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The Effect of GEMAS-Based Learning on Junior High School Students' Mathematical Problem-Solving Skills Based on Krulik and Rudnick's Indicators

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ABSTRACT

The PISA 2022 results indicate that Indonesian students' mathematical performance remains below the OECD average, which calls for instructional innovations that support mathematical problem-solving at the junior high school level. This study examined the use of the Mathematics Educational Game (GEMAS) in supporting students' mathematical problem-solving skills on linear equations in one variable (LEOV), systems of linear equations in two variables (SLETV), and combined linear equation problems. GEMAS was designed as a game-based learning medium that integrates mathematical tasks with problem-solving stages based on Krulik and Rudnick's framework, namely read and think, explore and plan, select a strategy, locate and answer, and reflect and extend. This study employed a quantitative approach with a one-group pretest-posttest quasi-experimental design involving 60 students of SMPN 12 Sukabumi in the second semester of the 2024/2025 academic year. The instruments consisted of a mathematical problem-solving test and semi-structured interviews. Data were analyzed using paired-sample t-tests and normalized gain scores. The results showed statistically significant differences between students' pretest and posttest scores across the three topics: LEOV, SLETV, and combined problems, with moderate normalized gain scores ranging from 0.3901 to 0.5465. These findings suggest that the use of GEMAS was associated with moderate improvement in students' mathematical problem-solving skills. The study contributes to the development of mathematics educational games by aligning game-based activities with explicit problem-solving indicators, making GEMAS a potential learning medium to support the implementation of the Merdeka Curriculum.

Keywords: Game Edukasi Matematika (GEMAS), Junior High School, Krulik & Rudnick, Mathematics Learning, Problem-Solving

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Introduction

Mathematical problem-solving is a fundamental competence in mathematics learning because it requires students to understand unfamiliar situations, connect relevant concepts, choose appropriate strategies, and evaluate the reasonableness of their solutions. In mathematics education, problem-solving is not merely associated with obtaining the correct final answer but also with how students interpret information, construct plans, carry out procedures, and reflect on the results obtained (Polya, 1973; Riyadi, Syarifah & Nikmaturrohmah, 2021). This competence is especially important at the junior high school level because students begin to encounter algebraic topics that demand abstraction, representation, and reasoning, such as Linear Equations in One Variable (LEOV) and Systems of Linear Equations in Two Variables (SLETV). Therefore, mathematics instruction should provide learning experiences that help students develop problem-solving processes in a structured and meaningful way (Sitohang & Suwanto, 2025; Tokac et al., 2019).

Several frameworks have been used to analyze mathematical problem-solving, including Polya's four-step model and heuristic-based approaches. However, this study adopts Krulik and Rudnick's problem-solving framework because it offers more operational indicators for identifying students' thinking processes in classroom-based assessment. Krulik and Rudnick's framework consists of five stages: read and think, explore and plan, select a strategy, determine an answer, and reflect and extend (Fadilah et al., 2023; Khairunnisa., 2024; Setiani et al., 2024). These indicators enable teachers and researchers to examine students' difficulties more specifically. For example, students might be able to read a problem and figure out what they already know, but they might still have trouble choosing a strategy, doing the math, or contemplating the answer they got (Lindy et al., 2023). Thus, Krulik and Rudnick's framework is relevant for assessing students' mathematical problem-solving skills because it emphasizes not only procedural completion but also planning, strategic reasoning, and reflective thinking.

Recent international evidence supports the need to strengthen students' mathematical problem-solving skills. The PISA 2022 results indicate that Indonesian students' mathematics performance remains below the OECD average, and only a small proportion of students reached at least Level 2 proficiency in mathematics (OECD, 2023). This result indicates that many students still face difficulties in interpreting mathematical situations, applying concepts, and using reasoning to solve contextual problems. Similar findings have also been reported in mathematics classrooms, where students' problem-solving difficulties often appear in the stages of planning strategies, constructing mathematical models, implementing procedures accurately, and evaluating answers (Pramuditya et al., 2022; Ziliwu & Mahmudi, 2025).These findings suggest that low mathematical performance is not only related to students' inability to calculate but also to weaknesses in understanding problems, selecting strategies, and reflecting on solutions.

One instructional approach that may support students' problem-solving development is the use of educational games. Educational games are learning media or activities that combine instructional objectives with game elements, such as rules, challenges, feedback, goals, interaction, and rewards (Alotaibi, 2024; Rahmatania & Setiawan, 2021). Educational games do not always have to be digital, they may appear in the form of board games, card games, puzzles, classroom games, digital games, or hybrid learning media. In mathematics learning, educational games can create an engaging learning environment, provide repeated practice, and encourage students to participate actively in solving problems (Dan et al., 2024; Debrenti, 2024). Recent studies also indicate that game-based learning can contribute to students' motivation, engagement, mathematical understanding, critical thinking, and problem-solving abilities when the game activities are aligned with mathematical objectives (Hidayat et al., 2024; Radityastuti et al., 2023). However, the use of games in mathematics learning should not only focus on enjoyment or competition, it should also guide students to reason, choose strategies, and evaluate solutions.

Previous studies have examined various forms of educational games and game-based learning in mathematics, such as digital game-based learning, virtual reality games, online quiz platforms, and game-based classroom activities (Ayyasy & Asrul, 2024; Muqoddaroh et al., 2024; Pramuditya et al., 2022). These studies generally show positive effects on students' motivation, learning outcomes, conceptual understanding, self-confidence, and mathematics achievement. Nevertheless, most previous research still tends to measure the impact of educational games through general learning outcomes or affective aspects, while fewer studies explicitly examine students' mathematical problem-solving skills based on structured indicators. In particular, studies that connect educational game activities with Krulik and Rudnick's stages remain limited. This gap is important because improvement in mathematics learning should not only be seen in students' scores but also in their ability to read and think, explore and plan, select a strategy, obtain an answer, and reflect on the solution.

To address this gap, this study implements GEMAS, or Mathematics Educational Game, as a learning medium designed to support mathematical problem-solving activities. GEMAS differs from general educational games because it is used to make learning more enjoyable and structured to guide students through Krulik and Rudnick's problem-solving indicators. The game contains contextual mathematical tasks on LEOV, SLETV, and combined linear equation problems. Through GEMAS, students are encouraged to identify information, explore possible strategies, choose appropriate solution methods, solve problems, and review their answers. In this sense, GEMAS is part of the learning material and instructional process, not merely an additional game activity. GEMAS aligns its tasks with the Merdeka Curriculum, which emphasizes reasoning, problem-solving, and higher-order thinking skills in mathematics learning.

This study's novelty lies in integrating a mathematics educational game with explicit problem-solving indicators based on Krulik and Rudnick's framework. While previous studies have widely discussed the benefits of educational games in mathematics learning, the specific contribution of GEMAS is its focus on guiding students' problem-solving processes across different algebraic topics and problem types. This study theoretically contributes to the development of problem-solving-based mathematics learning by demonstrating the connection between game-based learning and structured problem-solving stages. This study practically provides mathematics teachers with an alternative instructional medium to foster more engaging, reflective, and problem-solving-oriented learning. Therefore, this study aims to examine the effect of GEMAS-based learning on junior high school students' mathematical problem-solving skills using Krulik and Rudnick's problem-solving framework.

Methods

This study employed a quantitative approach with a quasi-experimental one-group pretest–posttest design. This design was used to examine students' mathematical problem-solving skills before and after the implementation of the Mathematics Educational Game (GEMAS). A one-group pretest–posttest design is appropriate when researchers intend to measure changes in the same group after a treatment, although it has limitations because it does not involve a control group (Campbell & Stanley, 1966; Creswell & Creswell, 2018). The study was conducted at SMPN 12 Sukabumi in the second semester of the 2024/2025 academic year, involving 60 eighth-grade students selected through purposive sampling. The participants were chosen because they had studied prerequisite algebraic concepts, learned under the Merdeka Curriculum, and had relatively homogeneous academic characteristics.

The research procedure consisted of three stages: preparation, implementation, and evaluation. In the preparation stage, the researcher developed GEMAS-based learning materials and problem-solving test instruments based on Krulik and Rudnick's five indicators: read and think, explore and plan, select a strategy, determine an answer, and reflect and extend (Krulik & Rudnick, 1995). GEMAS was designed as a mathematics educational game that integrates contextual problems with structured problem-solving activities. Through the game, students were guided to identify information, plan solutions, choose strategies, solve problems, and reflect on their answers.

The instruments consisted of a mathematical problem-solving test, a scoring rubric, and semi-structured interview guidelines. The pretest and posttest each consisted of five essay questions representing Krulik and Rudnick's problem-solving indicators. The instruments were validated through expert judgment involving mathematics education experts and mathematics teachers. The validation focused on content validity, construct validity, language clarity, and suitability with students' cognitive level. Instrument reliability was also examined before the main study.

In the implementation stage, students were first given a pretest to measure their initial problem-solving skills. GEMAS-based learning was then applied to the topics of Linear Equations in One Variable (LEOV), Systems of Linear Equations in Two Variables (SLETV), and combined linear equation problems. After the treatment, students completed a posttest with equivalent indicators and difficulty levels. Semi-structured interviews were also conducted with selected students to support the quantitative data.

Data were analyzed using descriptive statistics, a normality test, a paired-sample t-test, and normalized gain (N-Gain). The paired-sample t-test was used to examine differences between pretest and posttest scores from the same group. The hypotheses were formulated as follows: H_0 states that there is no significant difference between students' mathematical problem-solving skills before and after GEMAS implementation, while H_1 states that there is a significant difference. The decision criterion was based on a significance level of 0.05. If the significance value was less than 0.05, H_0 was rejected.

Data were analyzed using a paired-sample t-test to determine significant differences between pretest and posttest scores. Furthermore, normalized gain (N-Gain) analysis was used to measure the level of improvement in students' problem-solving skills using the formula.such as following equation (1). In this study, the interpretation of N-Gain scores adopted criteria (Hake, 1998).

$$g(N-Gain) = \frac{Posttest\ score - Pretest\ score}{Maximum\ Score - Pretest\ score} \qquad (1)$$

with the following (Hake, 1998) criteria as shown in Table 1

Table 1. *N-Gain Criteria*

Criteria	Value
High	g>0.7
Medium	0.3<g≤0.7
Low	0.3≤g

Results and Discussion

Before presenting the statistical results, this section first explains how GEMAS was implemented in the learning process. GEMAS was used as a mathematics educational game to support students in solving contextual problems related to Linear Equations in One Variable (LEOV), Systems of Linear Equations in Two Variables (SLETV), and combined linear equation problems. The learning flow in GEMAS was structured according to Krulik and Rudnick's five problem-solving indicators: read and think, explore and plan, select a strategy, determine an answer, and reflect and extend. Through the game, students were guided to identify known and unknown information, explore possible solution plans, choose suitable strategies, solve the problems, and reflect on the correctness of their answers.

GEMAS was not used merely as an additional learning game but as part of the instructional process. The game provided contextual challenges, guided questions, feedback, and opportunities for discussion.

These features were intended to help students become more active in understanding problems, planning strategies, and checking their answers. Therefore, the improvement in students' problem-solving skills was analyzed not only from the final test scores but also in relation to Krulik and Rudnick's problem-solving stages.

The first analysis was conducted using descriptive statistics to describe students' initial mathematical problem-solving skills before the implementation of GEMAS. The pretest results are presented in Table 2.

Table 2. *Statistical Description of Pretest Data*

Sample	Topic	N	$\overline{x}$	S
Experiment	LEOV	60	31.75	20.31
	SLETV	60	24.83	19.72
	Both	60	28.29	18.83

As shown in Table 2, students' initial scores were relatively low across the three topics. The mean pretest score was 31.75 for LEOV, 24.83 for SLETV, and 28.29 for combined LEOV and SLETV problems. These results indicate that before the implementation of GEMAS, students still experienced difficulties in solving mathematical problems, particularly in topics involving two variables and combined linear equation problems. This condition suggests that students needed learning support that could guide them through the stages of understanding, planning, selecting strategies, solving, and reflecting on mathematical problems.

Before conducting the paired-sample t-test, a normality test was carried out to ensure that the data met the assumption for parametric analysis. The results of the pretest normality test are presented in Table 3.

Table 3. *Results of the Pretest Data Normality Test*

Sample	Topic	N	L_{max}	L_{table}
Experiment	LEOV	60	0.1077	0.114
	SLETV	60	0.0960	0.114
	Both	60	0.0944	0.114

Based on Table 3, the pretest data for LEOV, SLETV, and combined problems were normally distributed. This conclusion can be seen from the Lmax values for LEOV (0.1077), SLETV (0.0960), and combined problems (0.0944), which were lower than the Ltable value (0.114). Therefore, the pretest data met the normality assumption and could be analyzed using parametric statistical tests. However, the normality test was used only to determine whether the data were normally distributed, not to conclude that students had the same average ability.

After the pretest, GEMAS-based learning was implemented. During the learning process, students worked on game-based mathematical tasks aligned with Krulik and Rudnick's indicators. In the read and think stage, students identified important information from the problem. In the explore and plan stage, they discussed possible representations and solution plans. In the select a strategy stage, students chose appropriate methods, such as substitution, elimination, or forming a mathematical model. In the find an answer stage, students completed the calculation and obtained the answer. Finally, in the reflect and extend stage, students reviewed whether their answers were reasonable and related them back to the problem context.

After the implementation of GEMAS, students were given a posttest to measure their mathematical problem-solving skills. The descriptive statistics of the posttest scores are presented in Table 4.

Table 4. *Statistical Description of Post Test Data*

Sample	Topic	N	$\bar{x}$	S
Experiment	LEOV	60	61.58	10.23
	SLETV	60	69.25	19.72
	Both	60	65.23	6.64

Table 4 shows that students' posttest scores were higher across all topics after the implementation of GEMAS-based learning. The mean posttest score was 61.58 for LEOV, 69.25 for SLETV, and 65.23 for combined LEOV and SLETV problems. The highest mean score was obtained in the SLETV topic, followed by combined problems and LEOV. This finding suggests that students performed relatively better on problems involving two-variable linear equations after learning with GEMAS. However, this result should be interpreted together with the N-Gain analysis to determine the level of improvement from pretest to posttest.

To determine whether students' final abilities are the same in terms of problem-solving abilities, a post-test data similarity test was conducted using the normality test with the Liliefors method, as shown in Table 5.

Table 5. *Results of the Pretest Data Normality Test*

Sample	Topic	N	L_{max}	L_{table}
Experiment	LEOV	60	0.1061	0.114
	SLETV	60	0.1067	0.114
	Both	60	0.0792	0.114

Based on the results of the normality test in Table 5, the Lmax value obtained in the One Variable Linear Equation (LEOV) material is 0.1061, which is less than Ltable, which is 0.114; the Lmax value in the Two Variable Linear Equation System (SLETV) material is 0.1067, which is less than Ltable, which is 0.114, and the Lmax value in the combined material (LEOV and SLETV) is 0.0792, which is less than

Ltable, which is 0.114. Because all materials have Lmax values that are less than Ltable, all samples come from a normally distributed population, or all samples have the same average final ability.

Because all data are normally distributed, the next step is to test the average results of the pretest and posttest to determine whether or not there is an increase in students' problem-solving abilities using the Two-sample T-Test with Microsoft Excel 2013 software. The results of this test can be seen in Table 6 as follows.

Table 6. *Paired Two-Sample T-Test Results*

Sample	Topic	N	df	T_{value}	T_{table}	p-value	Decision
Experiment	LEOV	60	59	10.87	1.671	< .001	Siginificant
	SLETV	60	59	14.27	1.671	< .001	Siginificant
	Both	60	59	13.80	1.671	< .001	Siginificant

Based on Table 6, the paired Two-Sample T-Test results indicate that the calculated T-values for LEOV, SLETV, and the combined topics were 10.87, 14.27, and 13.80, respectively, with df = 59. All calculated T-values exceeded the T-table value of 1.671. In addition, the p-values for all topics were less than .001, indicating that the differences were statistically significant. Therefore, it can be concluded that the Gemas game treatment given to students in the experimental class significantly improved their mathematical problem-solving abilities across all topics.

The Paired Two-Sample T-Test only indicates whether there is a significant difference in students' mathematical problem-solving abilities after receiving the GEMAS game treatment. To describe the level of improvement more clearly, an N-Gain analysis was conducted, as presented in Table 7.

Table 7. N-Gain Analysis of Students' Mathematical Problem-Solving Skills

Topic	Mean Pretest Score	Mean Posttest Score	Mean Gain Score	Category
LEOV	31.75	61.58	0.3901	Medium
SLETV	24.83	69.25	0.5465	Medium
BOTH	28.29	65.23	0.4767	Medium

Based on Table 7, the mean N-Gain scores indicate that students' mathematical problem-solving skills improved after the implementation of GEMAS-based learning. The LEOV topic obtained a mean N-Gain score of 0.3901, the SLETV topic obtained a mean N-Gain score of 0.5465, and the combined LEOV and SLETV topics obtained a mean N-Gain score of 0.4767. Referring to the N-Gain criteria, all topics were categorized as medium improvement. This means that the improvement in students' mathematical problem-solving skills occurred consistently across all topics, although the level of improvement was not classified as high.

Among the three topics, the highest mean N-Gain score was found in the SLETV topic, with a score of 0.5465. This result shows that students experienced the greatest improvement in solving problems related to systems of two-variable linear equations compared with one-variable linear equations and the combined topic. The higher N-Gain score in the SLETV topic may indicate that GEMAS-based learning helped students understand relationships between variables, represent problems mathematically, and determine appropriate solution strategies.

The improvement shown in the N-Gain results is also related to the problem-solving indicators proposed by Krulik and Rudnick. Through GEMAS-based learning, students were encouraged to read and understand the problem, explore the information given, plan possible solution steps, select suitable strategies, and determine the final answer. In particular, the medium improvement in the SLETV topic suggests that students benefited from activities that supported the explore and plan stage as well as the select strategy stage, because these stages are essential when students translate contextual problems into mathematical models and choose an appropriate method of solution.

This finding was also supported by students' responses during the learning process. Students showed more active involvement when identifying known and unknown information, discussing possible strategies with peers, and checking whether their answers matched the context of the problem. Several students' written answers also showed improvement in organizing solution steps, especially in forming mathematical models and selecting strategies to solve the given problems.

Therefore, the findings should be interpreted carefully. The N-Gain results do not indicate a high level of improvement, but they show that GEMAS-based learning was associated with moderate improvement in students' mathematical problem-solving skills. Thus, GEMAS-based learning can be considered to have potential in supporting students' problem-solving processes, particularly in helping them explore problems, plan solution strategies, and select appropriate mathematical procedures.

Based on the data analysis, students who learned through GEMAS showed higher mathematical problem-solving performance after the treatment. The paired-sample t-test indicated statistically significant differences between pretest and posttest scores, while the N-Gain results showed moderate improvement across LEOV, SLETV, and combined problems. Therefore, the findings suggest that GEMAS-based learning is associated with improvements in students' mathematical problem-solving skills. This aligns with research findings indicating that game-based learning can enhance students' conceptual understanding and interest in learning. With increased interest, students become more engaged in problem-solving (Fardian et al., 2024; Setiani et al., 2025; Widiana, 2022). Furthermore, students identified weaknesses in problem-solving, including expressing mathematical symbols, developing a solution plan, selecting a solution, and determining the final result or solution (Frenanto et al., 2023), However, through the GEMAS game, these weaknesses can be minimised because students will continuously practice solving problems through games that require them to solve problems in stages, according to Krulik Rudnick's problem-solving stages.

The instructional structure embedded in GEMAS explains the improvement. Unlike game-based activities that only emphasize competition, speed, or answer accuracy, GEMAS was designed to guide students through Krulik and Rudnick's problem-solving stages: read and think, explore and plan, select a strategy, determine an answer, and reflect and extend. In the read and think stage, students were guided to identify known and unknown information from contextual problems. In the explore and plan stage, they organized information and considered possible solution steps. In the select a strategy stage, students determined appropriate methods, such as substitution, elimination, or forming mathematical models. GEMAS strongly supported these stages by encouraging students to actively work, discuss solution strategies, and make decisions before solving the problems.

Based on the results of the pretest analysis, which showed that students' initial abilities were still relatively low, the implementation of GEMAS represents an innovative step in developing mathematical problem-solving skills. This finding aligns with research which emphasizes that the use of adaptive game-based learning media can enhance student learning outcomes and motivation through interactive and enjoyable learning experiences (Sulistyanto et al., 2023). Based on the same principles, GEMAS is designed to facilitate students' understanding of mathematical concepts, especially in the material of LEOV, SLETV, and both through active, analytical, and reflective thinking stages. This game-based learning not only fosters learning motivation but also encourages students to think critically and creatively in accordance with the problem-solving stages proposed by Krulik and Rudnick. Thus, the implementation of GEMAS is expected to provide more meaningful and effective mathematics learning in improving students' problem-solving abilities.

The N-Gain results also indicate that the highest improvement occurred in the SLETV topic. This suggests that GEMAS was particularly beneficial when students had to identify relationships between two variables, construct mathematical models, and select appropriate strategies. This finding is relevant to previous studies showing that game-based learning can support students' conceptual understanding, engagement, and problem-solving processes when the game activities are aligned with mathematical objectives (Pramuditya et al., 2022; Radityastuti et al., 2023; Widiana, 2022). In addition, students' weaknesses in mathematical problem-solving often appear in representing mathematical symbols, developing solution plans, selecting strategies, and determining final answers (Frenanto et al., 2023). GEMAS minimized these weaknesses by allowing students to practice solving problems repeatedly through structured game-based tasks.

The findings are also consistent with studies showing that adaptive, interactive, and gamified learning media can improve students' learning outcomes, motivation, and engagement by creating enjoyable and meaningful learning experiences (Dan et al., 2024; Debrenti, 2024; Lukman et al., 2023; Sulistyanto et al., 2023) found that gamified mathematics teaching materials were valid, practical, and effective for supporting mathematics learning. Gamification-based mathematics materials can be developed to enhance students' problem-solving and critical thinking skills through evaluated learning frameworks (Setiani et al., 2024). These findings support the present study because GEMAS was not only designed to increase students' interest in mathematics but also to provide a structured learning path that encouraged active, analytical, and reflective thinking.

The use of GEMAS also strengthens previous findings on educational games in mathematics learning. Game-based learning can support students' mathematical problem-solving through contextual and reflective learning experiences (Pramuditya et al., 2022). Then, digital game-based learning can improve junior high school students' critical thinking and mathematical problem-solving skills (Radityastuti et al., 2023). More specifically, GEMAS had a positive effect on students' mathematical problem-solving and critical-thinking abilities (Lukman & Setiani, 2025). These findings are in line with the present study because GEMAS integrates game elements with structured problem-solving activities based on Krulik and Rudnick's indicators. Thus, the contribution of GEMAS lies not only in its function as an engaging learning medium but also in its alignment with a specific problem-solving framework.

The interview findings provided additional support for the quantitative results. Students reported that GEMAS made mathematics learning more engaging and helped them understand the steps involved in solving problems. Several students stated that the game instructions helped them identify known and unknown information, while others explained that the game made it easier to choose an appropriate strategy, such as substitution, elimination, or other relevant methods.

The following excerpts are representative of the main patterns found in students' interview responses. They were selected to illustrate how students perceived the role of GEMAS in supporting different stages of mathematical problem solving.

One student explained that GEMAS helped them identify important information before solving the problem:

"The game helped me know which information should be used before solving the problem. I became more aware of what was known and what was asked in the question." (Representative excerpt, S1)

This response indicates that GEMAS supported students in the read and think stage. Through the instructions and activities in the game, students were encouraged to understand the problem first before choosing a solution strategy.

Another student stated that GEMAS supported the process of choosing a suitable problem-solving strategy:

> *"I understood better when I had to use substitution or elimination because the game guided me through the steps. It helped me decide which method was more suitable."* (Representative excerpt, S2)

This excerpt shows that GEMAS helped students in the explore and plan and select a strategy stages. Students were not only asked to solve the problem, but were also guided to consider which mathematical strategy was more appropriate for the given situation.

However, some students still experienced difficulty in explaining and justifying their answers. This can be seen in the following representative response:

> *"I could get the answer, but I was still confused when I had to explain why my answer was correct or check it again."* (Representative excerpt, S3)

This response suggests that although students were able to find the answer, they still needed further support in the reflect and extend stage. In this stage, students are expected to justify their answers, verify the correctness of their solutions, and explain the meaning of the results obtained.

Overall, these interview findings show that GEMAS was more influential in supporting students' early and middle problem-solving stages, namely understanding the problem, exploring information, planning possible strategies, and selecting appropriate solution methods. Meanwhile, the final stage of problem solving still required additional teacher support and classroom discussion. Therefore, the interview findings strengthen the N-Gain results, which showed that GEMAS-based learning was associated with moderate improvement in students' mathematical problem-solving skills rather than a high level of improvement. Therefore, students' thinking styles influence how they complete Krulik and Rudnick's problem-solving steps, particularly in the final stages of reviewing and discussing solutions (Rahmah et al., 2021).

Furthermore, previous studies have indicated that GEMAS can support students' computational thinking skills (Sholihatinnisa et al., 2024), while the present study expands its contribution to mathematical problem-solving skills in algebraic topics, namely LEOV, SLETV, and combined problems. This indicates that GEMAS has the potential to support not only computational thinking but also students' ability to interpret, plan, solve, and reflect on mathematical problems. This finding is also supported by studies showing that construct-based educational games, repeated practice, level-based tasks, and feedback-based activities can provide meaningful learning experiences and improve students' problem-solving abilities (Angwarmasse & Wahyudi, 2021; Ardiyani et al., 2024).

Overall, GEMAS has potential as a mathematics learning medium because it combines game-based learning with explicit problem-solving stages. Its contribution is different from general educational games because GEMAS is designed to guide students through structured mathematical reasoning rather than merely providing practice questions or competitive activities. Theoretically, this study contributes to the development of game-based mathematics learning by connecting educational games with Krulik and Rudnick's problem-solving framework. Teachers can practically use GEMAS as an alternative medium to support problem-solving-oriented mathematics learning in the Merdeka Curriculum. Nevertheless, the one-group pretest–posttest design of this study necessitates cautious interpretation of the findings. Future research is recommended to involve a control group, include more detailed analysis of students' written answers and interview transcripts, and examine the effectiveness of GEMAS on other mathematical topics.

Conclusion

Based on the findings and discussion, it can be concluded that the Mathematics Educational Game (GEMAS) model effectively improves students' problem-solving skills in Linear Equations in One Variable (LEOV), Systems of Linear Equations in Two Variables (SLETV), and combined problems, as measured by Krulik and Rudnick's indicators. The moderate gain from pretest to posttest and the statistically significant results confirm the positive and measurable impact of GEMAS. Consistent with the study's objective to examine the effect of GEMAS on enhancing junior high school students' problem-solving skills the findings provide empirical evidence that GEMAS is an effective instructional innovation. Therefore, GEMAS can be considered a viable alternative for mathematics instruction to promote higher-order thinking skills in alignment with the Merdeka Curriculum.

Recommendation

Based on the results of this study, the researcher suggests that further research can develop GEMAS Game-based learning media to investigate its effectiveness across different topics and educational levels using controlled experimental designs and to explore its influence on other mathematical competencies, such as mathematical communication and critical thinking.

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