APPLICATION OF THE BRAIN-BASED LEARNING MODEL ON STUDENTS' LEARNING OUTCOMES AND INITIAL MATHEMATICAL ABILITIES

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ABSTRACT

Along with advances in technology and understanding of the learning process, the Brain learning model emerged Based Learning is one of the innovative steps in improving the quality of learning. This research aims to see whether some differences and interactions occur in student learning outcomes which that implications for students' initial mathematical abilities and the basic competencies learned by students. This research was carried out at SDN Batujajar 3 with a quantitative approach. This research method uses survey methods and ANOVA test analysis to see the relationship between mathematics learning outcomes using the BBL model, Basic Competencies consisting of KD 3.3, KD 3.4, and KD 3.5, and students' Initial Mathematical Ability with high, medium, and low classifications. This research instrument uses a test to test the data analysis requirements used, consisting of a normality test using Kolomogorov-Smirnov and a homogeneity test assisted by SPSS version 26. In this study, it was found that there were differences in students' mathematics learning outcomes using the brain learning model-based learning on the basic competencies learned by students and students' initial mathematical abilities, but there is no significant interaction between them. This shows that there is a significant difference in students' mathematics learning outcomes between KD 3.3 and 3.4 and 3.3 and 3.5, but this does not happen at KD 3.4 and 3.5. Apart from initial mathematical abilities, students in the categories of high and medium, high and low, and medium and low obtained significant differences between the three. Thus, it is hoped that further research can have implications for students' level of cognition and geography regarding mathematics learning outcomes using the brain learning model-based learning.

Keywords: Brain-Based Learning, Initial Mathematical Ability, Basic Competency

A. INTRODUCTION

Education is the main axis in preparing future generations to face the dynamics of the 2nd century 1 (Sarah et al., 2024). In an era where information flows rapidly, successful learning no longer depends only on conveying information (Al Ayyubi et al., 2023), but also on a deep understanding of how our young brains respond, process, and process that information (Pancawardana et al., 2023). In the midst of continuously developing educational dynamics, challenges in the world of education are increasingly complex and require innovative approaches to be able to provide optimal results (Alfalah Riski, 2023; Lukmantya, 2023; Rahayu et al., 2022; Tamin et al., 2022).

Innovation in the learning process is a major milestone in advancing and developing the education system (Iswahyudi et al., 2023). Apart from that, learning innovation can also facilitate student character development and promote creativity and ingenuity in learning. This innovation can be in the form of new techniques, methods, or models in learning as an effort to make learning more relevant, meaningful, and motivating for students. With innovation in learning, education can become more flexible and responsive to changes occurring in society today (Afif, 2019).

Along with advances in technology and understanding of the learning process, the Brain learning model emerged Based Learning (BBL) is one of the innovative steps in improving the quality of learning (Mukaromah et al., 2020), especially in critical subjects such as mathematics (Al Ayyubi et al., 2018), because Brain-Based Learning is a learning model based on neuroscience concepts (Damayanti et al., 2023), which aims to maximize the potential of students' brains in the learning process.

This learning model is based on the principle that the human brain can learn and develop continuously (Juliantini et al., 2020). By deepening an understanding of how the brain thinks and learns, it is hoped that students will have a more meaningful and in-depth learning experience (Supena, 2023).

Mathematics is an essential subject to master because of its very high relevance in everyday life (Rani et al., 2021). However, mathematics is often still a touchstone for many students at various levels of education. Complex concepts, complex problem-solving, and conventional learning approaches often pose significant challenges for students (Putri et al., 2024). Thus, this research aims to see whether some differences and interactions occur in mathematics learning outcomes using brain model-based learning which has implications for students' initial mathematical abilities which are categorized as high, medium, and low. Apart from that, this research also connects with the basic competencies learned by students in the study of explaining and carrying out mixed arithmetic operations, explaining the elements of a circle, and explaining the circumference and area of a circle.

B. LITERATURE REVIEW
Brain-Based Learning

Learning model Brain-based learning (BBL) is an approach to learning that is based on understanding about function brain man (Anggraini et al., 2020). This model confesses that the brain man own role is important in the process of learning and viewing the brain as the center controller of cognitive, emotional, and behavioral somebody. The BBL learning model prioritizes the use of engaging learning strategies brain optimally, to ensure that the material taught can understood and applied effectively by students (Dewi, 2021). In this

model, teachers are expected to understand How the brain works and use knowledge as a base For designing activity-appropriate learning (Puspaningrum et al., 2021).

Brain-Based Learning (BBL) in its development uses knowledge neuroscience as a base For designing an approach that considers learning in a way deep into How the brain man functions and learns (Emilia, 2023). The basics of neuroscience in the Brain-Based Learning (BBL) model include important principles like neuroplasticity, the influence of emotion on learning, and the importance of the involvement of active students in the learning process. Influence emotion to learning emphasizes that students must feel motivated, comfortable, and engaged in a way that emotionally tends to make them more capable of processing and remembering information more effectively (Parnawi, 2021). Apart from that, it's important involvement active students that students always involved in active learning, like discussing or collaborating, not only to obtain more understanding profound, but also possible brain they for form strong connections, strengthen the learning process, and facilitate the formation of memory period long as well as mastery skills new (Saufi et al., 2020). With understanding and applying principles, BBL can become more effective in increasing results in learning and abilities beginning with mathematical students (Y. Handayani et al., 2021; Kusmawati et al., 2022; Nasution et al., 2020).

Brain-based learning expands understanding of the activity classification brain that has a unique function (Nurasiah et al., 2022). Brain Right and left work similarly with specialization certain. In context learning, the brain is left involved in a way deep in accepting knowledge and explanations conveyed by educators,

temporarily brain right responsible answer to obtain understanding holistically and track how knowledge the applied (Lutfillah et al., 2022). For example, when somebody listens song, the brain's left helps in understanding the lyrics and meaning of words, meanwhile brain's right appreciates rhythm and tone.

One of the experts known in neuroscience in the development of the BBL model is Eric Jensen. Eric Jensen pointed out seven stages in learning by applying the BBL model (Farida, 2021), namely as follows:

1. Pre-exposure
   At stage pre-exposure, the teacher presents information or concepts that would be diplomatic to students, however with an interesting and challenging way to stimulate the brain students pay attention and respond to information with Good. Pre-exposure can done through the use of images, or videos.

2. Preparation
   The stage at which students are given a chance to ponder the material to be studied and prepare themselves mentally and emotionally. Preparation This is important for open openness students accept new information and save it in a way effective over a long memory period.

3. Initiation and acquisition
   Stage reception information new and integration information the to in existing knowledge owned. Students are invited To actively participate in learning, through discussion, ask answers, or activity creating others who can strengthen the connection between the inner neurons brain.

4. Elaboration

Stages in which students requested To develop an understanding of the material that has been studied. This matter covers discussion groups, collaborative projects, or activity research that explores more about the topic.

5. Incubation and coding memory

Stages form patterns or strong connections between new information with information already There in the memory period. Incubation process This needs time and constant practice To ensure information can be accessed with ease when required.

6. Verification

Stage verification involves checking the understanding and mastery of students of material that has been studied (Yusuf, 2023). Teachers can use question reflective, quiz short, or discussions To test understanding students and make sure that the draft is understood with Good.

7. Celebration and integration

Stage lastly is where the student is given a chance to celebrate achievement and hook new knowledge studied with experience and knowledge previously. This can done through reflection end, presentation projects, or activities strengthening the appreciation understanding, and acceptance of participant education to material learning.

Brain-Based Learning (BBL) has lots of advantages, such as:

1. Improving student learning outcomes (Rahman, 2023).
2. Increase creativity student.
3. Push the involvement of active students in the learning process.
4. Help students For more easy interact with other people.

5. Increase Skills in social and emotional students.

Early Mathematical Abilities

The ability to begin mathematics is a descriptive term for abilities possessed by students before they start Studying mathematics. The ability to begin this role is important as a foundation for students to accept new knowledge for finishing problem mathematics. Test pre-lesson mathematics can become an effective method For measuring the ability of beginning students before they start learning (Permata et al., 2024). Apart from that, the ability of participants educated in finish problem math can do it too influenced by quality ability beginning they (Nisa et al., 2023).

Ability mathematical student covers various aspects knowledge knowledge and skills required to finish problems in mathematics (Rachmantika et al., 2019). Several abilities the main ones included in it as follows:

1. Mathematical understanding to understand mathematical concepts, formulas, and context.
2. Mathematical problem solving to solve problems effectively.
3. Reasoning mathematically to submit questions, manipulate, and create conclusions from statement mathematical.
4. Mathematical connections to connect mathematical concepts with other contexts.
5. Mathematical communication skills include students' ability to convey mathematical concepts orally, in writing, or using pictures.

When given questions by the teacher, students with low mathematical abilities may have difficulty answering them, while students with high abilities can understand

and answer the questions well. Improving initial mathematical abilities can be done through developing mathematical thinking, practical learning, and applying STEM approaches that can help students (Yusuf et al., 2022).

There are several methods to determine students' initial mathematical abilities, one of which is by conducting tests that evaluate mathematical literacy, conceptual understanding, problem-solving skills, reasoning abilities, communication skills, and the ability to connect mathematical concepts. The test aims to measure students' understanding of mathematical concepts, ability to solve problems, use of patterns, and ability to make generalizations. Apart from that, students' abilities in creating mathematical models, solving problems, and planning solutions can also be measured (Wibowo et al., 2019).

Several forms of tests that can be used to evaluate mathematical abilities are questions that can be read and answered in writing, or electronic questions that can be read, answered, and checked (Damayanti et al., 2023). Students' ability to solve mathematical problems depends on the basic skills they have. Several factors that influence students' basic mathematics abilities are as follows:

1. Prior Knowledge
   The knowledge-strong start is an important basis for students to understand concepts more math complex. With its good foundation, the student can more easily catch the new material and string connections between draft different mathematics.

2. Appreciation Mathematics
   Interests and hobbies students to mathematics can motivate them to hone their skills in mathematics they more carry on. Students who have a high appreciation for mathematics tend to be more persistent and persistent in solving problem mathematics because they see mathematics as something interesting and meaningful.

3. Appreciation Mathematics
   The ability of students to use logical math, like analyzing, concluding, and applying mathematics concepts, is the very influential ability they have in finishing problem mathematics. Students who have intelligent logical mathematics tend to be more skilled in identifying patterns, making generalizations, and discovering the right solution in context problem mathematics (Handayani, 2021).

4. Confidence
   The level of confidence in students in mathematics impacts their ability to finish problem mathematics. Students who believe self tend to be braver when facing challenges in math and are more persistent in looking for solutions, even when facing difficulty (Nurhayati et al., 2023).

5. Independence Study
   Learning independence is an important ability in solving mathematical problems. Students who can learn independently have a higher tendency to search for sources of information, explore various approaches, and try various problem-solving strategies without depending on the help of others (Nurfadilah et al., 2019).

6. Motivation Study
   Strong motivation to learn mathematics is a factor that influences students' ability to solve problem mathematics. Students who have intrinsic motivation, like a feeling of wanting to know and desire To reach achievement personally, are inclined to be more

diligent and persistent in facing challenging mathematics.

7. Background Mathematics

Background mathematics students, including the level of understanding and experience previously in learning materials mathematics, yes influence the ability they solve problem mathematics. Students with a background in strong mathematics usually own more Lots tools and strategies for finishing problems effectively.

8. Structure Problem

The ability of students to analyze structure problem math, like identifying patterns, relationships, and associated rules, can give they superiority in solving problem mathematics. Students who are skilled in analyzing problem structures tend to be more systematic and efficient in finding the right solution.

By understanding these factors, teachers can more effectively design learning strategies that suit student needs and characteristics. This includes identifying students' weak areas and providing appropriate guidance to improve their ability to solve mathematical problems. In addition, understanding these factors can also help teachers provide more targeted feedback and support students in developing their self-confidence, motivation, and learning independence in the context of mathematics.

Students' mathematical abilities in the Brain learning model Based Learning is influenced by various factors, including cognitive, affective, and psychomotor aspects. Apart from that, self-confidence, mathematical communication skills, and an open, objective attitude in interacting with groups and daily activities also play an important role. Apart from that, continuous

enthusiasm for learning, high curiosity, and strong interest and belief in mathematics also have a significant impact on students' abilities in this field (Hendriana, 2019).

C. METHOD

This research was carried out at SDN Batujajar 3 with a quantitative approach. This research method uses survey methods and ANOVA test analysis to see the relationship between mathematics learning outcomes using the BBL model, Basic Competencies consisting of KD 3.3, KD 3.4, KD 3.5, and Initial Mathematical Ability (KAM) of students with high, medium, and high classifications. low. The population of this study was students at SDN Batujajar 3 with a sample of 31 students in class VI who were divided based on their learning results for KD 3.3, 3.4, and 3.5 so that there were 93 data. Where KD 3.3 is concerned with explaining and carrying out mixed arithmetic operations, KD 3.4 is concerned with explaining the elements of a circle, and KD 3.5 explains the circumference and area of a circle. This research instrument uses a test with testing requirements for data analysis consisting of a normality test using Kolomogorov-Smirnov and a homogeneity test assisted by SPSS version 26. If the standard residual value is normally distributed then it continues with the Two Way ANOVA test, but if it is not normally distributed then it continues with Non-parametric statistical testing using the Median Test.

D. RESULTS AND DISCUSSION

The testing criteria for the hypothesis given in this study are to accept H_0 if the value is sig. ≥ 0.05 and reject H_0 if the value is sig. <0.05. The alternative Hypothesis (H_1) and Null Hypothesis (H_0) are as follows:

H₀ : There is no difference in students' mathematics learning outcomes using the brain learning model-based learning at KD 3.3, 3.4, and 3.5.

H₁ : There are differences in students' mathematics learning outcomes using the brain learning model-based learning at KD 3.3, 3.4, and 3.5.

H₀ : There is no difference in students' mathematics learning outcomes using the brain learning model based learning is based on initial mathematical abilities which are categorized as high, medium, and low.

H₁ : There are differences in students' mathematics learning outcomes using the brain learning model based learning is based on initial mathematical abilities which are categorized as high, medium, and low.

H₀ : There is no interaction between basic competencies 3.3, 3.4, and 3.5 and students' initial mathematical abilities in the high, medium, and low categories in determining mathematics learning outcomes using the brain learning model-based learning.

H₁ : There is an interaction between basic competencies 3.3, 3.4, and 3.5 and students' initial mathematical abilities in the high, medium, and low categories in determining mathematics learning outcomes using the brain learning model-based learning.

Table 1. Between Subjects Factors

		Value	N
KD		3.3	31
		3.4	31
		3.5	31
KAM		Tall	12
		Currently	48
		Low	33

Based on Table 1 above amount There are 31 students in class VI which is partially based on results learning against KD 3.3, 3.4, and 3.5, then on ability beginning matametis student based on category high, medium, and low as many as 12, 48, and 33 students.

Table 2. Descriptive Statistics

K.D	THURS	Mean	Std Deviation	N
3.3	Tall	85.50	4.123	4
	Currently	68.25	6,537	16
	Low	52.36	4,296	11
	Total	64.84	12,223	31
3.4	Tall	93.40	3,049	5
	Currently	77.46	6,063	13
	Low	64.15	2,794	13
	Total	74.45	11,348	31
3.5	Tall	90.00	,000	3
	Currently	79.63	6,473	19
	Low	65.78	3,767	9
	Total	76.61	9,373	31
Total	Tall	89.92	4,542	12
	Currently	75.25	8,054	48
	Low	60.67	6,945	33
	Total	71.97	12,076	93

Based on Table 2 above seen that students' average score on competency basic 3.3 on category ability beginning mathematical high, medium, low as many as 4, 16, 11 students amounting to 85.50, 68.25, 52.36 and for mark standard the deviation amounting to 4,123, 6,537, 4,296. Then on competence-base 3.4 on category ability beginning mathematical high, medium, low as many as 5, 13, 13 students of 93.40, 77.46, 64.15 and for mark standard the deviation

amounting to 3,049, 6,063, 2,794. Meanwhile regarding competence basic 3.5 on category ability beginning mathematical high, medium, low as many as 3, 19, 9 students amounting to 90.00, 79.63, 65.78 and for mark standard the deviation of 0,000, 6,473, 3,767. With thereby in a way overall competency basic 3.3, 3.4, and 3.5 in categories ability beginning mathematical high, medium, low as many as 12, 48, 33 students amounting to 89.92, 75.25, 60.67 and for mark standard the deviation amounting to 4,542, 8,054, 6,945.
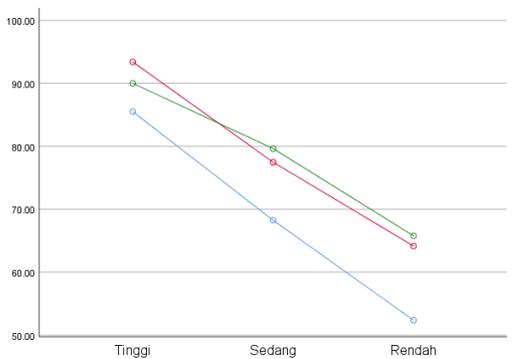

Figure 1.
Estimated Marginal Means

Table 3. Test of Normality

	Statistics	Sig.
Standardized Residual	.070	.200*

Based on Table 3 above seen that the standardized residual value is 0.200. From this data obtained the mark significance is bigger from 0.05 so it can concluded that the data is normally distributed. Besides that, you can also see the distribution of data from Normal QQ in the following picture.
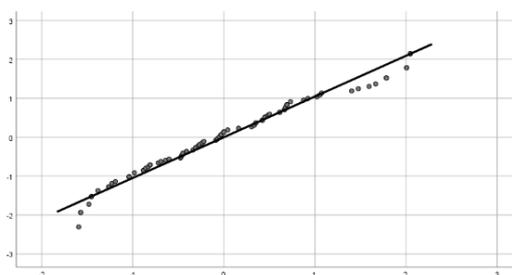

Figure 2.
Normal QQ Plot of Standardized Residuals

Based on Figure 2 above seen that part large data on the standardized residual value of results Study mathematics students using a brain-based learning model is around the diagonal line, so matter shows that the result data Study students in class VI based on competence bases 3.3, 3.4, and 3.5 are normally distributed. Then next the homogeneity test to view homogeneous data or no homogeneous.

Table 4. Levene's Tests of Equality of Error Variances[a,b]

	Levene Statistic	Sig.
Based on Mean	3.670	.001
Based on Median	2.424	.021
Based on Median and with adjusted df	2.424	.023
Based on trimmed mean	3.510	.002

Based on Table 4 above the mark significance based on mean is 0.001. From this data the mark significance more smaller than 0.05 so it can concluded that the variance mark from variable results Study mathematics students using the brain-based learning model reviewed based on competence basic 3.3, 3.4, and 3.5 are both homogeneous. Despite thereby Two Ways ANOVA testing can still done Because condition absolute from Analysis of Variances testing is normally distributed data.

Table 5. Tests of Between-Subjects Effects

Source	F	Sig.
Basic competencies	25.107	.000
Early Mathematical Abilities	146.802	.000

Basic Competencies*Primary Mathematical Abilities		1.046	.388

Based on Table 5 above seen that the significance of competence basics and abilities beginning with mathematical students of 0.000. Meanwhile, the significance value of students' basic competencies*initial mathematical abilities is 0.388. From these data, it was found that the significance value for students' basic competencies and initial mathematical abilities was smaller than 0.05, while the significance value for students' basic competencies*initial mathematical abilities was greater than 0.05. So it can be concluded that there are differences in students' mathematics learning outcomes using the brain learning model based learning at KD 3.3, 3.4, and 3.5, there are differences in students' mathematics learning outcomes using the brain learning model based learning is based on initial mathematical abilities which are categorized as high, medium and low, and there are no interaction between basic competencies 3.3, 3.4, 3.5 and students' initial mathematical abilities which are categorized as high, medium and low in determining mathematics learning outcomes using the brain learning model-based learning.

Table 6. Multiple Comparisons of Basic Competencies

KD	KD	Mean Difference	Sig.
3.3	3.4	-9.612*	.000
	3.5	-11.77*	.000
3.4	3.3	9.612*	.000
	3.5	-2.161	.327
3.5	3.3	11.77*	.000
	3.4	2.161	.327

Based on Table 6 above, it can be seen that the significance value between students' mathematics learning outcomes using the brain-based learning model in basic competencies 3.3 with 3.4 and 3.3 with 3.5 is 0.000. Meanwhile, the significance value between student learning outcomes in basic competencies 3.4 and 3.5 is 0.327. From these data, it was found that the significance value between KD 3.3 and 3.4 and 3.3 and 3.5 was smaller than 0.05. Meanwhile, the significance value between KD 3.4 and 3.5 is greater than 0.05. So it can be concluded that there are differences in students' mathematics learning outcomes using the brain-based learning model at KD 3.3 with 3.4 and 3.3 with 3.5. However, KD 3.4 and 3.5 show that there is no difference in the mathematics learning outcomes of students who study using the brain-based learning model.

Table 7. Multiple Comparisons of Initial Mathematical Ability

KAM	KAM	Mean Difference	Sig.
Tall	Currently	14.67*	.000
	Low	29.25*	.000
Currently	Tall	-14.67*	.000
	Low	14.58*	.000
Low	Tall	-29.25*	.000
	Currently	-14.58*	.000

Based on Table 7 above, it can be seen that the significance value between students' mathematics learning outcomes using the brain-based learning model on students' initial mathematical abilities which are categorized as high and medium, high and low, and medium and low is 0.000. From these data, it was found that the significance value of students' initial mathematical abilities in the categories of high and medium, high and low, and medium and low

was less than 0.05. So it can be concluded that there are differences in students' mathematics learning outcomes using the brain-based learning model in students' initial mathematical abilities which are categorized as high and medium, high and low, and medium and low.

Learning using the brain-based learning model for class VI students at SDN Batujajar 3 can be said to provide a significant difference to each basic competency which discusses orientation in explaining and carrying out mixed arithmetic operations, explaining the elements of a circle, and explaining the circumference and area of a circle which are reviewed based on Students' initial mathematical abilities are categorized as high, medium and low. However, these differences did not produce significant interactions in student learning outcomes using the brain-based learning model. This is in line with previous research conducted by (Farida, 2021), (Listiani, 2022), (Nurasiah et al., 2022), (Srimuliati et al., 2022), (Yahya et al., 2022), and (Waro et al., 2024) where mathematics learning using the brain-based learning model contributes to improving and making students more motivated in understanding learning so that it is more meaningful.

E. CONCLUSION

In this research it can be concluded that mathematics learning outcomes using the brain learning model-based learning provide significant differences and interactions in culminating learning based on students' initial mathematical abilities in the high, medium, and low categories which are oriented toward basic learning competencies regarding explaining and carrying out mixed arithmetic operations, explaining the elements of a circle, and

explaining the circumference and area of a circle. The results showed that there were differences in students' mathematics learning outcomes using the brain learning model-based learning at KD 3.3, 3.4, and 3.5, as well as initial mathematical abilities in the high, medium, and low categories, but there is no interaction between basic competencies 3.3, 3.4, 3.5 and students' initial mathematical abilities in the high, medium, and low categories in determining Mathematics learning outcomes using the brain learning model-based learning.

Then there are differences in students' mathematics learning outcomes using the brain learning model-based learning at KD 3.3 with 3.4 and 3.3 with 3.5. However, KD 3.4 and 3.5 show that there is no difference in the mathematics learning outcomes of students who study using the brain learning model. based on learning. Apart from that, there are differences in students' mathematics learning outcomes using the brain learning model based learning on students' initial mathematical abilities which are categorized as high and medium, high and low, and medium and low. Thus, it is hoped that further research can examine the brain learning model-based learning which has implications for students' cognitive and geographic levels of mathematics learning outcomes to see the interactions and differences that occur.

F. AUTHOR'S NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The author confirms that the data and content of the article are free from plagiarism.

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