

The Influence of Multirepresentation Based Science Student Worksheets Integrated with Virtual Laboratory on the Critical Thinking Skills of Junior High School Students

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Abstract

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This study aims to examine the effect and increase in the use of multirepresentation-based science worksheets integrated with virtual laboratories on the critical thinking skills of junior high school students. The research method used is a quasi-experiment with a non-equivalent control group design. The research subjects consisted of 54 seventh-grade students at SMP Negeri 14 Jember in the odd semester of the 2025/2026 academic year, who were divided into an experimental class and a control class. Data collection techniques were carried out through pretest and posttest administration, while data analysis included normality tests, independent samples t-tests, and n-gain tests to determine the improvement in students' critical thinking skills. The results showed that the use of multirepresentation-based science worksheets integrated with virtual laboratories had a significant effect on improving students' critical thinking skills.

Keywords: Critical thinking, Multirepresentation Based Science Student Worksheets, Science Education

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INTRODUCTION

Science education in junior high school emphasizes active student involvement through activities such as experiments, observations, and discussions. This education aims not only to master concepts, but also to develop scientific skills and systematic thinking. Through such active involvement, students are expected to be able to observe, analyze, and conclude natural phenomena scientifically, as well as have a curious attitude and critical thinking skills in problem solving (Ariani, 2020). Critical thinking skills are a cognitive process that includes six main skills, namely interpretation, analysis, evaluation, inference, explanation, and self-regulation. However, students' critical thinking skills are still not optimally developed. This is shown by the results of the 2015 TIMSS international study, which recorded Indonesia's science score at 397, ranking 44th out of 49 countries and still below the international average of 500 (Martin et al., 2016).

The low level of critical thinking skills is also reinforced by Mulia's (2024) research on eighth-grade students at a junior high school in Sumbawa Regency. The results of the study show that the average achievement of students' critical thinking skills is only 34.26%. In detail, interpretation and conclusion skills

were in the low category, analysis skills were in the moderate category, while explanation skills were in the very low category. This condition indicates that most students have not been able to develop higher-order thinking skills optimally.

One of the learning tools that plays an important role in supporting science learning is the student worksheet (LKPD). LKPD helps students understand scientific concepts through structured exercises and independent learning activities. However, many LKPDs used in schools are still monotonous and dominated by numerical problem-solving without presenting concepts in various forms of representation. Therefore, multi-representation-based LKPD are needed to present concepts through verbal explanations, images, mathematical expressions, and graphs, which can comprehensively support students' critical thinking processes (Mahardika et al., 2024). The use of multi-representation in science learning has been shown to reduce students' learning difficulties, as it enables them to understand concepts from multiple perspectives (Aprilina et al., 2023).

The implementation of learning using LKPD can be strengthened through direct data exploration activities that allow students to analyze observations and draw conclusions from practical work. However, observations conducted at a public junior high school in Jember Regency revealed that laboratory activities were not optimally implemented due to the functional conversion of science laboratories and limited availability of practical equipment (Fortuna et al. 2021). These limitations cause learning activities to focus more on completing worksheets rather than analyzing scientific concepts in depth. As a result, critical thinking indicator particularly analysis and evaluation skills have not been developed optimally.

To address these limitations, interactive learning media such as virtual laboratories can serve as a relevant and effective alternative. A virtual laboratory is a technology-based learning medium that digitally simulates laboratory activities through a combination of visual elements, animations, audio, and interactive text. This medium enables students to conduct experiments virtually in a manner similar to real laboratory activities without relying on physical tools and materials (Berlian et al., 2023). The integration of multi-representation-based LKPD with virtual laboratories is expected to provide meaningful learning experiences that actively engage students in exploration, data analysis, and conclusion drawing, thereby fostering the development of critical thinking skills in science learning.

RESEARCH METHOD

The present study employed a quantitative research approach conducted during the odd semester of the 2025/2026 academic year. This research was designed as a quasi-experimental study using a non-equivalent control group design. In this design, the participants were divided into an experimental group and a control group that were not randomly assigned. The experimental group received instructional treatment using the proposed learning intervention, while the control group was taught using conventional instructional methods. This research design was chosen to examine the effect of the implemented treatment by comparing learning outcomes between the experimental and control groups under natural classroom conditions.

Table 1 The research design is nonequivalent control group design

Class	Pre-test	Treatment	Post-test
Eksperimental	O ₁	X	O ₂
Control	O ₃	-	O ₄

(Sugiyono 2017)

This study was conducted in September 2025 at SMP Negeri 14 Jember. The research population consisted of all seventh-grade students of SMP Negeri 14 Jember. The sample comprised two classes: Class VII E was assigned as the experimental group, which received instruction using science student worksheets based on multi-representation (LKPD) integrated with a virtual laboratory, while Class VII C served as the control group and was taught using the instructional approach commonly applied by the school teacher, namely discovery learning. Both groups were provided with the same instructional content covering the topics of temperature, heat, and thermal expansion.

Data were collected using a test technique in the form of a pretest–posttest design. Therefore, the following formula was applied to analyze the data:

$$Score = \frac{Total\ score\ obtained}{Maximum\ total\ score} \times 100$$

After obtaining the students critical thinking data from both the experimental and control groups, statistical analyses were conducted to examine the significance of the effect of science student worksheets based on multi-representation integrated with a virtual laboratory. The data analysis procedure began with a normality test. If the significance value (Sig.) was greater than 0.05, the data were considered to be normally distributed, and an independent samples t-test was subsequently applied. Conversely, if the significance value (Sig.) was less than 0.05, the data were regarded as not normally distributed, and the Mann–Whitney test was employed for further analysis. When the data met the normality assumption and the resulting significance value was less than 0.05, the null hypothesis (H₀) was rejected and the alternative hypothesis (H_a) was accepted, indicating that the use of science student worksheets based on multi-representation integrated with a virtual laboratory had a significant effect on junior high school students' critical thinking skills.

After the data were confirmed to be normally distributed, the subsequent hypothesis testing was conducted using the N-gain test. The N-gain test was employed to measure the level of improvement in students' critical thinking skills after the implementation of the instructional treatment. The N-gain value was calculated using the following formula:

$$N - Gain = \frac{Score\ Posttes - Score\ pretest}{score\ maximum - Score\ pretest}$$

(Hake, 1998)

The interpretation of the N-gain values follows the criteria proposed by Hake (1998). An N-gain value of $g \geq 0.70$ is classified as high, indicating a substantial improvement in students' critical thinking skills after the implementation of the instructional treatment. An N-gain value in the range of $0.30 \leq g < 0.70$ is categorized as medium, which reflects a moderate level of improvement in students' learning outcomes. Meanwhile, an N-gain value of $0.00 < g < 0.30$ is considered low, suggesting that the improvement in students' critical thinking skills is minimal. These criteria are used to determine the effectiveness of the applied learning intervention in enhancing students' critical thinking abilities.

RESULTS AND DISCUSSION

Research Results

This study aimed to examine the effect of science student worksheets (LKPD) based on multi-representation integrated with a virtual laboratory on junior high school students' critical thinking skills. In addition, this study sought to investigate the improvement in students' critical thinking skills after the implementation of multi-representation-based science worksheets integrated with a virtual laboratory in the learning process.

Students' critical thinking skills were measured using descriptive test instruments administered in the form of pretest and posttest to both the experimental and control groups. The results of students' critical thinking skills are summarized in Table 2 below.

Table 2 Data on pretest and posttest learning outcomes

Elemen	Control class		Experimental class	
	Pretest	Posttest	Pretest	Posttest
Highest Score	61	85	19	94
Lower Score	18	30	68	68
Mean	37,63	60,48	38,56	82,63
Median	38	60	36	84
<i>Std. Er.</i>	1,61	2,58	2,36	1,27
<i>Std Dev.</i>	8,39	13,40	12,31	6,62

Table 2 indicates that there was no significant difference in students' initial abilities to answer the pretest questions between the experimental and control groups. However, after the instructional treatment was implemented, the experimental group demonstrated a greater increase in mean scores compared to the control group. The experimental group achieved a mean posttest score of 82.63, with the lowest score of 68 and the highest score of 94. In contrast, the control group obtained a mean posttest score of 60.48, with scores ranging from 30 to 85. The improvement in the control group's scores was relatively lower than that of the experimental group, as the control group did not receive the same instructional media. Consequently, the impact on students' critical thinking test results in the control group was not as significant as that observed in the experimental group.

Furthermore, to determine the effect of science student worksheets (LKPD) based on multi-representation integrated with a virtual laboratory on junior high school students' critical thinking skills, several statistical tests were conducted

to examine the significance of the results. The first statistical analysis performed after obtaining the pretest and posttest score data was a normality test. This test was conducted to verify whether the data met the assumption of normal distribution. The results of the normality test are presented as follows.

Table 3. Test of normality of learning outcomes

		Kolmogorov-Smirnov ^a		
	class	Statistic	df	Sig.
<i>Pretest</i>	Experimental	0,149	27	0,128
	Control	0,152	27	0,109
<i>Posttest</i>	Experimental	0,148	27	0,136
	Control	0,107	27	0,200

Based on Table 3, the Kolmogorov–Smirnov normality test indicates that the significance value of students’ critical thinking test scores in the experimental group was 0.149 for the pretest and 0.148 for the posttest. Meanwhile, in the control group, the pretest significance value was 0.152 and the posttest significance value was 0.148. These results show that the significance values of both pretest and posttest scores were greater than 0.05 (Sig. > 0.05). Therefore, the pretest and posttest data were normally distributed.

As the normality assumption was satisfied, the next stage of analysis involved conducting a second statistical test, namely a parametric independent samples t-test, to compare students’ critical thinking skills between the experimental and control groups. The results of the t-test analysis of students’ critical thinking skills are presented in Table 4.

Table 4. Independent sample t-test

Levene's Test for Equality of Variances		t-test for Equality of Means						
F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
3.612	.063	7.694	52	.000	22.148	2.879	16.372	27.924
		7.694	37.991	.000	22.148	2.879	16.321	27.976

Based on Table 4, the results of the independent samples t-test show that the Sig. (2-tailed) value is 0.000. According to the decision criteria of the independent samples t-test, a significance value lower than 0.05 ($0.000 < 0.05$) indicates that the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is accepted. These findings demonstrate a statistically significant difference in the mean scores of students’ critical thinking skills between the experimental group and the control group.

Furthermore, a hypothesis test using the N-gain analysis was conducted to determine which group exhibited a greater improvement in critical thinking skills, either the experimental group or the control group. The results of the N-gain analysis are presented in Table 5 below.

class	Rata-rata <i>Pretest</i>	Rata-rata <i>Posttest</i>	Nilai <i>N-gain</i>	Kriteria
control	37,62	60,48	0,37	medium
experimental	38,56	82,63	0,71	high

The improvement in students' critical thinking skills for each group is presented in Table 5. The results indicate that the experimental group achieved a mean pretest score of 38.56, while the mean posttest score increased to 82.63. The N-gain value for the experimental group was 0.71, which falls into the high category. In contrast, the control group obtained a mean pretest score of 37.56 and a mean posttest score of 60.48. The N-gain value for the control group was 0.37, which is categorized as medium. These findings indicate that the improvement in critical thinking skills in the experimental group was greater than that in the control group, with a high level of improvement (N-gain = 0.71).

DISCUSSION

The results of this study demonstrate that the implementation of science student worksheets (LKPD) based on multi-representation integrated with a virtual laboratory has a significant and positive effect on junior high school students' critical thinking skills. This finding is supported by the comparison of pretest and posttest scores between the experimental and control groups, as well as the results of the inferential statistical analyses.

Based on the descriptive statistics, both groups showed comparable initial abilities, as indicated by the relatively similar mean pretest scores of the experimental group (38.56) and the control group (37.63). This suggests that students in both groups had equivalent levels of critical thinking skills prior to the instructional treatment. However, after the learning intervention, the experimental group demonstrated a substantially higher mean posttest score (82.63) compared to the control group (60.48). This difference indicates that students who learned using LKPD based on multi-representation integrated with a virtual laboratory achieved better learning outcomes than those who received conventional discovery learning.

The results of the normality test confirmed that the pretest and posttest data from both groups were normally distributed, allowing for further parametric analysis using an independent samples t-test. The t-test results revealed a significant difference between the experimental and control groups, as indicated by a Sig. (2-tailed) value of 0.000, which is lower than the significance threshold of 0.05. This finding confirms that the observed difference in students' critical thinking skills was statistically significant and not due to chance, thereby supporting the acceptance of the alternative hypothesis.

Further analysis using the N-gain test strengthened these findings by illustrating the magnitude of improvement in students' critical thinking skills. The experimental group achieved an N-gain value of 0.71, categorized as high, while the control group obtained an N-gain value of 0.37, categorized as medium. These results indicate that the improvement in critical thinking skills among students who learned through LKPD integrated with a virtual laboratory was not only statistically significant but also educationally meaningful.

The higher improvement observed in the experimental group can be attributed to the characteristics of the implemented learning intervention. The use of multi-representations such as verbal explanations, visual illustrations, graphs, and mathematical representations helps students understand scientific concepts from multiple perspectives, thereby facilitating deeper conceptual understanding. Additionally, the integration of a virtual laboratory provides opportunities for students to actively engage in simulated experiments, analyze data, and draw conclusions, which are essential processes for developing critical thinking skills. In contrast, the control group did not experience the same level of interactive and exploratory learning, which may explain the relatively lower improvement in their critical thinking performance.

Overall, the findings of this study indicate that LKPD based on multi-representation integrated with a virtual laboratory is an effective instructional approach for enhancing junior high school students' critical thinking skills. This learning model encourages active participation, supports conceptual understanding, and promotes higher-order thinking processes, making it a promising alternative to conventional science instruction.

CONCLUSION

This study concludes that the use of science student worksheets (LKPD) based on multi-representation integrated with a virtual laboratory has a significant effect on junior high school students' critical thinking skills. The N-gain analysis shows that students in the experimental group experienced a high level of improvement, with an N-gain value of 0.71 (71%), indicating that this learning approach is effective in enhancing students' critical thinking skills in science learning.

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