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Implementation of Brain-Based Learning to Reduce Mathematics Anxiety in the Teaching of Fractions at Primary School

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Abstract
This research examines the application of the Brain-Based Learning (BBL) model to reduce math anxiety in teaching fractions at the elementary school level. This study used a quantitative approach with a pretest–posttest quasi-experimental control group design involving two fifth-grade classes: one experimental class that received fraction instruction through BBL and one control class that was taught using conventional methods, with 40 students in each group. Mathematics anxiety related to fractions was measured using a modified mathematics anxiety scale for elementary school students, while fraction achievement was evaluated through a valid written test. The results showed that both groups had relatively equivalent initial abilities, supported by normal and homogeneous pretest data and no significant differences in pretest scores. After the intervention, the experimental class showed consistently lower levels of anxiety related to fractions in all dimensions (tests/assessments, classroom learning situations, fraction tasks, and fraction avoidance) and significantly higher post-test scores than the control class, with an average difference of about seven points. The findings show that BBL, which aligns the learning process with the way the brain naturally learns by fostering positive emotions, multisensory experiences, and meaningful social interaction, is effective in improving students' understanding of fractions while simultaneously reducing their math anxiety. This study offers a unique perspective by conducting an experimental trial of BBL as a targeted intervention for math anxiety related to fractions in Indonesian elementary schools and highlighting its potential as a neuroeducation-based pedagogical strategy to foster numeracy and emotional well-being in math learning.

Abstract
Penelitian ini bertujuan untuk mengkaji efektivitas model Brain-Based Learning (BBL) dalam menurunkan kecemasan matematika dan meningkatkan hasil belajar pada materi pecahan di sekolah dasar. Penelitian menggunakan pendekatan kuantitatif dengan desain kuasi eksperimen tipe pretest–posttest control group, melibatkan dua kelas V SD Negeri Sukalarang, masing-masing 40 siswa sebagai kelas eksperimen (BBL) dan kelas kontrol (pembelajaran konvensional). Kecemasan matematika pecahan diukur dengan skala kecemasan matematika yang telah dimodifikasi untuk siswa sekolah dasar, sedangkan hasil belajar pecahan diukur dengan tes uraian yang telah divalidasi. Hasil uji prasyarat menunjukkan data pretest dan posttest berdistribusi normal dan homogen, serta tidak terdapat perbedaan signifikan pada skor pretest antara kelas eksperimen dan kontrol. Setelah perlakuan, rata-rata kecemasan pecahan siswa kelas eksperimen lebih rendah pada seluruh dimensi (tes/penilaian, situasi belajar di kelas, tugas pecahan, dan penghindaran pecahan) dibandingkan kelas kontrol, dan nilai posttest hasil belajar pecahan kelas eksperimen secara signifikan lebih tinggi sekitar 7 poin daripada kelas kontrol. Temuan ini menunjukkan bahwa penerapan BBL, yang menekankan iklim belajar yang aman dan menyenangkan, pengalaman konkret–visual, aktivitas multisensorik, serta keterlibatan aktif dan refleksi, efektif untuk menurunkan kecemasan matematika sekaligus meningkatkan pemahaman pecahan siswa sekolah dasar, serta menawarkan kontribusi baru sebagai intervensi pedagogis berbasis neuroedukasi dalam pengajaran pecahan.

Kata kunci : Brain-Based Learning, Kecemasan Matematika, Sekolah Dasar

INTRODUCTION

Basic mathematics education still relies heavily on a teacher-centered approach, which emphasizes mechanical memorization of formulas, repetitive exercises, and assessment that prioritizes correct answers over comprehension (Tamamal et al., 2025; Yurniwati, 2018). These methods often ignore students' cognitive processes and wellbeing, leading many children to view mathematics as a frightening and stressful subject. Recent studies show that mathematics anxiety among elementary school students is often moderate to high, associated with decreased self-confidence, lower class engagement, and poorer academic performance (Halim et al., 2024).

Research indicates that Indonesian elementary students commonly experience moderate to high levels of mathematics anxiety. This anxiety is associated with diminished self-confidence, a tendency to avoid math-related activities, and lower proficiency in numeracy(Mangkuwibawa et al., 2024). Furthermore, empirical data reveals a negative correlation between math anxiety and fundamental math skills, including numeracy literacy. Consequently, elevated anxiety levels are a contributing factor to poor national performance in large-scale numeracy assessments.

One material that consistently poses challenges and anxiety for students at Sukalarang Elementary School is the concept of fractions. Mastering fractions requires a cognitive shift from processing whole numbers to understanding part-whole relationships, comparatives, ratios, and different operational rules. Recent research on learning barriers related to fractions highlights several common misconceptions. These include a deep whole number bias, confusion about the roles of numerators and denominators, and difficulty connecting physical manipulatives, visual diagrams, and abstract symbols. These persistent barriers often lead to frustrating learning experiences, making fractions a major source of increasing math anxiety at the elementary school level. (I et al., 2022; Sari et al., 2024; Unaenah et al., 2024).

According to(Yu, 2023), the conceptual shift required to learn fractions is a key source of math anxiety in young learners. This anxiety manifests in cognitive strain, more frequent errors, and task avoidance, trapping students in a cycle where fear and poor performance perpetuate each other(I et al., 2022). Given that anxiety's negative impact is strongest on formal symbolic skills, instructional design must prioritize a progression from non-symbolic, intuitive exploration to symbolic mastery. Implementing Brain-Based Learning—through concrete manipulatives, visual models, and peer collaboration—offers a pathway to reduce threat, ease cognitive load, and build a solid conceptual foundation for fractions (Rahmawati et al., 2024)

The Brain-Based Learning (BBL) model is structured to align with the brain's innate cognitive and emotional processes. It advocates for cultivating a classroom atmosphere that is simultaneously stimulating, secure, enjoyable, interactive, and relevant. By prioritizing activities that generate positive affect, stimulate multisensory engagement, and encourage collaborative interaction, BBL posits that it can effectively mitigate the stress and anxiety responses commonly associated with mathematics learning(Lutfillah et al., 2022; Nurasiah et al., 2022).

This study introduces two novel contributions to the existing literature. First, while Indonesian research on mathematics anxiety has predominantly documented its prevalence and correlates, there is a scarcity of experimental studies that implement and evaluate targeted pedagogical interventions to alleviate this anxiety in primary education. Second, although international research has established links between math anxiety and fraction learning, the emphasis has been on cognitive explanations and performance outcomes rather than on developing practical, classroom-ready instructional designs informed by neuroeducational principles.(Sholichah & Aini, 2022b).

Third, existing applications of Brain-Based Learning (BBL) in Indonesian primary education have primarily investigated its effects on academic achievement, motivation, or critical thinking. There remains a specific gap regarding its targeted efficacy in mitigating mathematics anxiety, particularly within the challenging domain of fractions. Consequently, this study, "Implementation of Brain-Based Learning to Reduce Mathematics Anxiety in the Teaching of Fractions at Primary School," provides novelty by synthesizing neuropsychological insights into fraction-related anxiety with the empirical application of BBL as a structured, evaluable pedagogical intervention(Mangkuwibawa et al., 2024; Yu, 2023).

METHOD

This research adopts a quantitative methodology, utilizing a quasi-experimental pretest-posttest control group design(Kartikaningtyas et al., 2017). The study involved two intact fifth-grade classes at SD Negeri Sukalarang, selected through a purposive sampling technique aimed at identifying groups with comparable characteristics(Suharja et al., 2024), Class B (n=40) was assigned as the experimental group, receiving fraction instruction via the Brain-Based Learning (BBL) model, while Class A (n=40) served as the control group, taught the same content through conventional methods.

The Independent variables in this study are the learning models—specifically, the Brain-Based Learning approach applied to teaching fractions. The main dependent variable is students' math anxiety, with a particular focus on anxiety related to fractions. To provided a complementary measure of performance, student achievement in fraction learning was also evaluated. Math anxiety was measured using a modified version of the Math Anxiety Rating Scale (MARS), which has been adapted and validated for elementary school students. Achievement in fraction learning was measured through a structured response test, which has also been validated for reliability and validity.(Solihin & Mariana, 2025; Suharja et al., 2024).

This research followed a structured procedure initiated by piloting and validating the primary data collection tools: the mathematics anxiety scale and the fraction achievement test(Solihin & Mariana, 2025). Following instrument validation, a pretest—comprising both the anxiety scale and the fraction test—was administered to all participants in the experimental and control groups to establish baseline levels.The intervention phase then commenced. The experimental group received instruction on fractions structured around the core phases of the Brain-Based Learning (BBL) model. This involved an engaging orientation to activate prior knowledge, followed by the orchestration of multi-sensory (concrete and visual) learning experiences, active cognitive processing, guided reflection, and sessions to celebrate and consolidate learning gains. Conversely, instruction in the control group adhered to conventional methods, characterized primarily by teacher-led lectures, whole-class question-and-answer sessions, and routine individual practice exercises. Upon completion of the instructional intervention, a posttest identical to the pretest was administered to both groups to measure any changes in mathematics anxiety and fraction achievement.

Analysis was initiated by conducting prerequisite statistical tests for normality and homogeneity, ensuring the data satisfied the assumptions required for parametric analysis. Initial group equivalence was verified by examining differences in pretest scores. The core hypothesis—that Brain-Based Learning reduces mathematics anxiety more effectively than conventional teaching—was tested using an independent samples t-test, with pretest scores included as a covariate to control for baseline differences(Fadhilah & Kurniawan, 2025). This methodological approach allows for a rigorous quantitative examination of the intervention's specific impact on anxiety levels in primary school fraction instruction.

RESULTS AND DISCUSSION

The Results of The Mathematics Anxiety.

Instrument were obtained from respondents in both the experimental and control classes, and are summarized in Table 1.

Table 1. Presents The Mean Scores For Each Dimension of Fraction Related Anxiety.

Fraction anxiety dimension	Group	Mean	SD	Category
Test/assessment (A)	Experimental	10,8	2,1	Medium, tending to low
Test/assessment (A)	Control	12,4	2,3	Medium, tending to high
Classroom learning (B)	Experimental	11,0	2,0	Medium
Classroom learning (B)	Control	12,6	2,2	Medium, tending to high
Fraction tasks (C)	Experimental	10,5	2,4	Medium, tending to low
Fraction tasks (C)	Control	11,9	2,1	Medium
Fraction avoidance (D)	Experimental	11,6	2,3	Medium
Fraction avoidance (D)	Control	12,5	2,0	Medium, tending to high

Data in Table 1 indicate that the experimental group consistently shows lower levels of fraction-related anxiety than the control group across all dimensions (tests/assessment, classroom learning situations, fraction tasks, and fraction avoidance), even though both groups are still within the medium category range.

In the literature,(Sholichah & Aini, 2022a), mathematics anxiety is defined as feelings of fear, tension, or nervousness that arise when individuals engage in mathematical activities such as learning, doing assignments, or taking tests. Many instruments distinguish anxiety in two main contexts, namely learning math anxiety and math evaluation anxiety, which align with the dimensions in the table: tests/assessment (A), classroom learning situations (B), fraction tasks (C), and fraction avoidance (D)

The mean anxiety scores of the control group are consistently higher than those of the experimental group in all dimensions: tests/assessment (12.4 vs. 10.8), classroom situations (12.6 vs. 11.0), fraction tasks (11.9 vs. 10.5), and avoidance (12.5 vs. 11.6), even though both groups remain within the medium category (either medium–low or medium–high). A medium category indicates that students are not completely free from anxiety but have not yet reached a high-anxiety level, which is typically characterized by symptoms such as a racing heartbeat, mental blankness, or a strong desire to avoid mathematics.

The test/assessment dimension (A) corresponds to math evaluation anxiety, which refers to the anxiety that arises in situations involving exams or formal assessments. The classroom learning (B) and fraction tasks (C) dimensions are closely related to learning math anxiety, namely anxiety experienced during ongoing instruction and when working on practice problems or homework, whereas the fraction avoidance dimension (D) reflects attitudinal aspects and avoidance behaviours when students are confronted with fraction material. (Anita, 2014; Mukhlisa et al., 2024; Putri & Hakim, 2022)

Theories of mathematics anxiety state that lower anxiety tends to be negatively correlated with achievement, meaning that higher anxiety is generally associated with poorer mathematics performance. Therefore, the lower mean anxiety scores observed in the experimental group can be interpreted as an indication that the intervention in this class helped reduce fraction-related anxiety, which theoretically has the potential to support better performance in fraction learning(Anggraini et al., 2024; Nugroho et al., 2023)

Normality Test Results.

Table 2. Tests of Normality (Shapiro-Wilk)

	Class	Statistic	df	Sig.
Posttest	Experimental	0,987	40	0,614
	Control	0,956	40	0,122
Pretest	Experimental	0,957	40	0,434
	Control	0,980	40	0,687

Table 2 (“Tests of Normality”) shows that the posttest scores of the experimental class (Shapiro–Wilk = 0.978, Sig. = 0.614 > 0.05) are normally distributed, and the posttest scores of the control class (Shapiro–Wilk = 0.956, Sig. = 0.122 > 0.05) are also normally distributed. Likewise, the pretest scores of the experimental class (Shapiro–Wilk = 0.973, Sig. = 0.434 > 0.05) and the control class (Shapiro–Wilk = 0.980, Sig. = 0.687 > 0.05) both follow a normal distribution. Since all Shapiro–Wilk significance values for pretest and posttest in both classes are greater than 0.05, the normality assumption is satisfied and subsequent analyses can appropriately use parametric tests, namely the independent samples t-test.

The Homogeneity Test Results

Table 3. Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Pretest	Based on Mean	0,031	1	78	0,863
Posttest	Based on Mean	0,163	1	78	0,688

Based on Table 3, the Levene "Based on Mean" significance value for the pretest is 0.861 (> 0.05), indicating that the pretest score variances of the experimental and control classes do not differ significantly, so the pretest data for both groups are homogeneous and the equal-variance assumption is satisfied for further analysis. Similarly, for the posttest, the Levene "Based on Mean" significance value is 0.688 (> 0.05), meaning that the posttest variances of the experimental and control classes are also homogeneous, so the comparison of posttest means using an independent samples t-test can appropriately refer to the "Equal variances assumed" row in the SPSS 25 output

Independent Samples Test Results

Table 4. Independent Samples Test Results

		F	Sig.	t	df	Sig. (2-tailed)
Pretest	Equal variances assumed	0,032	0,861	1,845	78	0,069
	Equal variances not assumed			1,845	77,988	0,069
Posttest	Equal variances assumed	0,163	0,688	6,055	78	0,000
	Equal variances not assumed			6,055	77,733	0,000

The "Independent Samples Test" output shows that the initial (pretest) scores of the experimental and control classes do not differ significantly, whereas the final (posttest) scores differ significantly, with the experimental class scoring about 7.2 points higher on average than the control class. For the pretest, Levene's Test yields Sig. = 0.861 (> 0.05), indicating homogeneous variances and justifying the use of the "Equal variances assumed" row; the t-test result (t = 1.845, Sig. (2-tailed) = 0.069 > 0.05, Mean Difference = 2.550, 95% CI from −0.202 to 5.302) supports the conclusion that there is no significant difference in mean pretest scores between the two classes. For the posttest, Levene's Test gives Sig. = 0.688 (> 0.05), so the variances are also homogeneous and the "Equal variances assumed" row is again used; the t-test result (t = 6.055, Sig. (2-tailed) = 0.000 < 0.05, Mean Difference = 7.225, 95% CI from 4.849 to 9.601, not including zero) indicates a statistically significant difference, meaning the experimental class's posttest achievement is higher by about 7 points compared to the control class after the intervention.

The findings demonstrate that the implementation of Brain-Based Learning (BBL) resulted in a statistically significant enhancement in students' fraction achievement within the experimental class

relative to the control group. This outcome aligns with existing theory and research positing that BBL mitigates classroom stress and mathematics anxiety, thereby optimizing cognitive processes for learning(Rahmawati et al., 2024).The lack of a significant difference in pretest scores (Sig. = 0.069 > 0.05) confirms the initial equivalence of the two groups, establishing that subsequent performance differences can be attributed to the instructional intervention. Post-intervention, a highly significant difference emerged (Sig. = 0.000, mean difference ≈ 7.2 points), underscoring the efficacy of BBL for improving fraction learning outcomes. This is consistent with the BBL principle that instruction engaging positive affect, real-world contexts, multisensory input, and active involvement fosters deeper conceptual understanding and memory retention, leading to improved academic performance(Nurmilah et al., 2024).

Empirical evidence shows that mathematics anxiety specifically concerning fractions negatively impacts the execution of symbolic operations and increases student reluctance to engage with the topic. Brain-Based Learning (BBL) aims to counteract this by establishing a low-threat, positive learning atmosphere. This is achieved through emotional regulation, tiered task difficulty, and collaborative activities. By alleviating anxiety, BBL enables students to redirect critical cognitive capacities—particularly working memory—toward mastering fraction concepts (Supekar et al., 2015).

Studies on fraction-related mathematics anxiety reveal that elevated anxiety levels hinder performance on symbolic tasks and contribute to student avoidance of fraction work. The Brain-Based Learning (BBL) model directly addresses this by prioritizing a secure and positive classroom environment, the management of negative emotions, the provision of developmentally appropriate challenges, and structured social collaboration. These strategies are effective in reducing mathematics anxiety, thereby freeing critical cognitive resources like working memory for the deep conceptual understanding of fractions(Rahmawati et al., 2024).

CONCLUSION

The statistical analysis, including tests for normality, homogeneity, and an initial t-test, confirms that the pretest abilities of students in the experimental and control groups were comparable and met the necessary assumptions for parametric testing. Following the intervention, posttest results revealed a statistically significant advantage for the experimental group taught with the Brain-Based Learning (BBL) model. This outcome demonstrates BBL's efficacy in enhancing fraction learning achievement and suggests its concurrent potential to alleviate mathematics anxiety. This aligns with existing literature indicating that BBL methodologies can mitigate math anxiety, resulting in lower anxiety levels among students exposed to this approach compared to conventional instruction.

Consequently, it is recommended that primary school mathematics teachers consistently incorporate core BBL principles—such as cultivating a positive emotional environment, anchoring fraction concepts in real-world situations, and employing multisensory activities and didactic games. These strategies can reduce anxiety and foster deeper conceptual understanding. At an institutional level, schools and educational policymakers should prioritize BBL in professional development programs, particularly for teaching challenging and anxiety-inducing topics like fractions, to promote more brain-compatible and emotionally secure classrooms. For further inquiry, subsequent research could expand on this study by incorporating additional variables (e.g., critical thinking, motivation, or digital BBL tools) and by replicating the design across diverse grade levels and educational settings to verify the robustness of BBL's impact on reducing mathematics anxiety.

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