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The Implementation of the IMPROVE Learning Model Viewed from Mathematical Disposition on Students' Mathematical Critical Thinking Ability

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ABSTRACT

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This research was conducted to examine the influence of the IMPROVE learning model on students' mathematical critical thinking skills when viewed from their mathematical disposition. An experimental approach with a 2 × 3 factorial design was applied in this study. The collected data were analyzed using the Liliefors test, F-test, and two-way ANOVA. The findings revealed that the implementation of the IMPROVE learning model significantly enhanced students' mathematical critical thinking skills. Furthermore, mathematical disposition was found to contribute to the development of these skills. The results also indicated an interaction effect between the learning model and students' mathematical disposition. Consequently, the IMPROVE learning model can be considered an effective approach for fostering students' mathematical critical thinking abilities.

A. INTRODUCTION

Mathematics education has a significant role in fostering students' abilities to think logically, systematically, critically, and analytically. Beyond the acquisition of mathematical concepts and procedures, mathematics learning is expected to develop students' capacity to interpret problems, evaluate information, formulate appropriate solution strategies, and make reasoned conclusions. Consequently, mathematical critical thinking is recognized as one of the key competencies that should be cultivated through mathematics instruction.

Mathematical critical thinking can be defined as the ability to engage in active, reflective, and logical reasoning when addressing mathematical situations and solving problems (Wildaniati et al., 2021). Stacey, cited in Herman et al. (2024), emphasizes that mathematical critical thinking is not only an important educational objective but also an essential component of the mathematics learning process itself. Despite its importance, numerous studies have reported that students' mathematical critical thinking skills remain unsatisfactory. Anggraini, Siagian, and Agustinsa (2022) found that students' average level of mathematical critical thinking reached only 31.42%. Similarly, research conducted by Fitri, Maimunah, and Suanto (2023) indicated that students' critical thinking skills were still categorized as low, with an average achievement of 29.64%. Preliminary observations carried out by the researcher at an Islamic junior high school (MTs) in Pekanbaru also revealed similar findings. The average score of students' mathematical critical thinking ability was only 56.4, indicating that many students encountered difficulties in interpreting problems, processing information, selecting suitable solution methods, and providing logical justification for their answers.

To address this issue, innovative instructional approaches are needed to support the development of students' mathematical critical thinking skills. One learning model that has the potential to achieve this goal is the IMPROVE model (Introducing the New Concept, Metacognitive Questioning, Practicing, Reviewing and Reducing Difficulties, Obtaining Mastery, Verification, and Enrichment) (Lestari & Yudhanegara, 2018). This model places strong emphasis on metacognitive processes through a series of guiding questions that encourage students to reflect on their thinking and engage more deeply in problem-solving activities (Ansari & Abdullah, 2020). Empirical evidence also supports the effectiveness of this approach. Research conducted by Zulfa Razi et al. (2023) demonstrated that students who participated in learning through the IMPROVE model achieved higher levels of mathematical critical thinking compared with those who received conventional instruction.

B. RESEARCH METHODS

This study applied an experimental approach with a 2 × 3 factorial design and was carried out at MTs Darul Hikmah Pekanbaru in the second semester of the 2025/2026 academic year. The participants were determined through a cluster random sampling procedure, in which class VIII.I was assigned as the experimental class and class VIII.H as the control class. Students in the experimental class were instructed using the IMPROVE learning model, whereas those in the control class experienced conventional teaching methods. Data collection was conducted through achievement tests, questionnaires, observation sheets, and documentation. Both descriptive and inferential statistical techniques were utilized to analyze the data. Prior to testing the hypotheses, prerequisite analyses were performed, including a Liliefors normality test and an F-test for homogeneity. Subsequently, the research hypotheses were examined using a Two-Way ANOVA with a significance level of 0.05 (Hidayat et al., 2024, p. 55).

C. RESULT AND DISCUSSION

1. Result

Before conducting hypothesis testing with parametric statistics, the distribution of the post-test data was first evaluated through a Liliefors normality test. This procedure was intended to verify whether the data met the assumption of normality. The data were regarded as normally distributed if the obtained Liliefors statistic (L_{count})was less than the corresponding critical value (L_{table})at the 5% significance level. The results of the normality analysis are summarized as follows:

Table I. Post-Test Data Normality Test

Class	L_{count}	L_{table}	Kriteria
Experimental	0,1252	0,1700	Normal
Control	0,1097		Normal

Referring to Table I, the results of the Liliefors normality analysis for the experimental group revealed an L_{count}value of 0.1252. With a significance level of 5% and a sample size of 27 students, the critical value obtained from the Liliefors table was 0.1700. Since the calculated value was below the critical value ($0.1252 < 0.1700$), the post-test scores of students in the experimental class satisfied the assumption of normal distribution.

In the control group, the normality analysis produced an L_{count}value of 0.1097. Using the same significance level ($\alpha = 0.05$) and sample size ($n = 27$), the critical value remained 0.1700. The comparison showed that the calculated statistic was smaller than the critical value ($0.1097 < 0.1700$), indicating that the post-test data from the control class were also normally distributed.

Following the normality assessment, a homogeneity test was carried out using the F-test procedure. This analysis was intended to examine whether the variances of the groups were equivalent and whether the samples were drawn from the same homogeneous population. The decision rule stated that the homogeneity assumption was accepted when F_{count}did not exceed F_{table}at the 0.05 significance level. The results of the homogeneity test are summarized in the following table.

Table II. Homogeneity Test of Post-Test Data

Criteria	Experimental Class	Control Class
Variance	6,7123	5,9601
Sum	340	298
Df	2,5908	2,4413
F_{count}	1,1262	
F_{table}	1,9800	

Based on Table II, the homogeneity test of the post-test data showed that the variance of the experimental class was 6.7123, while the variance of the control class was 5.9601. The result of the F-test showed that $F_{count} = 1.1262$, while $F_{table} = 1.9800$at a significance level of $\alpha = 0.05$. Since $F_{count} < F_{table}(1.1262 < 1.9800)$, it can be concluded that the post-test data of both classes were homogeneous. Therefore, the sample classes used in this study originated from a homogeneous population.

Table III. Two-Way ANOVA of Post-Test Data

Source of Variance	Between Rows (Learning Model) A	Between Columns (Mathematical Disposition) B	Interaction A × B (Learning Model × Mathematical Disposition)
dk	1	2	2
JK	32,6667	31,8148	20,3823
RK	32,6667	15,9074	10,1912
F_{count}	11,7643	5,7288	3,6702
F_{table}	4,04	3,19	3,19
Conclusion	There was a difference in students' mathematical critical thinking ability between those taught using the IMPROVE learning model and those taught using the conventional learning model.	There was a difference in students' mathematical critical thinking ability among those with high, moderate, and low mathematical dispositions.	There was an interaction between the IMPROVE learning model and mathematical disposition on students' mathematical critical thinking ability.

Based on Table III, the results of the Two-Way ANOVA test showed significant findings for all three hypotheses.

a) First Hypothesis. Using the Two-Way ANOVA analysis, the first hypothesis showed that $F_{count} > F_{table}$, namely $11.7643 > 4.04$. Therefore, $H_0$was rejected and $H_a$was accepted. This means that there was a significant difference in students' mathematical critical thinking ability between those taught using the IMPROVE learning model and those taught using the conventional learning model.
b) Second Hypothesis. Using the Two-Way ANOVA analysis, the second hypothesis showed that $F_{count} > F_{table}$, namely $5.7288 > 3.19$. Therefore, $H_0$was rejected and $H_a$was accepted. This means that there was a significant difference in students' mathematical critical thinking ability among students with high, moderate, and low mathematical dispositions.

c) Third Hypothesis. Using the Two-Way ANOVA analysis, the third hypothesis showed that $F_{count} > F_{table}$, namely $3.6702 > 3.19$. Therefore, $H_0$was rejected and $H_a$was accepted. This means that there was an interaction between the IMPROVE learning model and mathematical disposition on students' mathematical critical thinking ability.

2. Discussion

The data presented represent students' learning outcomes in terms of mathematical critical thinking ability for those taught using the IMPROVE learning model and those taught using conventional learning. The post-test results from both the experimental and control classes are presented in Table IV below.

Table IV. Post-Test Results of Experimental and Control Classes

Descriptive Statistics	Experimental Class (VIII.I)	Control Class (VIII.H)
Total Score	340	298
Mean	12.5926	11.0370
Maximum Score	16	16
Minimum Score	8	7
Standard Deviation	2.5908	2.4413
Variance	6.7123	5.9601

Based on Table IV, the post-test results showed that the experimental class (VIII.I) obtained a total score of 340 with a mean score of 12.5926, while the control class (VIII.H) obtained a total score of 298 with a mean score of 11.0370. Both classes achieved the same maximum score of 16, whereas the minimum score in the experimental class was 8 and in the control class was 7. In addition, the standard deviation of the experimental class was 2.5908, which was slightly higher than that of the control class (2.4413). Similarly, the variance of the experimental class (6.7123) was higher than that of the control class (5.9601). These results indicate that students taught using the IMPROVE learning model achieved better mathematical critical thinking ability compared to those who received conventional learning.

Table V. Categories of Students' Mathematical Disposition Grouping

Class	Indicator	Mean	Standard Deviation	X Max	X Min	Ideal Score
Experimental	Elementary Clarification	3.2593	1.3472	4	0	4
	Inference	3.0741	1.1743	4	0	4
	Advanced Clarification	3.1481	1.0267	4	0	4
	Strategy and Tactics	3.1111	1.1795	4	0	4
Control	Elementary Clarification	2.7778	1.0127	4	0	4
	Inference	2.9630	0.9799	4	1	4
	Advanced Clarification	2.9630	1.0554	4	0	4
	Strategy and Tactics	2.3333	1.2710	4	0	4

The descriptive statistics presented above indicate that students in the experimental class achieved higher average post-test scores than those in the control class across all indicators of mathematical critical thinking ability. For the elementary clarification indicator, the mean score of the experimental class was 3.2593, whereas the control class obtained an average score of 2.7778. A similar pattern was observed for the inference indicator, where the experimental class recorded a mean score of 3.0741 compared to 2.9630 in the control class. These results suggest that students in the experimental class demonstrated a stronger ability to interpret information and formulate conclusions from mathematical problems.

On the advanced clarification indicator, the experimental class attained an average score of 3.1481, while the control class obtained 2.9630. Likewise, the strategy and tactics indicator showed a noticeable difference between the two groups, with average scores of 3.1111 and 2.3333 for the experimental and control classes, respectively. This finding indicates that students who experienced the IMPROVE learning model were more proficient in identifying and applying appropriate strategies to solve mathematical problems.

The variability of scores in both groups was relatively comparable, as reflected by their standard deviations. For the elementary clarification indicator, the standard deviation was 1.3472 in the experimental class and 1.0127 in the control class. On the inference indicator, the standard deviations were 1.1743 and 0.9799, respectively. The advanced clarification indicator yielded standard deviations of 1.0267 for the experimental class and 1.0554 for the control class. Meanwhile, the strategy and tactics indicator produced standard deviations of 1.1795 and 1.2710, indicating slightly greater score dispersion among students in the control class.

The maximum score achieved on every indicator in both classes was 4, representing the ideal score. This result shows that several students in each group were able to reach the highest level of achievement on the assessed indicators. Nevertheless, the consistently higher average scores obtained by the experimental class suggest that their mathematical critical thinking ability was superior to that of the control class, particularly in problem comprehension, inference, advanced explanation, and the selection of effective solution strategies.

Following the descriptive analysis of post-test scores on each indicator shown in Table V, an additional analysis was conducted to examine students' average mathematical critical thinking ability based on categories of mathematical disposition. The findings are presented in Table VI.

Table VI. Classification of Students' Mathematical Disposition Categories

Disposition Class		High Disposition Mean	Moderate Disposition Mean	Low Disposition Mean	Overall Mean
Critical Thinking Ability	Experimental	13.7500	12.9167	10.7714	12.5926
	Control	11.6667	11.4615	9.8750	11.0370

Based on the data presented in Table VI, students in the experimental class obtained higher average scores in mathematical critical thinking ability than those in the control class across all categories of mathematical disposition. For students classified in the high mathematical disposition category, the experimental group achieved a mean score of 13.7500, whereas the control group recorded an average score of 11.6667. This finding suggests that students with strong mathematical dispositions benefited more from the learning process implemented in the experimental class.

A similar trend was evident among students with moderate mathematical disposition. The experimental class achieved an average score of 12.9167, exceeding the control class average of 11.4615. Likewise, in the low disposition category, students in the experimental class obtained a mean score of 10.7714, while those in the control class achieved 9.8750. These results indicate that the experimental class consistently demonstrated better mathematical critical thinking performance regardless of students' levels of mathematical disposition.

When the results are examined according to disposition categories, both groups displayed the same tendency. Students with high mathematical disposition achieved the highest average scores, followed by those with moderate disposition, whereas students with low mathematical disposition obtained the lowest scores. This pattern implies that stronger mathematical disposition is associated with higher levels of mathematical critical thinking ability. In other words, mathematical disposition appears to contribute positively to the development of students' critical thinking skills in mathematics.

Overall, the average score of mathematical critical thinking ability in the experimental class reached 12.5926, while the control class obtained an average score of 11.0370. The higher mean score achieved by the experimental class indicates that students who participated in the learning model applied in that class demonstrated superior mathematical critical thinking ability compared to students who experienced conventional instruction. Furthermore, students' mathematical disposition, reflected in their interest, confidence, and positive attitudes toward mathematics, may also be strengthened through active involvement and meaningful engagement during classroom learning activities.

D. CONCLUSION AND SUGGESTIONS

1. Conclusion

Based on the findings obtained from this study, it can be inferred that the implementation of the IMPROVE learning model contributes significantly to the enhancement of students' mathematical critical thinking ability. Statistical analysis using Two-Way ANOVA confirmed the existence of significant differences between students who participated in learning through the IMPROVE model and those who received conventional teaching. The higher mean scores achieved by the experimental group indicate that students exposed to the IMPROVE approach demonstrated better mathematical critical thinking performance than their counterparts in the control group.

The study also identified mathematical disposition as an influential factor in the development of mathematical critical thinking skills. Students who exhibited stronger mathematical dispositions tended to achieve higher levels of critical thinking ability than those with moderate or weaker dispositions. Furthermore, the results indicated an interaction effect between the learning model and mathematical disposition, suggesting that the impact of the IMPROVE model may vary according to students' dispositions toward mathematics. These findings highlight the potential of the IMPROVE learning model as an effective pedagogical strategy for fostering students' mathematical critical thinking skills.

2. Suggestions

Based on the results of this study, the IMPROVE learning model can be considered as an alternative instructional approach in mathematics learning to improve students' mathematical critical thinking ability. Teachers are encouraged to implement learning models that involve metacognitive activities so that students become more active, critical, and capable of solving mathematical problems systematically.

For future researchers, this study may serve as a reference for developing similar research on different materials, educational levels, or other related variables so that broader and more in-depth findings can be obtained.

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