Jurnal Konseling dan Pendidikan
Volume 12, Number 3 2024

Improving Indonesian students' mathematical literacy with brain-based learning: a comparative study of pisa scores

Author Name(s): Thesa Kandaga, Elang Krisnadi, Suci Nurhayati, Valeria Yekti Kwasaning Gusti

Publication details, including author guidelines
URL: https://jurnal.konselingindonesia.com/index.php/jkp/about/submissions#authorGuidelines
Editor: Khairul Bariyyah

Article History
Received: 11 Jul 2024
Revised: 19 Aug 2024
Accepted: 28 Sep 2024

How to cite this article (APA)
Kandaga, T., Krisnadi, E., Nurhayati, S. & Gusti, V.Y .K. (2024). Improving Indonesian students' mathematical literacy with brain-based learning: a comparative study of pisa scores. Jurnal Konseling dan Pendidikan. 12(3), 99-111. https://doi.org/10.29210/1118500

The readers can link to article via https://doi.org/10.29210/1118500

The author(s) whose names are listed in this manuscript declared that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript. This statement is signed by all the authors to indicate agreement that the all information in this article is true and correct.

Jurnal Konseling dan Pendidikan
ISSN 2337-6740 (Print) | ISSN 2337-6880 (Electronic)

ISSN 2733-6740 (Print)
ISSN 2733-6880 (Electronic)

JKP Jurnal Konseling dan Pendidikan

iiCET Indonesian Institute for Counseling, Education and Therapy

Volume 12 Number 3 (2024)
https://doi.org/10.29210/1118500

Article

Improving Indonesian students' mathematical literacy with brain-based learning: a comparative study of pisa scores

Thesa Kandaga*), Elang Krisnadi, Suci Nurhayati, Valeria Yekti Kwasaning Gusti
Mathematics Education, Universitas Terbuka, Jakarta, Indonesia

ABSTRACT

This research is driven by Indonesia's comparatively low performance in the 2023 PISA assessment, which indicates a significant deficiency in students' capacity to solve literacy-based mathematical problems, largely attributable to the absence of comprehensive, structured guidance. This consequently gives rise to low levels of mathematical literacy, thereby underscoring the necessity for enhanced learning methodologies. The objective of this study is to evaluate the efficacy of the Brain-Based Learning (BBL) model in enhancing students' mathematical literacy abilities in comparison to the traditional learning approach. This study employed a quasi-experimental methodology with an unequal control group design. The research subjects were 72 grade VIII students at SMPN 1 Baleendah, comprising 36 experimental group students (grade VIII K) and 36 control group students (grade VIII L). The data were obtained through mathematical literacy tests and subsequently analysed using descriptive and inferential statistics with the assistance of IBM SPSS 24.0 software. The results of the n-gain analysis indicated that the data were normally distributed with homogeneous variances. The results of the independent sample t-test indicated a statistically significant difference in the improvement of mathematical literacy skills between the two groups, with the BBL group exhibiting a greater degree of improvement than the conventional method. These findings contribute to the scientific literature on the effectiveness of the Brain-Based Learning (BBL) model in addressing low mathematical literacy in Indonesia, with statistically significant improvements. This research provides new insights into the application of brain-based learning models in the Indonesian educational context.

Keywords:

Literacy,
Quasi experiment,
Brain-based learning,
Mathematic,
Indonesian secondary education

Corresponding Author:

Thesa Kandag.
Universitas Terbuka
Email: thesa.official@ecampus.ut.ac.id

Introduction

The impetus for this study was Indonesia's underperformance in the PISA 2023 assessment, which revealed considerable deficiencies in students' capacity to solve literacy-based mathematical problems. One of the principal factors contributing to this issue is the dearth of comprehensive and structured guidance in the mathematics learning process, which has resulted in low levels of mathematical literacy. In the context of developing higher-order thinking skills (HOTS), mathematical literacy is becoming increasingly important, as these skills facilitate students' comprehension and resolution of complex problems, which is a pivotal demand in the PISA evaluation (Gumrowi, 2020).

The objective of this study is to evaluate the efficacy of the Brain-Based Learning (BBL) model in enhancing students' mathematical literacy abilities when compared to the conventional learning approach. The methodology employed was a quasi-experimental design with an unequal control group (Intasena et al., 2023). The research subjects comprised 72 grade VIII students at SMPN 1 Baleendah, with 36 students in the experimental group (grade VIII K) and 36 students in the control group (grade VIII L). Data were obtained through mathematical literacy tests and analysed using descriptive and inferential statistics with the assistance of IBM SPSS 24.0 software (Azzahra et al., 2024).

The results of the n-gain analysis indicated that the data were normally distributed with homogeneous variance. An independent sample t-test demonstrated a statistically significant difference in the improvement of mathematical literacy skills between the two groups, with the BBL group exhibiting greater improvement than the conventional method. These findings contribute to the scientific literature on the effectiveness of the BBL model in addressing low mathematics literacy in Indonesia, as well as providing new insights into the application of brain-based learning models in the Indonesian educational context (Sugiarti et al., 2021).

It is, however, important to note that Indonesia's relatively poor performance in the Programme for International Student Assessment (PISA) has prompted the introduction of a number of educational policies, including the strengthening of character education (PPK) and the implementation of 21st-century skills such as 4C (critical thinking, creativity, collaboration and communication) in the national curriculum (PISA., 2012). Despite the implementation of these policies, the direct relationship between them and the improvement of mathematical literacy remains underexplored in the literature. Furthermore, this study emphasises the necessity for continuous reforms in mathematics teaching practices, in line with the PISA results that consistently demonstrate deficiencies in mathematical literacy in Indonesia from 2003 to 2022.

Mathematical literacy constitutes an essential element of the problem-solving process, particularly within the context of evolving educational paradigms. Nevertheless, the level of mathematical literacy achievement among students in several regions of Indonesia remains relatively low (Mukhlis et al., 2024). To illustrate, the mean mathematical literacy score in Medan was 26.8, in Bandung 28.0, in Samarinda 31.9, in Kendari 19.4, in Palembang 21.0, in Kupang 25.8, and in Yogyakarta 33.0. The mean scale was 50, with a standard deviation of 10 (-- & --, 2014). The data illustrates significant disparities between regions that require further attention. Factors such as access to education, teaching quality and socio-economic conditions may contribute to these differences in results, although they are not analysed in depth in the data presented (Tuti Isnani et al., 2023).

Moreover, while this data is undoubtedly important, its relevance to the main focus of the study, namely the application of Brain-Based Learning, is less clear (Mumtazah et al., 2024). It is necessary to elucidate how this approach can provide a solution to the low mathematical literacy scores in these areas. The integration of an analysis of the factors influencing achievement disparities with Brain-Based Learning strategies could serve to reinforce the argument and the relevance of this study. The emphasis on how Brain-Based Learning can assist students in achieving superior results, particularly in problems that require complex cognitive processes, as demonstrated by Mardiansyah & Rahmawati (2014), would facilitate a more unified discussion.

A number of previous studies have demonstrated that the mathematical literacy abilities of secondary school students in Indonesia remain at a relatively low level. To illustrate, research conducted by Rifai & Wustqa (2017) in Bantul District classified students' mathematical literacy skills as either low or very low, with 38.77% falling into the former category and 61.23% into the latter. Furthermore, mathematical literacy skills in the domains of number, probability and data were classified as moderate, whereas algebra and geometry were placed in the low and very low categories. This research demonstrates that there are significant challenges in mathematical literacy across various content domains (Rifai & Wutsqa., 2017).

Another study by Purwasih et al. (2018) in Bandung corroborates these findings, with students achieving a score of only 30 out of a maximum of 100, significantly below the Minimum Completion Criteria (KKM) average of 70. Of the 33 students, only 15 achieved the KKM. This low score was attributed to the students' difficulty in solving the mathematical literacy problems posed, particularly those at level 4, which is classified as low. While these findings highlight a significant challenge in mathematical literacy, there has been limited exploration of effective approaches to address this issue. Other studies have attempted alternative approaches, but their efficacy is constrained. This is where the Brain-Based Learning (BBL) approach may offer a potential solution. In contrast to traditional pedagogical approaches, the Brain-Based Learning (BBL) method is predicated on the premise that cognitive abilities can be developed in accordance with the natural workings of the brain, thereby enhancing mathematical understanding. The rationale for utilising BBL is grounded in neuropsychological research findings that emphasise the pivotal role of brain processing in learning. Consequently, the selection of BBL as an alternative teaching method is based on compelling evidence from these studies that indicate the necessity for innovative strategies to improve mathematical literacy (Suharja et al., 2024).

Yusepa (2016) posited that the creation of meaningful learning necessitates the application of diverse learning models by educators (Yusepa, 2016). In order to enhance students' mathematical learning outcomes, it is essential to implement learning models that foster student engagement and participation (Setiani, 2018). One of the most pertinent models for enhancing mathematical literacy abilities is Brain-Based Learning (BBL) (Jensen, 2011). As posited by Caine and Caine (Sukoco & Mahmudi, 2016), BBL represents a pedagogical approach that is congruent with the intrinsic workings of the brain, with the objective of facilitating meaningful learning, as opposed to mere memorization. This model underscores the significance of harnessing the full spectrum of brain functions, accounting for the heterogeneity of students' learning styles, and underscoring the pivotal role of emotional and multisensory environments in the learning process

In particular, BBL incorporates principles such as experiential learning, the utilisation of multiple senses to reinforce concept comprehension, and the establishment of an emotionally secure learning milieu. In the context of learning mathematics, these principles facilitate greater student involvement, encourage the use of diverse approaches to concept understanding, and foster the development of critical thinking skills. Empirical studies, such as those conducted by Wardono and Kurniasih, provide evidence of the effectiveness of BBL in enhancing students' mathematical literacy abilities. This is achieved by strengthening communication, representation, and conceptual understanding through more dynamic interactions between students and a focus on problem-solving.

Additionally, other studies, such as those conducted by Zakkia et al. (2019) and Kuswidi (2015), demonstrate that BBL can facilitate the development of mathematical literacy to a greater extent than conventional models. The Brain-Based Learning (BBL) approach encourages students to think comprehensively by exercising curiosity, investigation, and mathematical reasoning in solving problems from various contexts. This is in line with the stages in BBL, such as the preparation step that stimulates investigation and the elaboration step that leads students to formulate mathematical reasoning and use concepts and procedures to solve problems (Kuswidi, 2015). In light of the aforementioned theoretical foundation and empirical evidence, the present study seeks to ascertain whether the implementation of the Brain-based Learning (BBL) model can markedly enhance students' mathematical literacy abilities when compared to the conventional learning model. To this end, an experimental design will be employed to assess the efficacy of BBL, with the improvement of students' mathematical literacy skills serving as a key indicator of learning success.

Methods

The research method employed in this study was a quasi-experimental design with a nonequivalent control group. Although this design is frequently employed in educational research, it is susceptible to a significant limitation: the potential for selection bias, given that the groups are not randomly selected. This can compromise the internal validity of the study. To mitigate this potential bias, it is essential for researchers to elucidate the measures taken to minimise its impact. This may entail controlling for confounding variables or paying attention to the baseline characteristics of students in both groups. The study population comprised secondary school students in Indonesia, sampled using the convenience sampling technique, which was selected based on the convenience of the collaborating schools. However, this technique is often considered to be underrepresentative and may affect the external validity of the research results. Researchers should provide specific reasons why this technique was chosen, as well as how its limitations are taken into account in the interpretation and generalisation of the results.

The study subjects comprised 72 eighth-grade students from a secondary school in Indonesia. However, the researcher did not provide detailed information regarding the characteristics of the sample, such as gender distribution, prior academic achievement, or socio-economic background, which may affect the results, especially in a study comparing two teaching approaches. The research subjects were divided into two groups: an experimental group that learnt mathematics using the Brain-Based Learning model, and a control group that used conventional learning. The mathematics topic taught was statistics.

The experimental group was instructed using the Brain-Based Learning model; however, the researcher did not provide a detailed account of the specific methodology employed in the classroom, including the precise steps or adaptations made to the subject matter. A more detailed account of the implementation of the Brain-Based Learning model is required to ensure that the model is applied in accordance with the underlying theoretical principles. Furthermore, it is essential to ascertain whether the teachers in both groups were the same or different. In the event that the teachers are different, potential bias due to differences in teaching quality must be considered. The intervention was conducted over three sessions, with a total duration of six lesson hours. While this provides an initial insight into the effectiveness of the Brain-Based Learning model, the relatively short intervention period may be a limitation in evaluating the long-term impact of this model on improving mathematical literacy. It is often the case that changes in cognitive skills require a longer period of time to become significant.

A pretest was employed by the researcher to ascertain the students' initial abilities prior to the administration of the treatment, while a posttest was utilized to evaluate the extent of the intervention's impact on their final abilities. The instrument employed was a mathematical literacy test. The data were analysed using descriptive statistics to provide an overview of the pretest and posttest results and inferential statistics to draw more in-depth conclusions. Prior to conducting the mean difference test between the experimental and control groups, a normality test using the Shapiro-Wilk test and a homogeneity test using the Levene test were conducted. Should the data meet the assumptions of normality and homogeneity, the analysis proceeded with the t-test for independent samples; otherwise, non-parametric analyses were employed. All analyses were conducted with the assistance of IBM SPSS 24.0 for Windows software.

Results and Discussion

Pretest

Before the commencement of the learning process in the experimental class, which employed the Brain-Based Learning model, and the control class, which used the conventional teaching model, namely the expository learning model, the researchers first administered a pretest to the students. The data collected from the pretest results of both classes were then processed and analyzed using statistics as follows:

Table 1. Pretest Descriptive Statistics of Mathematical Literacy

Group	N	Maximum	Minimum	Mean	Std. dev.	Variance
Experimental	36	16,00	2,00	7,861	3,424	11,723
Control	36	16,00	2,00	7,250	3,442	11,850

Note: Ideal Maximum Score = 50

Based on Table 1 above, the experimental class obtained a maximum score of 16.00, a minimum score of 2.00, a mean of 7.861, a standard deviation of 3.424, and a variance of 11.723, while the control class achieved a maximum score of 16.00, a minimum score of 2.00, a mean of 7.250, a standard deviation of 3.442, and a variance of 11.850. In assessing the significant difference regarding the mathematical literacy abilities of the experimental and control class students before treatment, it was necessary to conduct inferential statistical tests. The first analysis conducted was the normality test with the hypothesis of normality test of pretest data for the experimental and control classes as follows:

H0: The pretest data of the control class and the experimental class were normally distributed.
Ha: The pretest data of the control class and the experimental class were not normally distributed.

The output of the normality test can be seen in Table 2 below.

Table 2. Pretest Normality Test

Tests of Normality				
Group		Shapiro-Wilk		
		Statistic	Df	Sig.
Score	Experiment	.972	36	.491
	Control	.946	36	.079

Based on the results of normality test output in Table 2, it was obtained that the significance value of the initial test data (pretest) for the experimental class was 0.491 and for the control class was 0.079. In this regard, since both classes have significance values > 0.05, it is concluded that H0 is accepted and Ha is rejected, thus indicating that the pretest data for both the experimental and control classes are normally distributed.

Based on the normality test results, the pretest data indicates that both classes are normally distributed, thus the analysis proceeded by testing the homogeneity of the two pretest data variances between the experimental and control classes using Levene's test with a significance level of 0.05. The hypothesis for testing the homogeneity of the two pretest data variances for both classes are as follows:

H0: The pretest variances for both research classes are homogeneous (equal)
Ha: The pretest variances for both research classes are not homogeneous (different)

The output of the homogeneity test of the two variances can be seen in Table 3.

Table 3. Homogenity Test for Pretest

Test of Homogeneity of Variances Score			
Levene Statistic	df1	df2	Sig.
.014	1	70	.905

Based on the homogeneity test output in Table 3, a significance value of 0.905 was obtained. In this regard, since the significance value is > 0.05, it can be concluded that H0 is accepted and Ha is rejected, indicating that the pretest data for both the experimental and control classes have homogeneous variances or originate from populations with the same variance. Based on the results of the normality test and homogeneity test, it is found that the pretest data for both the experimental and control classes have a normal distribution and have the same or homogeneous variance.

Therefore, the next step involves conducting a test of equality of means (t-test) with a significance level of 0.05. The formulation of the hypothesis in the form of statistical hypothesis is as follows:

$$H_0: \mu_1 = \mu_2$$
$$H_a: \mu_1 \neq \mu_2$$

Notes:

Ho: There was no significant difference in the initial mathematical literacy abilities between the experimental and control classes in the pretest.

Ha: There was a significant difference in the initial mathematical literacy abilities between the experimental and control classes in the pretest.

The output of the Independent Sample t-test can be observed in Table 4 below.

Table 4. Independent Sample t-test for Pretest

		t-test for Equality of Means						
		t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
							Lower	**Upper**
Score	Equal variances assumed	.755	70	.453	.61111	.80920	-1.00279	2.22501

Based on the results of the t-test output for the pretest data in Table 4 above, a significance value (sig. 2-tailed) of 0.453 was obtained. In this regard, since the significance value is greater than 0.05, it can be concluded that Ho is accepted and Ha is rejected, indicating that there is no significant difference in mathematical literacy abilities between the experimental and control classes in the pretest.

Posttest

After being given the treatment, the students were administered a final test (posttest) to assess the final mathematical literacy abilities of the students from both the experimental and control classes. The data collected from the posttest results were then processed using the following statistical analysis:

Table 5. Postest Descriptive Statistics of Mathematical Literacy

Group	N	Maximum	Minimum	Mean	Std. Dev.	Variance
Eksperimen	36	49,00	27,00	39,361	4,704	22,123
Kontrol	36	41,00	16,00	30,583	6,716	45,107

Note: Ideal Maximum Score = 50

Based on Table 5 above, the experimental class obtained a maximum score of 49.00, a minimum score of 27.00, a mean of 39.361, a standard deviation of 4.704, and a variance of 22.123, while the control class had a maximum score of 41.00, a minimum score of 16.00, a mean of 30.583, a standard deviation of 6.716, and a variance of 45.107. In examining the significant differences regarding the mathematical literacy abilities between the experimental and control classes after receiving treatment, it is necessary to conduct inferential statistical tests. The first analysis conducted is the normality test with the hypotheses for the normality test of the posttest data for the experimental and control classes as follows:

Ho: The posttest data for both the control and experimental classes are normally distributed.
Ha: The posttest data for both the control and experimental classes are not normally distributed.

The output of the normality test can be seen in Table 6 below.

Table 6. Postest Normality Test

Tests of Normality				
	Group	Shapiro-Wilk Statistic	Df	Sig.
Score	Experiment	.954	36	.136
	Control	.950	36	.108

Based on the results of the normality test output in Table 6 above, the significance value of the final test (posttest) data for the experimental class is 0.136 and for the control class is 0.108. In this regard, since both classes have significance values > 0.05, it is concluded that Ho is accepted and Ha is rejected, indicating that the posttest data for both the experimental and control classes are normally distributed. Due to both classes are normally distributed, thus the analysis proceeded by testing the homogeneity of the two posttest data variances between the experimental and control classes using Levene's test with a significance level of 0.05. The hypothesis for testing the homogeneity of the two posttest data variances for both classes are as follows:

Ho: The posttest variances for both research classes are homogeneous (equal)
Ha: The posttest variances for both research classes are not homogeneous (different)

The output of the homogeneity test of the two variances can be seen in Table 7 below.

Table 7. Homogenity Test for Postest

Test of Homogeneity of Variances Score			
Levene Statistic	df1	df2	Sig.
3.013	1	70	.905

Based on the homogeneity test results in Table 7 above, a significance value of 0.087 was obtained. In this regard, since the significance value is greater than 0.05, it can be concluded that Ho is accepted and Ha is rejected, indicating that the posttest data for both the experimental and control classes have homogeneous variances or originate from populations with the same variance. Due to the posttest data for both the experimental and control classes have a normal distribution and have the same or homogeneous variance. Therefore, the next step involves conducting an equality of means test (t-test) with a significance level of 0.05. The formulation of the hypothesis in the form of statistical hypothesis is as follows:

$$H_0: \mu_1 \leq \mu_2$$
$$H_a: \mu_1 > \mu_2$$

Notes:
Ho: There is no significant difference in the initial mathematical literacy abilities between the experimental and control classes in the final test (posttest).
Ha: There is a significant difference in the initial mathematical literacy abilities between the experimental and control classes in the final test (posttest).

The output of the Independent Sample T-Test can be seen in Table 8 below.

Table 8. Independent Sample t-test for Postest

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Score	Equal variances assumed	6.423	70	.000	8.77778	1.36657	6.05225	11.50331

Based on the results of the t-test output in Table 8 above, a significance value (sig. 2-tailed) of 0.000 was obtained with a one-tailed hypothesis test. Therefore, the proposed significance value is half of 0.000, which is 0.000. In this regard, since the significance value is less than 0.05, it can be concluded that Ha is accepted and H0 is rejected, indicating that there is a significant difference in mathematical literacy abilities between the experimental and control classes in the posttest. Furthermore, as the posttest data shows differences in mathematical literacy abilities, normalized gain (n-gain) data is utilized to determine the improvement in mathematical literacy abilities.

The results of the analysis indicated that the pretest data were normally distributed and exhibited homogeneous variances. The results of the independent sample t-test indicated that there was no statistically significant difference in the initial mathematical literacy skills between students in the experimental and control groups. This suggests that the initial abilities of students in both groups were similar (Effendi & Marlina, 2021). Following the pretest, the two groups employed different learning models: the experimental group utilized the Brain-Based Learning model, whereas the control group employed the conventional learning model, namely expository. The learning process in both groups spanned three meetings, or approximately six lesson hours (Kaewkumsai & Phusee-orn, 2024).

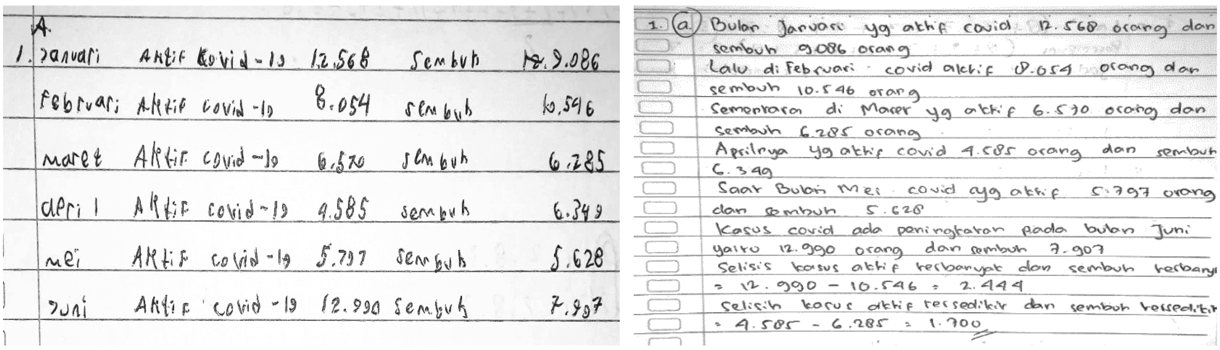
The dynamics of the learning sessions in the experimental class exhibited variability from one meeting to the next. In the initial session, the students appeared to be unfamiliar with the steps of the Brain-Based Learning model, necessitating more comprehensive guidance from the instructor (Susanti et al., 2019). In the second session, the students began to adapt to the learning model, demonstrating increased engagement in the learning process through their active questioning when encountering difficulties. This resulted in a more interactive classroom atmosphere. In the third session, students demonstrated an enhanced capacity to collaborate in groups and engage in more active discourse regarding the completion of the Learner Worksheet (LKPD). The provision of this LKPD encourages students to construct knowledge autonomously with teacher guidance (Riskiningtyas & Wangid, 2019). Furthermore, the opportunity to express mathematical ideas facilitated deeper comprehension of the material, as evidenced by the active discussions that took place among students (Kandaga, 2017). This aligns with the findings of Satria & Zanthy (2019), who asserted that discussions between students can enhance mathematics learning activities, fostering a more meaningful classroom atmosphere (Satria & Zanthy., 2019).

Figure 1. How Student Discuss in Experimental Group

In contrast to students in the control class, those in the teaching and learning activities tended to appear more passive. It was evident in every session, showing a lack of student response during learning, and students tended to only do what was directed by the teacher without any initiative (Xu et al., 2024). This was because students only received material explained by the teacher, leading to one-way learning. Students also became less able to explore mathematical ideas due to a lack of exchanging ideas and being accustomed to receiving knowledge only as conveyed by their teacher.

From these two teaching and learning activities, it was apparent that students in the experimental class were more active and dominated the class compared to those in the control class (Leahy & Smith, 2021).

Subsequently, after the treatment was given, both classes were administered a final test (posttest) consisting of mathematical literacy questions similar to those in the initial test (pretest). The results of the posttest data analysis indicated differences between students who received Brain Based Learning models and those who received conventional teaching models, in this case, the expository teaching model (Mastoni, 2019). This could be observed from the quality of the students' answers when responding to questions. One example is the answer to question number 1 part a, which involves identifying mathematical aspects in problems found in real context situations and identifying important variables (Jazuli et al., 2019). In the question, students were asked to elaborate on the information they obtained based on known table data. An example of one student's answer to question number 1 part a is shown in Figure 2 below.

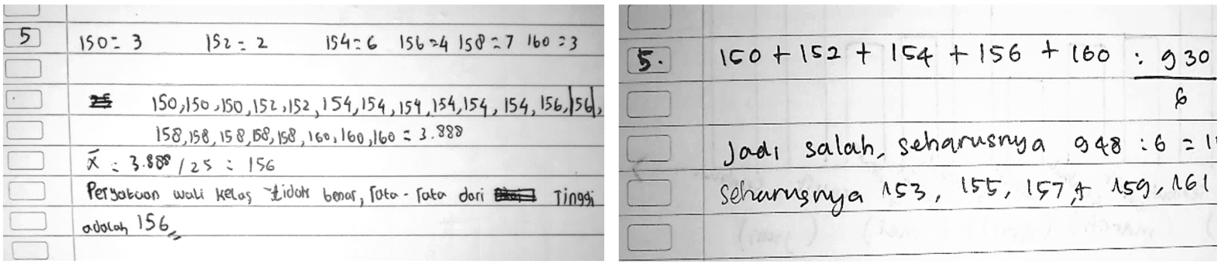


(a) Control Group (b) Experimental Group

Figure 2. Student Answer Sheet for Statistics Problem in Postest

In contrast, the control class exhibited a more passive learning process. The classroom interaction was predominantly one-way, with students following the teacher's instructions without initiating questions or discussions. This limited students' exploration of mathematical ideas and their capacity to develop their knowledge. Consequently, the classroom atmosphere was less dynamic than that observed in the experimental class (-, 2024). Following the learning intervention, both classes were subjected to a post-test comprising mathematical literacy questions analogous to those included in the pre-test. The results of the post-test demonstrated a notable discrepancy between the two groups of students, namely those who had received instruction through the Brain-Based Learning model and those who had been taught using the expository method. One illustrative example can be observed in response to question number one, part A, which required students to identify mathematical aspects of real-world problems.

The experimental class demonstrated a greater capacity to provide detailed responses and to elaborate on their knowledge in order to solve the problem. This is in line with the findings of Zakkia et al. (2019), which indicate that the Brain-Based Learning model facilitates the development of communication and concentration in learning mathematics. In contrast, the control class exhibited a tendency to simply reproduce information from the problem without developing a deeper understanding, which suggests a lack of interaction during the learning process. (Nabillah & Agung, 2019). In addition to the posttest answers to question number 1, there are also answers to question number 5 with indicators of interpreting mathematical results obtained and evaluating the reasonableness of mathematical solutions in the context of real-world problems. The posttest answers from students to question number 5 are as shown in Figure 3 below.



(a) Control Group (b) Experimental Group

Figure 3. Student Answer Sheet for Evaluating Answers Reasonableness in a Problem

Based on Figures 3(a) and 3(b), in the experimental group, it can be observed that students provided answers that were slightly different from the researchers' expectations because the students' work did not provide detailed explanations of what was known and asked in the questions. However, the students' solutions demonstrated correct answers (Anang Taufik et al., 2019). These students were able to interpret the mathematical results obtained and evaluate the statements in the questions by elaborating on their answers and providing sound conclusions. This aligns with the statement by Kholifasari et al. (2020) that students with high literacy skills are able to interpret and evaluate results quite well even though they may have difficulty providing logical reasoning (Kholifasari et al., 2020). Additionally, upon reviewing the answers of both students, it is evident that students in the experimental group were more accurate in answering the questions compared to those in the control group.

Students in the experimental group were able to respond based on the questions asked in the problems and provide appropriate conclusions. Meanwhile, students in the control group answered less accurately when elaborating and concluding their answers. This is consistent with the statement by Dila & Zanthy (2020) that students who do not understand the material will struggle in its application, where they cannot perform calculations quickly and do not provide accurate conclusions (Dila & Zanthy, 2020). Furthermore, looking at the work of students in the control group who did not interpret what was known in the questions, their solutions were consequently off-target. This indicates that these students lack good thinking patterns, which affects their understanding in solving problems. This statement is in line with the research by Zuhri et al. (2013), which states that students who tend to answer without understanding the concept of statistics may affect the development of students' thinking processes (Zuhri, 2013).

A similar outcome was observed in posttest question number 5, which requires students to interpret and evaluate the reasonableness of mathematical solutions in real contexts. The responses of the experimental class were, on the whole, more accurate, although they lacked a certain degree of detail. Nevertheless, they were able to provide conclusions that were appropriate to the question. In contrast, the students in the control class experienced difficulty in providing appropriate answers, which is indicative of their continued lack of understanding of the material. This finding is in accordance with Dila & Zanthy's (2020) assertion that students who have difficulty understanding the material will face difficulties in its application.

Following the analysis of the final test, an n-gain analysis was conducted to assess the enhancement of mathematical literacy abilities. The results demonstrated that the growth in mathematical literacy of students utilising the Brain-Based Learning model was more pronounced than that of students employing the expository model. This finding aligns with the findings of Wafi (2017), which indicated that the Brain-Based Learning approach can markedly enhance mathematical literacy skills in comparison to conventional learning. It is important to acknowledge the limitations of this study. Firstly, there is a possibility of teacher bias in the implementation of learning, as well as a limited intervention time of only three sessions. Secondly, the use of convenience sampling may affect the generalisation of the results. These limitations should be considered in further research to provide more in-depth and accurate results (Wafi, 2017).

Conclusion

The findings of the study indicated that the Brain-Based Learning (BBL) model demonstrated superior efficacy in enhancing students' mathematical literacy abilities when compared to the traditional learning approach, with a statistical significance level of 5%. Nevertheless, further investigation is required to substantiate this conclusion. Although students who used BBL demonstrated superior abilities in answering questions, elaborating on cognitive processes, and exploring knowledge to solve problems, the author has not provided more specific details on the magnitude of the observed improvement between the two groups. Furthermore, the authors have not provided a critical reflection on the limitations of the study, such as the short duration of the intervention or the possibility of sampling bias. To strengthen this study, the authors should also provide concrete recommendations regarding the implementation of BBL on a wider scale in various educational contexts, as well as suggest the need for further research to explore the long-term effects of this method. A more significant contribution to related educational literature and practice would be made by more specific and reflective conclusions.

References

M., & --, R. (2014). Literasi Matematika Siswa Pendidikan Menengah: Analisis Menggunakan Desain Tes Internasional dengan Konteks Indonesia. Jurnal Pendidikan Dan Kebudayaan, 20(4), 452–469. https://doi.org/10.24832/jpnk.v20i4.158

N. F. A. B. (2024). Brain-based Learning in Physics of Grade 7 Students. *International Journal For Multidisciplinary Research*, *6*(3). https://doi.org/10.36948/ijfmr.2024.v06i03.22826

Anang Taufik, M., Mulyoto, Sunardi, & Suryani, N. (2019). The Effectiveness of Mathematic Learning Materials Based on Contextual Teaching and Learning. *Journal of Physics: Conference Series*, *1339*(1), 012133. https://doi.org/10.1088/1742-6596/1339/1/012133

Azzahra, W., Diana, S., & Nuraeni, E. (2024). Enhancing students' numeracy literacy in human heredity material through a brain-based learning model. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan*, *6*(2), 257. https://doi.org/10.20527/bino.v6i2.19527

Dila, O. R., & Zanthy, L. S. (2020). Identifikasi Kesulitan Siswa Dalam Menyelesaikan Soal Aritmatika Sosial. Teorema: Teori Dan Riset Matematika, 5(1), 17. https://doi.org/10.25157/teorema.v5i1.3036

Effendi, K. N. sania, & Marlina, R. (2021). The Effect Of Motivation Towards Mathematical Communication In Mathematics Learning With Brain-Based Learning Model. *Aksioma: Jurnal Program Studi Pendidikan Matematika*, *10*(2), 808. https://doi.org/10.24127/ajpm.v10i2.3488

Gumrowi, A. (2020). Mengembangkan Rencana Pelaksanaan Pembelajaran (RPP) Abad 21 Melalui Individual Conference. Syntax Literate ; Jurnal Ilmiah Indonesia, 5(1), 1. https://doi.org/10.36418/syntax-literate.v5i1.851

Intasena, A., Nuangchalerm, P., & Srimunta, T. (2023). Brain-based learning management in primary students: Language literacy studies. *International Journal of Advanced And Applied Sciences*, *10*(6), 107–112. https://doi.org/10.21833/ijaas.2023.06.013

Jazuli, L. O. A., Solihatin, E., & Syahrial, Z. (2019). The Effect of Brain Based Learning Strategies and Project Based Learning on Mathematics Learning Outcomes in Students of the Kinesthetic Learning Style Group. *International Journal of Engineering and Advanced Technology*, *8*(6s3), 373–377. https://doi.org/10.35940/ijeat.F1064.0986S319

Jensen, E. (2011). Pembelajaran Berbasis Otak Paradigma Pembelajaran Baru.

Kaewkumsai, K., & Phusee-orn, S. (2024). Developing Achievement in Mathematics, Specifically in Elementary Logic, through Brain-Based Learning (BBL) Combined with Skill Practice Exercises for Grade 10 Students. *Higher Education Studies*, *14*(2), 130. https://doi.org/10.5539/hes.v14n2p130

Kandaga, Thesa. (2017). Penerapan Model Pembelajaran Time Token untuk Meningkatkan Kemampuan Pemahaman Dan Disposisi Matematis Siswa SMA. . Edumatica. 7(1): Hlm. 21-28.

Kholifasari, R., Utami, C., & Mariyam, M. (2020). Analisis Kemampuan Literasi Matematis Siswa Ditinjau Dari Karakter Kemandirian Belajar Materi Aljabar. Jurnal Derivat: Jurnal Matematika Dan Pendidikan Matematika, 7(2), 117–125. https://doi.org/10.31316/j.derivat.v7i2.1057

Kuswidi, I. (2015). Brain-Based Learning Untuk Meningkatkan Literasi Matematis Siswa. Al-Jabar : Jurnal Pendidikan Matematika, 6(2), 195–202. https://doi.org/10.24042/ajpm.v6i2.49

Leahy, K. S., & Smith, T. D. (2021). The self-directed learning of adult music students: A comparison of teacher approaches and student needs. *International Journal of Music Education*, *39*(3), 289–300. https://doi.org/10.1177/0255761421991596

Mastoni, E. (2019). The Brain Based Learning (BBL) and Intrapersonal Intelligence for Mathematics Learning in Junior High School. *Asia Proceedings of Social Sciences*, *4*(3), 17–19. https://doi.org/10.31580/apss.v4i3.815

Mukhlis, M., Sa'dijah, C., Sudirman, S., & Irawati, S. (2024). Students' Thinking Literacy Process in Mathematical Problem-Solving. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 2337–2345. https://doi.org/10.29303/jppipa.v10i5.7676

Mumtazah, N. W., Dahlan, J. A., & Mulyaning A., E. C. (2024). Students' Perceptions of Mathematics Learning Based on Their Brain Domination Group. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *8*(2), 1060–1072. https://doi.org/10.31004/cendekia.v8i2.3142

Nabillah, & Agung. (2019). Faktor Penyebab Rendahnya Hasil Belajar Siswa. . Sesiomadika. Hlm. 660-663.

PISA. (2012). PISA 2012 Assessment and Analytical Framework Mathematics, Reading, Science, Problem Solving and Financial Literacy. OECD.

Purwasih, dkk. (2018). Analisis Kemampuan Literasi Matematik dan Mathematical Habits of Mind Siswa SMP pada Materi Bangun Ruang Sisi Datar. Jurnal Numeracy. 5(1): Hlm. 67-76.

Pusat Penilaian Pendidikan Balitbang Kemendikbud. (2019). Laporan Nasional 2018 Indonesia.

Rifai & Wutsqa. (2017). Kemampuan Literasi Matematika Siswa SMP Negeri Se-Kabupaten Bantul. Jurnal Pendidikan Matematika Dan Sains. 5(2): Hlm. 152-162.

Riskiningtyas, L., & Wangid, M. N. (2019). Students' self-efficacy of mathematics through brain based learning. *Journal of Physics: Conference Series*, *1157*, 042067. https://doi.org/10.1088/1742-6596/1157/4/042067

Satria & Zanthy. (2019). Peningkatan Aktivitas dan Prestasi Belajar Matematika melalui Model Pembelajaran Jigsaw. Journal on Education. 3(1): Hlm. 166- 172.

Setiani, A. (2018). Penerapan Model Pembelajaran Brain Based Learning Untuk Meningkatkan Hasil Belajar Matematika Siswa. Symmetry: Pasundan Journal of Research in Mathematics Learning and Education. https://doi.org/10.23969/symmetry.v3i1.861

Sugiarti, L., Purwanto, A., & Sumantri, M. S. (2021). Literature Study of the Application of Brain Based Learning (BBL) Learning Models to Environmental Science Literacy. *International Journal of Multicultural and Multireligious Understanding*, *8*(2), 374. https://doi.org/10.18415/ijmmu.v8i2.2349

Suharja, S., Mustadi, A., & Oktari, V. (2024). Examining Brain Based Learning Models Assisted Open-Ended Approach To Mathematics Understanding Concept. *Jurnal Prima Edukasia*, *12*(1), 19–29. https://doi.org/10.21831/jpe.v12i1.67303

Sukoco, H., & Mahmudi, A. (2016). Pengaruh Pendekatan Brain-Based Learning terhadap Kemampuan Komunikasi Matematis dan Self-Efficacy Siswa SMA. PYTHAGORAS: Jurnal Pendidikan Matematika, 11(1), 11. https://doi.org/10.21831/pg.v11i1.9678

Susanti, V. D., Adamura, F., Lusiana, R., & Andari, T. (2019). Development of learning devices: brain-based learning and mathematics critical thinking. *Journal of Physics: Conference Series*, *1254*(1), 012082. https://doi.org/10.1088/1742-6596/1254/1/012082

Tuti Isnani, Hendri Handoko, & Saluky. (2023). Analysis of Students' Mathematical Literacy Ability in Solving Mathematical Problems in View of Logical Intelligence. *Educational Insights*, *1*(2), 41–57. https://doi.org/10.58557/eduinsights.v1i2.9

Wafi, M. S. (2017). Peningkatan Kemampuan Literasi dan Disposisi Matematis Siswa SMP melalui Pembelajaran Matematika dengan Pendekatan Brain Based Learning. .

Xu, X., Li, Z., Mackay, L., Li, N., Zhang, Y., Wu, Y., & Zhang, Y. (2024). The state of health professions students' self-directed learning ability during online study and the factors that influence it. *BMC Medical Education*, *24*(1), 25. https://doi.org/10.1186/s12909-023-04876-z

Yusepa, B. G. P. (2016). Analisis Perbandingan Kurikulum Pendidikan Indonesia dan Inggris untuk Meningkatkan Kompetensi Pe-dagogik dan Kompetensi Pro-fesional Guru Matematika. . Prosiding Seminar Nasional Matematika Dan Pendidikan Matematika:Strategi Mengembangkan Kua-Itas Pembelajaran Matematika Berbasis Riset. Hlm: 346-364.

Zuhri, M. S. , & A. K. , dkk. (2013). Karakteristik penalaran siswa kelas XI Sekolah Menengah Atas tentang sampel. . Jurnal Pembelajaran Matematika. 1(1): Hlm. 24-33.