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The Effectiveness of Brain-Based Learning with Think Pair Share Setting in Terms of Achievement, Representation Ability, and Anxiety of High School Students

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Abstract

Innovation in learning is needed by combining a learning approach and a classroom setting model to solve the problem of low student achievement and representation abilities. It can also be used as an effort to overcome problems in the aspect of attitude, for example, math anxiety. This study was aimed to (1) describe the effectiveness of the brain-based learning approach with a think pair share setting (BBL+TPS); (2) find out the difference between learning with BBL+TPS and the scientific approach; and (3) describe which one is more effective between the BBL+TPS and the scientific approach in terms of learning achievement, mathematical representation ability, and student's math anxiety in statistics and probability. This study was a quasi-experimental study with the population being students of class X SMAN 2 Bantul, and the sample was students of classes X MIA 3 and X MIA 4, which were determined by using random sampling technique. The data collection techniques used are interviews, observations, and questionnaires. Data analysis techniques are descriptive and inferential statistics. The results show that: (1) BBL+TPS is effective; (2) there are differences in the effectiveness of learning between the BBL+TPS and the scientific approach; and (3) BBL+TPS is more effective than the scientific approach in terms of learning achievement and mathematical representation ability, but not more effective in terms of math anxiety.

Keywords: Brain-Based Learning; Learning Achievement; Mathematics Anxiety; Representations Ability; Think Pair Share

Abstrak

Diperlukan suatu inovasi dalam pembelajaran dengan menggabungkan pendekatan pembelajaran dan model pengaturan kelas untuk menyelesaikan permasalahan prestasi belajar dan kemampuan representasi siswa yang rendah. Hal tersebut juga dapat digunakan sebagai upaya untuk mengatasi permasalahan dalam aspek sikap contohnya kecemasan matematika. Penelitian ini bertujuan untuk (1) mendeskripsikan keefektifan pendekatan brain-based learning dengan setting think pair share (BBL+TPS), (2) mengetahui adanya perbedaan antara pembelajaran dengan pendekatan BBL+TPS dan saintifik, dan (3) mendeskripsikan mana yang lebih efektif antara pendekatan BBL+TPS dan saintifik ditinjau dari prestasi belajar, kemampuan representasi matematika, dan kecemasan matematika pada materi statistika dan peluang. Penelitian ini merupakan penelitian eksperimen semu dengan populasi adalah siswa kelas X SMA Negeri 2 Bantul dengan sampel penelitian adalah siswa kelas X MIA 3 dan X MIA 4, yang ditentukan dengan menggunakan teknik random sampling. Teknik pengumpulan data yang digunakan antara lain wawancara, observasi, dan angket. Teknik analisis data yaitu statistik deskriptif dan inferensial. Hasil penelitian menunjukkan bahwa: (1) pendekatan BBL+TPS efektif, (2) ada perbedaan keefektifan pembelajaran antara pendekatan BBL+TPS dan saintifik, dan (3) pendekatan BBL+TPS lebih efektif dibandingkan dengan pendekatan saintifik ditinjau dari pretasi belajar dan kemampuan representasi matematika, namun tidak lebih efektif ditinjau dari kecemasan matematika.

Kata Kunci: Brain-Based Learning; Kecemasan Matematika; Kemampuan Representasi; Prestasi Belajar; Think Pair Share

Introduction

Mathematics is a science that is learned at all levels of education, ranging from primary, secondary, and tertiary education (Eileen, Rotenberg, & Bick, 2014) explain that mathematics is the study of patterns-abstract pattern that places concepts in a systematized relationship to one another, expressed in a symbolic system that we can manipulate using reason alone, with no necessary reference to the world. Mathematics removes itself into abstraction, into concepts. Therefore, learning mathematics in schools must be able to facilitate students' achieving the objectives of learning mathematics effectively and efficiently. Due to the abstract nature of mathematics, students still find it difficult to understand the material being studied. This is the following was stated by (Muijs & Reynolds, 2011) that the specific difficulty of mathematics knowledge for pupils lies in its abstract nature. Pupils often find it hard to link mathematics learned in the classroom to real-life situations, and also have difficulties making the connections between the mathematics knowledge they already possess and what they learn at school (Auliya, 2019; Malasari, Herman, & Jupri, 2019; Bhoke, 2020; Richardo, 2020; Taskiyah & Widyastuti, 2021). This affected the low learning achievement of students' mathematics. Based on the results of interviews and student achievement tests, their scores were quite low in statistics and probability. The achievement is the knowledge, skills, and abilities that students have developed as a result of learning (Nitko & Brookhart, 2011).

Learning statistics and probability in high school are certainly different from learning at previous school levels. In grades 9-12 students should gain a deep understanding of variability, i.e. collect, analyze data and draw conclusions from data to answer everyday questions or make decisions in everyday situations. Students learn how to determine sample statistical probabilities for a known population and draw simple conclusions about the population from a randomly generated sample. Standard processes in learning mathematics are problem solving skills, reasoning and proof, communication, connection, and mathematical representation (NCTM, 2000). The ability to represent mathematics is one of the most important skills in learning mathematics. In psychology, representation means the process of modeling concrete things in the real world into abstract concepts or symbols. Representation is defined as a configuration of characters, images, concrete objects, etc., which can represent or "represent" something else (Hwang, Chen, Dung, & Yang, 2007).

The learning process that emphasizes the ability of representation will train students in mathematical communication (Nashihah, 2020). There are three reasons why representation is one of the most important aspects of mathematics education: Students need practice in building representations so that they have the ability and understanding of good and flexible concepts that can be used in teaching and learning mathematics. The way the teacher presents mathematical ideas through various representations will have a huge impact on students' learning mathematics, and students need practice in building representations so that they have the ability and understanding of good and flexible concepts that can be used to solve the problem in teaching and learning mathematics (Sabirin, 2014). In current learning, there are still many students who have difficulty in representing the mathematical knowledge they have acquired. This is based on interviews with mathematics teachers at SMA Negeri 2 Bantul who stated that students' mathematical representation abilities were still low, for example, difficulties in translating information into symbols.

The purpose of learning mathematics for students is not only in terms of knowledge and skills but also in aspects of attitudes, such as math anxiety. Anxiety is something that everyone feels. Anxiety is a normal thing and is a part of everyday life. But when sadness fills most of your days or worries saturate your mind, that’s not so normal. You may be experiencing a real problem with depression or anxiety (Elliott & Smith, 2006). Anxiety and depression can affect how you think, behave, feel, and relate to others. Anxiety is currently viewed as a complex multidimensional construct embodying a series of interrelated cognitive, affective, somatic, and behavioral reactions (Zeidner & Gerald Matthews, 2011).

From the results of learning observations, it can be seen that some students tend to underestimate mathematics learning because of the assumption that mathematics is too difficult to understand. However, some feel hesitant when asked to present their work in front of a class because they feel too much anxiety. Students who experience excessive anxiety will affect the enthusiasm, fighting power, attitudes, and beliefs of students in learning mathematics, which can hinder the development of their abilities. In addition, students who do not feel anxiety will not have high motivation to learn. (Arem, 2010) said that the relationship between anxiety and learning achievement is like a curved curve, where at a medium level of anxiety, you will feel more alert, energetic, clear-minded, motivated, and creative to achieve optimal performance. The emergence of mathematics anxiety can be caused by several factors experienced by students in learning. There is an embarrassment, negative life experiences associated with learning math, social pressures and expectations, desire to be perfect, poor teaching methods, negative math games people play, cultural myths about mathematics, gender stereotyping, and socialization.

Students with higher math anxiety successfully completed the task, but they took longer to respond and exhibited greater use of working memory. In our study, we assessed math anxiety rather than giftedness, but higher math anxiety (HMA) seemed to have the effect of making students appear less gifted, presumably because of the demands math anxiety places on working memory. This is due to additional cognitive resources are required to regulate negative emotions associated with mathematical performance.Learning mathematics in the classroom is essentially aimed at helping and managing the anxiety experienced by students towards mathematics to create fun learning (Norton, Seok, & Choi-Koh, 2019). Learning mathematics in the classroom is essentially aimed at helping and managing the anxiety experienced by students towards mathematics to create fun learning.

Learning mathematics at SMA Negeri 2 Bantul uses a scientific approach, with its process being a combination of the learning processes that were originally focused on exploration, elaboration, and confirmation, equipped with observing, asking, reasoning, trying, and communicating. This approach is still not enough to be able to overcome the problems that exist in learning mathematics, as previously mentioned. To overcome problems, a varied and innovative learning approach is needed. Teachers need to understand the natural workings of the student's brain to determine which learning method to choose. Mathematics learning does not only emphasize the cognitive development of the left brain and does not optimize learning by involving the right brain.

The brain, as the center of information processing, has an important role in learning. The right-brain characteristics include creativity, the ability to see patterns, spatial awareness, and an understanding of how things relate to one another in different contexts. The right brain functions to develop emotional intelligence, which is important in helping students manage their math anxiety. While the left brain has characteristics in language, analytical skills, and mathematical concepts. The left brain plays an important role in developing students' cognitive abilities in learning, especially in learning mathematics. Teachers should be able to determine the right approach that is adapted to the work of the student's brain, namely brain-based learning (Sousa, 2015).

Brain-based learning (BBL) involves acknowledging the brain’s rules for meaningful learning and organizing teaching with those rules in mind. It is not focused on order or regularity, but rather focuses on the pleasure and love of learning for students (Caine & Caine, 1994). BBL is closely related to cognitive development based on the idea that each part of the brain has a specific function when it comes to learning. The important in the BBL approach is memory in the brain. The memory in the student's brain will not be easily forgotten by using a concept map or mind mapping (Klinek, 2009), (Siercks, 2012). In mathematics education, mind mapping may be used with several different aims, there is help organize information, can be used as a memory aid, can assist with repetition and summary, help to meaningfully connect new information with existing knowledge, may introduce new concepts, let the cognitive structure of student become visible, foster creativity, and can show connections between mathematics and the rest of the world (Brinkman, 2003).

The application of a brain-based learning approach in learning mathematics needs to pay attention to certain techniques. There are three techniques related to brain-based learning based on the abilities and limitations of the brain, namely (1) relaxed alertness, where students can concentrate why they are relaxed so to maximize the potential, alertness can be enhanced by eliminating fear but maintaining a challenging environment; (2) orchestrated immersion, creating a learning environment that will completely involve the learner in the subject; and (3) active processing, allowing students to process information to remember according to their abilities, this is accomplished by teaching the same material with several approaches (Kaur, 2013). The implementation of the BBL strategy involves teachers who must know what students' motivations for learning are. As we know, thoughts and emotions are inseparable and interrelated in learning. Furthermore, memory is a critical element in the learning process. Students are expected to be able to remember and understand the material that has been studied well. It is also important to pay attention to the physical environment, such as seating, temperature, lighting, and building design, to create pleasant and comfortable environmental conditions.

Learning mathematics with think pair share (TPS) cooperative settings can be applied as an alternative model or learning setting that makes students happy, stimulates student activity to think, discusses the results of their thoughts with friends, and stimulates students' courage to express their opinions in front of the class. Kinzie & Markovchick (Wahyuni & Abadi, 2014) suggested that think pair share is a strategy designed to encourage student involvement. In the first stage, students listen to the teacher's questions. Then think about the answers to the questions given. They pair up with another student and discuss each other's answers. In the final stage, they were asked to explain or share their answers with other groups.

This brain-based learning approach with think pair share settings (BBL+TPS) in mathematics learning helps students practice mathematical representation skills through solving challenging problems by presenting ideas individually and discussing them with friends. In learning, students present a concept map of what they have learned to check students' understanding. It is also interspersed with relaxation and listening to music that can develop students' emotional intelligence. They will be able to manage math anxiety while learning mathematics and mathematical representation skills can be improved by sharing them with group friends and classmates to improve mathematics learning achievement as well.

The objectives of the research are (1) to describe the effectiveness of the brain-based learning approach with think pair share (BBL + TPS) settings; (2) to find out the differences between learning with a brain-based learning approach and think pair share settings and learning with a scientific approach; and (3) to describe which is more effective between the brain-based learning approach with think pair share settings and the scientific approach in terms of learning achievement, mathematical representation ability, and students' math anxiety. The benefit of this research for mathematics teachers is that a brain-based learning approach with think pair share settings can be used as an alternative to mathematics learning that is oriented towards increasing learning achievement, students' mathematical representation abilities, and controlling student' math anxiety. While the benefits for researchers are to increase their knowledge and abilities in carrying out scientific work, it can also be used as a reference in conducting research that is in accordance with the learning approach or research variables in this study by other researchers.

Method

This type of research is quantitative research with a quasi-experimental method. This research using a quasi-experimental design was carried out in pre-existing classes without grouping randomly. This study uses two classes at SMA Negeri 2 Bantul for academic year 2019/2020. The sample was selected using a purposive sampling technique and obtained from class X MIA 3 as the experimental class, which was treated with a brain-based learning approach with think pair share class setting. XMIA 4 as a control class was treated with a scientific approach because it was the conventional method used in the school.

The research design used was a pretest-posttest nonequivalent group design involving the experimental and control groups, each of which received a different treatment.

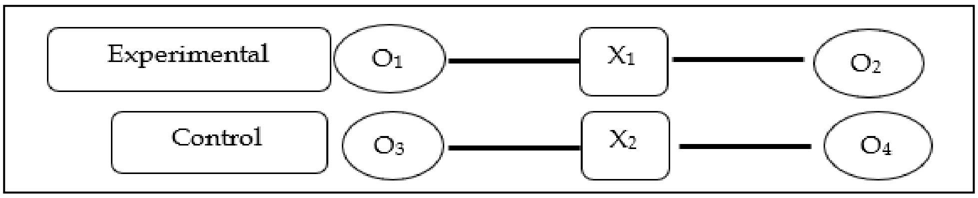

Figure 1. Nonequivalent Control Group Design

Description:

O_1 : pretest experimental group
O_2 : posttest experimental group
O_3 : pretest control group
O_4 : posttest control group
X_1 : BBL + TPS learning treatment
X_2 : scientific learning treatment

The data collection technique in this study used a test consisting of a pretest and a posttest in the form of multiple-choice questions to measure student achievement and essays to measure mathematical representation abilities. The questionnaire was used to determine the level of students' mathematics anxiety whish consists of 36 items with favorable and unfavorable statements. The scale used in this questionnaire is a Likert scale which consists of four answer choices, namely: strongly agree, agree, disagree and strongly disagree. This questionnaire was developed based on conceptual definitions which then obtained four aspects of mathematics anxiety, namely mathematics material, mathematics learning, mathematics teacher, and mathematics test. The list of indicators for the test instruments for mathematical representation and mathematical anxiety is shown in Table 1 and Table 2.

Table 1. The Indicators of Mathematical Representation Ability Instruments

Aspects of Mathematical Representation	Indicator
1. Create and use representations to organize, record, and communicate mathematical ideas	Write down the steps of problem solving ideas
2. Select, apply, and translate between mathematical representations to solve problems	Translate tables into charts Translate information into tables Translating symbols into statements
3. Using representations to model and interpret physical, social, and mathematical phenomena	Interpret phenomena from tables Interpret phenomena from histograms

Table 2. The Indicators of Math Anxiety Questionnaire Instruments

Dimensions	Math Aspects	Indicator
Cognitive	Math material	Assume math material difficult to understand
	Math learning	Thinks learning math is not fun
	Math teacher	Think math teacher is scary
	Math test	Think the math tests is burden
Affective	Math material	Feeling nervous when reading math material
	Math learning	Find math learning in class stressful
	Math teacher	Feeling scared of the math teacher
	Math test	Feeling anxious in facing and doing math test
Somatic	Math material	Give a negative response to math material
	Math learning	Give a negative response to learning mathematics
	Math teacher	Giving a negative response to the math teacher
	Math test	Give a negative response when taking a math test

Each test and questionnaire was tested for validity and estimated reliability, and the results showed that the tests and questionnaires were valid and reliable. In this study, the validity used is content validity and construct validity. To obtain evidence of content validity, it is done by asking for expert judgment. Content validity is used for test and non-test instruments to see the suitability of the instrument with the grid. Construct validity is used for non-test instruments to find out which items greatly affect student anxiety. To test the validity of the items performed by factor analysis with IBM SPSS 23.0 Software for Windows. The results of the calculation of validity with the help of the SPSS 23 for Windows program obtained a Kaiser-Mayer-Olkin (KMO) value of 0.639 meaning that the data was feasible for factor analysis because the value was more than 0.5. Barlett's value is also obtained for the value of the Chi Square approach, which is 2274,135; a significance value of 0.000 is smaller than 0.05, which means that the data is valid.

Furthermore, to estimate the reliability of the students' mathematics anxiety questionnaire instrument, Cronbach's Alpha formula was used as follows (Allen & Yen, 1979):

$$\alpha = \left\{\frac{N}{N-1}\right\}\left\{\frac{\sigma_X^2 - \sum \sigma_{Yi}^2}{\sigma_X^2}\right\}$$

where:

α = reliability coefficient
N = number of items
$\sum \sigma_{Yi}^2$ = number of variance scores for each item
σ_X^2 = total variance

The estimation of instrument reliability can also be calculated using IBM SPSS 23.0 Software for Windows. From the test results, it was found that the alpha value was 0.957. Therefore, it can be concluded that the instrument used is a reliable and consistent instrument because of its high reliability coefficient.

The research data analyzed were learning achievement test data, mathematical representation ability, and mathematical anxiety questionnaire before and after being given treatment. Data analysis before treatment to describe the initial conditions of the two groups and after treatment to determine the effectiveness of learning mathematics using a brain-based learning approach with think pair share settings and a scientific approach.

Data on learning achievement and mathematical representation ability are described from the scores obtained by students and then converted to a score of 0–100. Data on students' mathematics anxiety was described based on the number of questionnaire scores and then categorized based on the converted standard scores. To determine the category of measurement results, classification is used which is determined by the ideal mean (M_i) and ideal standard deviation (Sd_i), which can be seen in Table 3 (Azwar, 2015).

Table 3. Conversion of Qualitative to Quantitative Data

Score Interval (X)	Category
$117 < X \leq 144$	Very High
$99 < X \leq 117$	High
$81 < X \leq 99$	Medium
$63 < X \leq 81$	Low
$36 < X \leq 63$	Very Low

The data obtained were then analyzed to test its effectiveness. Data analysis was carried out with the SPSS 23 for Windows program. Before the effectiveness analysis test, the assumption of multivariate normality was tested using the

Mahalanobis distance test and univariate normality using the Kolmogorov-Smirnov test. The assumption of multivariate homogeneity by looking at the significance value of Box 'M and univariate homogeneity using the Lavene test. Test the effectiveness of each lesson in terms of the dependent variable was carried out with the one-group MANOVA test, with the following hypotheses:

$$H_0: \begin{pmatrix} \mu_{1i} \\ \mu_{2i} \\ \mu_{3i} \end{pmatrix} = \begin{pmatrix} 75 \\ 75 \\ 90 \end{pmatrix} \text{ dan } H_a: \begin{pmatrix} \mu_{1i} \\ \mu_{2i} \\ \mu_{3i} \end{pmatrix} \neq \begin{pmatrix} 75 \\ 75 \\ 90 \end{pmatrix}$$

The formula used to test the hypothesis is as follows (Stevens & Pituch, 2016)

$$T^2 = n\,(\bar{x} - \mu_0)'(S)^{-1}(\bar{x} - \mu_0)$$

where:

n = number of subjects
$\bar{x}$ = sample mean value
μ_0 = set average value
S = sample covariance matrix

The criteria used in decision making is that H_0 is rejected if $T^2 > \frac{(n-1)p}{(n-p)} F_{p,n-p}(\alpha)$, with p and $(n - p)$ degrees of freedom, where p is the number of dependent variables and n is the number of subjects. . That means the approach used is BBL+TPS and scientific effectiveness is reviewed of learning achievement, mathematical representation ability, and mathematics anxiety. If the approach is effective, then a further test is carried out, namely testing which variables influence the effectiveness of the approach by using a one-sample t-test with the help of IBM SPSS 23.0 Software for Windows. Furthermore, to find out which group is more effective, a two-group MANOVA test was carried out using Hotelling's T^2 test statistics (Stevens & Pituch, 2016), namely

$$T^2 = \frac{n_1 \,.\, n_2}{n_1 + n_2} (\overline{y_1} - \overline{y_2})' S^{-1} (\overline{y_1} - \overline{y_2})$$

The decision criteria are at a significance level of 5% by first looking at the initial ability conditions in the two classes. Furthermore, an analysis was carried out to determine which variables contributed to the difference in effectiveness, which was tested with the independent sample t-test. The hypothesis being tested is that the BBL+TPS approach is more effective than the scientific approach. The formula used in testing the hypothesis using the t-test statistic (Stevens and Pituch, 2016):

$$t = \frac{\overline{y_1} - \overline{y_2}}{\sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

The criteria used are the Bonferroni criteria, where the significance level is set at 0.05 for each t-test using 0.05/3 = 0.0167 criteria.

Results

The research took place seven times for each class, with details of five meetings for the implementation of the learning process and two meetings for giving a test. Jensen (2008) explain that seven outline stages of brain-based learning and learning planning, namely (1) pre-exposure, (2) preparation, (3) initiation and acquisition, (4) elaboration, (5) incubation and input memory, (6) verification, and (7) celebration and integration. And then, learning with BBL+TPS is carried out in the following stages: the teacher prepares and conditions students to learn by displaying a learning concept map in front of the class; the teacher presents problems and asks students to think individually regarding the resolution of the problem posed; students are asked to discuss in pairs where students process the information and ideas they have obtained; several groups are asked to share the results of the discussion with other friends; the teacher plays music and provides time for students to relax and rest while repeating the material that has been learned by describing a learning concept map for each meeting; students, with the guidance of the teacher, make conclusions to verify what the students have learned; and the teacher gives appreciation and celebrates the results of learning earned.

This study collected data in the form of learning achievement data, mathematical representation ability data, and students' mathematical anxiety data from the pretest and posttest results. The following is a description of the data for each variable, which can be seen in Table 4.

Table 4. Description of Student Achievement Data

Descriptive	Pretest		Posttest	
	BBL+ TPS	Scientific	BBL+ TPS	Scientific
Means	57,76	57,41	87,76	79,83
Variance	58,19	90,39	26,05	45,51
Max	70	75	100	95
Min	40	30	75	60

It appears that the average value of mathematics learning achievement in the two groups before being given treatment had not reached 75 (according to the KKM). After being given treatment, the average score of students was above 75, namely 87.76 for the BBL+TPS group and 79.83 for the scientific group. Data of mathematical representation abilities can be seen in Table 5.

Table 5. Description of Mathematical Representation Ability Data

Descriptive	Pretest		Posttest	
	BBL+ TPS	Scientific	BBL+ TPS	Scientific
Mean	50,86	51,15	91,38	83,19
Variance	131,92	69,32	91,68	68,80
Max	79,7	66,67	100	100
Min	33,33	37,50	67	60

The information indicates that the average value of students' mathematical representation abilities before the treatment for both the BBL+TPS and scientific groups has not reached an average value of 75. After being given treatment, the average value of students' mathematical representation abilities exceeds the average value of 75. Furthermore, the description of the students' mathematical anxiety data can be seen in Table 6.

Table 6. Description of Math Anxiety Data

Descriptive	Pretest		Posttest	
	BBL+ TPS	Scientific	BBL+ TPS	Scientific
Mean	72,31	75,83	84,38	85,41
Variance	136,08	122,29	94,35	93,25
Max	102	101	100	103
Min	50	55	61	63

Based on Table 6, it is known that the average score and category of students' mathematics anxiety experienced an increase in both the BBL+TPS group and the scientific group. The average score of the BBL+TPS group increased from 72.31 in the low category to 84.38 in the medium category, while in the scientific group the average value increased from an initial average score of 75.83 in the low category to 85.41 in the medium category. Furthermore, the frequency distribution of students' mathematics anxiety before and after treatment can be seen in Figure 2.

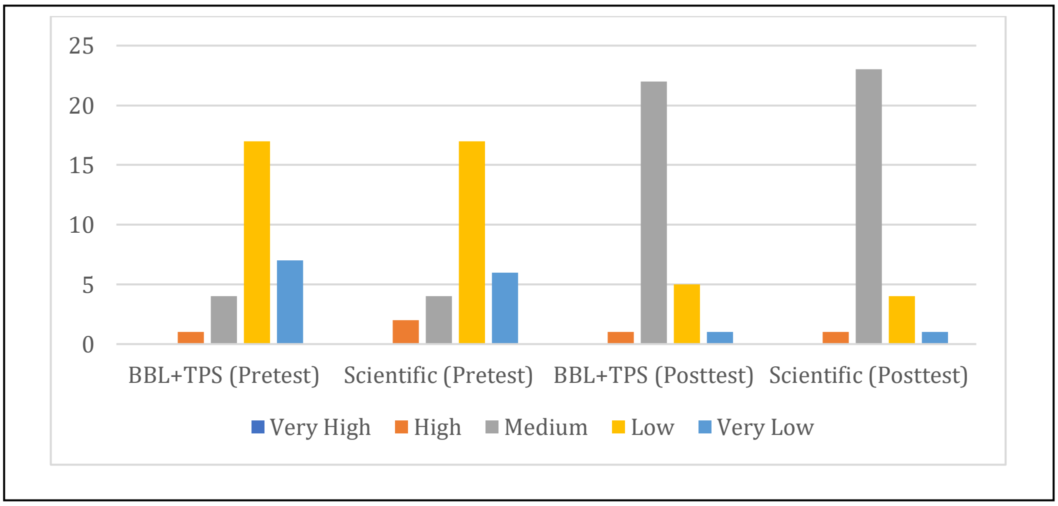

Figure 2. Frequency Distribution of Math Anxiety

It is obtained that the BBL + TPS group experienced an increase in the medium category as well as in the scientific group. More than 50% of students who filled out the questionnaire were in the medium category, namely 22 students in the BBL+TPS group and 23 students in the scientific group, out of a total of 29 students for each group. Data on students' mathematics anxiety was also grouped based on aspects of mathematics anxiety, namely materials, learning, teachers, and math tests, which can be seen in Table 7. It can be seen that the aspect of anxiety towards math tests has the highest average, indicating that students feel anxiety when facing math tests.

Table 7. The Average Value of Math Anxiety Based on ts Aspects

Aspect	Pretest		Posttest	
	BBL+ TPS	Scientific	BBL+ TPS	Scientific
Math material	17,28	18,34	19,48	20,17
Math learning	18,14	18,93	21,31	21,45
Math teacher	17,93	17,86	20,83	20,34
Math test	18,97	20,69	22,76	23,45

The assumption test results from the data obtained indicate that the research data meet the assumptions of normality and homogeneity in multivariate and univariate ways. The assumption of multivariate normality was fulfilled, which was shown based on the results of the Mahanolobis distance test for data before treatment in both the BBL+TPS group and the scientific group, with the percentages being 44.83% and 48.28%, respectively. The data after treatment also fulfilled the assumption of multivariate normality with a percentage of 51.72% and 44.83%. The univariate normality test obtained that the significance value of the data after treatment on the three research variables for the BBL+TPS and scientific groups is greater than 0.05, so it can be concluded that the assumption of univariate normality is fulfilled.

The multivariate homogeneity test using the Box's M test showed that the value of sig F = 0.065 for data before treatment and sig F = 0.225 for data after treatment, which means that the covariance variance of the populations of the two groups before and after treatment is the same. A Univariate homogeneity test of the data before and after treatment is obtained that the sig value for each variable is more than 0.05. This indicates that the assumption of homogeneity of variance of the two classes before and after treatment is the same.

The Effectiveness of Brain-based Learning Approach with Think Pair Share Settings

Before the effectiveness test, data analysis was carried out before being given treatment to see the difference in initial ability, which was tested with two-group MANOVA obtained sig value F = 0.703> 0.05. This shows that the initial conditions of the two groups for all aspects measured are the same. Furthermore, for the results of the BBL + TPS learning effectiveness test in terms of the three variables, it was found that the value of $T^2 = 281{,}17 > \frac{(28)(3)}{26} F_{3,26}(0{,}05) = 9{,}61$, which means that the BBL approach + TPS is effective in terms of learning achievement, mathematical representation ability, and math anxiety.

Then, testing the effectiveness of the brain-based learning approach by setting think pair share for each variable using the one-sample t-test by SPSS 23 for Windows program. One sample t-test was carried out on the data after treatment, with the results as shown in Table 8 below.

Table 8. Results of One-Sample t-test for BBL + TPS Group

Variable	*t*	*Sig.*	*Sig/2*
Achievement	13,462	0,000	0,000
Mathematical Representation Ability	9,211	0,000	0,000
Math Anxiety	-3,145	0,004	0,002

From these results, it is known that the significance value of t for all aspects, when divided by two, is less than 0.05, which indicates that learning with the BBL+TPS approach is effective in terms of each of these aspects. The results of the study are following the given hypothesis.

Differences in the Effectiveness of the BBL+TPS and Scientific Approach

The average difference test of the three variables before treatment was carried out to determine the type of test to be used to test the difference in the effectiveness of the two approaches. The average difference test used the MANOVA test with the SPSS 23 for Windows program, with the results as presented in Table 9 below.

Table 9. MANOVA Test Results Before and After Treatment

Hotelling's Trace	*F*	*Sig.*
Before Treatment	0,472	0,703
After Treatment	10,287	0,000

From the table, it is found that the significance value of F before treatment is 0.703 which is greater than 0.05. This shows that there is no difference in the effectiveness of the BBL+TPS and scientific approaches. And then, the value of F after treatment is 10.287 with sig = 0.000 < 0.05 indicating that there is a difference in effectiveness between learning with the BBL+TPS approach and the scientific approach.

Comparison of the Effectiveness of the BBL+TPS and Scientific Approach

A comparison test of the effectiveness between the two approaches was carried out using the independent sample t-test is presented in Table 10.

Table 10. Results of the Independent Sample t-test

Variable	*t*	Difference Mean	*Sig.(2-tailed)*	*Sig/2*
Achievement	5,049	1,571	0,000	0,000
Mathematical Representation Ability	3,481	2,352	0,001	0,0005
Math Anxiety	-0,409	-1,034	0,684	0,342

It is known that the significance value of t for the variables of learning achievement and mathematical representation ability if divided by two, is smaller than 0.0167, which indicates that learning with the BBL + TPS approach is more effective than learning with the scientific approach in terms of learning achievement and mathematical representation ability. As for the mathematics anxiety variable, the BBL+TPS approach is not more effective than the scientific approach. In both classes, the BBL+TPS and scientific classes have different but not significant averages for the mathematics anxiety variable, namely the BBL+TPS and scientific classes of 84.38 and 85.41, respectively. This average value is in the medium category.

Discussion

There are three things discussed in this study, namely the effectiveness of the brain-based learning approach with think pair share settings (BBL+TPS), differences in the effectiveness of the BBL+TPS and the scientific approach, and the comparison of the effectiveness of the BBL+TPS and the scientific approach. scientific research in terms of learning achievement, mathematical representation ability, and mathematical anxiety.

Based on the results of hypothesis testing, it was found that the BBL+TPS approach was effective in improving student achievement, mathematical representation ability, and controlling math anxiety. The results of this study are also following the results of research conducted by Awolola (2011) where brain-based learning can have a significant impact in improving students' mathematics learning achievement. The stages in BBL+TPS learning play a role in improving student achievement. Learning activities with this approach involve students actively both individually and in groups in solving problems contained in the Student Activity Sheet.

The application of a brain-based learning approach can improve student achievement and student motivation. In applying a brain-based learning approach, the teacher must consider the limitations of each group, and the division of group members so that students can be active during group discussions (Mekarina & Ningsih, 2017). Think pair share learning model is one alternative to create variations in the atmosphere of class discussion patterns, optimizing student participation which involves students actively studying in groups to solve problems. The research by (Sinaga, Syahputra, & Ahyaningsih, 2018) findings indicate that there is a significant effect of cooperative learning model type think pair share (TPS) with Autograph to the students mathematical representation ability.

The BBL+TPS approach is effective in terms of learning achievement because the learning activities with the BBL+TPS approach involve students actively, both individually and in groups, in solving problems contained in the LKS. This is following the opinion of Lie (2008), who states that TPS provides more opportunities for students to contribute both in their groups and in class. Awolola (2011) explains that the application of the BBL approach in mathematics learning aims to achieve optimal learning objectives. This strategy is adopted to teach mathematics, students improve in terms of contextual thinking, creative reasoning, logical thinking, sequential learning, intuitive knowledge, and insightful learning which are resistant to forgetting and these would aid better cognitive and affective learning outcomes in mathematics.

Learning with the BBL + TPS approach provides relaxation time so that students do not feel bored and there is no pressure to continue learning. During breaks, students are asked to repeat the material learned by making mind mappings while listening to instrumental music. Brinkman (2003) says that concept maps aim to organize information that supports thinking processes naturally and through concept maps, the material will be stored in long-term memory. It is in line with the results of research conducted by Fitriani & Irawan (2019) that the BBL approach can improve students' mathematical connection skills and Sukoco & Mahmudi (2016) where the BBL approach affects mathematical communication skills which are closely related to mathematical representation abilities. The BBL+TPS approach can also help students to practice mathematical representation. This is because students have broad opportunities to develop ideas in solving problems. Caine &

Caine (1994) reveal that the search for meaning occurs through patterns. In the student's brain, patterns are generated related to the material being studied.

Learning with the BBL+TPS approach is fun but still challenging, so that math anxiety in students can be managed properly concerning material, learning, teachers, or math tests. Mathematics anxiety is closely related to students' emotions. Caine & Caine (1994) explain that one of the principles of BBL learning is that emotion is a critical thing that is important to pay attention to in learning. Anxiety in the medium category is a good category where students do not feel afraid and do not feel anxious at all. As revealed by Arem (2010) if students feel low anxiety, then they are not motivated enough, feel free without challenges and perform poorly, while in the high anxiety category, students are unable to think clearly because of panic and fear, thoughts freeze and performance deteriorates.

There is a difference in effectiveness between learning with the BBL+TPS approach and the scientific approach in both classes after being given treatment. In both classes, learning is carried out in a group setting. However, what makes the difference is that in the class with the BBL + TPS approach, students are in groups with their partner friends, while in the class with the scientific approach, the student group consists of 4-5 people. Before grouping with their partner friends, students individually think of ideas for solving math problems. This is one of the reasons for the differences in the effectiveness of the two approaches. In learning with the BBL + TPS approach, there is an incubation stage and inserting memory where students listen to music and make concept maps of what they are learning. Nolen (Boyd, 2013) explains that music can be used as a tool for cognitive development because of its activities, in which students are directly involved. Music can also be used as a motivational factor to understand students' emotional responses.

Furthermore, it will be discussed which variables make the BBL+TPS approach more effective than the scientific approach. Learning with the BBL + TPS approach is more effective than learning with the scientific approach in terms of learning achievement and mathematical representation ability. As for the mathematics anxiety variable, the BBL+TPS approach is not more effective than the scientific approach. Descriptively, it can also be seen that the average in the BBL+TPS class is higher than in the scientific class. Although problems were presented in both classes at the beginning of learning, in the BBL+TPS class, students were asked to repeat the material they had learned while relaxing. At the incubation stage and entering memory in the BBL + TPS approach, where students make concept maps of what they have learned in each meeting, it has a considerable influence on students' understanding. This is thought to be the cause of learning in the BBL+TPS class being more effective, as the average score obtained is higher than that of the scientific class. According to (Noureen, Awan, & Fatima, 2013) study indicated that academic achievement with BBL approach significantly higher as compared to conventional method. Present study also revealed that teaching through brain-based learning method needs more time as compared to conventional method. Individual performance of the students of experimental group improved more significantly as compared to control group.

Students in the BBL+TPS class are trained in mathematical representation skills by solving the problems presented in the worksheets by writing individual steps or ideas, which are then discussed in groups. In the scientific class, activities are also carried out that assist students in developing their mathematical representation skills by practicing problems in groups. However, this becomes less able to provide opportunities for each student to express their ideas individually, so when students try to work on the mathematical representation ability test questions, they have some difficulty. Research by (Priatna, 2017) show that the increase in the mathematical representation ability of students who were treated with mathematics instruction applying the brain-based learning principles aided by GeoGebra was greater than the increase of the students given conventional instruction, both as a whole and based on the categories of students'initial mathematical ability.

In both classes, the BBL+TPS and scientific classes have different but not significant averages for the mathematics anxiety variable, namely the BBL+TPS and scientific classes of 84.38 and 85.41, respectively. This average value is in the medium category. This insignificant difference is estimated because, in both classes, students feel that learning in class is fun. Presenting problems at the beginning of learning provides challenges and curiosity to students, but then they discuss them in groups so that the anxiety that exists in students can be managed properly. Students who were initially less anxious became motivated to learn because the BBL + TPS and scientific learning applied in the learning was interesting and conducive to a comfortable and conducive classroom atmosphere. In addition, if in BBL + TPS learning, students present the results of group discussions with their partners and students from other groups are allowed to provide responses to information submitted by other groups, then similar activities are also found in learning using a scientific approach.

Conclusion

Based on the results of hypothesis testing and discussion, the following conclusions are obtained, first the brain-based learning approach with think pair share settings is effective in terms of learning achievement, mathematical representation ability, and mathematical anxiety, second there is a difference in effectiveness between the brain-based learning approach and think pair share setting and scientific approach in terms of learning achievement, mathematical representation ability, and mathematical anxiety, and third brain-based learning approach with think pair share setting is more effective than the scientific approach in terms of learning achievement and mathematical representation ability, but not more effective in terms of math anxiety.

There are several limitations in this study; namely, the brain-based learning approach with think pair share settings is an approach that is still new for students; the material in this study is only limited to statistical material and opportunities, the aspects that are measured are only learning achievement, mathematical representation ability, and students' mathematical anxiety, so that the generalization of research results is limited. Based on the conclusions and taking into account the limitations of the study, the suggestions that can be conveyed are that it is better for the application of a new learning approach to be carried out over a relatively long period of time so as to provide maximum results. Students' mathematical representation abilities in statistics and probability learning need to be improved by using appropriate methods or approaches. With improvements in classroom planning and implementation, this approach will be effective in improving student achievement, mathematical representation skills, and controlling math anxiety.

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