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The Brainstorming Method on Pesantren Students' Mathematical Connection and Metacognition Skills

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Abstract

This research investigates the use of the Brainstorming method in the learning process to withdraw the best idea for improving students' Mathematical connection skills and the relation of Mathematical connection skills with metacognition skills. This study utilizes a quantitative method with a quasi-experimental model pretest-posttest control group design involving 60 Junior High School students in Sukabumi, West Java, Indonesia. The instrument used in this research is the developed mathematical connection skill test and the adapted metacognition questionnaire. Data analysis used to measure the comparison between control and experiment groups on students' Mathematical connection skills was the Mann-Whitney, and Correlation Product moment to analyze the correlation between Mathematical connection and metacognition on the experimental group. The result of the study shows that; (1) the Mathematical connection and metacognition skills of students who learn using the Brainstorming method is better than those who use expository learning. (2) there is an improvement in students' mathematical connection and metacognition skills by using the Brainstorming method (3) there is a relation between connection skills and the metacognition of students.

Keywords: brainstorming, mathematical connection, metacognition

Introduction

Islamic Boarding School or *Pesantren* is the oldest educational institution in Indonesia which is different from other institutions in Indonesia (Masqon, 2014). Another term states that Islamic boarding schools are learning places focusing on Islamic religious education (Wekke & Hamid, 2013). Students living in these places are labelled as "*santri*" (Gufron, 2019). In its development, Islamic boarding schools are classified into three typologies, namely: *Salafiyah* (traditional), which only teaches religious knowledge traditionally using classical books, *khalafiyah* (modern) which is not only teaching the Islamic religion but also teaches other sciences such as mathematics, English, and Arabic in everyday life, and integrated ones who are in the teaching process can use classical such as *salafiyah* or modern such as *khalafiyah*, but still hold religious and general sciences (Gufron, 2019).

This development is identified by the number of Islamic boarding schools providing formal education, from elementary to higher education. This development is also an alternative for parents to involve their children in Islamic boarding schools, hoping their children can simultaneously gain religious and general knowledge (Supriatna, 2018). However, for *santri*, living in a boarding school dormitory is an absolute requirement that must be met, with complicated consequences that are far from the parent's role, accompaniment, and supervision (Syafe'i, 2017).

The existence of the *pesantren* has received recognition from the government with the issuance of act 18 of 2019 concerning Islamic Boarding Schools (The ministry of religious Affairs, 2019). This act focuses on the pesantren's

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function as a national education unit involving two curricula: the *pesantren* curriculum and the general curriculum. The derivative of this regulation is stated in the ministry of religious affair no. 31 of 2020 concerning Islamic boarding school education. The *pesantren* curriculum in the law is handed into each *pesantren* manager, while the government will regulate the general curriculum through the ministry of religious affairs. An essential point in the broad curriculum made by the Ministry of Religious Affairs is that it is mandatory to study at least five general subjects, namely Pancasila and Citizenship Education, Mathematics, Indonesian Language, Social Sciences, and Natural Sciences.

This regulation is a challenge for the managers of Islamic boarding schools, including researchers. How far the law has been carried out by the *pesantren*, absolutely, must be of more concern. Therefore, there is a need for conducting research to obtain information or an overview of the extent "*santri*" understand general subjects, one of which is mathematics. For students, mathematics is still complex to understand. To understand mathematics, it takes a solid effort to connect complex numbers; if numbers are in the form of equations, and inequalities, then they must realize variables (Kikas et al., 2020). This relationship between mathematical concepts is often referred to as mathematical connection ability (Jailani et al., 2020).

Problems or difficulties in understanding mathematical connections can cause anxiety because it requires students to recall the material studied and connect it with the material being studied (Anita, 2014), as it is known that the ability of mathematical connections is an essential factor in understanding mathematical concepts. This standard provides three separate indicators, namely (1) Connections between mathematical concepts, (2) Connections of mathematical concepts with other sciences (3) Connections of mathematical concepts with real everyday life (Ndiung & Nendi, 2018). In addition, some researchers consider that the relationship between concepts and procedures is part of understanding mathematical connections for mathematical connections require knowledge integration and interdisciplinary (García-García & Dolores-Flores, 2018a) (Zengin, 2019).

It is crucial to present mathematical connections in the teaching and learning process because they are seen as an integrated, interrelated, and inseparable field (García-García & Dolores-Flores, 2018b). Connections between mathematical concepts are meaningful because students must have other mathematical abilities as a prerequisite for further learning. Because if students already understand mathematical concepts before, it will adjust opportunities for these students to understand advanced mathematical concepts, either in the form of ideas or procedures (Baiduri et al., 2020). Likewise, with mathematical concepts in everyday life, mathematics is a part of everyday life, and humans will never be separated from mathematics (Dolores-Flores et al., 2019); (Diana et al., 2020). The next important thing is the concept of mathematics with other disciplines. Students must have the ability to connect mathematics with other sciences, such as physics, chemistry, and others, since mathematics is an interrelated science. Mathematics is the basis for developing other sciences, so "Mathematics is the Queen of science" is always said (Ramesh et al., 2019). This indicator of mathematical connection skill is considered sufficient to be practiced in Islamic boarding schools because, in addition to containing mathematical topics, mathematical connections also include the relationship between mathematical concepts and other sciences conveyed in Islamic boarding schools, such as Arabic and other religious content. The relationship between mathematics and Islamic boarding school contents will be tested in this study by looking at how deep understanding there is in the world of Islamic boarding schools.

As it is well known, mathematical connection is included in five standard process categories issued by the National Council of Teachers of Mathematics (NCTM) including problem-solving, reasoning and proving, connections, communication, and mathematical representation (National Council of Teachers of Mathematics, 2000a);(Yaniawati et al., 2019). Although these five standards were issued by NCTM 20 years ago, many students do not understand mathematical concepts. This report can be shown by the results of studies that state that students' mathematical connection abilities are still meagre (Hermawan & Prabawanto, 2015)(Kenedi et al., 2019); (Baiduri et al., 2020). Other studies also show that students' mathematical connection skills are still deficient and provide suggestions to improve students' mathematical connection skills by paying more attention (deep carrying) (Rahmi et al., 2020). Meanwhile, Yaniawati and Indrawan provide a solution that students' mathematical connection abilities will increase if they use one of the CORE (Connecting-Organizing-Reflecting-Extending) learning models (Yaniawati et al., 2019). Learning methods are essential to consider, especially in *pesantren*.

Dealing with that, another learning method in accelerating the improvement of mathematical connection is addressed in this study, that is the Brainstorming method. several previous studies in educational disciplines have suggested the Brainstorming learning method as an intervention that can facilitate quality ideas in solving complex problems and impacting learning outcomes. Al-khatib (2012) uses Brainstorming Techniques to cultivate problem-solving and critical thinking skills that can develop each student's idea selection by creating a conducive learning climate (Al-Samarraie & Hurmuzan, 2018). The Brainstorming method is more effective in learning and communication than others. These results indicate that this method has an impact on generating ideas and influencing the learning and

communication process in a positive way (MW. Karamer, CL Kuo, 1997). Another study also showed that the brainstorming method significantly positively affected the two study groups. The significance value in this study shows the number 0.01 (Emami et al., 2013). Based on the research they have done; the brainstorming method to contribute to the problems faced by students on the ability to connect mathematics by using other learning methods.

To expand Rahmi's research and try new learning methods beside CORE conducted by Yaniawati, the researchers applied the Brainstorming learning method. The brainstorming method (suggestion/gathering opinion) combines the question-and-answer form with the discussion method. Litchfield (2009) concluded that the rules of Brainstorming would further increase the number of views that arise if, in the brainstorming process, a specific goal has been set (Litchfield, 2009). Osborn (1957) mentioned that Brainstorming is specific and uncritical instruction but prefers harmony in group creativity. The main rule in Brainstorming is that should not be criticism during the learning process because it will confuse students with the many ideas that arise (Coskun & Yilmaz, 2009). Elimination of criticism is a form of concern about the final evaluation, and not criticizing someone's thoughts or ideas is at the core of the "special instructions" of the Brainstorming learning method (Nemeth et al., 2005); (Emami et al., 2013)

With this concept, the author assumes that with the Brainstorming method, students will be able to communicate effectively with either the teacher or other students, so that it can stimulate them to think faster and eliminate verbalism, which is memorizing material but unable to understand the concept. This method is also expected to bring up ideas about mathematical concepts that have been studied by each student so that it can reopen the insights of other students who forget or do not understand the material. If their best ideas are agreed upon, it will be easier for students to solve math connection problems.

Besides using the Brainstorming learning method, researchers also see the need for other skills for students who can reflect on their abilities, monitor, and control progressive thinking processes, and evaluate what they have done. These skills are called Metacognition (Norman et al., 2019).

Metacognition skills consist of three essential skills: (1) planning; students can choose the right strategy in solving problems, (2) monitoring; students' awareness to understand ways to solve problems, (3) evaluation; students can measure their actions in solving problems (Chatzipanteli et al., 2014).

Studies show that aspects of Metacognition have an important role in mathematics performance and are one of teachers' and parents' ways to stimulate children's cognitive development. Metacognition also provides an advantage for children with very low math performance and can be an "opportunity" for children to present content in learning (Schneider & Artelt, 2010); (Byrnes & Miller-Cotto, 2016); (Wang et al., 2013). Based on research finding explained, it is obvious that metacognition has been proved in contributing good effects on Mathematical skills. However, ironically, metacognition activities are not always carried out optimally since teachers in primary and secondary schools do not have sufficient knowledge to perform Metacognition (Dignath & Büttner, 2018). In this case, the urgency of improving students' mathematical metacognition skills should be concerned.

The rationalization of the explanation above shows that by using the brainstorming learning method and developing metacognitive awareness, students will be trained to always plan and design the best strategy for recalling the mathematical material they studied. Through the development of metacognitive awareness, students are expected to be accustomed to continuous monitoring, controlling, and evaluating what they have done. This view can also be assumed that there is an urgency for a discussion in building the improvement of students' mathematical connection skills and Metacognition, the relationship of Metacognition with students' mathematical connections through the Brainstorming learning method.

Literature Review

Brainstorming Learning Method

Brainstorming is a learning method that facilitates several big ideas (Litchfield, 2009). With the rule, participants are asked to identify problems so that new knowledge emerges from different points of view, allowing them to find better solutions with collaboration (Hagen et al., 2016).

Six new *brainstorming* principles will result in a higher quantity of quality ideas. The principles are; 1). *Brainstorming* rules are fundamental, and it should be emphasized that the basic rules of *Brainstorming* are not only on the number of ideas but also on the quality of ideas; 2) Specific goals should be set for the number of ideas that are generated during the *brainstorming* process; 3). The initial idea should be started individually, not as a group; 4). Use group interactions to collect and filter ideas from each individual and refine ideas; 5). Determines the final conclusion by voting from group members and increasing commitment to the selected idea; 6) The time spent for generating initial ideas should not be too long (Hagen et al., 2016) (Göçmen & Coşkun, 2019)

Metacognition

Flavell introduced the concept of metacognition in 1979. According to Flavell, the concept of metacognition is the idea of thinking about one's mind, where the object is the thought process that occurs in oneself (Siegesmund, 2016).

Metacognition is a learning skill, including how learning should be conducted and what is or is not known. It consists

of three stages, namely, planning, monitoring, and evaluating. Three things should be arranged; what to learn, what strategy is compatible, and when to study. In monitoring, the learning process that is done is monitored. Finally, in the evaluating stage, evaluating what has been planned, done, and the process's results (Dafik et al., 2019a).

In previous studies, qualitatively, the results showed that student problem-solving skills were different when using their metacognition so that other things were needed that could encourage them to try to solve various mathematical problems by honing their metacognition (Aek et al., 2019)

Mathematical Connection

The basic principles and school standards to complement the mathematics curriculum are the ability to solve problems. To give reasons and verification, to communicate, to connect, and to represent (National Council of Teachers of Mathematics, 2000b). These abilities should be assured gained by the students in the mathematics learning process.

Mathematical connections make mathematical understanding more long-term because mathematics is an integrated field of study, which shows that between mathematical topics as one unit. Mathematical connections also have a wealth of connecting with other subject skills, interests, and daily life experiences (National Council of Teachers of Mathematics, 2000a). In line with this, previous studies stated that the indicators of a mathematical connection are: a) build relationships between mathematical ideas;b) the relationship of mathematics with other subjects; and) mathematics relationship with everyday life (Tran et al., 2020)

Method

Design and Model

This quantitative research uses a quasi-experimental model pretest-posttest control group design. The purpose of this study was to see the effect of the Brainstorming learning model on increasing Mathematical connection and metacognition skills of class VIII junior high school students; therefore, an experimental research model needs to be done to be able to see the changes caused by the treatment given. This experimental research cannot be done purely (pure experiment) because the behavior of students involved in the study cannot be fully controlled, so quasi-experimental can solve this problem. This model is used intentionally in manipulating and controlling the independent variables to determine the dependent variable (Valente & MacKinnon, 2017). The design is shown in table 1.

Table 1: Pre-Test and Post-Test Control Group Design

Group	*Pre-test*	*Treatment*	*Post-test*
An (Experimental Group) n= 30	O	X	O
B (Control Group) n=30	O		O

Note: "O" is a response to the Mathematical connection test and Mathematical metacognition questionnaire given to two groups of classes. "X" is the implementation of the treatment in the form of the brainstorming learning model to one of two groups involved (an experimental group).

Population and Sample

The population in this study was grade 1 SMP Al-Masthuriyah based on a *pesantren* in Sukabumi, West Java, Indonesia. The subject population is 156 students divided into 5 classes, namely class VII A, VII B, VII C, VII D, and VII E, with the number of each class being 30 and 32 students. The samples used in this study were students of classes VII C and VII E. This sampling was based on the cluster sampling technique. Cluster Sampling is a method of determining the sample if the object to be studied, or the data source is comprehensive. The sampling is based on a predetermined population area to determine which sample will be used as the data source. This sampling technique is used in two stages, namely the first stage to determine the sample area and the second stage to determine the individuals in the region by sampling (Etikan & Bala, 2017).

The cluster sampling technique used by the researcher is only one step, namely determining the sample in the form of a class from the class VII population. The population of class VII students was tested for homogeneity of the value of the final test of the odd semester. The homogeneity test results showed that the significance level = 0.321, which means the significance level is more than 0.05, indicating that the population data is homogeneous. To determine the sample, the researcher conducted a lottery for each class. The draw results obtained two classes, namely class VII C and VII E, with 30 students each. Class VII E, as the experimental class, will be given learning treatment using the brainstorming learning method, and class VII C, as the control class, will be given no treatment, or experience the usual learning method and atmosphere. Implementation in schools for six meetings with the material discussed in this study are Intersecting Sets, Combined Sets and Venn Diagrams.

Implementation of Brainstorming and Research Procedure

There are 5 stages carried out in implementing the brainstorming learning method: (1) the Information and motivation stage (Orientation), (2) Identification stage (Analysis), (3) the Classification stage (Synthesis), (4) the Verification stage, and (5) Evaluation and Conclusion Stage (Agreement)(Anaguna & Suhendra, 2019).

a. The stage of information and motivation (orientation)
The teacher gives a problem as a question and invites students to play an active role in contributing their ideas. At this stage,

students are divided into 5 groups of 6. In this session, the teacher builds motivation for students to be able to solve the problem.

b. Identification Phase (Analysis)
Students are invited to provide as many ideas as possible at this stage. All suggestions are accommodated, written down, and not criticized. Group leaders and participants may only ask questions to ask for an explanation. It is so that students' creativity is not hampered.

c. Classification Stage (Synthesis)
All suggestions and input from participants were written down and then classified based on criteria made and agreed upon by the group. Classification can be found on structure/ other factors.

d. Verification Stage
The group together looks back at the brainstorming that has been classified. Each brainstorming is tested for its relevance to the problem. If there is the same suggestion, one is taken, and irrelevant suggestions can be crossed out, then the suggestion givers can be asked for an argument. Each group is asked to explain in front of the class at this stage.

e. Evaluation and Conclusion Stage (Agreement)
The teacher and all other students try to conclude the agreed-upon alternative problem-solving points. After all, are satisfied, the final agreement is taken on how to solve the problem which is considered the most appropriate.

Data Collection Tools

Data of this research were obtained from the mathematical connection skill test to see the improvement of students' mathematical connection skills and a metacognition questionnaire to examine the student's mathematical thinking skills. The mathematical connection skill instrument was developed independently, while the mathematical metacognition instrument was adapted from an existing mathematical metacognition instrument.

The mathematical connection skill instrument consists of 5 questions developed from three indicators of mathematical connection skill. Each indicator has one or two questions in the form of essay. The metacognition skill instrument consists of 28 statements from 3 aspects and 14 indicators.

Instrument

Mathematical Connection Skill Test

The mathematical connection skill test refers to three indicators of mathematical connection with five essay questions. The connection scoring system has a score of 0 to 20, adjusted according to complexity and achievement, so the ideal maximum score is 100.

The instrument validation test uses content validity involving 3 experts in the field of mathematics. The instrument analysis uses the Aiken V formula, while the reliability uses the KR-20. The Aiken V formula is used to calculate the coefficient of validity based on the assessment of experts with the validity criteria of high, medium, and low (Kholis et al., 2020). The validity coefficient value less than equal to 0.4 is said to be of low validity, 0.4 to 0.8 is said to be of moderate validity, and more than 0.8 is said to be high. Generally, acceptable validity evidence has an index value of more than 0.4, categorized as medium or high (Istiyono, 2018)(Retnawati, 2016). The reliability test uses an estimated value with a minimum coefficient threshold of more than 0.5 (Pienaar et al., 2021) and the highest one is close to 1 or from 0.80 to 0.90 (Crocker & Algina, 2008); (Saputra et al., 2021)

Mathematical Metacognition skills

The instrument used in this research is an adaptation of an article written by Rohim in 2019 which has been adapted. This adaptation instrument contains a Likert scale questionnaire with 28 statements taken from 3 aspects and 14 indicators (Dafik et al., 2019b).

The validity used in this instrument is content validity involving 3 psychologists. The instrument validity was analyzed using the Aiken V formula, while the reliability was analyzed using the KR-20.

Data Analysis

Data analysis used quantitative data from the mathematical connection skill test instrument and mathematical metacognition skill questionnaire. Quantitative data were obtained from pre-test, post-test, and metacognition skill questionnaire. The data on the mathematical connections skill and metacognition skills will be tested for normality first using the Kolmogorov-Smirnov test, followed by a homogeneity test of variance using the F-test. This test was conducted to see the differences in the mathematical connection abilities of two groups, namely the experimental and control classes (Ross & Willson, 2017). Data that are not normally distributed will be tested using the Mann-Whitney nonparametric test. To see the increase in mathematical connection skill and metacognition skills, it will be tested with the N-Gain calculation (Krisdiana et al., 2019). Furthermore, the post-test data will be tested using the product-moment correlation test to determine the relationship between mathematical connection skills and metacognition skills.

Findings

This study produced several findings related to mathematical connection skills, metacognitive skills, and the correlation between the two. Some of these findings are discussed in the following points.

Mathematical Connection Skills

The normality test of the pretest data revealed that the significant values for the experimental and control classes were 0.53 and 0.083, respectively. Both have a significance level of ≥0.05, indicating that the experimental and control class pretest data are normally distributed. Furthermore, the homogeneity test resulted in a significance value of 0.755 ≥ 0.05, indicating that the data for the two classes were homogeneous. Since the data is normal and homogenous, the next step is to apply the t-test to compare the means of the two classes. The t-test findings showed that the significant value achieved is 0.616 ≥ 0.05, indicating that the mean mathematical connection skills pretest of the experimental and control classes is the same.

The post-test results are treated in the same manner. The normality test yielded values of 0.08 and 0.062 ≥ 0.05, respectively, whereas the homogeneity test yielded a value of 0.964 ≥ 0.05. These findings imply that the post-test data is normally distributed and homogeneous, allowing the t-test to be performed. The t-test findings yielded a value of 0.644 > 0.05. This suggests that the post-test mean of the experimental and control classes' mathematical connection skills is the same. As a result, there is no difference in the average post-test of mathematical connection skills between the experimental and control classes.

In general, the value of mathematical connection skills for each topic in the cycle is shown in table 2.

Based on these findings, the average mathematical connection skills of the experimental class students is practically identical on the pretest, while the experimental class is slightly superior to the control class on the posttest. In general, the difference is not significant, and each of these courses has improved.

This data was examined using the normalized N-Gain Test in a different test to compare the increase. This test computed the difference between the two classes' pretest and posttest scores, and the outcomes of the difference were assessed using the average comparison test. Before performing the average comparison test, the N-gain data were tested for normality and homogeneity. The findings of the analysis based on the normality test employing the Kolmogorov-Smirnov method yielded significant values of 0.440 and 0.011 for the experimental and control classes, respectively. The control class has a significance value of 0.05, whereas the experimental class has a significance value of 0.05, indicating that the normalized gain data for the experimental and control classes are not normally distributed. The following test, as listed in table 3, employs a non-parametric statistical test based on Mann-Whitney.

The value of sig 0.036 0.05 in table 3 indicates that there is a difference in the improvement of students' mathematical connection skills while using the Brainstorming learning approach versus expository learning.

Metacognition Skills

The normality test of the metacognition questionnaire scale pretest data yielded findings of 0.02 and 0.041 < 0.05. The Mann-Whitney test was used in the following test to determine the differences between each group. The Mann-Whitney test yielded a significant value of 0.04 < 0.05, implying that there is a metacognitive difference between the experimental and control classes.

The posttest data on the metacognition scale should next be analyzed. The normality and homogeneity tests yielded Sig = 0.22 and 0.130 0.05, respectively, indicating that the data from the two classes are normally distributed. If the homogeneity test analysis yielded a value of Sig = 0.217 0.05, the two data have homogeneous variances. The Independent Sample T-Test was then used to test the mean difference.

The sig value is 0.012 0.05, as can be observed. It means that students who utilize the Brainstorming learning approach have superior metacognitive skills than those who use the Expository learning method.

The last step is to use the normalized N-Gain Test to compare the improvement of each group statistically. The results of the normality test analysis were 0.324 and 0.01, indicating that the two data were not normally distributed because they were less than 0.05. The Mann-Whitney test was used as the next nonparametric test. Table 4 shows the findings.

The correlation between the skills of mathematical connections and students' metacognition skills

Using the product-moment correlation test, post-test data from the experimental class were examined to determine the correlation between connection and metacognition.

The correlation coefficient has a significance value of 0,023 <α = 0,05, indicating that there is a significant correlation between mathematical connection and metacognition skills.

Table 2: Test results for average mathematical connection skills

Average	*Minimum completeness criteria*	*Pre-test*	*Minimum completeness criteria*	*Topic I*	*Topic II*	*Topic III*	*Post-test*
Experiment Class	70	13,63	70	76,28	83,17	78,34	75,56
Control Class	70	13,96	70	65,17	75,28	70,45	72,67

Table 3: Mann Whitney Test Results of Mathematical Connections

Test Statisticsa	
	Mathematical Connection
Mann-Whitney U	351.500
Wilcoxon W	816.500
Z	-1.460
Asymp. Sig. (2-tailed)	.036

Table 4: Independent Samples T-Test

		Metacognition	
	Equal variances assumed		*Equal variances not assumed*
Levene's Test for Equality of Variances	F	.098	
	Sig.	.012	
t-test for Equality of Means	T	-.504	
	Df	58	
	Sig. (2-tailed)	.012	
	Mean Difference	-.333	
	Std. Error Difference	.231	
	95% Confidence Interval of the Difference Lower		-1.656
	Upper	.989	.989

Table 5: The correlation between mathematical connection and metacognition skills

Correlations			
		Posttest Experiment	*Metacognition Experiment*
Connection Experiment	Pearson Correlation	1	.359
	Sig. (2-tailed)		.023
	N	30	30
Metacognition Experiment	Pearson Correlation	.359	1
	Sig. (2-tailed)	.023	
	N	30	30

Discussion

The improvement of math connection skills

Using brainstorming and expository learning approaches, this study aims to improve the skills of mathematical connections on set material, particularly intersecting sets, combining sets, and Venn diagrams.

Prior to treatment, the preliminary study revealed no significant difference in the initial mathematical connection skills of class students who received the Brainstorming learning approach against the expository method. This confirmed that the research individuals' academic skills were generally homogeneous. This condition is very useful in determining how significant the relationship from the Brainstorming learning method is in an increase in students' mathematical connection skills. However, after a different treatment, students who received the Brainstorming learning method rather than expository learning showed an increase in mathematical connection skills. This is consistent with the findings of Rohmah and Herdiman, who discovered that the Brainstorming learning approach can develop mathematical connection skills more than the expository learning method (Rohmah & Herdiman, 2017).

Furthermore, indicators that combine mathematical concepts with other sciences, in this example the Arabic language, outperform in terms of advancement.

This is due to students' familiarity with the notion of Arabic, which is frequently taught in pesantren-based schools (Suardi, 2015); (Ritonga & Nurdianto, 2022). Brainstorming appears to be more influential this time because they believe that the concept of mathematics this time is linked to the better topic in every pesantren-based school, namely Arabic. This is consistent with earlier research indicating that using Arabic as a mother tongue has a significant impact on learning English in schools. Furthermore, the concepts of religion and culture must be taught in the mother tongue, Arabic (Hamid & Ta, 2019). This context demonstrates that Arabic is extremely possible if taught in schools because their mother tongue is in the United Arab Emirates, and Arabic is also a language that has been accustomed daily in Islamic boarding schools. Other research indicates that being able to read the Arabic Koran has a very favorable effect on solving mathematics issues (Hamid & Ta, 2019). Furthermore, a correlation between science and other sciences, particularly physics, has been discovered. According to the opinion, mathematics is required to understand physics because mathematics is the king of science (Tashpulatovich & Qizi, 2021).

In terms of the brainstorming approach's effectiveness in supporting the learning process, research shows that there is a considerable difference for the experimental class adopting this strategy (Taleb et al., 2013). Other studies have found that this strategy has a significant impact on students' creative thinking processes when studying mathematics (Lim et al., 2019).

Metacognition Skills

The differences in metacognition skills between students in the Brainstorming class and students in the Expository class must be thoroughly investigated. Because we can use these results as a reference when applying learning approaches. It was discovered that there was an increase in metacognition between the Brainstorming class and the expository class based on the results of data processing on differences in

metacognitive skills between students in the Brainstorming class and the expository class.

In general, the application of the Brainstorming learning approach affects students' metacognition skills. This situation demonstrates how the application of the Brainstorming learning approach is connected to students' metacognition. This is achievable due to the compatibility between learning activities and real-world challenges encountered by students in their daily lives, making mathematics more beneficial to students. These findings suggest that a well-designed learning approach promotes strong metacognition because students can better monitor and assess their learning outcomes. Additionally, metacognition awareness will be difficult to use without the support of proper learning methods (Rivers, 2020). As with other learning methods, the conclusion that learning methods can improve students' metacognition is the same (Suendarti & Liberna, 2018).

The Brainstorming learning approach divides students into various small groups so that learning becomes an activity that can make students more communicative and can collect previously studied new ideas (Lianasari & Purwanto, 2016). Critical thinking skills are developed in students in terms of planning, monitoring, and evaluation (Tok, 2013). Then, in group work activities to solve problems, students exchange ideas and engage in an interactive conversations with their peers. They appear excited and work hard to reply to other people's thoughts, without criticizing or blaming, and they appear to exhibit knowledge of the knowledge that was launched by others so that they are ready to conclude the conclusions of a lesson. This is consistent with the findings of other studies, which show that metacognition plays a significant role in creativity. Components of metacognitive skills, such as planning and selecting tactics, as well as evaluating, can bridge the cognitive aspects through awareness and self-confidence. Secondary schools have the most prominent creative metacognitive component in terms of creative strategy selection and student self-regulation (Anderson & Haney, 2021).

Correlation between Mathematical Connection skills and Metacognition

Previous research has found a relatively significant correlation between the accomplishment of mathematical connecting skills and students' metacognition. The existence of a relationship between the achievement of mathematical connection skills and students' metacognition is feasible because metacognition affects students, allowing them to solve a problem well.

Previous research has shown that students' thinking skills, particularly metacognitive skills, improve with age. It is possible to maximize the empowerment of students' thinking skills, including metacognitive skills (Siswati & Corebima, 2017).

Other research indicates that metacognitive learning can influence students' mathematical connection skills (Asmawati et al., 2019). In reality, metacognition can improve students' mathematical literacy skills as well as their mathematical connections (Mevarech & Fan, 2018). Thus, if students fully comprehend each step of metacognition, their cognitive results will always be favorable. This is based on idea development and strategy, monitoring at each stage of completion, and evaluating all work completed. This is consistent with prior research findings that metacognitive skills influence the process and performance of mathematics learning (Veenman & van Cleef, 2019). Furthermore, the results of other studies also show that metacognition is the most effective and significant predictor for assessing the accuracy of math work at every level in all classes (Desoete & Craene, 2019).

Conclusion

The following conclusions were reached: 1) Students who study using the Brainstorming approach have superior mathematical connection skills and metacognition skills than those who learn through expository learning. (2) The Brainstorming approach increases students' mathematical connection skills and metacognitive skills; (3) there is a correlation between the connection skills and metacognition.

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