribution is carried out to identify the extent of regularity of students' cognitive and psychomotor data. The distribution normality test using Kolmogorov-Smirnov analysis is considered to accept the null hypothesis (H0) if the significance value is greater than 0.05. Data from the Kolmogorov-Smirnov analysis in more detail can be seen in Table 1 below.

TABLE I.
DISTRIBUTION NORMALITY TEST RESULTS

Class	Kolmogorov-Smirnov			Decision	Conclusions
	N	KS-Z	Asymp. Sig. (2-tailed)		
Experiment	210	1.026	0.243	H0 is Accepted	Distributed normally
Control	210	1.198	0.114	H0 is Accepted	Distributed normally

Based on the results of the normality test of students' cognitive and psychomotor data, it shows that the two groups, namely the experimental class using ACS and the control class using a manual book wiring system, are statistically acceptable that the data comes from a normal distribution. This refers to the significance value (Asymp. Sig. 2-tailed) which is greater than the commonly used alpha value (0.05) [3]. Therefore, it can be concluded that the normality of the cognitive and psychomotor value data from the two groups is accepted. Next, data analysis in the homogeneity test uses Levene's statistical test to obtain information about the similarity of variance between populations used in product effectiveness testing.

The basis for decision-making in the homogeneity test is that if the significance level is greater than 0.05 (Sig. > 0.05), then the variance of the data used is considered homogeneous and can be continued for hypothesis testing[3].

TABLE II.
VARIANCE HOMOGENEITY TEST RESULTS

Levene Statistic	df1	df2	Sig.	Decision	Conclusion
5.619	1	418	0.523	H0 is Accepted	Homogen

The homogeneity test results can be seen in Table 2. Based on this table, it is known that the Sig. Based on the average of 0.523 > 0.05. These results indicate that the data variance is homogeneous. Thus, the homogeneity requirement is met and hypothesis testing can be carried out to determine the influence of ACS in learning the motorbike body electrical system. Next, to determine the effectiveness of ACS in learning motorbike body electricity, a t-test (independent samples t-test) was used. The decision-making criteria for hypothesis testing are as follows:

This section is a comparative or descriptive analysis of research results based on research findings, previous literature, and so on. Results should be presented logically, providing the most important findings first and addressing the stated objectives.

- If the significance level value (Sig.) is <0.05 or if $t_{count} > t_{table}$, then H0 is rejected and H1 is accepted.
- If the significance level value (Sig.) > 0.05 or if $t_{count} < t_{table}$, then H0 is accepted and H1 is rejected.

Hypothesis testing was carried out to prove "Does ACS have a significant influence in improving students' prior knowledge and practical skills?". The hypothesis that has been formulated to determine the testing decision is as follows:

H0 = ACS does not have a significant influence in increasing students' prior knowledge and practical skills in learning motorbike body electrical systems.

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H1 = ACS has a significant influence in increasing students' prior knowledge and practical skills in learning motorcycle body electrical systems.
Results of statistical analysis of the independent sample t-test with the help of the SPSS 20 application.

TABLE III.
INDEPENDENT SAMPLE T-TEST RESULT

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Equal variances assumed	18.395	418	.000	6.986	.380	6.239	7.732
Equal variances not assumed	18.395	408.380	.000	6.986	.380	6.239	7.732

Based on the statistical analysis seen in the table above, it is known that the Sig. (2-tailed) is 0.000 < 0.05, so it refers to the decision-making criteria for testing the hypothesis 'H0 is rejected and H1 is accepted'. To quantify the magnitude of ACS's influence beyond mere statistical significance, an effect size was calculated using Cohen's. The result was a d value of 1.8. According to Cohen's conventions (1988), this represents a considerable effect size, indicating that the use of ACS has a substantial and powerful impact on improving students' prior knowledge and practical skills, far exceeding a minimal or moderate effect. Thus, the conclusion obtained from hypothesis testing is that ACS practicum has a significant influence in increasing students' prior knowledge and practical skills in learning motorcycle body electrical systems, or it can be concluded that students who study with ACS have significant differences in prior knowledge and practical skills in learning motorcycle body electricity than students who learn with a manual book wiring motorcycle body electrical systems.

B. Discussion

Based on the results of the effectiveness test, the use of multimedia practical simulations has proven to be quite effective in increasing students' prior knowledge and practical skills in learning motorcycle body electrical systems. The very large effect size (d=1.8) confirms that the improvement is not only statistically significant but also practically substantial and highly relevant for educational application. Evaluation of multimedia practical simulations is carried out based on effectiveness before the final product can be created and distributed to a wider range of students and teachers. The effectiveness of multimedia is measured based on the results of students' cognitive and psychomotor assessments. The assessment of the effectiveness of the multimedia practical simulation was carried out by assessing students' skills through two stages of testing, namely pre-test and post-test in the experimental class and control class. The assessment results show that multimedia practical simulations have a significant effect on improving students' skills. This statement is proven by the score obtained based on the results of statistical tests, which state that there is an average difference between the experimental class and the control class. In addition, the average post-test score for the experimental class was higher than the average post-test score for the control class. These results indicate that learning about the motorbike body electrical system using ACS (Automotive Circuit Simulation) simulation is more effective than classes that use conventional methods or using a manual book wiring the motorbike body electrical system.

By using simulation, several benefits can be obtained, among others, (1) [1]students understand more conceptually before doing practical work with an actual trainer because the electrical system is very risky of short circuits and students tend to try it out without paying attention to the initial concept of the vehicle body electrical system. In itself, (2) extends the life of the trainer used for practical work on motorbike body electrical systems because students understand and understand the concept before carrying out the practical work with the actual trainer.

However, the implementation of ACS in vocational schools may face several practical constraints. Key challenges include: (1) Device Limitations: Not all schools may have enough computers or tablets with adequate specifications to run the simulation software smoothly. (2) Connectivity Issues: If the ACS requires online access for certain features, unstable internet connections in some regions could hinder its use. (3) Teacher Competency: Effective integration of ACS into the curriculum requires teachers to be proficient not only in the subject matter but also in the pedagogical use of the simulation tool. A lack of training could lead to underutilization of its features.

To overcome these potential barriers, several strategies can be implemented. A phased rollout strategy, starting with well-resourced pilot schools, can provide a model for others. Comprehensive and ongoing training programs for teachers are essential, focusing on both technical operation and innovative teaching methods with ACS. Schools could also explore offline versions of the software or schedule lab sessions to mitigate connectivity issues.

Furthermore, seeking support from industry partners like Honda for infrastructure grants or shared resource models could be a viable long-term solution to address hardware limitations.

Apart from that, based on research by Roemintoyo & Wibawanto (2023), using simulation media that integrates multimedia and ICT in learning can influence and improve vocational students' skills, which is also a learning goal in the 21st-century skills era [3]. Srian-dhi, Restu, & Sitompul (2021) also developed a multimedia simulation to support electrical practicum. The results of data analysis prove the superiority of multi-media simulation as a practical and efficient practical learning medium [4]. Multimedia simulations can also be an alternative learning media for classes that lack practicum facilities and infrastructure so that student learning outcomes can improve and comply with predetermined competency standards [14], [15]. In line with the development of multimedia to support previous online practicums, Mertayasa, Agustini, & Subawa (2022) stated that digital practicum learning multimedia is practically effective for learning in Vocational High Schools [16]. The learning experience gained by students has been able to instill practical skills through multimedia.

Based on research results which are strengthened by previous research, multimedia practical simulation can be a tool that can increase the effectiveness of the learning process [12]. The use of multimedia simulations in learning has also been proven to increase self-confidence and practice skills in medical professionals [17]. Apart from that, simulation-based learning is also applied in the vocational field of nursing, as in research by Jarelnape & Sagiron (2023) that simulation-based learning in various aspects of nursing education shows that simulations improve students' knowledge, skills, clinical reasoning abilities, and clinical decision making. nursing, as well as impacting clinical behavior and patient outcomes. Simulation-based training has shown potential to improve the cognitive, affective, and psychomotor domains of learning[18]. Multimedia that integrate simulation into learning can also reflect practical environments with artificial situations [19], [20]. This is a good way to optimally improve students' practical abilities[21]. Apart from that, it's a simulation can also support the implementation of online practicum activities [22]. Automotive Circuit Simulation (ACS) is a practical multimedia simulation that can be used as a practical learning medium for motorbike body electrical systems for students in the Motorcycle Engineering and Business Vocational School Program which can increase students' knowledge and acquire practical skills.

IV. Conclusion

The success of integrated learning with multimedia simulation, namely Automotive Circuit Simulation, to increase students' knowledge and acquisition of practical skills is measured based on the results of students' cognitive and practical assessments of the material of motorcycle body electrical systems. ACS was stated to be quite effective as a learning medium for increasing students' knowledge and acquiring practical skills in vehicle body electrical systems. The findings of this research indicate that the application of automotive circuit simulation, which simulates the electrical system circuit of a motorcycle body, is useful for improving initial abilities and acquiring practical skills. Apart from that, it is also to reduce damage to the trainer or vehicle directly because students have studied and simulated the circuit and understand the concept of the motorcycle body electrical circuit. The results of this research and development certainly show that multimedia can not only improve students' cognitive abilities but also their skills, as is the result of the research conducted in this study. However, this research still has limitations, namely that it still covers one subject topic, and not all topics can be loaded because it will impact the multimedia file size which will be larger and therefore not flexible to install on digital devices. This study suggests that future research can provide innovation through applications to other subjects, as well as using simulation models that can be combined with other current technologies, such as Augmented Reality and other multimedia.

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