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Implementing the Vernier Caliper Application in Vernier and Micrometer Measurements to Improve Students' Learning Outcomes

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Abstract

Teaching aids are instructional media that help students understand learning materials more clearly through direct observation. In vocational education, the use of appropriate media is essential to support the achievement of learning objectives and optimize students' competencies. This study aims to examine the improvement of student learning outcomes through the implementation of an Android-based Vernier Caliper application for measuring with calipers and micrometers in Grade X Electrical Installation students at SMKN 1 Cerme Gresik. The research employed a pre-experimental method with a one-group pretest–posttest design, involving students of class X TITL 1 as the research subjects. The instrument used consisted of pretest and posttest assessments. Data were analyzed quantitatively using a paired t-test and N-Gain calculation. The results showed a significance value of 0.000 < 0.05, indicating that H_0 is rejected and the application effectively improves student learning outcomes. The average pretest score of 76 increased to 92.67 on the posttest, while the N-Gain analysis showed an improvement of 54.72% (categorized as moderately effective). Thus, the Vernier Caliper application is proven to enhance students' cognitive abilities in the Basic Electrical Equipment course and serves as a viable technology-based learning medium at SMKN 1 Cerme Gresik.

Keywords: *Implementation, Vernier Caliper application, improvement, learning outcomes*

Abstrak

Alat peraga merupakan media pembelajaran yang membantu peserta didik memahami materi secara lebih jelas. Dalam pembelajaran vokasi, penggunaan media harus selaras dengan tujuan pembelajaran agar kompetensi siswa berkembang optimal. Penelitian ini bertujuan mengetahui peningkatan hasil belajar siswa melalui implementasi aplikasi Vernier Caliper berbasis Android pada materi pengukuran menggunakan jangka sorong dan mikrometer di kelas X Teknik Instalasi Tenaga Listrik SMKN 1 Cerme Gresik. Metode yang digunakan adalah pre-experimental dengan desain one-group pretest–posttest, melibatkan siswa kelas X TITL 1 sebagai subjek. Instrumen penelitian berupa tes pretest dan posttest. Data dianalisis menggunakan uji paired t-test dan perhitungan Gain. Hasil penelitian menunjukkan nilai signifikansi 0,000 < 0,05 sehingga H_0 ditolak, yang berarti aplikasi Vernier Caliper efektif meningkatkan hasil belajar. Nilai rata-rata pretest sebesar 76 meningkat menjadi 92,67 pada posttest. Perhitungan Gain menunjukkan peningkatan sebesar 54,72% (kategori cukup efektif). Dengan demikian, aplikasi Vernier Caliper terbukti mampu meningkatkan kemampuan kognitif siswa pada materi Dasar-Dasar Peralatan Kelistrikan dan dapat dijadikan alternatif media pembelajaran berbasis teknologi di SMKN 1 Cerme Gresik.

Keywords: *Implementation, vernier caliper application, improvement, learning outcomes*

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INTRODUCTION

The digital transformation in education over the past three years has brought significant changes to learning methods, particularly in vocational education units that emphasize the mastery of technical skills with precision. Since 2021, various studies have noted that the use of application-based media has become an urgent need in supporting practical learning that is difficult to do only with lecture methods (Ariani et al., 2023) . This condition indicates the need for learning media innovations that are not only informative but also interactive.

In the context of technical learning, teaching aids remain a key component in providing concrete experiences for students. Lamuhamad & Laruli, (2023) states that teaching aids serve to clarify the delivery of material so that students can understand concepts more easily. However, in recent developments, physical teaching aids often have limitations in terms of quantity, age of use, and flexibility for use by many students at the same time.

Many vocational schools report that the limited availability of practical tools is one of the causes of low measurement competency among students, especially in the fields of electrical engineering and mechanical engineering (Arham et al., 2024) . The imbalance between the number of tools and the number of students results in low training intensity, so that students do not gain sufficient experience in using precision measuring instruments.

Competence in reading measuring instruments such as calipers and micrometers is very important because it forms the basis of the engineering process. Measurement accuracy affects the quality of the final product and work safety. Therefore, learning about measuring instruments must be able to provide students with a strong procedural and conceptual understanding(Tjalla et al., 2023) .

However, recent findings show that most vocational high school students still have difficulty reading vernier scales due to inaccuracy, lack of understanding of basic principles, and minimal routine practice (Muflihah & Mayasari, 2024) . These measurement errors have an impact on the low level of competence achieved by students in basic electrical subjects.

A similar condition was found at SMKN 1 Cerme Gresik. Based on the results of observations during the School Field Introduction (PLP), many students were not active in asking questions, did not pay attention to the teacher's instructions, and lacked confidence when taking measurements. The lack of student involvement in learning indicates problems with learning motivation and limitations in the media used.

Some students even showed basic errors in reading vernier calipers and micrometers, such as incorrectly determining the main scale value, misreading the nonius, and not understanding the units used. These findings indicate that there is a gap between the theoretical and practical learning carried out in the classroom.

Low learning outcomes are also evident from the achievement of the Minimum Passing Criteria (KKM). Student score data shows that most have not been able to meet the minimum standards, especially in precision measurement evaluations. This reinforces the assumption that the learning methods used have not been able to comprehensively address student difficulties.

In line with this issue, recent research confirms that digital application-based learning can improve conceptual understanding because it provides realistic simulations and allows for unlimited practice (Setiawan et al., 2023) . Application media also reduce students' anxiety about practical tools that are considered "complicated."

The Android-based Vernier Caliper application is one innovative solution that is relevant to overcoming the limitations of measuring instruments in schools. This application can display accurate measurement simulations, providing an experience similar to using the actual instrument. In addition, this application allows students to practice anywhere and anytime.

Research indicates that the use of measurement tool simulation applications improves measurement accuracy, scale reading skills, and confidence (Utari, 2022) . Furthermore, digital

applications provide opportunities for independent learning that cannot be obtained through conventional methods.

In addition to improving technical understanding, digital media also contributes to increasing student motivation and learning activity. Technology-based learning environments are considered more attractive to digital native generations, who have a higher attention span for visual and interactive content (Faiza & Wardhani, 2024) .

Considering the issues of motivation, lack of student engagement, and low understanding of measuring instruments at SMKN 1 Cerme Gresik, the use of the Android-based Vernier Caliper application is a highly relevant alternative. This application is expected to bridge the gap between theory and practice so that students not only know the procedures but are also able to master them.

The implementation of the Vernier Caliper application also supports the Merdeka Belajar (Freedom of Learning) policy, which encourages the use of technology in practical learning in vocational high schools. By utilizing the application, teachers can provide different, adaptive, and more easily accepted learning for students (Dewantara et al., 2020)

Based on these issues, this study was conducted to test the effectiveness of the Vernier Caliper application in improving student learning outcomes in the subject of vernier caliper and micrometer measurement. This study is expected to make a real contribution to the innovation of digital-based learning media that supports the improvement of vocational competencies in vocational education.

RESEARCH METHOD

This type of research is a *pre-experimental* design. *Pre-experimental* research is often considered to be an incomplete experiment, because there are still external variables that influence the formation of the dependent variable. This pre-experimental design research method was conducted on one group, namely the experimental group that received treatment using the *Contextual Teaching and Learning* (CTL) model. The design used by the researcher is *a One Group Pretest Posttest Design*, in which the subjects are given a pretest before the treatment and are tested again with the same test questions as *a posttest* after the treatment (*posttest*) (Sugiyono, 2019).

The researchers used *a pre-experimental design* in the form of *a one-group pretest-posttest design*. It is referred to as *a pre-experimental design* because this design is a research design in which external variables still influence the formation of the dependent variable (Sugiyono, 2019; Wahyuningrum et al., 2021). The *One-Group Pretest-Posttest* Design is a design in which participants are first given a pretest before receiving treatment and are then retested with the same test questions as *a posttest* after receiving treatment (Al Muhandis & Riyadi, 2023).

Table 1 *Pretest and Posttest Research Design*

O_1	**X**	O_2

Description:

O_1 = *pretest* score (before treatment)

X = Treatment given

O_2 = *posttest* score (after treatment)

In this design, there are two groups selected randomly, then given *a pretest* to determine the initial condition of whether there is a difference between the experimental group and the control group. The pretest results are good if the experimental group scores do not differ significantly. The effect of the treatment is (O_2-O_1). Table 3.1 provides an example of a more operational *Pretest-Posttest* experimental design.

In this study, the author did not use a population and sample but instead used test subjects as a substitute for the population and sample. The test subjects in the experiment were Class X TITL 1 SMKN 1 Cerme. In this study, the author used primary data collection techniques. Primary data is data obtained or collected directly in the field by researchers from the people concerned. Balaka, (2022) states that primary data is obtained by researchers directly through interviews, surveys, experiments, and so on. Primary data is usually available in its raw form and needs to be processed further. However, researchers can be more specific in obtaining the data they need because they will search for it from the main source. Therefore, researchers can adjust their selection of informants in order to obtain the data they need.

The data collection technique used in this study was a *vernier caliper* application test. The data collection instrument used a test technique. Observations were made to collect data related to students' cognitive learning outcomes and responses. Data on students' cognitive learning outcomes and responses were collected using observation sheets.

This test sheet contained a number of written questions that revealed attitudes and opinions about the basic measurement competencies *of the vernier caliper* using calipers and micrometers. The completion and distribution of this questionnaire was carried out after learning activities using the *vernier caliper* application. In completing the questionnaire, students were asked to choose answers that corresponded to their opinions or responses regarding the learning media using the *vernier caliper* application applied in the learning process by choosing the correct answers from the options provided. The results of this student response questionnaire are used as an indicator to assess the effectiveness of learning using the *Vernier caliper* application in teaching basic measurement competencies using calipers and micrometers in class X at SMKN 1 Cerme Gresik.

(t) test

The paired sample t-test is a test of the difference between two paired samples. Paired samples are the same subjects, but they experience different treatments. This test model is used to analyze research models before and after. According to Widiyanto (2013:35), the paired sample t-test is one of the testing methods used to assess the effectiveness of treatment, characterized by a difference between the average before and after treatment.

The basic assumption for using this test is that the observations or research for each pair must be under the same conditions. The difference in means must be normally distributed. The variance of each variable can be the same or not. To perform this test, interval or ratio scale data is required. What is meant by a paired sample is that we use the same sample, but the test is performed on the sample twice at different times or at certain time intervals. The test is conducted using a significance level of 0.05 (α=5%) between the independent variable and the dependent variable. The basis for accepting or rejecting Ho in this test is as follows. The T-test is defined as a statistical testing method that compares the means of two samples to test whether a hypothesis in a population is true or not.

The basis for deciding whether to accept or reject H_0 in this statistical test is determined by the significance value (sig). If the significance value is greater than 0.05, then H_0 is accepted and H_a is rejected, which means that there is no significant difference in performance or effect before and after treatment. Conversely, if the significance value is less than 0.05, H_0 is rejected and H_a is accepted, so it can be concluded that there is a significant difference in performance and that the treatment given has a real effect on the variable being tested.

This test is to prove whether the research samples before and after the IPO have significantly different averages or not. The reason the author uses this analysis tool is because this study uses two paired samples. These paired samples are the same subject but undergo two different treatments or measurements, namely before and after the IPO.

Paired T-test formula:

$$t = \frac{\overrightarrow{D}}{(\frac{SD}{\sqrt{N}})}$$

Formula 1 Paired T-test

Explanation:
t = Calculated t-value
$\overrightarrow{D}$ = Average of sample 1 and 2 measurements
SD = Standard deviation of measurements from samples 1 and 2
N = Number of samples

To interpret the Paired sample t-test, the following must first be determined:

1. α value
2. df (degree of freedom) = N-k
   For a paired sample t-test, df = N-1
3. Compare the calculated t-value with the t-table value

Next, the calculated t-value is compared with the t-table value at a 95% significance level. The decision criteria are:

1. T table > T calculated = Ho accepted or Ha rejected
2. T table < T calculated = Ho rejected or Ha accepted

N Gain Test

In this study, after the researcher obtained the *pretest* and *posttest* values, an analysis was conducted on the scores obtained. In this case, the analysis used was the N Gain test to determine the effectiveness of the treatment given (Kusuma & Julianto, 2023)

$$\text{N Gain} = \frac{S_{post} - S_{Pre}}{S_{maks} - S_{Pre}}$$

Formula 2 N Gain Test

According to (Anggie Bagoes Kurniawan & Hidayah, 2021):

N Gain : indicates the N Gain test score
S_{Post} : indicates the *posttest* score value
S_{Pre} : indicates the *pretest* score
S_{maks} : indicates the maximum score value

The criteria for effectiveness and the normality of gain according to (Anggie Bagoes Kurniawan & Hidayah, 2021) can be seen in the following table.

Table 2 Classification of Gain Normality Values
Source: (Anggie Bagoes Kurniawan & Hidayah, 2021)

N Gain Value	Criteria
$0.70 \leq n \leq 1.00$	High
$0.30 \leq n \leq 0.70$	Moderate
$0.00 \leq n \leq 0.30$	Low

RESULTS AND DISCUSSION

Student learning outcomes in the cognitive domain are important indicators in determining the success of the learning process, especially in vocational subjects that require precision and accuracy in understanding the basic concepts of measuring instruments. According to Magdalena et al., (2021) , the cognitive domain includes the ability to remember, understand, apply, and analyze information obtained by students. Therefore, an increase in student learning outcomes indicates that learning interventions through the use of the Vernier Caliper application have a significant impact on the understanding of caliper and micrometer measurement concepts.

In this study, cognitive learning outcomes were measured using a multiple-choice test based on Google Forms, which was administered before and after the application was implemented. The use of pre-tests and post-tests is a common method to observe changes in students' knowledge after receiving certain treatment (Arib et al., 2024) . Thus, a comparison of the scores of the two tests can serve as empirical evidence of the effectiveness of application-based learning media.

The One-Group Pretest-Posttest design was chosen to assess the direct impact of using the Vernier Caliper application on student understanding. Although this design does not involve a control group, this model is still widely used in vocational education research because it is able to show changes in learning outcomes in a measurable and systematic manner (Bakar, 2022) .

The results of the paired t-test in this study are presented in Table 3 below.

Table 3 Paired T-Test

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	PRETEST - POSTTEST	-16.41935	20.82910	3.74102	-24.05953	-8.77918	-4.389	30	.000

(Source: Personal)

The results of the statistical test using a paired t-test show a sig. value (2-tailed) of 0.000 < 0.05, which means that there is a significant difference between the pre-test and post-test scores. This finding confirms that the Vernier Caliper application has a positive effect on improving learning outcomes. According to Arikunto (2020), strong statistical significance indicates that the learning treatment has a clear and scientifically accountable effect.

After obtaining the pre-test and post-test scores, the analysis continued with the calculation of Gain to determine the level of improvement in students' mastery of the concept. Gain calculations are often used in educational research to measure the effectiveness of learning interventions (Wahab et al., 2021) . The Gain value obtained was 54.72%, indicating a moderate or fairly effective improvement. The average *pre-test, post-test*, and Gain scores are presented in Table 4.

Table 4 Gain Test Results

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
NGain	31	-8.38	1.00	.5472	1.66748
Valid N (listwise)	31				

(Source: Personal)

Table 5 Average and N Gain Results

Number Students	**Average**		**Gain**	**Category Gain**
	Pre-Test	Post-Test		
31	76	92.67	54.72	Fairly Effective

(Source: Personal)

The average pre-test score of 76 and post-test score of 92.67 indicate that students experienced a significant increase in understanding after using the application. Previous studies have also shown that the use of interactive digital media can improve students' understanding of practical concepts, especially in the fields of engineering and science(Husamah et al., 2024).

This improvement in learning outcomes is also in line with the needs of 21st-century learning, which emphasizes the use of digital media to enhance understanding of technical and applied concepts (Azhar et al., 2024) . The Vernier Caliper application provides more realistic visualizations and simulations of measurements, making it easier for students to learn the mechanisms of measuring instruments.

Before the treatment was given, students still had difficulty reading the measurements taken with calipers and micrometers because they were not yet familiar with the main scale and vernier scale. According to Abidin, (2021) , errors in reading measuring instruments are one of the problems that often arise in basic electrical instrument learning. The Vernier Caliper application helps overcome this obstacle by providing a clearer and more interactive digital display.

The results of this study support the findings ofet al., (n.d.) , which state that the use of digital vernier applications can improve the accuracy of students' measurement tool readings and produce an average N-Gain in the moderate category. This shows the consistency of the positive effects of digital applications in improving measurement skills.

The research Sujaya et al., (2023) also reinforces this finding, where the use of interactive e-modules in technical learning can significantly improve cognitive learning outcomes. These findings provide evidence that technology-based media has a positive impact on the process of understanding technical concepts.

Application-based learning such as Vernier Caliper provides the advantage of measurement simulations that can be repeated many times without the risk of damaging the equipment, thereby improving students' readiness before using the actual measuring instruments (Firdaus, 2023) . This condition is very relevant to practical learning situations that require high precision.

The increase in post-treatment scores indicates that this application successfully supports effective learning, especially for vocational school students who need a deep understanding of measurement concepts. When students can practice measurement through digital media, their knowledge retention levels also increase.(Gusteti, 2024) .

In addition, the use of digital vernier applications has been proven to increase student motivation to learn because it provides a new learning experience that is relevant to current technological developments. According to Ali et al., (2024) , student motivation to learn increases when learning media is interactive and closely related to their daily digital lives.

Thus, the high post-test scores and increase in gain prove that the Vernier Caliper application is effective in teaching the basics of electrical equipment. This effectiveness not only improves knowledge but also reduces students' errors in reading measuring instruments, which is a problem that arises in electrical engineering education in various vocational schools(, 2024) .

Overall, this study shows that the use of the Vernier Caliper application contributes significantly to improving students' cognitive learning outcomes. The use of appropriate learning technology can address the problem of poor understanding of measuring instruments, which has been a challenge in vocational classes. These findings can be used as recommendations for teachers to integrate digital media into the learning process in order to improve the quality of technical education in vocational schools.

CONCLUSION

Based on the results of the study, it can be concluded that the application of the Vernier Caliper application is proven to be effective in improving students' cognitive learning outcomes in the subject of Electrical Equipment Basics (DDPK) in class X TITL SMKN 1 Cerme Gresik. This effectiveness is demonstrated by a significant increase between the pre-test and post-test scores, as evidenced by the paired t-test results, which obtained a significance value of 0.000

< 0.05. In addition, the N-Gain calculation of 54.72% indicates that the increase in concept mastery is in the fairly effective category.

The use of the Vernier Caliper application had a positive impact on the understanding of the concepts of caliper and micrometer measurement, especially in minimizing scale reading errors that students previously experienced. This application-based learning media also helped strengthen visual skills, improve accuracy, and provide a more interactive learning experience that is relevant to the development of digital-based learning technology.

Thus, the Vernier Caliper application can be recommended as an alternative learning medium in electrical engineering subjects in vocational schools, particularly to improve students' basic competencies in understanding and using measuring instruments. The implementation of digital media such as this has the potential to improve the quality of practical learning and support the continuous improvement of students' technical competencies.

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