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Original Research

The Implementation of BBL Assisted by Ice Breaking Games on Mathematical Reasoning Reviewed from The Mathematical Resilience Ability of Students

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Abstract: The purpose of this research is to determine the effect of the implementation of Brain-Based Learning assisted by Ice Breaking Games on students mathematical reasoning, the effect of mathematical resilience abilities on students mathematical reasoning, and the interaction between the learning model and mathematical resilience abilities on students mathematical reasoning. This type of research is included in quasi-experimental research, the population taken is all students of class VIII *SMP Negeri* 2 Sendang Agung. The sampling technique uses cluster random sampling where class VIII A is the experimental class 1 with BBL learning assisted by ice breaking games, class VIII B as the experimental class 2 with BBL learning, class VIII C as the control class with lecture learning, questions and answers, and assignments. The data analysis technique in the study is a two-way ANOVA test. Based on the results of the first hypothesis test, the value $F_{count} = 37{,}145$ with $F_{count} = 37{,}145$ and degree of significance is 0.05. This indicates $p - value < 0{,}05$ that it H_0 is rejected and H_1 accepted. So, it can be concluded that there is an effect of the BBL learning model assisted by ice breaking games on students' mathematical reasoning abilities. The second hypothesis shows a value $F_{hitung} = 19{,}200$ with $p - value = 0{,}000a$ significance level of 0.05. This indicates $p - value < 0{,}05$ that it $H_0$is rejected and H_1accepted. Therefore, it can be concluded that there is an influence of mathematical resilience on students mathematical reasoning abilities. And the third hypothesis shows a value $F_{count} = 0{,}179$ with $p - value = 0{,}949a$ significance level of 0.05. This indicates $p - value > 0{,}05$ that H_0it is accepted and H_1 rejected. Therefore, it is concluded that there is no interaction between the learning model and mathematical resilience on students mathematical reasoning abilities.

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INTRODUCTION

Mathematical reasoning is the process of drawing logical and accountable conclusions based on mathematical evidence (Norhidayah, 2023). This ability is essential because it supports students in analyzing problems, formulating conjectures, performing mathematical manipulations, and drawing valid conclusions, while also contributing to critical thinking and problem-solving skills (Mukuka et al., 2023). However, many students still experience difficulties in developing mathematical reasoning due to limited conceptual understanding and learning obstacles encountered during mathematics instruction (Hajar et al., 2021; Ramdan & Roesdiana, 2022).

Mathematical reasoning is closely related to mathematics because problem solving requires logical thinking and justification (Seepiwsiw, & Seehamongkon, 2023). Nevertheless, international assessments indicate that Indonesian students' mathematical performance remains relatively low. The PISA 2022 results showed that Indonesia scored below the OECD average in mathematics (OECD, 2023), while TIMSS 2019 reported that Indonesian students performed below the international benchmark, particularly in reasoning-related domains (Martin et al., 2020). These findings highlight the need for innovative learning approaches that can effectively enhance students mathematical reasoning abilities.

Low mathematical reasoning ability also occurs in *SMP Negeri* 2 Sendang Agung, based on the results of interviews with mathematics teachers at the school, it was found that the learning process used by educators has not used a variety of learning models. Educators tend to use a one-way learning model and only rely on the ability to explain and then record the material on the board. During the learning process, quite a few students actively ask questions and can answer math questions correctly. This makes it difficult for students to understand the material, students feel bored during math lessons in class, students always complain, lack confidence and their mathematical reasoning ability is very low so that learning objectives are not achieved. This condition can be seen from the results of the pre-research test of students mathematical reasoning abilities conducted in classes VIII A, VIII B, VIII C. The following Table 1. is the results of the mathematical reasoning test.

Table 1. Results of Pre-Research of Students' Mathematical Reasoning Tests

Class	Minimum Competency (*KKM*)	Student Values		Number of Students
		$x \geq 70$	$x < 70$	
VIII A	70	4	26	30
VIII B	70	7	25	32
VIII C	70	2	27	29
	Amount	13	83	91

Based on Table 1., it can be seen that students mathematical reasoning abilities are still relatively low. This can be seen from the way students solve problems, where students do not present mathematical statements, are less able to put forward conjectures, are less able to carry out mathematical manipulations, and do not provide conclusions from statements.

Previous research on improving mathematical reasoning has shown that students mathematical reasoning abilities are still low. Mathematical reasoning abilities can be developed in mathematics learning through teaching methods or strategies that involve students in an effort to encourage active learning, thereby helping them develop their mathematical reasoning abilities. Selecting an appropriate, engaging, creative, and innovative learning model will create a pleasant learning atmosphere that can improve mathematical reasoning abilities and achieve learning objectives well. One such model is implementing the BBL learning model assisted by ice-breaking games. BBL itself is a learning model that is aligned with the way the brain works and is scientifically designed for learning, not focusing on sequence but rather prioritizing students love and enjoyment in learning, making it easier for students to understand the material in class.

The BBL learning model aims to help students fully utilize their cognitive potential, including a balanced left and right brain (Winantaka, et al., 2024). BBL learning helps students learn new

material and then integrate it with their existing knowledge. Meanwhile, icebreaking games are simple games that function to restore student concentration, then can change feelings of boredom, fatigue, and drowsiness in class. The ice breaking method gives students the opportunity to relax and create a pleasant learning atmosphere. Ice breaking activities can be carried out in between lessons with the hope of making learning more interesting and making the material easier to absorb.

Research conducted by Rahmawati, Rochmad, and Isnarto (2021) concluded that the BBL model provides students with better mathematical reasoning skills than the Instruction learning model (direct learning). The BBL learning model, viewed from the perspective of students' mathematical resilience, is a new idea in learning that has not been widely researched. Researchers also combined the BBL learning model with ice-breaking games, which are expected to provide a novel teaching and learning process in the classroom regarding students mathematical reasoning skills.

METHOD

This study employed a quasi-experimental method using a 3×3 factorial design. According to Priyono (2018), quasi-experimental research is conducted to examine the effect of a treatment on a dependent variable without randomly assigning individual participants to groups. The study involved three learning groups: (1) Brain-Based Learning (BBL) assisted by Ice-Breaking Games, (2) Brain-Based Learning (BBL), and (3) conventional learning through lectures, question-and-answer sessions, and assignments. The BBL model was implemented through the stages of pre-exposure, preparation, initiation and acquisition, elaboration, incubation and memory encoding, verification, and celebration. Ice-Breaking Games were integrated during the incubation and memory encoding stage to restore students concentration and create a more engaging learning environment.

The population consisted of all eighth-grade students of *SMP Negeri* 2 Sendang Agung, totaling 91 students. Using cluster random sampling, Class VIII A (30 students) was selected as Experimental Class 1, Class VIII B (32 students) as Experimental Class 2, and Class VIII C (29 students) as the Control Class. Data were collected using a mathematical reasoning test and a mathematical resilience questionnaire. The mathematical reasoning test was developed based on four indicators: presenting mathematical statements, proposing conjectures, performing mathematical manipulations, and drawing conclusions. Meanwhile, mathematical resilience was measured through three indicators: perseverance and confidence in solving mathematical problems, willingness to collaborate in learning activities, and positive responses to challenges encountered during mathematics learning. Prior to implementation, the instruments were tested for validity and reliability. The research procedure included preparing lesson plans and instruments, conducting instrument trials, implementing the learning treatments for six meetings, administering the tests and questionnaires, and analyzing the data. The data were analyzed using two-way Analysis of Variance (ANOVA) to examine the effects of the learning model, mathematical resilience, and their interaction on students' mathematical reasoning ability.

RESULTS

This study uses cluster random sampling technique or random class technique so that class VIII A is obtained as experimental class 1 with a total of 30 students who received BBL learning assisted by ice breaking games, then class VIII B as experimental class 2 with a total of 32 students who received BBL learning, class VIII C as a control class with a total of 29 students who received lecture learning, questions and answers and assignments. The object in this study is BBL learning assisted by ice breaking games reviewed from the ability of mathematical resilience symbolized by (X) as the independent variable and mathematical reasoning symbolized by (Y) as the dependent variable. Data collection techniques in this study used tests and questionnaires.

Before the test questions and questionnaire were given to students, a trial of the instrument was conducted. The mathematical reasoning test was developed based on four indicators, namely presenting mathematical statements, proposing conjectures, performing mathematical manipulations,

and drawing conclusions. Meanwhile, the mathematical resilience questionnaire measured students' perseverance and confidence, collaboration in learning, and positive responses to challenges in mathematics. The results of the trial were as follows:

Validity test

Researchers used the *r* product moment formula to calculate construct validity. The following Table 2. are the calculation results.

Table 2. Results of the Validity Test of Mathematical Reasoning Questions

No.	r_{hitung}	r_{tabel}	Criteria
1	0.903	0.374	Valid
2	0.197	0.374	Invalid
3	0.713	0.374	Valid
4	0.645	0.374	Invalid
5	0.219	0.374	Invalid
6	0.294	0.374	Valid
7	0.654	0.374	Valid
8	0.859	0.374	Valid

Based on Table 2., the results show that out of 8 questions, 5 questions are suitable for the test, namely questions number 1, 3, 4, 7, and 8.

Table 3. Results of The Validity Test of The Mathematical Resilience Questionnaire

No.	r_{hitung}	r_{tabel}	Criteria
1	0.695	0.374	Valid
2	0.376	0.374	Valid
3	0.631	0.374	Valid
4	0.692	0.374	Valid
5	0.461	0.374	Valid
6	0.538	0.374	Valid
7	0.532	0.374	Valid
8	0.502	0.374	Valid
9	0.234	0.374	Invalid
10	0.434	0.374	Valid
11	0.613	0.374	Valid
12	0.577	0.374	Valid
13	0.742	0.374	Valid
14	-0.069	0.374	Invalid
15	0.739	0.374	Valid
16	0.106	0.374	Invalid
17	0.558	0.374	Valid
18	0.355	0.374	Invalid
19	0.382	0.374	Valid
20	0.664	0.374	Valid

Based on Table 3., the results of the validation calculations for 20 statements of the mathematical *resilience questionnaire* show that there are 16 questionnaire items that are valid and suitable for testing, namely numbers 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 17, 19, 20. Then there are 4 questionnaire items that are invalid, namely numbers 9, 14, 16, 18.

Difficulty level test

The following Table 4. are the results of the analysis of the difficulty level test.

Table 4. Results of the Mathematical Reasoning Question Difficulty Level Test

No.	Difficulty Level	Criteria
1	0.730	Easy
2	0.185	Difficult
3	0.678	Currently
4	0.788	Easy
5	0.123	Difficult
6	0.087	Difficult
7	0.805	Easy
8	0.646	Currently

In the difficulty level test, the researcher used a difficulty level with easy criteria $(0{,}70 < TK \leq 1{,}00)$, namely numbers 1, 4, and 7. Then 2 questions with medium criteria $(0{,}30 < TK \leq 0{,}70)$, namely numbers 3 and 8.

Differential power test

The following Table 5. are the results of the differential power test analysis.

Table 5. Results of the Test of Differential Power of Mathematical Reasoning Questions

Question No.	Differential Power	Criteria
1	0.442	Very good
2	0.097	Bad
3	0.331	Enough
4	0.214	Not enough
5	0.012	Bad
6	0.045	Bad
7	0.220	Not enough
8	0.331	Enough

In the discrimination power test, the researcher used discrimination power with very good criteria $(DB \geq 0{,}40)$, namely number 1. Then questions with sufficient criteria $(0{,}30 \leq DB < 0{,}40)$, namely numbers 3 and 8. And questions with less criteria $(0{,}20 \leq DB < 0{,}30)$, namely numbers 4 and 7.

Reliability test

The results obtained from the calculation of the reliability test of the questions are: $r_{11} = 0{,}763$. Because $r_{11} \geq r_{tabel}$, with $r_{tabel} = 0{,}71$. So it can be concluded that the question is categorized as reliable. Then the results obtained from the questionnaire reliability test, $0{,}833 \geq 0{,}70$it can be concluded that the mathematical resilience questionnaire is reliable.

At the end of the lesson, students were given a test and questionnaire. The test consisted of written questions (essays) on the topic of flat-sided geometric shapes. This test served as a measure of mathematical reasoning ability. The observational data obtained from the study are as follows Table 6.

Based on Table 6., it can be seen that in experimental class 1, the highest score is 96 and the lowest score is 65. In experimental class 2, the highest score is 90 and the lowest score is 58. Meanwhile, for the control class, the highest score is 80 and the lowest score is 43. The measure of

central tendency which includes the average class value mean for experimental class 1 is 80.90 with a total of 30 students, experimental class 2 is 75.03 with a total of 32 students, and in the control class it is 59.58 with a total of 29 students. Meanwhile, the median value *for* experimental class 1 was 80, experimental class 2 was 77, and control class was 60. Then the mode value for experimental class 1 was 87, experimental class 2 was 85 and control class was 54. The standard deviation for experimental class 1 was 9.628, experimental class 2 was 9.991 and control class was 10.867. From the results of the data analysis, it was concluded that the mathematical reasoning ability of students in the experimental class was better than the control class.

Table 6. Mathematical Reasoning Ability Test Results Data

Class	X_{max}	X_{min}	Measures of Central Tendency			Group Variance Measure	
			$\bar{X}$	M_e	M_o	N	Elementary School
Experiment 1	96	65	80.90	80	87	30	9,628
Experiment 2	90	58	75.03	77	85	32	9,991
Control	80	43	59.58	60	54	29	10,867

The researchers used a questionnaire to measure students' mathematical resilience. Data collection was conducted before the mathematical reasoning ability test was administered to students. The questionnaires were distributed to respondents and then collected to determine the highest and lowest scores between the experimental and control classes.

Table 7. Mathematical Resilience Questionnaire Data

Class	Mathematical *Resilience* Criteria			Amount
	Tall	Currently	Low	
Experiment 1	7	14	9	30
Experiment 2	6	20	6	32
Control	4	22	3	29

Based on Table 7., it can be seen that in experimental class 1, there were 7 students who obtained high mathematical resilience criteria, 14 students obtained medium mathematical resilience criteria, and 9 students obtained low mathematical resilience criteria with a total of 30 students. Then in experimental class 2, there were 6 students who obtained high mathematical resilience criteria, 20 students obtained medium mathematical resilience criteria, and 6 students obtained low mathematical resilience criteria with a total of 32 students. While in the control class, there were 4 students who obtained high mathematical resilience criteria, 22 students obtained medium mathematical resilience criteria, and 3 students obtained low mathematical resilience criteria with a total of 29 students.

Once the data has been obtained, a prerequisite test must be conducted. The results show that the data meets the requirements, namely that it comes from a normally distributed population with homogeneous variance. Therefore, to answer the problem formulation, a two-way ANOVA can be conducted using *SPSS 26 software*, as follows Table 8.

Table 8. Two-Way ANOVA Test Results

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Learning model	5304,848	2	2652,424	37,145	0,000	0,475
Mathematical Resilience	2742,072	2	1371,036	19,200	0,000	0,319
Mathematical Resilience Learning Model	51,090	4	12,772	0,179	0,949	0,009
Total	488550,000	91				
Corrected Total	16229,824	90				

From the results of the two-way ANOVA test in Table 8., conclusions were obtained referring to 3 hypotheses

First hypothesis

Based on the results of the hypothesis obtained, which is H_0 rejected and H_1 accepted, it shows that there is an influence of the learning model on students mathematical reasoning abilities. The results of this study are in accordance with previous research by Latifah, R. A., & Mahmudi, A. (2018). with the results of the mathematics learning process by applying the BBL model having an effect on improving students' mathematical reasoning abilities. Another study by Nahdi (2015) concluded that the BBL model has a positive effect on improving students' critical thinking skills and mathematical reasoning ability.

Second hypothesis

Based on the results of the hypothesis obtained, which is H_0 rejected and H_1accepted, it shows that there is an influence of mathematical resilience on students' mathematical reasoning abilities. The results of this study are in accordance with previous research by Anzika (2022) which concluded that there is a positive and significant influence between mathematical resilience on students' mathematical reasoning abilities. Another study conducted by Amaliyah (2019), shows that students who have high mathematical resilience abilities can solve mathematical logical reasoning test questions well and fulfill all indicators of reasoning.

Third hypothesis

Based on the results of the hypothesis obtained, which are H_0 accepted and H_1 rejected, it shows that there is no interaction between the learning model and mathematical resilience on students mathematical reasoning abilities. Thus, the initial assumption that states that there is an interaction between the learning model and mathematical resilience on students' mathematical reasoning abilities is not proven.

DISCUSSION

The findings indicate that the implementation of the Brain-Based Learning (BBL) model assisted by Ice-Breaking Games positively influenced students mathematical reasoning ability. Students in Experimental Class 1 demonstrated higher mathematical reasoning scores than those in Experimental Class 2 and the Control Class. This result is consistent with Latifah and Mahmudi (2018), who reported that Brain-Based Learning improves students mathematical reasoning ability by engaging learners in meaningful and active learning experiences. Similar findings were reported by Rahmawati et al (2021), who found that BBL facilitates students in constructing mathematical ideas and communicating their reasoning more effectively. Furthermore, international studies have emphasized that learning environments that actively engage students in exploration, discussion, and

problem-solving contribute significantly to the development of mathematical reasoning skills (Jonsson et al., 2022; Jeannotte & Kieran, 2017).

The results also revealed that mathematical resilience significantly affected students mathematical reasoning ability. Students with high mathematical resilience demonstrated greater confidence, persistence, and participation during learning activities than students with moderate and low resilience levels. These characteristics enabled them to analyze problems more effectively and justify their solutions. This finding supports the studies of Amaliyah (2019) and Anzika (2022), which concluded that mathematical resilience contributes positively to students' reasoning performance. International evidence likewise suggests that resilient learners tend to persist when facing mathematical challenges and are more likely to develop higher-order thinking skills, including mathematical reasoning (Kooken et al., 2016).

The absence of a significant interaction between the learning model and mathematical resilience indicates that the effectiveness of the BBL model assisted by Ice-Breaking Games was relatively consistent across different levels of mathematical resilience. One possible explanation is that students were not yet fully accustomed to the BBL approach, collaborative learning activities, and brain gym exercises incorporated during instruction. As noted by Kumala et al. (2020), students often require an adaptation period before they can fully benefit from innovative learning models. In addition, learning-model effects and individual resilience characteristics may operate independently, resulting in significant main effects but not necessarily producing an interaction effect. Similar findings have been reported in educational studies showing that student characteristics do not always moderate the effectiveness of instructional interventions when the intervention period is relatively short.

CONCLUSION

For educators, the Brain-Based Learning (BBL) model assisted by ice breaking games is expected to be used as an alternative learning model in mathematics learning to improve students mathematical reasoning abilities. The implementation of this model can help teachers create a more active, enjoyable, and meaningful learning atmosphere, so that students are more engaged in the learning process. In addition, educators are expected to apply this learning model to other mathematics topics in order to optimize students learning outcomes and encourage the development of higher-order thinking skills.

For students, the application of the Brain-Based Learning (BBL) model assisted by ice breaking games is expected to encourage students to become more active, enthusiastic, and confident during the learning process. This learning model is also expected to improve students' mathematical resilience, especially in facing challenges and difficulties in solving mathematical problems. Through better mathematical resilience, students are expected to be more persistent, motivated, and able to develop their mathematical reasoning abilities effectively.

Furthermore, for future researchers, this study is expected to become a reference for conducting further research related to the implementation of the Brain-Based Learning (BBL) model assisted by ice breaking games in mathematics learning. Future researchers are encouraged to examine the effectiveness of this learning model on different mathematical abilities, educational levels, or learning variables in order to enrich the findings and contribute to the development of innovative learning models in mathematics education.

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