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APPLICATION OF INTERACTIVE LEARNING MULTIMEDIA TO IMPROVE STUDENT LEARNING OUTCOMES IN READING THE SCALE ON A MEASURING CALIPER INCH UNITS

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ABSTRACT

The purpose of this study is to investigate how interactive learning multimedia can enhance the learning outcomes of tenth-grade Motorcycle Engineering students at SMK Bina Nusantara Ungaran when it comes to reading the imperial (inch) scale of vernier callipers in the Automotive Engineering Basic Work course. To help students grasp measurement processes, the interactive multimedia included practice tasks, visual demonstrations, and teaching resources. 50 students were split equally into an experimental group and a control group (n = 25 each) for this quantitative study's pretest-posttest control group design. Normality, homogeneity, analysis of covariance (ANCOVA), and Normalised Gain (N-Gain) analyses were used to examine the data, which were gathered by observation, documentation, and objective cognitive assessments. While the control group's mean score improved from 48.2 to 80.8, the experimental group's mean score rose from 44.0 to 87.6. According to the N-Gain analysis, the control group received a score of 63% (moderately effective category), while the experimental group had a score of 78% (effective category). These results indicate that, in the context of this study, the use of interactive learning multimedia demonstrated higher effectiveness than conventional instruction in improving students' learning outcomes.

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INTRODUCTION

Education plays a central role in developing the knowledge, abilities, and skills that people need to meet the demands of business and society. Globalisation and the rapid development of technology are driving up demand for highly skilled workers, making it essential for vocational education, particularly vocational high schools (SMK), to equip graduates with real-world skills relevant to industry demands. According to (Rasyid, 2015), education should be regarded as a long-term investment in developing competitive human resources capable of supporting national development. To ensure that students acquire the competencies required by industry, the quality of instruction in vocational education must be continuously improved (Nurkholis, 1970).

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One of the persistent challenges in vocational education is implementing teaching strategies that help students grasp both theoretical concepts and practical skills. Conventional teaching is commonly teacher-centred, which tends to lower learning effectiveness and student engagement, so teachers are encouraged to adopt instructional media that keep pace with technological advancement and promote active student participation (Handayani et al., 2023). This challenge was evident in preliminary observations conducted during the LANTIP program at SMK Bina Nusantara Ungaran, particularly in the Automotive Engineering Basic Work (Pekerjaan Dasar Teknik Otomotif, PDTO) course. Because the learning resources available were limited to conventional teaching materials, students had few opportunities to independently practise reading measuring scales. As inch measurements are rarely used in Indonesian industrial practice, many students struggled to read the imperial (inch) scale on vernier callipers accurately and tended to rely solely on the metric system, indicating a need for more dynamic and engaging instructional materials that help students master both measurement systems.

Interactive multimedia is one of the most promising instructional tools for addressing this challenge. By combining text, graphics, animation, audio, video, simulation, and interactive exercises into a single learning environment, interactive multimedia allows students to practise learning materials independently and visualise abstract concepts. Prior studies have shown that, compared with conventional teaching, interactive multimedia can increase students' motivation, support conceptual understanding, and improve learning outcomes (Ariani & Festiyed, 2019). In vocational settings specifically, (Akmaludin et al., 2025) reported that Android-based interactive media significantly improved students' competence in reading micrometer screw scales, (Wibawanto et al., 2022) found that simulation-based interactive multimedia improved vocational students' practical learning outcomes, and (Fahira et al., 2025) demonstrated that augmented-reality-based media enhanced vocational students' informatics learning outcomes. Research focusing specifically on measurement instruction has likewise begun to emerge: (Kurniawan & Marsono, 2024) reported gains in students' vernier-calliper measurement competence through a project-based learning model, (Wijayanto et al., 2025) improved students' vernier-calliper reading skills through a skill-training method, and (Putrarisna et al., 2025) found that audio-visual multimedia significantly improved vocational students' cognitive achievement in reading vernier callipers at 1/128- and 1/1000-inch precision.

Despite these encouraging findings, most of this research has either addressed general engineering competencies that do not involve imperial-scale measurement (Akmaludin et al., 2025; Fahira et al., 2025; Wibawanto et al., 2022) or examined vernier-calliper measurement using non-multimedia interventions such as project-based learning or skill training (Kurniawan & Marsono, 2024; Wijayanto et al., 2025). Even the most closely related study, (Putrarisna et al., 2025), was conducted with Motorcycle Engineering students at a different vocational school and focused on higher-precision (1/128- and 1/1000-inch) scale reading as a stand-alone skill, rather than within the context of the Automotive Engineering Basic Work (PDTO) course taken by first-year students. Consequently, the effectiveness of PowerPoint-based interactive multimedia specifically for helping first-year vocational students read the standard imperial (inch) scale of vernier callipers within the PDTO course remains largely unexamined.

This gap is significant because many automotive components and industrial measuring instruments still use imperial units, so first-year vocational students must become proficient in both metric and imperial measurement systems from the outset of their technical training. The present study addresses this gap by developing and testing PowerPoint-based interactive multimedia specifically designed to help first-year Motorcycle Engineering students in the PDTO course read the imperial (inch) scale of vernier callipers, an area of measurement instruction that has not been specifically targeted by prior interactive-multimedia research.

Accordingly, this study aims to examine the effectiveness of PowerPoint-based interactive learning multimedia in improving the learning outcomes of tenth-grade Motorcycle Engineering students at SMK Bina Nusantara Ungaran in reading the imperial (inch) scale of vernier callipers within the Automotive Engineering Basic Work (PDTO) course.

METHOD

This study used a pretest-posttest control group design using a quantitative, quasi-experimental methodology. The purpose of the design was to compare the learning results of students in an experimental group and a control group before and after interactive learning multimedia was implemented. After completing a pretest to gauge their starting proficiency, both groups received various instructional strategies. While the control group was instructed using traditional teaching

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techniques, the experimental group received instruction through interactive learning multimedia. To assess improvements in learning outcomes, both groups took the same posttest at the conclusion of the lesson.

The study was carried out in May 2026 at SMK Bina Nusantara Ungaran, which is situated in Jl. Kisarino Mangunpranoto No. 5, Bandarjo, Ungaran, Semarang Regency, Central Java, Indonesia. Fifty tenth-grade students in the Motorcycle Engineering class participated in the study. There were twenty-five students in the experimental group and twenty-five in the control group, and the participants were split into two complete classes. The study concentrated on the Automotive Engineering Basic Work (Pekerjaan Dasar Teknik Otomotif/PDTO) course, particularly the ability to read vernier callipers' imperial (inch) scale.

In order to facilitate the learning of imperial (inch) scale reading on vernier callipers in the Automotive Engineering Basic Work (Pekerjaan Dasar Teknik Otomotif, PDTO) course, Microsoft PowerPoint was utilised to create the interactive learning multimedia employed in this study. Through an interactive learning environment, the multimedia was created to help students comprehend measuring principles.

Learning goals, theoretical explanations, illustrative visuals, interactive navigation, and practice activities pertaining to reading imperial-scale vernier callipers were all incorporated into the multimedia. In accordance with their learning requirements, students were allowed to independently traverse the course materials and go over each part several times. The goal of combining interactive, audiovisual, and visual components was to enhance students' comprehension of the course material and encourage active learning.

There were four steps in the research process. To find learning challenges associated with reading imperial-scale vernier callipers, a preliminary study was first carried out through a review of the literature and classroom observations. Second, before being used, the interactive multimedia and research tools were created and verified by professionals. Third, a pretest was administered to both groups in order to assess their initial competency. The control group got traditional training from the classroom teacher without the multimedia, whereas the experimental group subsequently received instruction utilising interactive multimedia. Lastly, the same cognitive achievement exam was used to provide a posttest to both groups. The efficiency of the interactive multimedia was then assessed by analysing the gathered data.

Cognitive accomplishment tests, documentation, and observation were used to gather data. To record the learning process and students' involvement in class activities, observations were made in the classroom. Supporting data on research activities and learning implementation was gathered through documentation.

An objective cognitive exam was used as a pretest and a posttest to gauge the learning results of the students. Students' abilities to recognise measuring components, decipher imperial-scale graduations, and precisely calculate measurement values using vernier callipers were evaluated. Only cognitive test results were statistically examined because the study's goal was to assess cognitive learning outcomes.

Descriptive and inferential statistics were used to analyse the gathered data. Students' pretest and posttest results were summarised using descriptive statistics. To make sure the assumptions for parametric analysis were met, the data were subjected to normality and homogeneity-of-variance tests before hypothesis testing. Because the pretest scores of the two groups were not identical, a one-way analysis of covariance (ANCOVA) was performed on the posttest scores, with group as the independent variable and the pretest score entered as a covariate, in order to statistically control for pre-existing differences between the experimental and control groups before evaluating the effect of the treatment. The homogeneity-of-regression-slopes assumption underlying the ANCOVA was tested by examining the group-by-pretest interaction term prior to interpreting the covariate-adjusted main effect. Additionally, the Normalised Gain (N-Gain) score, which was interpreted in accordance with the defined effectiveness criteria (Hake, 1998), was used to assess the interactive multimedia's efficacy.

RESULT AND DISCUSSION

Table 1. Test of Normality

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Group	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Control Group	0.173	25	0.051	0.945	25	0.191
Experiment Group	0.189	25	0.022	0.920	25	0.050

Source: Data processed by the researcher using IBM SPSS Statistics (2026).

A normality test was conducted to determine whether the learning outcome data from the control and experimental groups followed a normal distribution. In this study, the Shapiro–Wilk test was employed because it is appropriate for relatively small sample sizes. The decision-making criterion was that data were considered normally distributed if the significance value (Sig.) was ≥ 0.05, whereas a significance value (Sig.) < 0.05 indicated that the data were not normally distributed.

Based on the normality test results presented in the table above, the control group obtained a significance value of 0.191, while the experimental group obtained a significance value of 0.050. The significance value of 0.191 for the control group is greater than 0.05; therefore, the data for the control group were considered normally distributed. Meanwhile, the experimental group obtained a significance value of 0.050. This value is exactly at the specified significance threshold of 0.05 and therefore still meets the predetermined criterion of Sig. ≥ 0.05.

Although the significance value for the experimental group was exactly 0.05, it remains within the normality criterion established in this study. Therefore, based on the Shapiro–Wilk test, both groups met the normality assumption, with a significance value of 0.191 for the control group and 0.050 for the experimental group. Thus, the data from both groups were considered normally distributed and were eligible for further statistical analysis.

Table 2. Test of Homogeneity of Variance

Levene Statistic	df1	df2	Sig.
Based on Mean	0.036	1, 48	0.849
Based on Median	0.025	1, 48	0.875
Based on Trimmed Mean	0.033	1, 48	0.856

Source: Data processed by the researcher using IBM SPSS Statistics (2026).

The homogeneity of variance was assessed using Levene's test to determine whether the variances of the control and experimental groups were equivalent. The decision-making criterion was that the variances were considered homogeneous when the significance value (Sig.) was greater than 0.05, whereas a significance value of 0.05 or less indicated that the variances were not homogeneous. Based on the results, the *Based on Mean* approach produced a Levene statistic of 0.036 with a significance value of 0.849. The *Based on Median* approach yielded a Levene statistic of 0.025 with a significance value of 0.875, while the *Based on Trimmed Mean* approach resulted in a Levene statistic of 0.033 with a significance value of 0.856. Since all significance values were greater than 0.05, the variances of the control and experimental groups were considered homogeneous. Therefore, the data met the homogeneity assumption required for the subsequent ANCOVA.

Table 3. ANCOVA Summary for Posttest Scores Adjusted for Pretest

Source	df	F	Sig.
Pretest (covariate)	1, 47	12.94	.001
Group (Experiment vs. Control)	1, 47	16.38	<.001
Homogeneity-of-regression-slopes check (Group × Pretest)	1, 46	0.53	.472

Source: Data processed by the researcher using IBM SPSS Statistics (2026).

Because the experimental group's pretest mean (44.0) was lower than the control group's (48.2), the posttest scores were analysed with a one-way ANCOVA in which the pretest score served as a covariate. The interaction between group and pretest was not significant, $F(1, 46) = 0.53$, $p = .472$, indicating that the regression slopes were homogeneous and that the covariate-adjusted model could be interpreted. After adjusting for initial differences in pretest scores, the covariate-adjusted posttest mean was higher for the experimental group (88.24) than for the control group (80.16). The effect of group remained

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statistically significant after controlling for pretest scores, $F(1, 47) = 16.38$, $p < .001$, as did the effect of the pretest covariate itself, $F(1, 47) = 12.94$, $p = .001$. This result indicates that the difference in learning outcomes between the experimental and control groups cannot be attributed to the groups' unequal starting scores and reflects a genuine effect of the interactive multimedia treatment.

Table 4. N-Gain Test

Group	Pretest Mean	Posttest Mean	N-Gain (%)	Category
Experiment	44	87,6	78%	Effective
Control	48,2	80,8	63%	Moderately Effective

Source: Data processed by the researcher (2026).

The N-Gain results provide additional evidence regarding the magnitude of improvement in both groups. The experimental group achieved an N-Gain percentage of 78%, categorized as effective, whereas the control group achieved 63%, categorized as moderately effective. The higher N-Gain in the experimental group indicates that the improvement was not merely attributable to students completing the learning process or taking the test for a second time. Rather, the experimental group demonstrated a greater increase relative to its initial learning achievement after receiving the interactive multimedia intervention.

The difference in improvement is also meaningful when the pretest and posttest results are considered together. Although the experimental group started with a lower mean pretest score (44.0) than the control group (48.2), it achieved a higher mean posttest score (87.6) than the control group (80.8). This pattern suggests that the experimental group not only overcame its initial score disadvantage but also achieved a higher level of learning achievement after the intervention. The finding strengthens the interpretation that the use of interactive multimedia contributed to improved students' ability to understand and read the imperial scale of the vernier caliper.

These findings are also consistent with, and can be explained by, broader theory and research on multimedia and interactive learning. The higher N-Gain in the experimental group is unlikely to stem simply from the presence of more visual elements; rather, it reflects design features that are known to support how learners process instructional information. First, dual coding theory holds that pairing verbal explanations with corresponding visuals allows learners to build separate but connected mental representations, which strengthens comprehension and recall relative to text alone (Clark & Paivio, 1991). The interactive multimedia used in this study paired procedural visuals of vernier-calliper scale reading with explanatory text and narration, which plausibly supported this dual-channel processing. Second, because reading an imperial-scale vernier calliper is a step-by-step procedural skill, the multimedia's illustrative visuals and worked demonstrations gave students a concrete, repeatable model of the measurement procedure, reducing the extraneous cognitive load associated with imagining the procedure from text alone and freeing cognitive resources for the essential steps of the task (Mayer & Moreno, 2003; Sweller et al., 2019). Third, because students could independently revisit and repeat sections of the multimedia, they were able to engage in self-paced practice with the material until they were confident in their understanding, a form of practice associated with improved procedural learning. Fourth, the interactive exercises embedded in the multimedia offered students a way to check their understanding as they progressed, and feedback of this kind is well documented as one of the more powerful influences on learning and achievement (Hattie & Timperley, 2007). Finally, the combination of visual, audio, and interactive elements is likely to have increased students' behavioural and cognitive engagement with the material relative to the conventional, teacher-centred instruction received by the control group (Fredricks et al., 2004), which is consistent with meta-analytic evidence that interactive, technology-based instruction tends to produce stronger learning gains than non-interactive instruction, although the size of this benefit depends on the type and design of the learning environment (Merchant et al., 2014). Taken together, these mechanisms provide a plausible explanation for why the experimental group's N-Gain exceeded that of the control group beyond the general observation that multimedia was used.

Overall, the statistical and descriptive findings consistently demonstrate the superiority of the experimental group. The ANCOVA showed a statistically significant effect of group on posttest scores after adjusting for pretest differences, $F(1, 47) = 16.38$, $p < .001$, with a higher covariate-adjusted posttest mean in the experimental group (88.24) than in the control

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group (80.16). Descriptively, the experimental group also achieved a higher raw posttest mean (87.6) than the control group (80.8), and a higher N-Gain (78%) than the control group (63%). Taken together, these findings indicate that the implementation of interactive multimedia learning was more effective than conventional learning in improving students' learning outcomes in reading the imperial (inch) scale of vernier calipers.

CONCLUSION

This study concludes that PowerPoint-based interactive learning multimedia demonstrated higher effectiveness than conventional instruction in improving the learning outcomes of first-year Motorcycle Engineering students in reading the imperial (inch) scale of vernier calipers. After adjusting for pretest differences, the experimental group recorded a significantly higher posttest mean than the control group, and it also achieved a higher N-Gain (78%, effective category) than the control group (63%, moderately effective category), for this study's participants.

Nevertheless, this study has several limitations. The research was conducted at only one vocational school and involved a relatively limited number of students. Therefore, the findings should be interpreted within the context of the participants and learning conditions of this study and should not be generalized broadly. Further research is recommended to involve larger and more diverse samples, different vocational schools, and longer intervention periods. Future studies may also examine the effectiveness of interactive multimedia on other measurement competencies or practical skills to provide broader evidence of its applicability in vocational education.

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