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Brain-based learning: How does mathematics creativity develop in elementary school students?

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Abstract: The urgency that occurs in the learning process at the Bima Regency Elementary School is the difficulty of students learning how to find innovative, effective, and creative answers, so they cannot solve problems from various points of view. This study aims to determine how the Brain-Based Learning model influences mathematics creativity in elementary school students. The type of research using true experimental design with technique pretest-posttest control group design. The research held in elementary schools, with the sampling technique used was probability sampling theory with the cluster sampling method. Data collection techniques using test questions and data analysis techniques pretest-posttest, normality test, homogeneity test, and t-test. The results showed that the Brain-Based Learning model had an innovative impact in developing students' creativity, provided opportunities for students to express their ideas, and supported an active and conducive learning environment. This research provides benefits and deserves to continue improving education quality, especially in Indonesia.

Keywords: Brain-Based Learning, Mathematical Creativity

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INTRODUCTION

The urgency that occurs in the learning process at the Elementary School in Bolo District, Bima Regency, West Nusa Tenggara Province is the difficulty of students learning how to find innovative, practical, and creative answers so that they are unable to solve problems from various points of view, especially in learning mathematics. The development of creativity in learning mathematics is the most important thing in elementary schools, this is supported by the results of research conducted by Adiansha et al (2018); Catarino et al (2016); Kashefi et al (2013); Suhadi et al (2016) states that creativity is the key to success in solving problems. Also, a person needs two mathematical thinking skills: creative thinking, which is often identified with intuition, and analytical thinking ability, which is identified with thinking logically by reflecting fluency, flexibility, novelty, and detail. Thus, creativity is able to bridge between the cognitive management stage and the execution stage so that a student has convincing achievements and results in learning, especially in learning mathematics.

The development of mathematical creativity aims to instill creative thinking skills in students, instill qualification skills and develop competence in solving mathematical problems in elementary school students. The development of students' mathematical creativity can be measured by exploring student work that represents the creative process and is based on what students communicated verbally and in writing (Amato-Henderson et al., 2011; Krebs et al., 2020; Lobert & Dologite, 1994; Vishkaie, 2018).

Kusumawardani (2015) stated that the indicators in measuring the development of mathematical creativity in this study are fluency, flexibility, novelty, and detail. Fluency is related to the number of solutions, flexibility is related to the variety of ideas, novelty is related to the uniqueness of students' answers, and detail is related to the detail and coherence of answers. Assessment indicators on the development of mathematical creativity, namely the fluency aspect includes the ability to (1) solve problems and provide many answers to these problems; or (2) provide many examples or statements related to a particular mathematical concept or situation. Aspects of flexibility include the ability to (1) use various problem-solving strategies; or (2) provide various examples or statements related to a particular mathematical concept or situation. The novelty aspect includes the ability (1) to use strategies that are new, unique, or unusual to solve problems; or (2) provide examples or statements that are new, unique, or unusual. Aspects of detail include the ability to explain in detail, coherently, and coherently to certain mathematical procedures, answers, or mathematical situations.

One way of evaluating student creativity is with open questions, which have various solutions or strategies for solving and making questions, questions, or statements related to some mathematical issues or situations (Rahmawati et al., 2019). This method is used to measure aspects of the development of mathematical creativity, namely fluency, flexibility, novelty, and detail. One example of measuring the development of mathematical creativity in this study is drawing many pictures in the circle, for example, by drawing the sketch or line inside, outside and outside the circle and giving the title to **Figure 1** and **Figure 2**.

The test instrument used was to determine students' mathematical creativity by containing the results of fluency, flexibility, novelty, and detail. So that symptoms will be found on students in developing their creativity. The Brain-Based Learning Model shows the importance of student creativity and learning as an alternative to positively influence students' conceptual understanding.

The Brain-Based Learning model developed by Eric Jensen in 2011 states that learning aligned with the way the brain works is naturally designed for learning (Gueorguieva, 2017; Suarsana et al., 2017). It is supported by Niswani (2016); Stevens-Smith (2020) found that implementing the Brain-Based Learning Model was influential in the learning process. Another finding states that there is a positive influence on mathematical communication skills in terms of student creativity, and there is an interaction between the Brain-Based Learning model and student creativity (Adiansha et al., 2018, 2020; Adiansha & Sumantri, 2017; Kusumawardani, 2015; Putri et al., 2019)

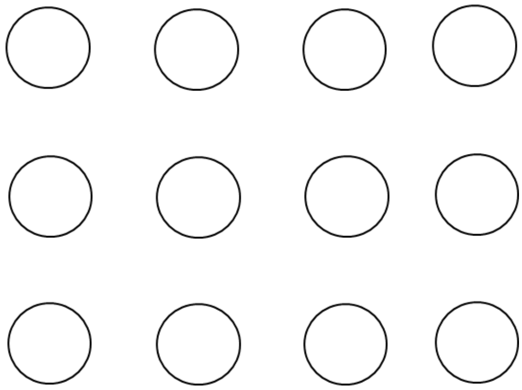

FIGURE 1. *Measuring creativity development through circles*

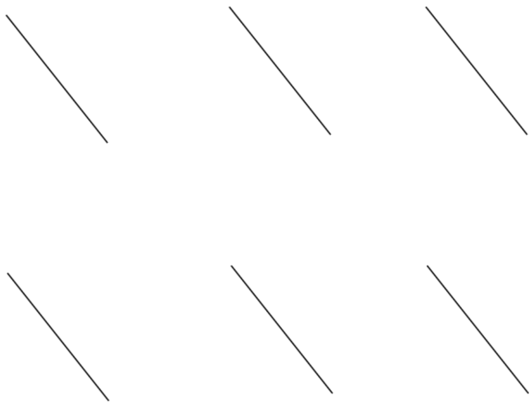

FIGURE 2. *Measuring creativity development through lines*

Innovation in this study was analyzed from the findings of previous research conducted by Sukoco & Mahmudi (2016) on learning using the Brain-Based Learning model positively influences students' mathematical communication skills and self-efficacy. Then it is developed by Widiana et al (2017) that in his research, he found significant differences in the understanding of concepts and students' creative thinking skills and provided significant interactions. It was continued by Adiansha et al (2020) in its findings; the Brain-Based Learning model can develop student's creativity and encourage students to have the latest ideas and ideas in solving problems in the learning process according to their knowledge. The results of the analytical study of some of the findings above found significant differences in the research including 1) The focus of the problems studied related to the Brain Based Learning model on the development of mathematical creativity in elementary school students has not been widely carried out by previous researchers; 2) Making new contributions to elementary school students in Kabupaten Bima; 3) Brain Based Learning model gives positive results in developing mathematical creativity in elementary school students in Bima Regency; 4) This research produces a critical finding that has never been done by previous researchers in developing mathematical creativity in elementary school students. From the research analysis results, this research has a novelty in research and is very innovative to be developed.

Based on the scientific analysis of the research problem, it was found that this research is important to be developed because there are innovative results for elementary school students. So, the title in this study is the influence of the Brain-Based Learning model on the development of mathematical creativity in elementary school students. The main target of the research is to find out how the influence of the Brain-Based Learning model on the development of mathematical creativity in elementary school students.

METHOD

The research has been carried out at the Bolo District Elementary School, Bima Regency, West Nusa Tenggara, for one semester in the odd semester in 2020. This type of research uses experimental research. This research was conducted to discover the effect of developing students' mathematical creativity using the Brain-Based Learning model.

Research design

The research design is experimental research using the One-group pretest-posttest design technique. In research conducted by Hastjarjo (2019); Forsyth (2018); Gueorguieva (2018) said that the measurements in the pretest provided information about the counterfactual principle, although it was relatively weak. However, there was a difference between 01 and 02. So, the design of one group pretest and posttest can be seen in Figure 3. The research design carried out in this study is as follows; 1) Conducting a pretest, where giving a pretest is done to determine the extent of the development of mathematical creativity in students who use the Brain-Based Learning model. The pretest questions were carried out in the form of questions related to creativity in students, as in Figure 1 and Figure 2. From the results of the pretest assessed by the researcher, the categorization of students' mathematical creativity are derived to high, medium, and low creativity; 2) delivering material, the researcher first explains and provides direction on learning mathematics that further emphasizes students' creativity and ability to solve problems in learning mathematics ; 3) Giving treatment, where this treatment was given to the subjects in this study, namely to elementary school students in Bolo Subdistrict, Bima Regency, the implementation of giving this treatment was carried out each for 7 meetings and 1 meeting in the form of a posttest; 4) Conducting Posttest, to know the development of creativity in students through the Brain-Based Learning model.

Research Subjects and Characteristics

The research subjects were taken from elementary schools in Bolo District, Bima Regency, West Nusa Tenggara, then the sampling technique of this study was using probability sampling theory with the method used, namely cluster sampling. (Forsyth, 2018; Gueorguieva, 2018; Levy & Lemeshoe, 1999; Sampatb, 2000). The reason for using this cluster sampling method is to provide equal opportunities for each member of the population to be selected as a sample. After using the cluster sampling method, the research samples were selected, namely SDN Nggembe and SDN Rada, used as research sites, as shown in Figure 4. In each of these schools, they were selected in class V to research by knowing the development of students' mathematical creativity through the model. Brain-Based Learning can be seen in table 1. The characteristics of the two schools include 1) The environmental conditions at the school are the same because they are located in Bolo District, Bima Regency, West Nusa Tenggara, 2) The results of the student's initial ability test show that the abilities of class V students are not there are significant differences, 3) In the data collection, both are in class V, and 4) the treatment given in this study is the same.

TABLE 1. *Characteristics of age of students in research*

No	SDN Rada			SDN Nggembe		
	Age	Grade	Amount	Age	Grade	Amount
1	10 years old	Five	12	10 years old	Five	10
2	11 years old	Five	10	11 years old	Five	11
3	12 years old	Five	1	12 years old	Five	2
	Amount		23	Amount		23

Research Data Collection Procedure

The research procedure was carried out in several stages, including the planning, implementation, and final stages. The implementation stages include asking for a research location permit, designing instruments, conducting instrument trials to validate reliability criteria, discriminating power and the level of instrument difficulty, and processing the instrument. At the implementation stage, it was carried out with the implementation stage in the experimental class and the control class. The two stages were carried out by giving a pretest to determine the development of students' mathematical creativity, carrying out learning activities using the Brain-Based Learning model, and then giving a post-test to determine the development of creativity in student mathematics. Then in the final stage of collecting research data, managing and analyzing data using SPSS Version 25, and concluding. The research flow can be seen using **Figure 5**.

$0_1 \quad x \quad 0_2$

FIGURE 3. *One-group pretest-posttest design*

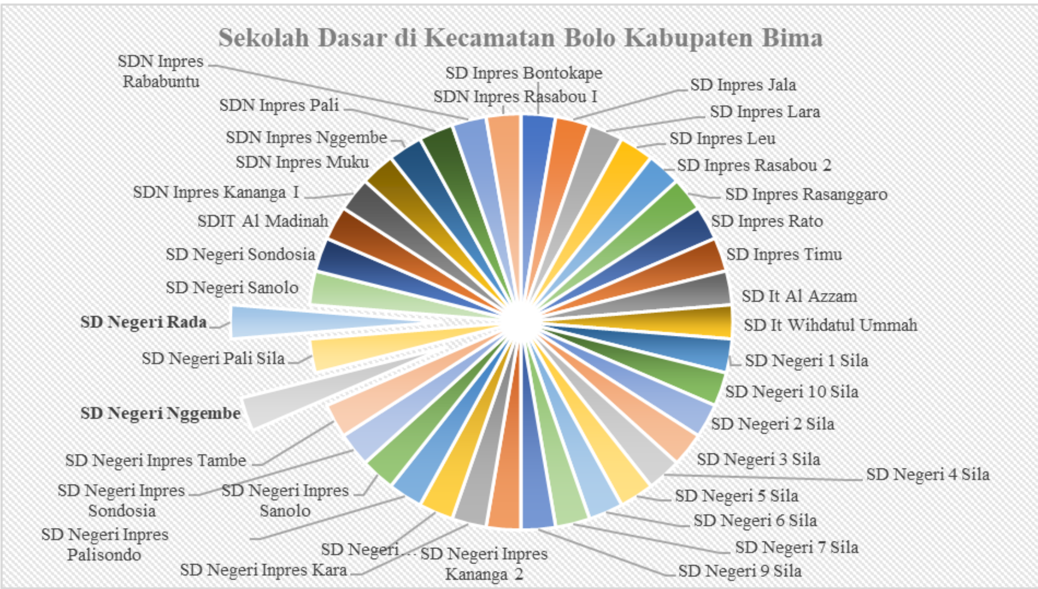

FIGURE 4. *Research population of elementary schools in bolo, bima district*

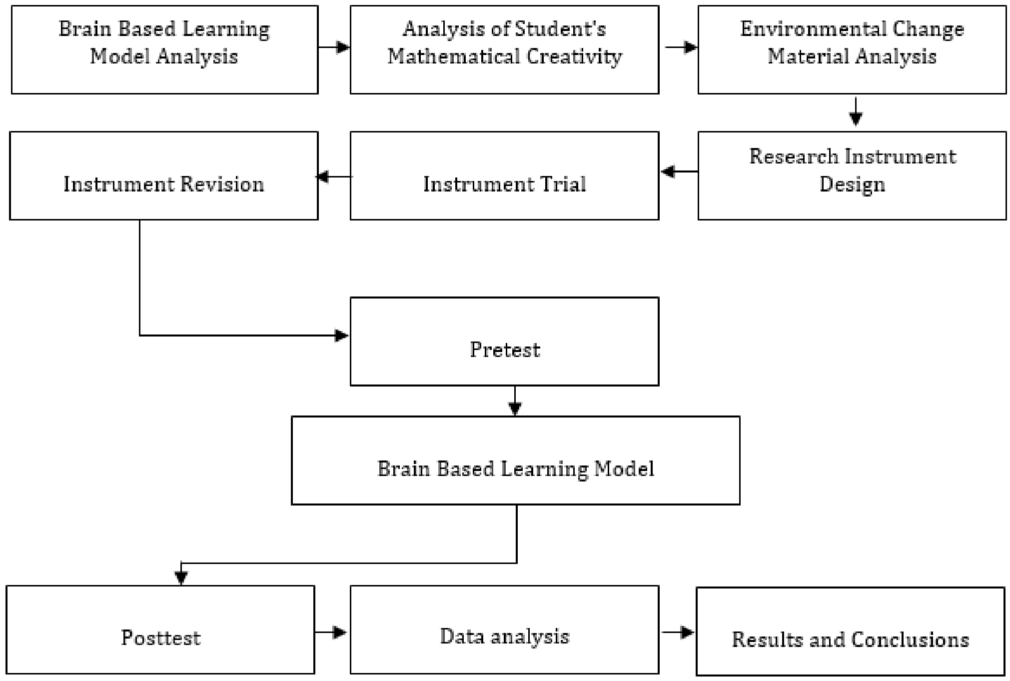

FIGURE 5. *Research flow*

TABLE 2. *Guidelines for assessment of student's mathematical creativity*

No	Indicator	Measured Aspect	Skor
1	Smoothness	Provides a relevant idea in solving the existing problem	1
		Gives two relevant ideas but the disclosure is not clear	2
		Provides three ideas that are relevant to the problem and complete and clear disclosure.	3
		Gives four relevant ideas and problem solving but the disclosure is less clear.	4
		Gives five relevant ideas and their disclosure is complete and clear	5
2	Flexibility	Gives only one answer	1
		Gives two answers in only one way and there is an error in the process	2
		Gives three answers in one way and correct	3
		Gives four answers in more than one way (various) but the result is still an error	4
		Gives five answers in more than one way (various) process and the result is correct.	5
3	Novelty	Gives only one answer	1
		Gives two answers in his own way but hard to understand	2
		Gives three answers in his own way is understandable but not complete	3
		Gives four answers but not finished	4
		Gives five answers and correct	5
4	Details	Gives an answer	1
		There is a mistake in expanding the situation without going into details	2
		There is an error in expanding the situation and it is accompanied by incomplete details	3
		Expands the situation properly detailing it lacks detail	4
		Expands the situation properly detailing it in detail	5

Research Instruments and Indicators

The test instrument used in this study is a test item to measure students' mathematical creativity (figure 1 and figure 2). The test questions have been validated by 2 people and tested by 3 practitioners. The data was collected in the form of data validity and reliability of students' creativity development instruments. The Cronbach Alpha formula determined reliability for the research instrument. The indicators used are fluency, flexibility, information, and detail, as shown in **Table 2**.

Data Analysis Techniques

The data analysis technique begins with analyzing the results of the pretest by conducting a normality test. In the normality test, to determine whether the data is normally distributed or not, the steps taken are to calculate the pretest-posttest score, normality test, homogeneity test, and t-test. The aim is to use the normality test, which is to assess the distribution of data in a group of data or variables, whether the distribution of the data is normally distributed or not. The purpose of homogeneity is to ensure that the number of populations to be measured is homogeneous. At the same time, the purpose of the t-test is to test how the influence of the Brain-Based Learning model on the development of creativity in elementary school students.

RESULT

Data Description

The results of the data in knowing how the influence of the Brain-Based Learning model on the development of students' mathematical creativity can be seen in **Table 2** and **Table 3** with the findings showing that the results of the description test of student creativity using the Brain-Based Learning Model in developing student creativity show that the average is equal to 12.93, the standard deviation is 2.816, the maximum score is 18, the minimum score is 8, and the number of statistics for 46 students is 595.

TABLE 3. *Descriptive test results of student creativity*

	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Smoothness	46	3	2	5	150	3.26	.126	.855
Flexibility	46	3	2	5	150	3.26	.126	.855
Originality	46	3	2	5	147	3.20	.130	.885
Elaboration	46	2	2	4	149	3.24	.129	.874
Creativity	46	10	8	18	595	12.93	.415	2.816
Valid N (listwise)	46							

TABLE 4. *Descriptive test results of creativity on the average amount*

	N Statistic	Range Statistic	Sum Statistic	Mean Statistic	Std. Error	Std. Deviation Statistic	Variance Statistic
SDN_Rada	23	10	295	12.83	.664	3.186	10.150
SDN_Nggembe	23	10	300	13.04	.513	2.458	6.043
Valid N (listwise)	23						

TABLE 5. *Normality test results of student creativity data*

	School	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Creativity	SDN Nggembe	.173	23	.072	.960	23	.465
	SDN Rada	.117	23	.200*	.944	23	.217

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

TABLE 6. *Test of student creativity homogeneity*

		Levene Statistic	df1	df2	Sig.
Creativity	Based on Mean	1.740	1	44	.194
	Based on Median	1.448	1	44	.235
	Based on Median and with adjusted df	1.448	1	43.921	.235
	Based on trimmed mean	1.761	1	44	.191

TABLE 7. *One-sample test of student creativity at SDN Bolo*

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Creativity	31.155	45	.000	12.935	12.10	13.77

Test Requirements Analysis includes the results of the normality test and the results of the homogeneity test. The purpose of the normality test is to determine whether the research data is normally distributed or not, while the purpose of the homogeneity test is to find out whether the research data has homogeneous variance or not. The level of significance is 0.05. The data is normally distributed and homogeneous if the significance value of the prerequisite test results is > 0.05. The SPSS 25 output results in Table 4 Test of Normality above obtained the Shapiro-Wilk Sig value. for data at SDN Nggembe is 0.465, and SDN 1 Rada is 0.217.

Based on decision making in the normality test above, the data for all SDN, both SDN Nggembe and SDN Rada are > 0.05; thus, it can be concluded that the data in SDN Bolo District is normally distributed. Then in Table 5 "Test of Homogeneity of Variances" above, it is known that the significance value (Sig.) of the student creativity variable at SDN Nggembe and SDN Rada students is 0.194. Because of the value of Sig. 0.194 <0.05, so as the basis for making decisions in the homogeneity test above, it can be concluded that the variance of student creativity data at SDN in Bolo District is homogeneous.

Then, in Table 6. One-Sample Test it is known that the value of t (t count) is 31,155. The value of df (degree of freedom) or degrees of freedom is 45. The value of Sig. (2-tailed) Alternatively, the significance value with the two-tailed test is 0.000. The basis for decision making is if the value of sig. (2 tailed) < 0.05, then Ho is rejected, and if the value is sig. (2 tailed) > 0.05, then Ho is accepted. Then it is known that the value of t count is 31,155.

Based on the research findings above, the Brain-Based Learning model has an innovative influence on students' mathematical creativity in learning. Students' mathematical creativity and opportunities for students to express their ideas and ideas are then concluded jointly by students and teachers to create an active and conducive learning environment, and evaluation occurs during the learning process.

DISCUSSION

Based on the creativity data test results on elementary school students in Bolo District using the Brain-Based Learning Model, it shows that the analysis of the creativity value of students is reasonable compared to conventional learning models. The development of creativity is significant in improving the quality of learning (Dwi Wiwik Ernawati et al., 2019; Glăveanu, 2018; Henriksen et al., 2020; Kupers et al., 2019; Sari et al., 2017; van Broekhoven et al., 2020; Wilson, 2016), because learning can improve students' abilities through the ability to maximize brain function to produce learning with new ways of thinking, ideas, and ideas.

Developing students' creativity is determined by how teachers in schools can use learning models that stimulate students to maximize brain function actively. It is by the findings made by (Adiansha et al., 2018; Gladys et al., 2018) states that the Brain-Based Learning model can grow students' brain functions in the learning process so that they can improve the abilities of students through the ability to maximize their brain functions to produce learning with new ways of thinking, ideas and ideas.

The study results indicate that the null hypothesis (H0) is rejected, and the working hypothesis (Ha) is accepted. With the rejection of H0 from the results of hypothesis testing, it can be concluded that there is a significant development of student creativity using the Brain-Based Learning model.

The difference in students' creativity development using the Brain-Based Learning model at SDN Nggembe has an average value of 13.04, which is higher than students' creative development using conventional learning models at SDN Rada, which has an average value of 12.83. It shows that the Brain-Based Learning model can develop students' creativity and encourage students to have the latest ideas and ideas in solving problems in the learning process according to their knowledge.

In the learning process using the Brain-Based Learning model, where the teacher activates the knowledge that students already have through the use of the students' brain functions, then the teacher allows students to express their ideas and then concludes it together by students and teachers, to create an active and conducive learning environment, and evaluation occurs during the learning process. Thus, the development of students' creativity through the Brain-Based Learning model can provide excellent development.

CONCLUSION

Based on the research and discussion above, the development of mathematical creativity possessed by students at the elementary school level has an innovative influence on the learning process in fifth-grade elementary school students in Bolo District, Bima Regency. Students' mathematical creativity and providing opportunities for students to express their ideas and ideas are then concluded together by students and teachers to create an active and conducive learning environment, and evaluation occurs during the learning process. The brain-Based Learning model provides benefits and deserves to be developed on research variables with high-level thinking skills so that the quality of education, especially in elementary schools, can improve and develop well.

This research will continue to be sustainable by using the Brain-Based Learning Model as a learning model that can improve student learning outcomes in the cognitive, psychomotor, and affective domains. However, the psychomotor and affective aspects have not been evaluated. Suggestions to researchers throughout Indonesia to continue developing this Brain-Based Learning model in developing students' abilities from various indicators of student learning outcomes, such as literacy and numeracy.

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