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The Effect of Brain-Based Learning Assisted by Brain Gym on Mathematical Problem-Solving Ability

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Abstract

The purpose of this study was to determine the effect of the Brain-Based Learning learning model assisted by Brain Gym on students' mathematical problem-solving ability. This research is a type of quantitative research with a one-group pretest-posttest pre-experimental design. The implementation of the research was carried out with 3 meetings involving 27 students of grade VII as the research population, selected through purposive sampling. The data collection technique used was a test to measure problem-solving abilities, which was then analyzed using the N-Gain test and a paired samples t-test. The results of the study indicate that while the practical improvement was moderate, as shown by an N-Gain score of 0.47, this change was found to be statistically significant (tcount = 11,222 > ttable = 1,708 at α = 0,05). This suggests that the application of the Brain-Based Learning Model Assisted by Brain Gym had a measurable effect on Mathematical Problem-Solving Ability, leading to the rejection of H0 and acceptance of H1. The findings indicate that this study has the potential to make mathematics classes more interesting, facilitate better problem-solving skills among students, and inspire them to pay more attention and take an active role in their own education.

Keywords: *Brain Based Learnin; Brain Gym; mathematical problem-solving ability*

1. Introduction

Mathematics is a foundational discipline within the educational landscape, essential for its broad practical applications and its role in developing logical reasoning. Mastery of mathematical concepts is critical, yet students frequently perceive the subject as inherently difficult, leading to significant challenges in comprehension and application. Widespread issues such as mathematical anxiety, a lack of intrinsic motivation, and the implementation of non-engaging pedagogical methods can severely impede a student's ability to develop robust problem-solving skills. To counteract these challenges, it is imperative for educators to adopt innovative and captivating learning strategies that not only stimulate student interest but also facilitate a deep and lasting understanding of mathematical principles.

A promising pedagogical framework designed to address these issues is **Brain-Based Learning (BBL)**. BBL is a comprehensive educational approach grounded in the principles of neuroscience, aiming to align instructional practices with the brain's natural mechanisms for learning. According to Syafa'at (2009), as cited by Susi Sulastri Lubis (2022:68), BBL prioritizes the cultivation of students' cognitive faculties through three core strategies: (1) creating a classroom environment that actively promotes critical thinking, (2) designing learning materials that are inherently interesting and enjoyable, and (3) enhancing student engagement by establishing a relevant and meaningful learning context. Widyantara et al. (2014) further elaborate that "brain-based learning is learning that activates students to construct their own knowledge by utilizing and empowering their brain's capabilities" (in Amalia Solihat et al., 2017:453). The BBL model is structured around a seven-stage process, as outlined by Jensen (2011), which includes Pre-Exposure, Preparation, Initiation and Acquisition, Elaboration, Incubation and Memory Encoding, Verification and Confidence Checking, and Celebration and Integration (in Syifa Oktaviana & Edi Rohendi, 2017; 103). This structured yet flexible approach is designed to make learning more meaningful by encouraging students to actively build their own knowledge base.

To further amplify the effects of BBL, this study integrates **Brain Gym**, a program of simple physical movements developed by Dr. Paul and Gail Dennison. Brain Gym is founded on the principles of Educational Kinesiology and is designed to enhance brain function by improving the coordination between the left and right cerebral hemispheres. The 26 distinct movements, such as the *Cross Crawl* and *Lazy Eights*, are intended to improve concentration, reduce stress, and overcome learning obstacles, thereby preparing students physically and mentally for cognitive tasks (Dennison & Dennison, 2002, in Sri Suneki, et al., 2022:3-4).

Preliminary observations conducted on February 17, 2025, at SMP Negeri 1 Pondidaha revealed that seventh-grade students exhibited underdeveloped mathematical problem-solving skills. Interviews with mathematics teachers identified passive learning environments and a weak grasp of foundational concepts as primary contributing factors. While educators employed various teaching models, there was a clear need for a more cohesive and brain-compatible strategy. This aligns with established frameworks for problem-solving, which typically involve understanding the problem, devising a plan, executing the plan, and reviewing the solution (Mauleto, 2019).

Previous research has demonstrated the efficacy of BBL and related approaches. For instance, Dara Azhari (2021:4) found that a BBL model significantly influenced students' problem-solving abilities in physics, yielding a moderate N-gain of 0.50. Similarly, Ivah S. Fajriati (2016: 11) reported that BBL assisted by Brain Gym significantly improved student learning outcomes in biology. Further supporting this, Syahir Sasri Habibi & Izwita Dewi (2023:390) concluded that the combined BBL and Brain Gym model positively affected students' mathematical communication skills. These studies, along with others by Hajati et al. (2023:231) and Irma et al. (2015:11), collectively suggest that brain-centric pedagogical models can enhance various cognitive outcomes across different subjects.

This study builds upon this existing literature by investigating the specific impact of the BBL model, augmented by Brain Gym exercises, on the mathematical problem-solving abilities of seventh-grade students. The primary research question guiding this investigation is: "Is there a significant effect of the Brain-Based Learning model assisted by Brain Gym on the mathematical problem-solving abilities of students at SMP Negeri 1 Pondidaha?". The objective is, therefore, to empirically determine the existence and magnitude of this effect. The research hypothesis posits that a significant positive effect exists.

2. Method

2.1. Type of Research

This study utilized a quantitative, **pre-experimental research design**. Specifically, the **One-Group Pretest-Posttest Design** was implemented, as described by Sugiyono (2019:74, in Beti Arliana et al., 2022:1120). This design was chosen for its practicality in a natural classroom setting where establishing a separate control group was not feasible. It involves measuring the dependent variable (mathematical problem-solving ability) before the intervention (O_1), administering the treatment (X), and then measuring the dependent variable again after the intervention (O_2). The treatment consisted of three instructional sessions based on the Brain-Based Learning model, with each session incorporating Brain Gym exercises.

Table 1 Research Design Scheme

O_1	X	O2
Pretest	*Treatment*	*Posttest*

2.2. Setting and Participants

The research was conducted at SMP Negeri 1 Pondidaha, located in the Konawe Regency, Southeast Sulawesi, Indonesia. The **population** for the study comprised all 110 seventh-grade students enrolled during the 2025 academic year. From this population, a **sample** of 27 students from class VII A was selected to participate as the experimental group. The sampling method used was **purposive sampling**, a non-probability technique where participants are selected based on specific characteristics relevant to the study's objectives. In this case, the class was chosen based on its representative academic average and recommendations from the mathematics teacher to ensure the sample was typical of the broader student population at the school.

Table 2. Population Data or Sample Size

Class	VII A	VII B	VII C	VII D	Total
Number of students	27	28	25	30	110

Source: SMP Negeri 1 Pondidaha

2.3. Variables and Instruments

The study involved two key variables:

- Independent Variable (X): The pedagogical intervention, which was the Brain-Based Learning model assisted by Brain Gym.
- Dependent Variable (Y): The students' mathematical problem-solving ability, as measured by test performance.

The primary data collection instrument was a written **test** designed to assess students' ability to solve problems related to plane geometry (parallelograms, rhombuses, and kites). The same test, comprising seven questions, was used for both the pretest and the posttest to ensure consistency in measurement. The instrument underwent rigorous validation. **Content validity** was assessed using Aiken's V coefficient, which confirmed that all test items were valid. **Reliability** was established using the Cronbach's Alpha formula. The pretest instrument yielded a reliability coefficient of 0.77, and the posttest yielded a coefficient of 0.93. Both values are well above the 0.70 threshold, indicating that the instrument was highly reliable for measuring the intended construct.

2.4. Data Analysis

The collected data were analyzed using both descriptive and inferential statistical techniques.

1. Descriptive Analysis: The Normalized Gain (N-Gain) test was employed to measure the effectiveness of the intervention. This method is widely used in educational research to quantify the improvement from pretest to posttest scores while accounting for the pre-existing knowledge of the students. The N-Gain formula is: $N-Gain = \frac{Posttest\ Score - Pretest\ Score}{Maximum\ Score - Prestest\ Score}$. The resulting scores were interpreted as high $(g \geq 0{,}70)$, medium $(0{,}30 \leq g < 0{,}70)$, or low $(g < 0{,}30)$.
2. Inferential Analysis: Before hypothesis testing, a Shapiro-Wilk test was conducted to confirm the normality of the pretest and posttest data distributions. The research hypothesis was then tested using a paired samples t-test. This test was selected because it is appropriate for comparing the means of two related groups (i.e., the same subjects' scores before and after a single intervention). The test was conducted at a significance level (α) of 0.05 to determine if the observed improvement in scores was statistically significant.

3. Results and Discussion

This section presents the empirical findings of the study, followed by an in-depth interpretation and discussion. The results are organized to first provide a descriptive overview of the data, followed by the inferential statistics used to test the research hypothesis. The discussion then contextualizes these findings within the existing literature and theoretical frameworks, explores their implications, and acknowledges the study's limitations.

3.1. Presentation of Quantitative Results

The primary objective of the data analysis was to determine whether the intervention—a Brain-Based Learning (BBL) model assisted by Brain Gym—had a measurable effect on students' mathematical problem-solving abilities. The analysis began with a descriptive overview of the pretest and posttest scores.

Descriptive Statistics and N-Gain Analysis As summarized in Table 1, the data show a substantial improvement in student performance following the intervention. The mean score increased dramatically from 31.88 on the pretest to 65.15 on the posttest, representing an increase of over 100%. This upward trend was consistent across the entire performance spectrum, with the minimum score rising from 14 to 45 and the maximum score increasing from 57 to 85. Furthermore, the decrease in both the standard deviation (from 13.09 to 10.57) and the variance (from 171.47 to 111.82) suggests that the intervention not only improved overall performance but also helped to create a more homogenous distribution of scores, reducing the gap between the highest and lowest-achieving students.

Table 3. Descriptive Statistics and N-Gain Analysis

Statistic	Pretest	Posttest
Mean	31.88	65.15
Standard Deviation	13.09	10.57
Variance	171.47	111.82
Minimum Value	14	45
Maximum Value	57	85

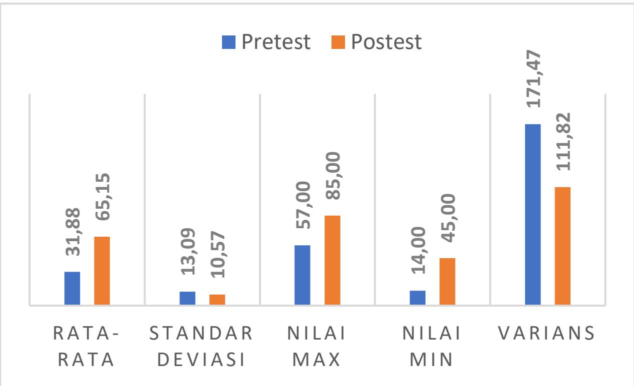

Figure 1. Graph of Percentage of Pretest and Posttest Values

To quantify the effectiveness of the intervention, a Normalized Gain (N-Gain) analysis was performed.

The calculation yielded a mean N-Gain score of **0.47**. According to the standard criteria for interpreting N-Gain scores, this value falls within the **"moderate"** range $(0{,}30 \leq g < 0{,}70)$. This indicates a meaningful and substantial improvement in students' problem-solving abilities, though it did not reach the "high" effectiveness threshold.

Before conducting the primary hypothesis test, a Shapiro-Wilk test confirmed that the data from both the pretest and posttest were normally distributed, satisfying a key assumption for parametric testing. Subsequently, a paired samples t-test was conducted to determine if the observed difference between pretest and posttest means was statistically significant.

The test yielded a calculated t-value of t_{count} = 11,222. For this study, with a sample size of 27 participants, the degrees of freedom were 26 (*df = n - 1*). At a significance level of α = 0,05, the critical t-value from the distribution table is t_{table} = 1,708. A comparison of these values shows that the calculated t-value is substantially greater than the critical t-value (11,222 > 1,708). Therefore, the null hypothesis (H_0), which posited no significant difference between the means, was **rejected**. This result confirms that the observed improvement in mathematical problem-solving scores was statistically significant ($p < 0{,}05$).

3.2. Discussion of Findings

The rejection of the null hypothesis provides a clear and affirmative answer to the research question: the Brain-Based Learning model assisted by Brain Gym does have a significant positive effect on students' mathematical problem-solving abilities. The discussion below interprets this central finding, compares it with existing literature, analyzes its nuances, and considers the study's limitations and implications.

The statistically significant improvement in student scores strongly suggests that the intervention was the primary driver of the observed academic growth. This finding lends empirical support to the theoretical foundations of Brain-Based Learning. BBL posits that learning is optimized when instructional methods align with the brain's natural processes of engagement, pattern recognition, and meaning-making. By creating a more stimulating, emotionally positive, and physically active learning environment, the BBL model likely fostered deeper cognitive engagement than traditional, more passive teaching methods. The inclusion of Brain Gym exercises may have acted as a catalyst in this process. These movements are designed to enhance neural connectivity and prepare the brain for learning, potentially improving students' focus, reducing cognitive load, and increasing their readiness to tackle complex mathematical problems.

The results of this study are highly consistent with the broader body of research on brain-centric pedagogy.

- The finding aligns closely with **Azhari** (2021), who also found a moderate N-Gain (0.50) when applying a BBL model to teach physics concepts. This parallel suggests that the moderate level of effectiveness observed may be a consistent outcome of short-term BBL interventions across different STEM subjects.
- The significant effect is also in line with Fajriati (2016) and Habibi & Dewi (2023), both of whom found that combining BBL with Brain Gym yielded significant improvements in biology outcomes and mathematical communication, respectively. This reinforces the idea that the synergy between the cognitive framework of BBL and the physiological priming of Brain Gym is a potent combination.
- Furthermore, the results resonate (Irma et al., 2015); Kaharuddin et al, 2025), who reported that BBL enhanced critical thinking skills, and Hajati et al. (2023), who found it increased student motivation. The current study extends these findings by specifically linking the BBL model to the applied skill of mathematical problem-solving.

While the intervention was successful, the "moderate" N-Gain score is an important nuance that warrants further discussion. Several factors could explain why the effectiveness did not reach the "high" level.

1. Short Intervention Duration: The study was conducted over only three sessions. This is a very brief period in which to expect a fundamental shift in students' cognitive approaches to problem-solving. It is plausible that students were still in an adaptation phase, becoming accustomed to the new instructional style. A longer, more sustained intervention over several weeks or a full semester might yield a larger effect size as the principles of BBL become more deeply ingrained.
2. Novelty of the Approach: For students accustomed to traditional, teacher-centered instruction, the shift to a more active, student-driven BBL environment can be initially disorienting. The initial session was noted to be less than optimal as students adjusted to group dynamics and the new pedagogical structure. This initial learning curve may have tempered the overall measured gain.
3. Complexity of the Dependent Variable: Mathematical problem-solving is a high-level cognitive skill that relies on a combination of conceptual knowledge, procedural fluency, and strategic thinking. Improving such a complex skill is inherently more challenging than improving factual recall, and thus a moderate gain over a short period can be considered a substantial achievement.

A critical discussion requires acknowledging the study's limitations, which in turn provide clear directions for future research.

- A critical discussion requires acknowledging the study's limitations, which in turn provide clear directions for future research.
- Sample Size and Generalizability: The study was conducted with a small, purposively selected sample from a single school. This limits the generalizability of the findings to other populations and contexts. Future research should aim to replicate these findings with larger, more diverse samples across different demographic and geographic settings.
- Short-Term Measurement: The study measured the immediate impact of the intervention. It did not assess the long-term retention of the problem-solving skills. A longitudinal study that includes follow-up tests weeks or months after the intervention would be valuable to determine if the gains are sustained over time.

Based on these limitations, it is recommended that future research investigate the long-term effects of BBL and Brain Gym using robust experimental designs and larger samples. Additionally, qualitative research, such as student interviews and classroom observations, could provide deeper insights into the specific mechanisms through which this integrated approach enhances learning.

4. Conclusion

In conclusion, this study provides compelling preliminary evidence that the implementation of a Brain-Based Learning model, supplemented with Brain Gym exercises, has a statistically significant positive effect on the mathematical problem-solving abilities of seventh-grade students. The intervention successfully elevated student performance from pretest to posttest, confirming that pedagogical strategies grounded in the principles of neuroscience are highly effective for fostering complex cognitive skills in the mathematics classroom.

While the magnitude of the improvement was classified as moderate, this outcome represents a substantial achievement within the context of a short-term educational intervention. The novelty of this research lies in its integrated approach, which systematically combines the cognitive framework of Brain-Based Learning with the physiological priming of Brain Gym to specifically target and enhance the higher-order skill of mathematical problem-solving. This study moves beyond examining these components in isolation and provides a practical model for their synergistic application within a specific STEM discipline.

The findings contribute a valuable perspective to the field of mathematics education by demonstrating a practical, engaging, and low-cost strategy that educators can adopt to move beyond traditional instruction. This research reaffirms the profound importance of creating learning environments that are not only intellectually stimulating but also emotionally supportive and physically engaging. Ultimately, this study concludes that by aligning teaching methods with the natural learning processes of the brain, educators can unlock significant potential in their students and cultivate a deeper, more resilient capacity for solving complex problems.

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