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Effectiveness of Android-Based Lathe Machine Simulator on Students' Understanding of Lathe Components at SMK 3 Pancasila Ambulu

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ABSTRACT

This study examined the effectiveness of the Android-based Lathe Simulator Lite application in improving Grade X Machining Engineering students' understanding of lathe machine components at SMK 3 Pancasila Ambulu. The study was motivated by limited workshop facilities and an insufficient number of lathe machines, resulting in restricted practical learning opportunities. The research employed a pre-experimental one-group pretest-posttest design involving 65 students selected through simple random sampling from a population of 80 students. Data were collected using validated and reliable multiple-choice tests and analyzed using a paired sample t-test and Hake's N-gain. The treatment consisted of learning activities using the Lathe Simulator Lite application to study lathe components and basic operating procedures. The results showed that the mean score increased from 56.69 on the pretest to 82.38 on the posttest. Statistical analysis indicated a significant difference between pretest and posttest scores ($p < 0.001$). The N-gain value of 0.53 was categorized as moderate, indicating a meaningful improvement in students' understanding. These findings suggest that the Lathe Simulator Lite application is an effective learning medium for improving students' understanding of lathe machine components and basic operations under limited workshop conditions.

Informasi Artikel

Kata Kunci:
Komponen Mesin Bubut; Lathe Simulator Lite; Pembelajaran Berbasis Android Teknik Pemesinan; Sekolah Menengah Kejuruan.

ABSTRAK

Penelitian ini bertujuan untuk menguji efektivitas aplikasi Lathe Simulator Lite berbasis Android dalam meningkatkan pemahaman komponen mesin bubut pada siswa kelas X Teknik Pemesinan di SMK 3 Pancasila Ambulu. Penelitian dilatarbelakangi oleh keterbatasan fasilitas bengkel dan jumlah mesin bubut yang tidak sebanding dengan jumlah siswa sehingga kesempatan praktik menjadi terbatas. Penelitian menggunakan metode pre-eksperimental dengan desain one-group pretest-posttest yang melibatkan 65 siswa yang dipilih melalui simple random sampling dari populasi 80 siswa. Data dikumpulkan menggunakan tes pilihan ganda yang telah memenuhi uji validitas dan reliabilitas, kemudian dianalisis menggunakan uji t berpasangan dan N-gain Hake. Perlakuan dilakukan melalui pembelajaran menggunakan aplikasi Lathe Simulator Lite untuk mempelajari komponen mesin bubut dan prosedur dasar pengoperasiannya. Hasil penelitian menunjukkan bahwa rata-rata nilai meningkat dari 56,69 pada pretest menjadi 82,38 pada posttest. Analisis statistik menunjukkan adanya perbedaan yang signifikan antara nilai pretest dan posttest ($p < 0,001$). Nilai N-gain sebesar 0,53 termasuk kategori sedang yang menunjukkan adanya peningkatan pemahaman siswa. Dengan demikian, aplikasi Lathe Simulator Lite efektif digunakan sebagai media pembelajaran pada kondisi keterbatasan fasilitas praktik di bengkel.

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1. Introduction

Vocational High School (SMK) education plays a crucial role in preparing competent human resources ready to compete in the global era. SMK not only equips students with theoretical knowledge but also develops skills relevant to the needs of the workforce. According to [1] Vocational education emphasizes mastery of scientific and technical skills and work attitudes so that graduates are better prepared for work than graduates of general education. This emphasis on mastering skills through real-world experience aligns with the constructivist and experiential learning paradigms, which emphasize that knowledge is built through direct experience, reflection, and student involvement in authentic activities [2]. Based on this foundation, learning in vocational schools needs to be designed based on practice and contextual projects that encourage active participation while developing critical, creative, and collaborative thinking skills.

In practice-based learning, the availability of workshop facilities and infrastructure is a determining factor in the quality of the learning process. Limited facilities prevent vocational learning from being optimally and equitably delivered to all students. This is supported by research [3] who reported that the adequacy of lathe work facilities in vocational high school machining workshops was only around 65.75%, thus not meeting the ideal standards for supporting practice. This condition was also found in various regions, including Jember Regency, indicating that the problem of learning facilities is quite widespread. Another finding by [4] Studies at SMK Negeri 6 Malang City show that the machining workshop facilities and infrastructure are still limited and do not meet national standards, resulting in learning shifting to theoretical explanations and brief demonstrations with minimal practical opportunities.

The Machining Engineering Expertise Program is one form of vocational education implementation that focuses on mastering practical competencies in the machining field. This program requires a balance between theoretical knowledge as a foundation for technical thinking and practical skills to prepare graduates for entry into the industrial world. In this context, lathe operation is one of the basic competencies that must be mastered because this machine is widely used in the manufacturing of cylindrical components in the machining industry [5]. Before operating a lathe directly, students need a solid understanding of machine components, including the ability to recognize component names, explain the function of each part, and understand the interrelationships between parts in supporting the machining process. Inadequate understanding of components can potentially lead to procedural errors, reduce the effectiveness of the learning process, and increase safety risks in the workshop.

This limited practical training facility is also evident in the learning process at SMK 3 Pancasila Ambulu. The number of students in a class in the Machining Engineering Expertise Program is greater than the number of lathes available, resulting in limited and uneven practice time for each student. [6] that the limited number of machines, practice time, and the use of alternating tools are the main inhibiting factors in learning practical lathe machining techniques, so that teachers cannot always provide adequate direct practice opportunities to all students. In line with this, feasibility studies of machining workshops in several vocational schools reported that the percentage of facility feasibility was in the low to medium category in one vocational school, the feasibility of facilities and infrastructure was only around 36.5% and was classified as less feasible based on the Minister of National Education Regulation Number 40 of 2008 [7]. This situation further limits practical experience and leaves many students struggling to recognize component names, explain their functions, and fully understand the interrelationships between parts of a lathe.

Given these challenges, utilizing digital-based learning technology is a relevant alternative to address the limited practical facilities in school workshops. One potential medium for supporting practical learning is an Android-based lathe simulator, an interactive application that virtually simulates machining processes, allowing users to learn operating techniques, identify key components, and understand cutting parameter settings without relying entirely on a physical machine in the workshop. Simulation tools enable students to learn complex processes or systems through safe and controlled, simulated representations [8], making it suitable for use when direct practice is hampered by facilities or involves high risks. Using an Android smartphone-based simulator also gives students the opportunity to practice independently anytime and anywhere and repeat the learning process until they achieve a better understanding [9]. [10] reported that before the use of the lathe simulator application, no students achieved the Minimum Completion Criteria (KKM), whereas after the use of the simulator, 97% of students achieved scores above the KKM with an average N-gain of 0.735 (high category) and very good student responses. However, the study emphasized improving general learning outcomes and had not specifically examined the understanding of lathe components or their application at SMK 3 Pancasila Ambulu. Based on this gap, this study was directed to analyze the effectiveness of using an Android-based lathe simulator on students' understanding of lathe components. The focus of the study was on grade X students of the Machining Engineering Expertise Program at SMK 3 Pancasila Ambulu.

2. Research Method

This study used a One-Group Pretest–Posttest pre-experimental design to test the effectiveness of using the

Android-based Lathe Simulator Lite application on students' understanding of lathe components [11]. This design involved one group given a pretest before treatment and a posttest after treatment without using a control group. In this context, the treatment provided was in the form of practical learning using the Lathe Simulator Lite application on the material of lathe components and basic operations. This model was chosen because it allows researchers to compare initial and final abilities in the same group so that changes in student understanding after treatment can be identified more clearly.

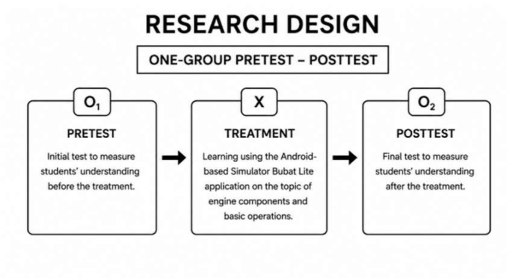

Figure 1 Design of One-Group Pretest-Posttest

The subjects of this study were 65 tenth-grade students of the Machining Engineering Expertise Program at SMK 3 Pancasila Ambulu in the current academic year, selected from a population of 80 students using the Slovin formula at a 5% error rate, thus obtaining a representative sample size for the study. The sampling technique used was simple random sampling, which provides an equal opportunity for each member of the population to be selected as a research sample. The independent variable in this study was the use of the Android-based Lathe Simulator Lite application as a learning medium for lathe practice, while the dependent variable was understanding of lathe components, as measured by a cognitive learning outcome test. The test instrument was designed to reveal students' abilities in recognizing component names and functions, understanding the working relationships between components, and explaining basic lathe operating procedures. The use of the
Slovin formula in sample determination was carried out to obtain an efficient sample size while remaining proportionally representative of the population [12], so that the research results are expected to have an adequate level of generalizability.

The research instrument was a multiple-choice test developed based on indicators of understanding lathe components and was designed referring to learning evaluation principles so that the questions align with the measurement objectives [13]. Instrument development began with the creation of a grid based on the competencies to be measured, then formulated into questions representing each indicator. The developed instrument was tested for item validity using Product Moment correlation and internal reliability using Cronbach's Alpha coefficient. The use of these two techniques is common in educational research to ensure that the test has adequate validity and reliability before being used for primary data collection.

Data collection was conducted through a pretest before learning using the Lathe Simulator Lite and a posttest after students completed a series of lessons using the simulator. During the treatment, students learned the components and basic operations of a lathe through the Lathe Simulator Lite application in several sessions according to the allocated time for practical learning. Pretest and posttest scores were analyzed to assess changes in student understanding; improvement was calculated using the N-gain formula to determine the relative magnitude of improvement and its categorization (low, medium, high) [14]. Before the hypothesis test, the score data was tested for normality to ensure that the distribution met the assumptions of the parametric test [15] then continued with a paired sample t-test to determine the difference in the average pretest and posttest scores in the same group with a significance level of 0.05 [12]. The Lathe Simulator Lite media was declared effective if the significance value of the t-test was less than 0.05 and the N-gain category showed a minimal increase in the moderate category.

3. Result and Discussion

This section describes the results of data analysis from a one-group pretest-posttest pre-experimental design involving 65 10th-grade students of the Machining Engineering Expertise Program at SMK 3 Pancasila Ambulu. It focuses on the effectiveness of the Android-based Lathe Simulator Lite in improving cognitive understanding of lathe components, including recognition of names, functions, relationships between parts, and basic operational procedures. This is integrated with a discussion of theoretical and practical implications aligned with the digital constructivism paradigm in vocational education.

3.1 Students' Learning Outcome Profil

This section presents a descriptive overview of students' learning outcomes before and after the implementation of learning activities using the Lathe Simulator Lite application. The analysis was conducted to identify changes in students' understanding of lathe machine components based on pretest and posttest scores.

Table 1. Descriptive Statistics of Pretest and Posttest Scores

	N	Min	Max	Mean	Std. Deviation
Pretest	65	5	100	56,69	29,742

Posttest	65	30	100	82,38	18,669

Table 1 presents a comprehensive descriptive statistical distribution of pretest and posttest scores, where the minimum pretest score reached 5 and the maximum 100 with a mean of 56.69 (standard deviation 29.742), reflecting the heterogeneity of students' initial understanding influenced by limited access to direct practice in the machining workshop such as uneven rotation of the lathe as reported [16] while in the posttest, the score range increased to 30-100 with a mean of 82.38 (SD 18.669), indicating not only an overall positive shift but also a homogenization of variability in post-treatment learning outcomes, which is mathematically indicated by a decrease in the coefficient of variation from 52.48% to 22.66%, thus confirming the role of the simulator in leveling the disparity in abilities between individuals due to physical facility constraints while revolutionizing learning accessibility for grade X students with limited practical experience.

3.2 Normality Test Analysis

This analysis was conducted to verify whether the residual data fulfilled the normality assumption required for parametric statistical testing.

Table 2. Normality Test Result

Variable	Test Statistic	Sig.
Residual Data	0.097	0.200

Table 2 provides a report of the Kolmogorov-Smirnov test on unstandardized residuals with normal parameters of mean 0 and SD 15.28141378, where the absolute extreme difference reaches 0.097 (positive 0.097, negative -0.095), resulting in a test statistic of 0.097 and Asymp. Sig. (2-tailed) 0.200 (>0.05), which statistically states that the distribution of residual data is normally distributed, further strengthening comes from the Monte Carlo Sig. (2-tailed) 0.140 with a 99% confidence interval (0.131-0.149), so that the parametric assumptions for the t-test are met without distribution bias, validating the robustness of the inferential analysis and the generalization of the findings to a wider population of students of Mechanical Engineering Vocational High Schools, where the fulfillment of this residual normality not only meets the statistical prerequisites but also strengthens external validity, especially in the context of the Slovin sample of 80 students at SMK 3 Pancasila Ambulu.

3.3 Paired Sample t-Test Analysis

This analysis was conducted to determine whether there was a significant difference between students' pretest and posttest scores after using the Lathe Simulator Lite application.

Table 3. Paired Sample t-Test and Effect Size Analysis

Comparison	Mean Difference	t	df	Sig. (2-tailed)	Cohen'sd
Pretest-Posttest	-25.692	-8.490	64	<0.001	1.05

Table 3 summarizes the paired sample t-test output that measures the significant difference between pretest and posttest scores, with a mean difference of -25.69231 (SD 24.39706, SEM 3.02608) and a 95% confidence interval at the lower limit of -31.73760 to the upper limit of -19.64701, where the t-value = -8.490 at 64 degrees of freedom produces a two-tailed p-value <0.001, so that with a significance level of $\alpha = 0.05$ the null hypothesis of no difference is strongly rejected, proving that the application of Lathe Simulator Lite causally contributes to the improvement of understanding of lathe components with a Cohen's d effect size of around 1.05 (large), consistent with the findings [10] reported an N-gain of 0.735 in a similar context; this negative mean difference and narrow confidence interval confirm the consistency of the effect across student subgroups, thus the implication for vocational school policy is the mandatory adoption of simulators as a supplement to the Phase E curriculum of Basics of Mechanical Engineering, especially in areas with workshop feasibility <65% such as in Jember and Malang Districts based on [17], [18].

3.4 N-Gain Analysis

This section presents the effectiveness level of the learning intervention based on the normalized gain score.

Table 4. N-Gain Analysis Results

Indicator	Value
Mean N-Gain	0.532
Category	Moderate

Table 4 shows that the average N-gain value obtained was 0.531948, which falls within the moderate category according to Hake's criteria ($0.3 < g < 0.7$). This result indicates that the implementation of the Lathe Simulator Lite application provided a moderate level of improvement in students' understanding of lathe machine components and basic operating procedures. The N-gain value demonstrates that the learning intervention was effective in increasing students' cognitive achievement from their initial level of understanding, although the improvement had not yet reached the high category. These findings suggest that the simulator can serve as an effective alternative learning medium to support vocational learning, particularly in conditions where access to practical workshop facilities is limited.

3.5 Discussion

The results showed that the use of the Android-based Lathe Simulator Lite application significantly improved students' understanding of lathe components. This improvement was evident in the average pretest score, from 56.69 to 82.38 in the posttest, a 25.69-point difference, and a significant paired-sample t-test result ($p < 0.001$). The N-gain value of 0.53, in the moderate category, indicates that the simulator is quite effective in improving learning outcomes. Theoretically, these findings support the constructivist and experiential learning approaches, which emphasize active student involvement in constructing knowledge through learning experiences. The simulator provides an interactive learning experience that allows students to understand the functions and relationships between machine components more concretely, even without direct practice in the workshop.

These findings are also consistent with previous research showing that Android-based simulation media can significantly improve learning outcomes. [15] reported an increase with high N-gain (0.735), while [9] emphasizes learning flexibility that increases student independence. From a practical perspective, simulators are able to overcome the limitations of workshop facilities that cause unequal opportunities for practice, as expressed by [6]. The decrease in the coefficient of variation from 52.48% to 22.66% indicates that the ability gap between students can be minimized. This reinforces the fact that the simulator not only improves learning outcomes but also supports equitable student understanding in conditions of limited practical facilities.

However, this study has limitations due to its pre-experimental design without a control group, which means it is not fully able to isolate the influence of external variables. Therefore, further research using a quasi-experimental or pure experimental design is needed to obtain stronger causal evidence. Furthermore, it is important to examine the transfer of learning outcomes from the simulation to actual practice on a lathe. Long-term retention evaluations are also necessary to assess the sustainability of student understanding. Therefore, the results of this study remain relevant as a basis for developing digital-based learning in vocational schools.

4. Conclusion

Based on the research results, it can be concluded that the use of the Android-based Lathe Simulator Lite application is effective in improving students' understanding of lathe components. This effectiveness is demonstrated by a significant increase in the average score from 56.69 in the pretest to 82.38 in the posttest, an N-gain value of 0.53, which is in the moderate category, and a t-test result showing a significant difference ($p < 0.001$). Furthermore, the decrease in the coefficient of variation from 52.48% to 22.66% indicates that the use of the simulator not only improves overall learning outcomes but also contributes to reducing the ability gap between students. Thus, the simulator can be positioned as an effective, flexible, and safe alternative learning medium to address limited practical facilities in vocational schools. These findings also emphasize the urgency of integrating digital technology into vocational learning to improve the quality of the learning process and outcomes.

In line with these conclusions, several suggestions can be put forward for practical implications and further research development. Teachers are advised to integrate the use of the simulator with hands-on practice to create a balance between virtual and real-world experiences in learning. Schools are expected to support the implementation of digital-based learning media by providing adequate facilities and integrating them into learning systems such as Learning Management Systems (LMS). Future researchers are advised to employ more robust research designs, such as quasi-experimental or pure experiments, and further examine the transfer of learning outcomes to real-world practice and long-term student retention. Furthermore, media developers need to increase the level of interactivity and suitability of simulators to actual industrial conditions. With continued development, simulators have the potential to become innovative learning media capable of optimally enhancing vocational high school students' competencies in the field of machining.

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