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Playing, Moving, and Thinking: Game-Based Outdoor Learning to Mathematical Problem-Solving Ability

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Article Info	ABSTRACT
	The low level of students' mathematical problem-solving ability, particularly in learning linear equations in one variable, is influenced by monotonous conventional instruction, making it necessary to adopt a more effective and engaging learning approach to improve this ability. However, empirical studies examining the implementation of game-based outdoor learning to enhance mathematical problem-solving ability in linear equations in one variable at the junior high school level remain limited. Accordingly, this study aims to examine the improvement in mathematical problem-solving ability of VIII students after the implementation of game-based outdoor learning. The research participants were 24 students of class VIII B at a junior high school in Jambi City, selected using a cluster random sampling technique. This study adopted a quantitative descriptive method with a pre-experimental One-Group Pretest–Posttest Design. Students' improvement in mathematical problem-solving ability was analyzed using N-gain, which was classified into high, moderate, and low categories. Based on the N-gain analysis, of the 24 students involved, 4 students showed a high level of improvement, 14 students demonstrated moderate improvement, and 6 students exhibited low improvement in mathematical problem-solving ability These findings contribute empirical evidence supporting the implementation of game-based outdoor learning to improve junior high school students' mathematical problem-solving ability in linear equations in one variable.

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Introduction

Problem-solving ability is a crucial skill that must be mastered in the 21st century, particularly to enable individuals to adapt and compete in an era of rapid scientific and technological advancement (Silmi & Wahyu, 2023). According to Siswanto & Meiliasari

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(2024), problem-solving ability is a fundamental skill that students need to develop, as it helps them understand and solve mathematical problems while also applying mathematical concepts in everyday life. Mathematical problem-solving ability can be understood as students' capacity to solve word problems, non-routine problems, and various mathematical situations encountered in daily contexts (Andayani & Latifah, 2019; Muslihah & Suryaningrat, 2021). Therefore, this ability needs to be systematically fostered through different mathematics topics taught in schools, one of which is linear equations in one variable, a topic that requires strong conceptual understanding and the ability to apply appropriate problem-solving strategies.

Linear equations in one variable constitute a topic in Grade VIII junior high school mathematics that is widely regarded as challenging for students (Serina et al., 2022). In learning this topic, difficulties frequently arise, particularly related to conceptual misunderstandings that hinder students' comprehension of linear equations in one variable; these difficulties may stem from both teachers and students (Rofiki et al., 2023). Students' challenges in solving problems related to linear equations in one variable are not solely caused by internal factors such as lack of focus or low learning engagement, but may also be influenced by classroom instructional practices, including the teaching methods employed by teachers (Rofiki et al., 2023).

Based on observations, it was found that students' mathematical problem-solving ability remains low. Students were able to understand the given problems and plan solution strategies; however, they struggled to carry out the solution process and interpret the obtained results. Furthermore, interviews with a mathematics teacher revealed that mathematics instruction is still predominantly conventional, conducted entirely inside the classroom and centered on the teacher. This condition results in students being less active, easily bored, and lacking motivation during the learning process. Consequently, there is a need for an instructional approach that offers a new learning atmosphere and provides students with direct learning experiences, thereby enhancing their motivation and engagement in learning activities.

Experiential learning approaches, such as outdoor learning, have been shown to deepen students' understanding of mathematical concepts, foster critical thinking skills, increase learning motivation and interest, and promote positive attitudes toward mathematics (Karim, 2025). Outdoor learning allows students to develop exploratory skills, as they interact directly with objects in their surrounding environment (Setyani & Amidi, 2022). One effective implementation of outdoor learning is game-based outdoor learning in which learning content is integrated into play activities so that students can engage in enjoyable and non-monotonous learning experiences (Sindi et al., 2023). In mathematics learning, games have been proven to support students' understanding of abstract concepts, increase learning interest and motivation (Wijayanti & Yanto, 2023), and develop critical thinking skills as well as mathematical problem-solving ability (Nurlaili et al., 2025).
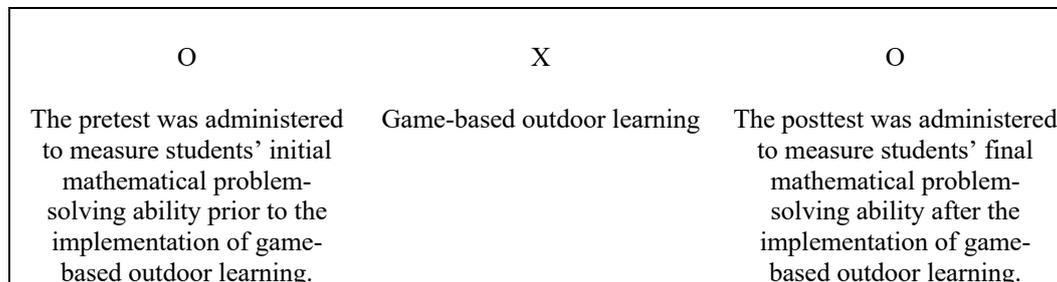
Several previous studies have examined mathematical problem-solving ability through various innovative learning approaches and models. For example, Christina & Adirakasiwi (2021) reported that students' problem-solving ability based on Polya's stages in linear equations and inequalities was still predominantly at a low level. Meanwhile, Luh et al. (2024) demonstrated that the implementation of a Problem-Based Learning model combined with outdoor learning activities was effective in improving elementary students' mathematical problem-solving ability. In addition, Prasetiyo et al. (2023) showed that game-based outdoor learning activities can train problem-solving skills and encourage student creativity, while Jadidah & Baalwi (2025) confirmed the effectiveness of Game-Based Learning in enhancing elementary students' mathematical problem-solving ability. However, based on a review of these studies, there has been no research that integrates outdoor learning with game-based learning to improve students' mathematical problem-solving ability, particularly in the context of learning linear equations in one variable.

This study focuses on the implementation of outdoor learning integrated with game-based activities. The novelty of this research lies in the design of game-based outdoor learning that is intentionally developed to enhance students' mathematical problem-solving ability. Accordingly, the research question addressed in this study is: *How does the mathematical problem-solving ability of Grade VIII B students at SMP Negeri 9 Kota Jambi improve after participating in game-based outdoor learning?*.

Method

Type of Research

This study aims to examine the improvement in students' mathematical problem-solving ability after participating in game-based outdoor learning. A descriptive quantitative approach was employed to systematically explain the changes and improvements in students' mathematical abilities following the learning activities. This section describes the research methodology, including the research design and the rationale for its selection, the population and sample, the research instruments, as well as the data collection and data analysis procedures used in the study. The quantitative research design applied in this study is a pre-experimental design. Specifically, this study adopted a one-group pretest–posttest design, in which only one experimental class was involved and received the instructional treatment. This design was selected because it allows the researcher to compare the condition of a single group before and after the implementation of the learning intervention in the absence of a control group. The research design is illustrated as follows:

O	X	O
The pretest was administered to measure students' initial mathematical problem-solving ability prior to the implementation of game-based outdoor learning.	Game-based outdoor learning	The posttest was administered to measure students' final mathematical problem-solving ability after the implementation of game-based outdoor learning.

Figure 1. The One-Group Pretest-Posttest Research Design

In this design, students were first given a pretest (O) to measure their initial mathematical problem-solving ability prior to the treatment. The group then received the treatment (X) in the form of game-based outdoor learning as an instructional intervention. After the treatment was implemented, students completed a posttest (O) to assess their final mathematical problem-solving ability. The comparison between the pretest and posttest results was used to determine the extent to which students' mathematical problem-solving ability improved.

Population and Sample

The population of this study comprised all Grade VIII students of SMP Negeri 9 Kota Jambi in the 2025/2026 academic year. As the study did not employ a control group and focused on only one experimental class, all 24 students of Grade VIII B were selected as the research sample.

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Instrument

The instruments used in this study consisted of a mathematical problem-solving ability test (pretest and posttest) and an observation sheet to assess the implementation of learning activities by the teacher. The mathematical problem-solving ability test was selected because it is appropriate for measuring students' ability improvement by comparing their performance before and after the learning intervention, while the observation sheet was used to ensure that the learning activities were implemented in accordance with the planned instructional procedures. The items of the mathematical problem-solving ability test were developed based on a test blueprint that had been previously designed in accordance with the learning objectives and the mathematical problem-solving indicators proposed by Wildaniati et al. (2021), which include understanding the problem, planning the solution, solving the problem, and interpreting the obtained solution. Table 1 presents the blueprint of the mathematical problem-solving ability test instrument.

Table 1. Blueprint of Pretest and Posttest Mathematical Problem-Solbing Ability Test Instrument

Indicators of Learning Objective Achievement	Indicators of Mathematical Problem-Solving Ability	Question Number	Questions
Students are able to identify open and closed sentences.	Understanding the problem	1. a	The price of fried rice at a canteen is RP. 5.000. the price of fried rice is Rp. 3.000 higher than the price of risoles. Determine the price of risoles at the canteen. a. write down the given information and what is being asked in the problem. Alaso, determine the open sentence and the closed sentence!
Students are able to model an open sentence into a linear equation in one variable and determine its solution.	Planning the solution	1.b	Construct a mathematical model in the form of a linear equation in one variable from the open sentence and solve it!
	Solving the problem	1.c	If Naykila has Rp9,000 and wants to buy fried rice and risoles, determine the combination of food items that Naykila can purchase so that her money is sufficient!
Students are able to solve real-life problems related to linear equations in one variable.	Interpreting the Obtained Solution	1.c	Review your calculation results and write a conclusion based on the solution obtained.

The mathematical problem-solving ability test instrument has undergone a validation process by an expert in mathematics education. The assessment was conducted using a four-point rating scale, namely: 1) strongly disagree, 2) disagree, 3) agree, and 4) strongly agree. Based on the expert's evaluation, it can be concluded that, in general, the items of the mathematical problem-solving ability test are considered appropriate for use. The results of the validation of the mathematical problem-solving ability test instrument are presented in Table 2.

Table 2. Validation Result of the Students Mathematical Problem-Solving Ability Test

No	Aspect	Assessment Criteria
1	knowledge	The mathematical problem-solving ability test items were developed in accordance with the formulated indicators.
		Test items designed to assess mathematical problem-solving skills in accordance with the stated learning objectives.
		Test items designed to assess mathematical problem-solving ability in accordance with the indicators of mathematical problem-solving competence.
2	Construct	The test items designed to measure mathematical problem-solving ability were clearly formulated.
		The problem contexts in the mathematical problem-solving test items are genuinely functional.
		The formulation of the mathematical problem-solving test items is precise and unambiguous.
		The main test items assessing mathematical problem-solving ability are constructed without providing any hints toward the correct answers.
		The test items assessing mathematical problem-solving ability are independent of one another.
3	Language	The wording of the mathematical problem-solving test items is clear and communicative.
		The sentences in the mathematical problem-solving test items adhere to correct Indonesian spelling and grammar rules.
		The formulation of the mathematical problem-solving test items is free from ambiguity and misinterpretation.
		The mathematical problem-solving test items use standard and widely understood language, rather than local or regional expressions.
		The wording of the mathematical problem-solving test items avoids any offensive or insensitive language.
		The mathematical problem-solving test items are free from content related to ethnicity, religion, race, or intergroup sensitivity.
		The instructions for completing the test are clearly stated.

This study also employed observation sheets as instruments to evaluate the implementation of the learning process carried out by the teacher. The teacher observation sheet was used to determine the extent to which the planned learning activities were implemented optimally in the experimental class. The assessment was conducted by placing a check mark in the appropriate column for each statement based on the following rating scale: (1) not implemented, (2) poorly implemented, (3) adequately implemented, and (4) well implemented.

Table 3. Blueprint of the Teacher Observation Sheet for the Implementation of Game-Based Outdoor Learning

Steps	Observed Aspect	Item
	Introduction (Preparation)	
Orientation	The teacher opens the lesson by greeting the students.	1
	The teacher invites the students to pray.	2
	The teacher checks the students' attendance and readiness to participate in the learning process.	3
	The teacher states the topic to be learned.	4
Aperception	The teacher reviews prior knowledge and connects it to the new topic.	5
Motivation	The teacher provides motivation by explaining the benefits of the material to be learned.	6
Providing an Overview	The teacher states the learning objectives.	7
	The teacher introduces a real-life problem to attract students' interest.	8
	The teacher explains the learning strategy that will be used.	9

	The teacher clearly explains the rules of the activity and prepares the learning equipment as well as the code of conduct during the journey and at the destination to ensure an orderly activity.	10
	The teacher divides the students into several groups, with each group consisting of 6–7 students.	11
	The teacher distributes the student worksheets (LKPD) to each group.	12
	The teacher directs the students to go outside the classroom.	13
Main Activity (Implementation)	Mission 1: Concept Introduction The teacher provides guidance for the activities, facilitates group discussions, and supports students in independently discovering the concept.	14
	Mission 2: Formulation of the Mathematical Model The teacher ensures that each group is able to correctly formulate the mathematical model.	15
	Mission 3: Solving the Equation The teacher monitors the problem-solving process and provides feedback on the strategies used.	16
	Mission 4: Application The teacher supervises the students' work and provides feedback	17
	Closing (Follow-Up)	
Feedback	The teacher and students jointly conclude the lesson and emphasize the key points.	18
Follow-up	The teacher gives exercises to the students.	19
	The teacher conveys the learning objectives for the next lesson.	20
Reflection	The teacher asks students about their learning experiences and the strategies they used.	21
Appreciation	The teacher gives appreciation or praise to groups or individuals who are active and successfully complete the tasks.	22
Closing Greeting	The teacher closes the lesson with a greeting.	23

Data Collection

Data were collected using two methods, namely a mathematical problem-solving ability test and observation. The data collection process was conducted over six instructional sessions. In the first session, a pretest was administered to assess students' mathematical problem-solving abilities prior to the implementation of game-based outdoor learning. The instructional treatment was carried out from the second to the fifth sessions, during which game-based outdoor learning activities were implemented in the selected sample class using previously prepared learning materials. Throughout these sessions, observations were conducted to examine the implementation of the outdoor learning activities. In the sixth session, a posttest was administered to measure students' mathematical problem-solving abilities after participating in the game-based outdoor learning program.

Data Analysis

The data analysis techniques in this study were adjusted to the characteristics of the data obtained, namely observation data on the implementation of learning activities and data from students' mathematical problem-solving ability tests. The test data were used to identify improvements in students' mathematical problem-solving abilities after participating in game-based outdoor learning. Meanwhile, the observation data were utilized to describe the implementation of the game-based outdoor learning process throughout the study. The analysis of the observation data was conducted to ensure that the learning activities were carried out as planned and implemented effectively. Well-implemented learning activities were regarded as

an indicator that the learning conditions supported the improvement of students' mathematical problem-solving abilities.

The data on students' mathematical spatial ability obtained from the pretest and posttest were analyzed using descriptive statistics and N-gain analysis. Descriptive statistical analysis was employed to present the data by calculating the minimum score, maximum score, mean, and standard deviation. Furthermore, N-gain analysis was applied to determine the level of improvement in students' mathematical spatial ability. The N-gain value was calculated by comparing the change in scores between the pretest and posttest, and the results were then classified into high, moderate, or low improvement categories. This analysis served as the basis for testing the research hypothesis, namely that students' mathematical spatial ability improved.

Research Results

This study was conducted at SMP Negeri 9 Kota Jambi during the odd semester of the 2025/2026 academic year. The research subjects consisted of one experimental class that was selected randomly, namely Class VIII B. The learning process in this class was implemented using a game-based outdoor learning approach. The implementation of the learning activities was designed and carried out through three main stages: the preparation stage, the implementation stage, and the follow-up stage. During the preparation stage, the teacher formulated the learning objectives and selected objects from the surrounding environment to be used as learning resources. In addition, the teacher prepared the technical aspects of the learning activities, including the game rules, the flow of game implementation, student worksheets (LKPD), as well as the tools and materials that students were required to bring. During the implementation stage, the teacher guided and accompanied the students in carrying out the learning activities at the designated locations in accordance with the previously prepared plan. The students observed and examined the objects that became the focus of learning, then worked collaboratively in groups to complete each task or mission listed in the student worksheets (LKPD) in order to obtain rewards in the form of checklist.

Figure 2. Mission 1: Concept Familiarization

Figure 2 shows that students conducted observations and collected data in the school canteen, including the names of items and their prices. Through this activity, students were able to develop their mathematical problem-solving skills, particularly in the indicator of understanding the problem, because they were required to identify relevant information, recognize given and asked elements, and interpret real-world situations into mathematical contexts.

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Figure 3. Mission 2: Formulating a Mathematical Model

Figure 3 shows that students were working on Mission 2, in which they transformed the information obtained from Mission 1 into mathematical equations. Through this activity, students were able to develop their mathematical problem-solving skills, particularly in the indicator of planning a solution, because they were trained to formulate problem-solving strategies by modeling real-world situations into equations before determining the subsequent solution steps.

Figure 4. mission 3: Solution of Equations

Figure 4 shows students working on Mission 3, in which they solved one-variable linear equations systematically. Through this activity, students were able to develop their mathematical problem-solving abilities, particularly in the indicator of solving the problem, because they were trained to apply appropriate solution steps, perform calculations in a logical sequence, and obtain final solutions in accordance with the previously constructed mathematical model.

Figure 5. Mission 4: Application

Figure 5 shows students working on Mission 4, in which they interpreted the results of solving one-variable linear equations obtained in the previous mission. Through this activity, students were able to develop their mathematical problem-solving abilities, particularly in the indicator of interpreting the obtained solution. Because they were trained to relate mathematical

solutions to the given problem context, make logical sense of the calculation results, and draw appropriate conclusions based on real-world situations. After students completed Missions 1 through 4, at the end of the learning activity the teacher provided rewards in the form of prizes to the group that completed all missions most quickly and accurately.

Results of the Observation on the Implementation of Game-Based Outdoor Learning

Observation of the implementation of game-based outdoor learning was conducted throughout the learning process. The observation was carried out by a single observer who was a colleague of the researcher. Table 4 describes the criteria for the percentage of learning implementation concted by the teacher

Table 4. Criteria for the Percentage of Learning Implementation Concted by the Teacher

Interpretation	Criteria
$90\% < P \leq 100\%$	Very Good
$75\% < P \leq 90\%$	Good
$60\% < P \leq 75\%$	Fairly Good
$40\% < P \leq 60\%$	Not Good
$0\% < P \leq 40\%$	Very Poor

Source: Ramadhana & Hadi (2022)

The results of the observation on the implementation of game-based outdoor learning by the teacher over four meetings are presented in Table 5.

Table 5.Observation Results of Game-Based Outdoor Learning Implementation

Description	Avarage Implementation Observations in Outdoor Game-Based Learning				Average (%)
	1	2	3	4	
Average (%)	92,4%	94,5%	90,2%	92,4%	92,4%
Criteria	Verry Good				Very Good

Table 5 presents the results of observations on the teacher's implementation of learning. The findings show that the average percentage of learning implementation in the first and fourth sessions was 92,4%, the second session reached 94,5%, and the third session was 90,2% Overall, the average percentage of learning implementation across the four sessions was 92,4%. According to the criteria proposed by Ramadhana & Hadi (2022), learning implementation percentages within the range of $90\% < P \leq 100\%$ are categorized as very good. Therefore, it can be concluded that the implementation of outdoor game-based learning over the four sessions was carried out very effectively.

Results of Students' Mathematical Problem-Solving Ability Test

In this study, 24 students from Class VIII B were administered a mathematical problem-solving ability test after participating in game-based outdoor learning activities. The test instrument consisted of a single problem divided into several sub-questions designed to represent four key indicators of mathematical problem-solving ability: understanding the problem, planning a solution, carrying out the solution process, and interpreting the results obtained.

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Table 6. Description of Mathematical Problem-Solving Ability Base Indicators and Students' Responses

Indicators of Mathematical Problem-Solving Ability	Indicator Description	Sample of Students' Responses
understanding the problem	For the problem-understanding indicator, students were able to write down all the information contained in the problem, including the given data and what was being asked.	**Given:** • The price of fried rice is Rp5,000. • The price of fried rice is Rp3,000 higher than the price of a rissole. **Question:** What is the price of the rissole? **Open sentence:** • The price of fried rice is Rp3,000 higher than the price of the rissole. **Closed sentence:** • The price of fried rice is Rp5,000.
planning a solution	Students were able to plan a problem-solving strategy; in this problem, they were required to transform an open sentence into a mathematical expression.	**Open sentence:** The price of fried rice = the price of the rissole + Rp3,000. Let the price of the rissole be x, then: Rp5,000 = x + Rp3,000. Solving the equation to find the price of the rissole: Rp5,000 = x + Rp3,000 Rp5,000 − Rp3,000 = x + Rp3,000 − Rp3,000 Rp2,000 = x x = Rp2,000 Therefore, the price of the rissole is Rp2,000.
carrying out the solution process	Students were able to present the solution steps in a systematic manner until an appropriate solution was obtained. In this problem, students were faced with a contextual situation that required them to write their answers in a clear and well-organized sequence.	• **If Naykila buys 1 serving of fried rice and 1 rissole**, the amount of money needed is Rp5,000 + Rp2,000 = Rp7,000. (Naykila has Rp9,000, which is sufficient and leaves Rp2,000 in change.) • **If Naykila buys 1 serving of fried rice and 2 rissoles**, the total cost is Rp5,000 + 2(Rp2,000) = Rp5,000 + Rp4,000 = Rp9,000. (Naykila's Rp9,000 is exactly sufficient.)
interpreting the results obtained	Students made a final interpretation based on the solution obtained.	Therefore, the price of a rissole at the canteen is Rp2,000. If Naykila has Rp9,000, the possible food combinations she can • 1 serving of fried rice and 1 rissole • 1 serving of fried rice and 2 rissoles

The data obtained from the students' mathematical problem-solving ability tests were further processed using descriptive statistical analysis and N-gain calculations to determine the improvement in students' abilities. The results of the data analysis of the mathematical spatial ability tests of class VIII B students at SMP Negeri 9 Kota Jambi are presented below. Descriptive statistical analysis was conducted to provide an overall overview of the collected data. The statistical measures calculated included the mean, maximum score, minimum score, and standard deviation of students' mathematical problem-solving abilities. A summary of the descriptive statistical analysis results is presented in Table 7.

Table 7. Descriptive Statistics Results

	N	Minimum	Maximum	Mean	Std.Deviation
Mathematical Problem-Solving Ability	24	20,00	79,10	61,3167	17,75827
Valid N (listwise)	24				

Source: Output *IBM SPSS Statistics*

Based on the results of the descriptive statistical analysis, the distribution of the obtained data illustrates students' mathematical spatial abilities as follows: the minimum score was 20, the maximum score reached 79.10, the mean score was 61.3167, and the standard deviation was 17.75827. Furthermore, the improvement in students' mathematical problem-solving abilities was analyzed using the normalized gain (N-gain), as proposed by Hake (1998). The N-gain formula $N - gain = \frac{posttest\ score - pretest\ score}{100 - pretset\ score}$. The resulting N-gain values were then classified into three categories, namely high ($N - gain \geq 0,70$), Moderate ($0,30 \leq N - gain < 0,70$), and low ($N - gain < 0,30$). Based on the results of the study, the levels of students' improvement are presented in Table 8.

Table 8. Levels of Students Improvement

N-Gain Category	Frequency	Percentage
High	4	16,67%
Moderate	14	58,33 %
Low	6	25,00%
Total	**24**	**100%**

Discussion

The findings of this study indicate that the implementation of game-based outdoor learning has a positive effect on improving students' mathematical problem-solving abilities in the topic of one-variable linear equations. This result is consistent with the study conducted by Prasetiyo et al. (2023), which reported that outdoor learning activities designed in the form of games not only train problem-solving skills but also encourage the emergence of new ideas among students. The integration of game elements in learning also has a beneficial impact on students' learning motivation. This is in line with the findings of Nurlaili et al. (2025), who stated that game-based learning is an effective strategy for enhancing student engagement and motivation during the learning process. Motivation plays an important role in problem-solving, as students who are more engaged tend to persist longer when facing mathematical challenges.

Furthermore, this study demonstrates that game-based outdoor learning contributes to the improvement of students' mathematical problem-solving abilities, particularly in understanding problems related to one-variable linear equations through direct learning experiences outside the classroom. This finding supports the study by Luh et al. (2024), which revealed that the application of Problem-Based Learning combined with outdoor learning activities strengthens problem-solving skills through more meaningful hands-on learning experiences. This is also reinforced by the findings of Istiqomah & Lailasari (2024), who emphasized that outdoor learning offers advantages by providing authentic experiences through direct interaction with the natural environment, thereby making learning easier to comprehend.

Based on the obtained data, more than 50% of the students demonstrated a moderate level of improvement in their mathematical problem-solving abilities. Rather than simply indicating score improvement, this suggests that most students benefited from the learning process by gradually developing their ability to approach problems systematically. This active participation is also consistent with collaborative problem-solving principles, as students work together, share strategies, and construct solutions through group interaction during outdoor activities. This result aligns with the study by Abimanyu et al. (2024),which found that outdoor learning enables students to engage more actively and freely in learning activities compared to classroom-based instruction, which tends to impose spatial and activity-related limitations.

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Game-based outdoor learning was found to have a positive influence on the development of students' mathematical problem-solving abilities across all indicators proposed by Wildaniati et al. (2021), namely understanding the problem, planning a solution, carrying out the solution, and interpreting the obtained results. Through direct observation of real objects in their surrounding environment, students were better able to comprehend the given problems. Game activities incorporated into the learning process also encouraged students to actively engage in each stage of problem-solving. Moreover, students' interaction with real objects and participation in group discussions helped them connect real-life problems with the mathematical concept of one-variable linear equations.

The novelty of this study lies in the use of games within outdoor learning that are specifically applied to the topic of one-variable linear equations. This combination of game-based learning and outdoor learning simultaneously remains rarely examined, particularly at the junior high school level in the context of linear equations in one variable. Games designed with clear rules contribute to a more structured learning process and have a positive impact on enhancing students' mathematical problem-solving abilities. Overall, this study confirms that the implementation of game-based outdoor learning provides students with direct learning experiences in real-world contexts and creates an active and enjoyable learning environment, which ultimately supports the improvement of students' mathematical problem-solving abilities in the topic of one-variable linear equations. Therefore, this approach offers practical implications for classroom instruction, especially in overcoming the limitations of traditional learning environments that may not fully facilitate students' active problem-solving development. In practice, teachers may adopt this approach as a complementary strategy to enrich classroom learning, particularly when introducing abstract algebraic concepts that require contextual understanding.

Conclusion

The implementation of game-based outdoor learning on the topic of one-variable linear equations was found to improve students' mathematical problem-solving abilities. This improvement was evident in the N-gain analysis of 24 students, 4 students demonstrated a high level of improvement, 14 students showed moderate improvement, and 6 students experienced low improvement. These results explicitly address the research objective by showing that game-based outdoor learning can serve as an effective instructional approach to enhance students' mathematical problem-solving skills. Furthermore, the findings highlight that integrating outdoor environments with structured games provides meaningful and relevant learning contexts that support students in developing problem-solving strategies in mathematics. Despite these contributions, several limitations should be considered. The implementation of outdoor learning in certain locations occasionally affected students' focus during activities. In addition, the use of a single-group research design without a control group limits the ability to attribute the observed improvement solely to the intervention. Moreover, this study was restricted to one mathematical topic, namely one-variable linear equations. Therefore, future research is recommended to employ experimental designs involving control groups, explore a wider range of outdoor learning contexts and game activities, apply this approach to other mathematical topics, and conduct deeper analyses of students' mathematical problem-solving abilities across each problem-solving indicator.

Acknowledgments

Conflict of Interest

The author declares no conflict of interest.

Authors' Contributions

R.P.S. was directly involved in all stages of the research process, including study implementation, data collection, instrument development, manuscript drafting, discussion of findings, and refinement of the manuscript to its final version. S. and K.A. contributed to the formulation of the main research ideas, strengthening of the theoretical framework, methodological design, data management and analysis, interpretation of results, and approval of the final manuscript. All authors have reviewed and approved the final version of this article. The respective contributions to conceptualization, writing, and manuscript revision were 40% for R.P.S.: 40%, S.: 30% and K.A.: 30%

Data Availability Statement

The authors declare that data sharing is not applicable, as no new data were created or analyzed in this study.

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