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The Application of an Open-Ended Approach to Improve the Mathematical Representation Skills of Students at Amanuban Tengah State Junior High School 1

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Abstract

One of the reasons for the low mathematical representation skills of students at SMP Negeri 1 Amanuban Tengah is the use of teaching approaches that are not yet appropriate for the characteristics of the learning material. This study aims to determine the effectiveness of the open-ended approach in improving students' mathematical representation skills in the subject of systems of linear equations with two variables. This study was conducted using an experimental method with a quasi-experimental design in the form of a pretest-posttest control group design. The research sample consisted of two classes selected using cluster random sampling. The instrument used in this study was a test of students' mathematical representation skills. Data analysis employed a one-sample t-test to assess students' learning achievement and an independent two-sample t-test to test the similarity of initial ability means before the treatment and the difference in mathematical representation skills between the experimental and control classes after the treatment. The results of the study indicate that the mathematical representation skills of students who participated in learning using the open-ended approach improved significantly more than those in the conventional learning group and exceeded the minimum mastery criteria (KKM).

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Introduction

In the educational system, mathematics is a required subject taught at every level of education, from elementary school, junior high school, senior high school, to higher education. Mathematics is a discipline that plays a crucial role in developing logical, critical, systematic, and argumentative thinking skills (Miagusttin et al., 2025). Furthermore, mathematics contributes to solving various problems in daily life and the workplace, as well as supporting the development of science and technology (Mone et al., 2025). To achieve these goals, students are not only required to understand mathematical concepts but also to present and communicate their mathematical ideas through various forms of representation. The ability to represent mathematical concepts is crucial because it helps students understand concepts, connect various mathematical ideas, and solve problems effectively. According to Sonya Heswari (2022), mathematics learning is an educational process designed by educators to foster students' creative thinking, enabling them to construct new knowledge and enhance their mastery of mathematical content.

In line with the importance of representational skills in mathematics learning, mathematical representation is the method students use to communicate ideas, thoughts, concepts, or solutions to a problem (Azzahra & Sopiany, 2023). This ability allows students to express mathematical ideas in various forms, such as drawings, diagrams, tables, graphs, symbols, or other mathematical language that can assist in problem-solving. Problem-solving can be approached through various representations that provide students with a visual representation of the solution, enabling them to determine the steps for resolution and evaluate the results obtained (Setyawati et al., 2022). One learning approach that can help improve students' mathematical representation skills is the open-ended approach. The open-ended approach provides students with the opportunity to think actively, creatively, and openly in discovering various alternative solutions to a mathematical problem (Matondang et al., 2023).

Students' mathematical representation skills are crucial to pay close attention to. According to (Azkiah & Sundayana, 2022), this is because through mathematical representation, students can organize their ideas and mathematical thinking both verbally and in writing. Students with strong mathematical representation skills can create diverse representations. This facilitates their ability to identify alternative solutions when facing a problem. However, field observations indicate that mathematical representation skills remain low. Atikasuri & Kusaeri (2024) state that low scores on daily quizzes are attributed to students' insufficient mathematical representation skills. Furthermore, the learning process has not provided students with sufficient opportunities to communicate their ideas effectively, which ultimately results in low mathematical representation skills. Students often struggle to present and interpret mathematical problems in various forms of representation, which should ideally strengthen their understanding of mathematical concepts.

Based on observations and interviews with mathematics teachers at SMP Negeri 1 Amanuban Tengah, it was found that students' mathematical representation skills remain relatively low. This is evident from students' learning outcomes, the majority of which still fall below the school's Minimum Passing Score (MPS) of 75. Students struggle to transform problems into diagrams, tables, graphs, or mathematical models, as well as to restate the mathematical ideas they possess. Additionally, during the learning process, students tend to be less active in expressing opinions, asking questions, or engaging in discussions to solve the problems presented. Based on the interview results, some students also view mathematics as a difficult subject to understand due to the numerous concepts and symbols that must be mastered. This low level of mathematical representation skills and student engagement is suspected to be caused by a learning approach that remains teacher-centered, where the teacher dominates by explaining the material and providing example problems, while students merely receive information and mimic the given solution procedures. This situation results in students having fewer

opportunities to explore ideas, develop problem-solving strategies, and communicate their thoughts through various forms of mathematical representation.

One alternative that can be used to address this issue is the implementation of an open-ended approach. The open-ended approach provides students with the opportunity to solve problems through various methods and different possible answers (Yunadia et al., 2023). Through this approach, students are encouraged to think actively, creatively, and critically in finding solutions, while expressing their mathematical ideas in various forms of representation. Thus, the open-ended approach is expected to improve students' mathematical representation skills, foster active learning, and reduce the perception that mathematics is a difficult subject to understand.

The open-ended approach is a learning approach that presents open-ended problems—that is, problems that have more than one solution, more than one correct answer, or both (Dewi & Juandi, 2023). Through this approach, students are given the opportunity to develop their own ideas, strategies, and ways of thinking in solving mathematical problems. According to Shigeru Shimada, the open-ended approach aims to foster students' creative activities and mathematical thinking skills through the resolution of open-ended problems (Rahmah et al., 2022). In this learning process, the focus is not only on the final answer but also on the thinking process and the various strategies employed by students. The steps for implementing the open-ended approach are outlined in Table 1.

Table 1. Learning Steps Using the Open-Ended Approach (Matondang et al., 2023)

Stages of the Open-Ended Approach	**Teacher Activities**	**Student Activities**
Presentation of an open-ended problem	The teacher communicates the learning objectives and presents an open-ended problem that allows for various strategies or answers.	Students listen to the teacher's explanation and understand the problem presented.
Understanding and Exploring the Problem	The teacher guides students to identify known and unknown information without immediately providing a solution.	Students identify key information and explore various possible solutions.
Solving the problem	The teacher guides and facilitates students throughout the problem-solving process. The teacher provides prompting questions if necessary.	Students solve problems individually or in groups using various strategies and mathematical representations.
Presenting the results	Teachers provide students with the opportunity to present their work in front of the class.	Students present their strategies, solution steps, and results.
Discussion and comparison of various solutions	The teacher facilitates a class discussion, guiding students to compare the various strategies and representations that emerge.	Students provide feedback, ask questions, compare, and evaluate the various solutions presented.
Drawing conclusions	The teacher guides students in formulating concepts, principles, or material learned based on the results of the discussion.	Students, together with the teacher, summarize the learning and reflect on the problem-solving process that has been carried out.

Characteristics of the open-ended approach include: The problems presented have multiple solutions; students are encouraged to discover and develop their own strategies; the teacher acts as a facilitator, not the primary source of information; discussions and the exchange of ideas among students are an essential part of learning; and the diversity of students' answers and thought processes is valued.

The open-ended approach is closely linked to the development of students' mathematical representation skills (Mawaddah et al., 2025). In this approach, students are presented with open-ended problems that allow for various solution strategies and more than one correct answer. These conditions encourage students to construct their own knowledge and express mathematical ideas through various forms of representation. As students strive to discover and explain the solutions they have obtained, they will use drawings, tables, graphs, mathematical models, symbols, or written explanations to clarify their thought processes. Thus, learning focuses not only on the final result but also on how students represent and communicate their mathematical ideas.

Mathematical representation skills are one of the essential abilities students must possess in mathematics learning. These skills help students understand concepts, connect various mathematical ideas, and solve problems effectively (Elvina et al., 2024). The indicators of mathematical representation ability used in this study, adapted from Abdurahman et al. (2023), include: (1) presenting situations or data in the form of visual representations such as pictures, diagrams, graphs, or tables; (2) presenting problems in the form of symbolic representations such as mathematical models, equations, or mathematical expressions; and (3) expressing ideas, solution steps, and results obtained in the form of verbal or written representations. Through the application of the open-ended approach, students gain broader opportunities to develop these three indicators because they are required to explore various solution methods, communicate the reasoning behind their answers, and compare the representations they use with those presented by other students.

Through learning using the open-ended approach, students are encouraged to explore various solution methods, express opinions, discuss, and explain the reasoning behind the answers obtained. These activities provide students with the opportunity to express mathematical ideas through various forms of representation (Arini, 2024). Through the open-ended problem-solving stage, students can develop visual representation skills by presenting information in the form of images, diagrams, tables, or graphs. Additionally, students develop symbolic representation skills through the use of mathematical models, equations, and mathematical notation to solve problems. During discussions and presentations of results, students are trained to communicate their thought processes and solutions both orally and in writing, thereby fostering the development of verbal representation skills.

Thus, the more frequently students engage in learning activities that use an open-ended approach, the greater the opportunity for them to develop visual, symbolic, and verbal representation skills.

Therefore, the open-ended approach is believed to enhance students' mathematical representation skills compared to conventional, teacher-centered instruction.

Method

This study is a quantitative study using a quasi-experimental method with a pretest-posttest control group design. The population of this study consists of all students at SMP Negeri 1 Amanuban Tengah for the 2025/2026 academic year. The research sample consists of two classes selected using cluster random sampling, namely one class as the experimental class that received instruction using the open-ended approach and one class as the control class that received conventional instruction. Before the treatment was administered, both classes were first given a pretest to determine the students' initial mathematical representation skills. Subsequently, the experimental class was given instruction using the open-ended approach, while the control class received conventional instruction. After the entire instructional sequence was completed, both classes were given a posttest to measure students' mathematical representation skills following the intervention. The data obtained were then analyzed to determine the effect of implementing the open-ended approach on students' mathematical representation skills. Research design can be seen in Figure 1.

The instruments used in this study consisted of an Observation Sheet and a test of students' mathematical representation skills, which were administered at the beginning of the learning process (pretest) and at the end of the learning process (posttest). The analysis techniques used in this study consisted of two stages, namely a test of the similarity of the mean mathematical representation ability before the treatment to ensure that both groups started from the same mathematical representation ability and a test of the effect of the open-ended approach as seen from individual and class achievement, a comparison test, and a test of the improvement in mathematical representation ability.

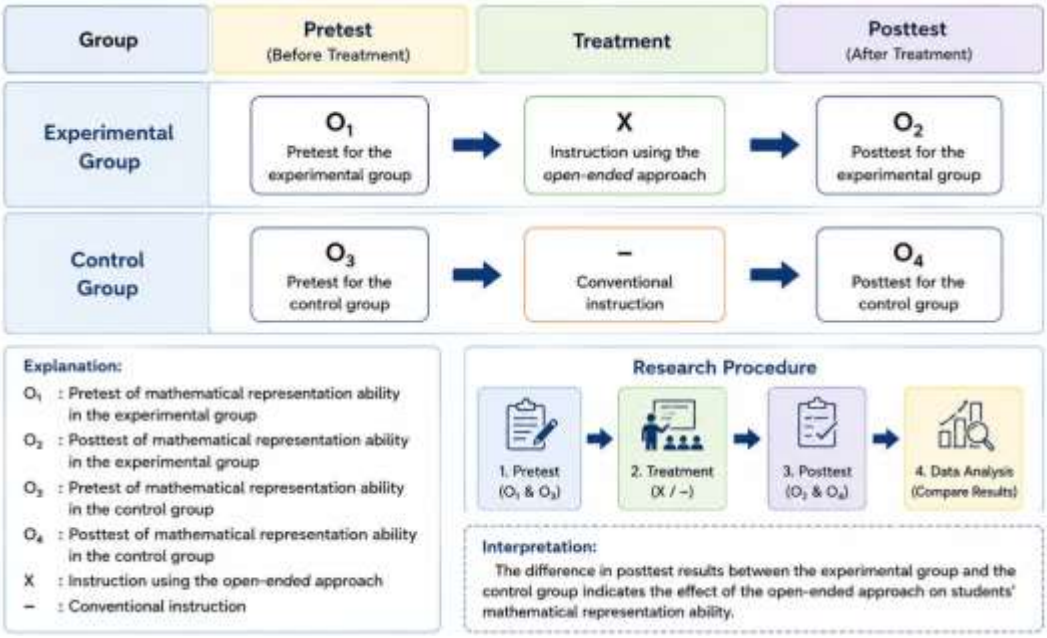

Figure 1. Pretest-Posttest Control Group Design (Sugiyono, 2016)

The statistical test used in this data analysis technique is the one-sample t-test (Iba & Wardhana, 2023) to assess achievement, namely

$$t = \frac{\underline{X} - \mu_0}{S/\sqrt{n}} \qquad (1)$$

Where S : sample standard deviation,$\underline{X}$: sample mean,μ_0 : hypothesized mean, and$n$: sample size.

Next, the independent samples t-test was used to test for equality of means and to perform a comparison test (Iba & Wardhana, 2023), namely

$$t = \frac{\underline{X}_1 - \underline{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \qquad (2)$$

Where,t : t-test value,$\underline{X}_1$: mean of group 1,$\underline{X}_2$: mean of group 2,S_p^2 : combined variance,S_1^2 : variance of group 1,S_2^2 : variance of group 2,n_1 : sample size for group 1,n_2 : sample size of group 2.

Next, the gain test uses the n-gain score formula according to Richard R. Hake (Novita et al., 2024), namely

$$g = \frac{\text{Skor Posttest} - \text{Skor Pretest}}{\text{skor maksimum} - \text{skor pretest}} \qquad (3)$$

With the following criteria

Table 2. N-Gain Score Categories

N-Gain Value	Category
$(g \geq 0{,}70)$	High
$(0{,}30 \leq g < 0{,}70)$	Medium
$(g < 0{,}30)$	Low

The open-ended approach is considered successful if students demonstrate mastery of mathematical representation skills, the experimental class outperforms the control class in mathematical representation skills, and the n-gain score falls into the at least moderate category.

Research Results and Discussion

Preliminary Test Results

The results of the prerequisite tests for the use of parametric statistics, namely the normality and homogeneity tests, are presented in Table 3 below

Table 3. Results of the Data Normality Test

	Class	Shapiro-Wilk		
		Statistic	Df	Sig.
Value	Pre-test Control	.095	24	.200*
	Post-test Control	.128	24	.200*
	Experimental Pretest	.133	24	.200*
	Experimental Posttest	.105	23	.200*

Based on the analysis results presented in the Normality Test Results Table 3, it can be seen that all research data, both pretest and posttest data in the control and experimental classes, have significance values above 0.05. The control class pretest data showed a significance value of 0.692, while the control class posttest data showed a value of 0.455. Furthermore, the experimental class pretest data had a significance value of 0.558 and the experimental class posttest data had a value of 0.633. These values indicate that all four data groups are normally distributed.

The prerequisite test for parametric statistics involving two samples is the homogeneity test, which aims to determine the distribution of data from both sample groups. The results of the homogeneity test are shown in Table 4 below

Table 4. Results of the homogeneity test for the pretest of the experimental and control classes

		Levene's Statistic	df1	df2	Sig.
Pretest_score	Based on Mean	.0748	1	48	.392
Posttest_score	Based on Mean	.11.853	1	47	.0.01

The Table 4 shows that the significance value (Sig.) for Levene's Test is 0.392. This value is greater than the significance level used, namely $\alpha = 0.05$. Since Sig. = 0.392 > 0.05, it can be concluded that the data on mathematical representation ability before the treatment have homogeneous variances or that there are no significant differences in variance between the control group and the experimental group before the treatment. After the treatment was applied and the post-test was conducted, the results of the Post-test Homogeneity Test using Levene's Test for Equality of Variances were obtained. The significance value (Sig.) in Levene's test is 0.001, which is smaller than the significance level $\alpha = 0.05$. Thus, it can be concluded that the variance of the mathematical representation ability data between the control group and the experimental group is not homogeneous after the treatment was applied.

Table 5. Results of the Test for Equality of Means

		Levene's Test for Equality of Variances		**t-test for Equality of Means**		
		F	**Sig.**	**T**	**Df**	**Sig. (2-tailed)**
Pretest	Equal variances assumed	.748	.392	.550	46	.585
	Equal variances not assumed			.550	43.875	.585

The results of the t-test show a Sig. (2-tailed) value of 0.585, which is also greater than 0.05. These results indicate that there is no significant difference in means between the groups being compared. In other words, the two groups are at equivalent or the same average level.

Hypothesis Test Results

Hypothesis testing to determine the effectiveness of the Open-Ended Approach in mathematics learning consisted of an assessment of mathematical representation skills, a comparison of the average mathematical abilities of the experimental and control classes, and an assessment of the improvement in mathematical representation skills in the experimental class after the intervention was implemented. The post-test data for the experimental class were analyzed, and a test of achievement against the minimum passing score (KKM) of 75 was conducted using a one-sample t-test, yielding the results shown in Table 6 below

Table 6. Results of the Proficiency Test

	Test Value = 70					
	T	**Df**	**Sig. (2-tailed)**	**Mean Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
Post-test_experiment	19.068	22	.000	11.957	10.66	13.26

Based on the results of the one-sample t-test with a cutoff score of 70, the value of `$t_{hitung}$ ` was found to be 19.068. With df = 22 and a significance level of 0.05, the p-value (t_{tabel}) was 1.717. Since the t-value (t_{hitung}) of 19.068 is greater than the p-value (t_{tabel}) of 1.717, and the significance level of 0.000 is less than 0.05, H_0 is rejected and H_1 is accepted. This means that the average mathematical representation ability of the experimental class students after participating in learning using the open-ended approach has reached and exceeded the established minimum passing score of 70. Thus, it can be concluded that the open-ended approach is effective in achieving student learning mastery.

In addition to the mastery test, the second indicator of the effectiveness of the open-ended approach is seen from the results of a comparison of the average mathematical representation abilities of the experimental and control classes. The post-test results of the experimental and control classes were used as data to conduct the comparison, and the results are shown in Table 7 below

Table 7. Comparison Test Results

		Levene's Test for Equality of Variances		**t-test for Equality of Means**		
		F	**Sig.**	**T**	**Df**	**Sig. (2-tailed)**
Value	Equal variances assumed	11.853	.001	34.570	45	.000
	Equal variances not assumed			34.118	31.929	.000

Based on the t-test results, the value of t_{count} is 34.118. With dk = $n_1 + n_2 - 2 = 45$ and a significance level of $\alpha = 0.05$, the value of t_{table} is 1.679. Since $t_{count} = 34.118 > t_{table} = 1.679$, H_0 is rejected and H_1 is accepted. This means that there is a highly significant difference in the mean learning outcomes between the control class and the experimental class.

The third indicator of the effectiveness of the open-ended approach is based on the N-Gain test results. The pretest and posttest data for the experimental class are shown in Table 8 below.

Table 8. N-Gain Test Results

No.	**Name**	**Pre-test**	**Posttest**	**N-gain**
1	Mas	37.5	62.5	0.4
2	Fmt	37.5	87.5	0.8
3	Ybk	37.5	50	0.2
4	Vb	37.5	75	0.6
5	Aks	25	87.5	0.83
6	Rdpb	25	62.5	0.5
7	Me	25	87.5	0.83
8	Ace	37.5	87.5	0.8
9	Kl	37.5	62.5	0.4
10	Vsk	25	87.5	0.83
11	Dbjd	50	50	0
12	Gd	37.5	75	0.6
13	mL	50	50	0
14	Cmb	37.5	87.5	0.8
15	Yl	37.5	62.5	0.4

16	Yil	25	87.5	0.83
17	Dal	37.5	87.5	0.8
18	MB	37.5	75	0.6
19	Vn	37.5	87.5	0.8
20	Oa	37.5	75	0.6
21	Ncb	25	75	0.67
22	Yb	50	87.5	0.75
23	Af	25	75	0.67
24	Sat	37.5	87.5	0.8

Based on the calculation results, the class average N-Gain was 0.62, which falls into the moderate category.

Based on the results of the mastery test, the comparison test, and the N-gain test, it was concluded that the use of open-ended questions is effective in improving the mathematical representation skills of students at SMP Negeri 1 Amanuban Tengah.

Discussion

Based on the results of the One-Sample t-Test with a comparison value of 70, it was found that the respondents' learning outcomes were above the established standard, meaning students achieved mastery of mathematical representation skills after being taught using the open-ended approach. Furthermore, based on the results of the comparison test, it was concluded that the average mathematical representation ability of students in the experimental class using the open-ended approach was significantly higher than that of the control class using conventional learning. Based on the calculations, the class's average N-Gain was 0.62, which falls into the moderate category. From these three analysis results, it was concluded that the open-ended approach is effective in improving students' mathematical representation abilities. These results indicate that the majority of students experienced improvements in the moderate to high categories. The significant dominance of the high category suggests that the open-ended approach is capable of encouraging students to be more active in constructing conceptual understanding and developing various mathematical representations.

The implementation of learning was assessed using observation sheets for teacher and student activities in both classes. The observation results showed that the percentage of teacher activities implemented in the experimental class reached 91%, while in the control class it was 75%. Meanwhile, the percentage of student activities in the experimental class was 86%, significantly higher than in the control class, which reached only 40%. The high implementation rate in the experimental class indicates that all stages of learning using the open-ended approach were carried out very well, from orientation, the presentation of open-ended problems, group discussions, to the presentation of results, thereby encouraging students to be more active, bold in expressing ideas, and exploring various problem-solving strategies. Conversely, the low percentage of student activities in the control class reflects that conventional teacher-centered learning has not been able to optimally encourage student engagement.

This aligns with the view (Arini, 2024) that the open-ended approach is capable of simultaneously fostering students' creative activities and mathematical thinking because students are given the freedom to develop ways of thinking and problem-solving strategies in accordance with their own understanding.

This improvement in mathematical representation skills is evident in students' ability to present problem solutions using various forms of representation, such as visual representations (diagrams or drawings), symbolic representations (mathematical equations), and verbal representations (written explanations). The Open-Ended approach gives students the freedom to choose problem-solving strategies according to their individual ways of thinking, so that students focus not only on a single correct answer but also on the thinking process and how to convey mathematical ideas (Aziz et al., 2025). This indicates that learning is no longer procedural in nature but emphasizes conceptual understanding and mathematical communication.

In addition to the issue of poor mathematical representation skills, another problem that frequently arises in mathematics education is the lack of student engagement and participation in the learning process. Based on observations during the learning process, the implementation of the Open-Ended approach was able to significantly increase student engagement. Students were more willing to express their opinions, discuss with peers, and present their thoughts in various ways. This situation created a more interactive and student-centered learning environment, thereby encouraging students to actively engage in constructing their own understanding (Ghaffar, 2016).

The results of this study are consistent with previous research findings indicating that the Open-Ended approach has a positive effect on improving students' mathematical representation skills. Mawaddah et al. (2025) found that students who learned using the Open-Ended approach were able to produce more diverse and flexible mathematical representations compared to students who learned using conventional approaches. Furthermore, Junita et al. (2022) also stated that the Open-Ended approach is effective in improving mathematical representation skills because it provides students with the opportunity to express their understanding in accordance with their individual thinking styles.

Theoretically, the findings of this study support the view of Khoerunnisa & Maryati (2022), who assert that mathematical representation skills develop effectively when students are given the opportunity to construct and communicate mathematical ideas through various forms of representation. The Open-Ended approach provides a learning environment that supports this development, as students are not confined to a single procedure or a specific answer but are instead guided to think openly, creatively, and reflectively.

Thus, it can be concluded that the implementation of the Open-Ended approach has a positive and significant impact on improving the mathematical representation skills of students at SMP Negeri 1 Amanuban Tengah. This approach not only improves students' learning outcomes to exceed the

minimum passing grade but also encourages student engagement, creativity, and the ability to express mathematical ideas through various forms of representation. Therefore, the Open-Ended approach can be used as an effective learning alternative to improve the quality of mathematics education in schools.

Conclusion

Based on the results of the study and discussion regarding the application of the open-ended approach to improve the mathematical representation skills of students at SMP Negeri 1 Amanuban Tengah, it can be concluded that the application of the open-ended approach is effective in improving students' mathematical representation skills.

The research results show that the mathematical representation skills of students in the experimental class improved significantly after the open-ended approach was implemented. This is indicated by the increase in the average posttest score compared to the pretest score. In addition, based on the mastery test, it was found that the average mathematical representation skills of students in the experimental class had reached and exceeded the minimum passing score (KKM) of 70.

Furthermore, based on the results of a comparative analysis between the control class and the experimental class, it was found that the mathematical representation skills of students who participated in open-ended learning were better than those of students who participated in conventional learning. Thus, it can be concluded that open-ended learning is effective in improving students' mathematical representation skills.

Recommendations

Based on the results of this study regarding the application of the open-ended approach to improve students' mathematical representation skills, the author suggests that mathematics teachers adopt the open-ended approach as an alternative teaching method because it encourages students to think actively and creatively and to express mathematical ideas through various forms of representation. Schools are also encouraged to consider implementing this approach to improve the quality of mathematics education, particularly in developing students' mathematical representation skills. Furthermore, future researchers are advised to expand this study to different mathematical topics, educational levels, or other aspects of mathematical representation skills in order to obtain broader and more in-depth research findings.

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