IMPROVING VOCATIONAL HIGH SCHOOL STUDENTS' LEARNING OUTCOMES USING THE VIRTUAL MECHSIM LABORATORY FOR MANUAL TRANSMISSION SYSTEMS AT SMK ANTARTIKA SURABAYA

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Abstrak

Manual transmission systems in vocational education require learning media that connect conceptual understanding with visualization of power-transfer mechanisms. This study examined changes in students' learning outcomes after a learning session using the Virtual MECHSIM Laboratory. A quantitative one-group pretest–posttest design was used with 18 eleventh-grade students at SMK Antartika Surabaya. Data were collected through achievement tests administered before and after instruction and analyzed using descriptive statistics, the Shapiro–Wilk test, a paired-samples t-test, and normalized gain (N-gain). The mean score increased from 80.56 on the pre-test to 86.22 on the post-test, a mean difference of 5.67 points. The difference scores met the normality assumption ($W = 0.902$, $p = 0.061$). The paired-samples t-test indicated a statistically significant difference, $t(17) = 8.694$, $p < 0.001$. The mean N-gain was 0.324, categorized as moderate. These findings indicate that students' scores were higher after the learning sequence, which combined virtual power-flow exploration with verification using a physical manual-transmission trainer. Because the study had no control group, the observed change cannot be attributed exclusively to the Virtual MECHSIM Laboratory.

Keywords: Virtual laboratory; MECHSIM; manual transmission; power flow; learning outcomes

INTRODUCTION

Vocational high schools integrate theoretical knowledge with practical skills aligned with occupational competencies. In automotive education, students are expected not only to understand theoretical concepts but also to explain component

functions and the relationships between components. Learning in chassis and power-transfer systems should therefore connect conceptual explanations with the mechanical processes found in vehicles.

A manual transmission is an important part of a vehicle's power-transfer system. It transmits and regulates engine power to the drive wheels according to operating conditions. Understanding a transmission requires more than identifying its components; students must also explain how power travels through those components. Power flow is one topic that requires this type of understanding.

Students must analyze the power path at different gear positions, including neutral, first through fifth gears, and reverse. Because the path passes through several components and changes with the selected gear, it may be difficult to understand through verbal explanations or static two-dimensional images alone. Dynamic visualization may help make these mechanical relationships more accessible.

Digital technology offers opportunities to provide visual and interactive learning experiences in vocational education. (Siregar et al., 2022) discussed virtual laboratories as a means of supporting productive learning in vocational schools through simulations, tutorials, assignments, and assessment. Developed an augmented-reality virtual laboratory application for productive learning in vocational high schools, demonstrating an application of virtual technology in this educational context (Darmawan & Komaro, 2023).

Digital learning media have also been developed specifically for manual-transmission instruction. (Tamanolies et al., 2024) developed an Android-based interactive learning medium and reported improved scores after its use. (Permana et al., 2023) developed a practical learning medium for a five-speed manual transmission. (Saputro et al., 2026) Examined a physical demonstration medium for a motorcycle manual transmission and reported improved learning outcomes. More recent work has explored video-based learning (Tyassmadi et al., 2025) and interactive modules integrating augmented reality and video (Setyono et al., 2024) . At a broader level, (Bödding et al., 2025) reviewed mixed-reality applications in vocational education and training and identified outcomes across cognitive, affective, and behavioral domains, while also noting the need for stronger comparative research.

Virtual MECHSIM Laboratory is used in this study to support visualization of power flow in a manual transmission. Students select a gear position and trace the power path through the components represented in the simulation; the system then provides feedback on their responses. The activity is combined with a physical manual-transmission trainer so students can compare the virtual representation with a mechanical assembly.

Although earlier studies have explored digital and demonstration media for transmission learning, the present study focuses on learning outcomes following a learning sequence combining Virtual MECHSIM Laboratory and a physical trainer at SMK Antartika Surabaya. The study aims to describe changes in students' achievement scores from pre-test to post-test and the normalized gain. Given the one-group design, the study does not claim that the virtual laboratory alone caused any observed change.

METHODS

Reasearch Design

This study used a quantitative approach with a one-group pretest–posttest design. Students completed an initial test, participated in the learning activity, and then completed a final test.

$$\mathbf{O_1 \rightarrow X \rightarrow O_2}$$

O_1 = pre-test; X = learning using Virtual MECHSIM Laboratory combined with a physical manual-transmission trainer; O_2 = post-test.

The pre-test measured students' initial achievement. Students then explored power flow using the Virtual MECHSIM Laboratory, verified power paths with the physical trainer, analyzed the relationship between gear ratio, torque, and speed, and discussed their observations. The post-test was administered after the learning sequence.

Participants And Learning Content

The participants were 18 eleventh-grade students at SMK Antartika Surabaya who studied the Chassis and Power Transfer subject, focusing on the manual transmission system. The learning content included transmission functions and operating principles, component identification, power-flow analysis across gear positions, and the relationship between gear ratio, torque, and speed.

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Data Collection

Data were collected using achievement tests administered before and after instruction. The available study record identifies the number of participants and aggregate test results; the full test instrument and individual-level score sheet should be retained as supporting research documentation

Data Analysis

Descriptive statistics were used to summarize the mean, standard deviation, minimum, maximum, and median. The Shapiro–Wilk test was applied to the difference scores (post-test minus pre-test); a p-value greater than 0.05 was treated as meeting the normality assumption. A paired-samples t-test was then used to examine the difference between pre-test and post-test scores at a 5% significance level.

Normalized gain was calculated using the following formula:

g = (post-test − pre-test) / (100 − pre-test)

The categories used in the source manuscript were low ($g < 0.30$), moderate ($0.30 \leq g \leq 0.70$), and high ($g > 0.70$). The interpretation of these categories follows the source manuscript and should be checked against the intended methodological reference before submission.

Research Location and Time

The research was conducted in a classroom at SMK Antartika Surabaya during the first semester of the 2026/2027 academic year.

RESULT AND DISCUSSION

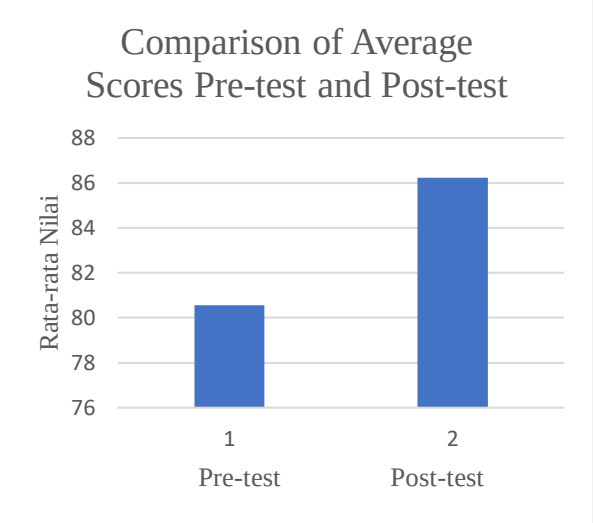
Descriptive Statistics

The descriptive results for the 18 participants are presented in Table 1.

Table 1. Descriptive Statistics of Pre-test and Post-test Scores

Statistic	Pre-test	Post-test
N	18	18
Mean	80.56	86.22
Standard deviation	5.12	5.61
Minimum	74	80
Maximum	90	100
Median	80	84

The mean score increased from 80.56 on the pre-test to 86.22 on the post-test, a difference of 5.67 points based on the reported means. The minimum score increased from 74 to 80, while the maximum increased from 90 to 100. Descriptively, students' scores were higher after the learning sequence.



Normality Test

The Shapiro–Wilk test was conducted on the difference between post-test and pre-test scores. The result is shown in Table 2.

Table 2. Shapiro–Wilk Test of Difference Scores

Data	W	p-value
Post-test − pre-test	0.902	0.061

The test produced $W = 0.902$ and $p = 0.061$. Because the p-value exceeded 0.05, the difference scores did not show a statistically significant departure from normality. The paired-samples t-test was therefore used for the pre-test/post-test comparison.

Paired-Samples T-Test

Respons mahasiswa diperoleh melalui angket yang terdiri atas 20 pernyataan dengan skala Likert 1–4. Hasil analisis respons mahasiswa disajikan pada Tabel 5.

Table 3. Paired-Samples t-Test Results

Comparison	Mean difference	t	df	p-value
Post-test − pre-test	5.67	8.694	17	< 0.001

The paired-samples t-test indicated a mean difference of 5.67 points, $t(17) = 8.694$, $p < 0.001$. This result indicates a statistically significant difference between scores before and after the

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learning sequence. Statistical significance does not, by itself, establish that the virtual laboratory was the sole cause of the change.

Normalized Gain

The aggregate N-gain results are presented in Table 4.

Table 4. Summary of N-Gain Scores

Parameter	Value
N	18
Mean N-gain	0.324
Standard deviation	0.238
Minimum	0.000
Maximum	1.000
Mean category	Moderate

The reported mean N-gain was 0.324, categorized as moderate according to the thresholds used in the source manuscript. This suggests a moderate normalized improvement across the group. However, the pre-test mean was already relatively high (80.56), leaving less room for score increases toward the maximum of 100.

Discussion

The increase in the mean score suggests that students achieved higher test results after participating in the learning sequence. This finding is broadly consistent with earlier work on digital and demonstration media for manual-transmission instruction [3–7]. However, the size of the change should not be compared directly across studies because the participants, instructional conditions, media, and assessment instruments may differ.

Virtual MECHSIM Laboratory allows students to explore the power path for different gear positions and receive feedback on their selections. This can provide a way to examine relationships among transmission components that may be difficult to infer from a static diagram alone. The activity was followed by verification using a physical trainer, giving students an opportunity to connect a virtual representation with a mechanical assembly. Because these elements were delivered as a combined learning sequence, the present data cannot separate the contribution of the simulation from the contribution of the trainer, teacher explanation, practice, or discussion.

The moderate mean N-gain (0.324) also indicates that the observed improvement was not uniformly large relative to the available score range. Students' initial achievement, individual differences, and the duration and content of instruction may be relevant, but these factors were not independently tested in the reported analysis. The individual-level data would be needed to examine variation in score changes more fully.

Several limitations should be considered. First, the study included only one group and no comparison group; therefore, the results do not establish a causal effect attributable exclusively to Virtual MECHSIM Laboratory. Second, the sample consisted of 18 students from one school, which limits generalization. Third, the available manuscript reports aggregate statistics but does not include the full assessment instrument or the individual score dataset. Future research could include a comparison group, a larger sample, transparent reporting of the test instrument and score data, and additional outcomes such as power-flow reasoning, practical performance, learning engagement, and student responses.

CONCLUSION

Students' mean achievement score increased from 80.56 on the pre-test to 86.22 on the post-test, a reported mean difference of 5.67 points. The Shapiro–Wilk test on difference scores yielded $W = 0.902$ and $p = 0.061$, and the paired-samples t-test indicated a statistically significant pre-test/post-test difference, $t(17) = 8.694$, $p < 0.001$. The mean N-gain was 0.324, classified as moderate under the thresholds used in the source manuscript.

The findings indicate that higher scores were observed after a learning sequence combining Virtual MECHSIM Laboratory with a physical manual-transmission trainer. The one-group design does not allow the change to be attributed exclusively to the virtual laboratory. Future studies should use a comparison group, recruit more participants, and report the assessment instrument and individual-level data to strengthen the evidence.

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