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An Open-Ended Based Realistic Mathematics Learning Approach To Students' Creative Mathematical Thinking Abilities

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ABSTRACT
The study aims to assess the level of students' creative thinking abilities for each indicator within their creative mathematical thinking using the open-ended iPMRI approach, specifically targeting fifth-grade elementary students. This quantitative study employs a quasi-experimental design. The research population consists of 44 fifth-grade students from SD Negeri 105346 Aras Kabu. The sample was selected through random sampling to identify both the experimental and control groups. Data collection methods include questionnaires, tests given to 10 students with 10 questions, and accompanying documentation. The research findings, based on the results of the sig value. (2-tailed) value of 0.000 < 0.05 and a t_{count} *of 12.493 compared to the t-table value of 1.68595 at df 38, indicate that the t-count is significantly greater than the t-table value (*$t_{count} > t_{table}$*). This result leads to the rejection of* H_0 *and acceptance of* H_1*. Therefore, it can be concluded that the implementation of an open-ended based realistic mathematics learning approach significantly influences the creative mathematical thinking abilities of fifth-grade students at SD 105346 Aras Kabu, Beringin District, during the 2023/2024 academic year.*
***Keywords**: Realistic mathematics, Open-Ended, Think creatively*

ABSTRAK
Penelitian bertujuan untuk menilai tingkat kemampuan berpikir kreatif siswa pada setiap indikator dalam berpikir kreatif matematisnya dengan menggunakan pendekatan open-ended iPMRI yang khusus menyasar siswa kelas V SD. Penelitian kuantitatif ini menggunakan desain eksperimen semu. Populasi penelitian terdiri dari 44 siswa kelas V SD Negeri 105346 Aras Kabu. Sampel dipilih melalui random sampling untuk mengidentifikasi kelompok eksperimen dan kontrol. Metode pengumpulan data meliputi angket, tes yang diberikan kepada 10 siswa dengan 10 soal, dan dokumentasi yang menyertainya.Temuan penelitian, berdasarkan hasil nilai sig. (2-tailed) nilai 0,000 < 0,05 dan t_{hitung} sebesar 12,493 dibandingkan dengan nilai t_{tabel} sebesar 1,68595 pada df 38, menunjukkan bahwa t_{hitung} jauh lebih besar dibandingkan nilai t_{tabel} ($t_{hitung} > t\text{-}_{tabel}$). Hasil ini menyebabkan penolakan H_0 dan penerimaan H_1. Oleh karena itu, dapat disimpulkan bahwa penerapan pendekatan pembelajaran matematika realistik berbasis open-ended berpengaruh signifikan terhadap kemampuan berpikir kreatif matematis siswa kelas V SD 105346 Aras Kabu Kecamatan Beringin pada tahun ajaran 2023/2024..
Kata Kunci: Matematika Realistik, *Open-Ended*, Berfikir Kreatif.

INTRODUCTION

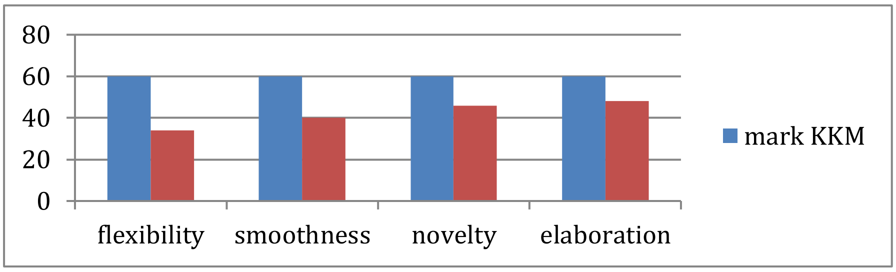
Mathematics has always been an inseparable part of every level of education. Every human action involves the application of mathematical concepts, so mathematics has a major role in everyday life (Nurdiana et al., 2022). The objective of mathematics education in schools is to ensure that students (1) comprehend mathematical concepts, explain the relationships between these concepts, and apply concepts or algorithms effectively, accurately, flexibly, and precisely to solve problems. (2) Utilizing deductions based on patterns and characteristics, applying mathematical operations to formulate generalizations, construct arguments, or elaborate mathematical concepts and statements (Safran et al., 2024). (3) Addressing problems involves the ability to understand the problem, formulate a mathematical model, solve the model, and interpret the resulting solution. (4) Communicate ideas by using symbols, tables, diagrams, or other media to describe situations or problems more clearly. (5) Realizing the important value of mathematics in the context of everyday life, including having curiosity, interest and enthusiasm in understanding mathematics and having determination and confidence in dealing with mathematical challenges (Husen et al., 2022).

One of the goals of learning mathematics is for students to have the ability to think creatively (Husen et al., 2022). The importance of having the ability to think creatively cannot be separated from a problem given by the teacher. Success in solving a mathematical problem is closely related to all aspects of daily life (Sapri & Simbolon, 2022). Basic abilities in learning mathematics are usually formed through activities that are convergent (only have one correct answer). Mathematics learning often tends to focus on algorithmic, mechanistic and routine mathematical exercises. However, to develop creative thinking competence, activities are needed that are divergent, allow for various alternative answers, and require investigating mathematical problems from various points of view. Through this approach, students can optimize their understanding in solving various problems. However, mathematics learning practices, especially at the elementary school level, are still often dominated by exercises to achieve basic mathematics skills only (Mursidik et al., 2018).

Creative thinking ability is the ability to create new ideas in dealing with problems (Maysarah et al., 2023) Creative thinking refers to a series of processes for creating innovative, new work, resulting from organized activities or actions in accordance with set goals. The ability to think creatively has a close relationship with mathematics learning (Yahfizham et al., 2023). This ability must be possessed by every student with the aim of learning mathematics to equip students with the ability to think analytically, logically, critically, systematically and creatively (Wandini et al., 2021). Creative thinking can be defined as a cognitive activity or thought process to produce new, creative and innovative ideas (Jumaisyaroh et al., 2023).

Creative thinking skills are characterized by fluency, flexibility, originality, elaboration, and evaluative thinking. According to Munandar, creative thinking ability can be assessed through four indicators: a) fluency, which means students can solve problems by providing a variety of correct answers; b) flexibility, where students can solve problems in multiple ways and produce at least two different answers. c) originality (novelty/authenticity), namely students can solve problems with different answers from most other students. and d) elaboration (elaboration/detail), namely students can solve problems by developing, adding to and detailing the answer in detail (Hasanuddin, 2019). All students are able to master these four indicators, because each student has different creative abilities (Hamdani & Nurkholidah, 2022). According to psychoanalytic theory, creativity is generally seen as the result of solving a problem which generally starts from childhood. creative action transfers an unhealthy psychic state to a healthy one (Nur Kamalia et al., 2023).

In the journal Sanggih Utomo Aji (Aji et al., 2024) stated that Indonesian students' mathematical creative thinking abilities are still relatively low. This problem also occurred at SD 105346 Aras kabu. Based on initial observations, researchers obtained data from the results of distributing questionnaires as follows:



Picture 01

Histogram of students' initial mathematical creative thinking ability scores

From this diagram, it can be seen that the creative thinking abilities of class V students at SD 105346 Aras Kabu are still relatively low. Researchers also observed teachers' teaching activities. Based on the results of observations carried out on 7-8 February 2024 in class V SD 105346, it can be seen that even though the teacher has implemented several learning models, there are still several obstacles in the learning process. One of the main obstacles is the teacher-centered learning approach, which results in students becoming less active. As a result, students' understanding and abilities are not explored properly. Apart from that, teachers are still too focused on the textbooks they are holding, so that students' interaction and exploration of the material is limited.

Based on the problems that have been found, learning is needed to optimize students' mathematical thinking abilities. Students' creative thinking abilities can be improved by using innovative learning approaches or models, as well as providing opportunities for students to participate actively in the learning process. Several stages to encourage creative thinking include: a) understanding the problem; b) designing a settlement strategy; c) implement a resolution strategy; d) evaluate the answers. These stages are interrelated in developing creative thinking abilities (Wahyuni & Pasaribu, 2022).

One approach that gives students the opportunity to think creatively is the Open Ended Realistic Mathematics Education (PMR) approach. Realistic Mathematics Education (PMR) is often called Realistic Mathematics Education (RME). (RME) is a special mathematics learning theory that was first developed in the Netherlands, specifically at the Freudenthal Institute, Utrecht University, since the 1970s by Freudenthal (Johar et al., 2021).

In Indonesia, RME is referred to as PMRI, and it was initiated by mathematician Prof. Dr. R. K. Sembiring along with Prof. Soedjadi, Prof. Ruseffendi, Prof. Suryanto, Dr. Yansen Marpaung, and Pontas Hutagalung. The efforts of the PMRI founders were supported by the Director General of Higher Education (Dikti) and consultants from the Netherlands. PMR, or Realistic Mathematics Learning, is an approach to mathematics learning that emphasizes students as the center of learning (Sembiring, 2010). In this approach, mathematics is considered an activity that is relevant to students' daily lives and must be integrated concretely into their real-life context as part of the learning experience (Sohilait, 2021).

Treffers (1987) explains the five characteristics of the PMR Approach as follows:

First, Real context is used as a basis for learning mathematics. This context does not always have to be a real world situation, but can be a game, the use of props, or other situations that have meaning and can be understood by students. By utilizing this context, students are actively involved in problem exploration. The results of this exploration are not only aimed at finding solutions to existing problems, but also at developing various problem-solving strategies that can be applied. Apart from that, the use of context at the beginning of learning also aims to increase students' motivation and interest in learning mathematics (Kaiser (1986) dalam De Lange (1987).

Second, The term "model" refers to situation models and mathematical models that students learn (self-developed models). The role of these self-created models is to help students understand the relationship between real situations and more abstract mathematical concepts. In other words, students create their own models in solving problems. First, they build models that relate closely to their real-world context. Then, generalization and formalization of these models will produce a model of the problem they are facing. Through the process of mathematical reasoning, the model of the problem will be transformed into a model that can be applied to similar problems, and finally become a formal mathematical model (the on model turns into a for model) (Wulandari et al., 2020)

Third, A major contribution to the teaching and learning process is expected to come from students, meaning that all thoughts (contribution and production) from students contribute to learning

Fourth, Based on Freudenthal's thinking which states that mathematics should not be given to students as a ready-made product, but rather as a concept constructed by students themselves, the PMR approach places students as active learning subjects. In this context, students are given the freedom to develop problem-solving strategies. The strategies produced by these students then become the basis for developing mathematical concepts.

Fifth, In mathematics, concepts are not isolated from each other, but are interrelated. Therefore, the PMR approach emphasizes the importance of paying attention to the interrelationships between mathematical concepts during the learning process. Through this approach, mathematical concepts are not taught separately or in isolation. On the other hand, mathematics learning is designed in such a way that one learning topic can introduce and strengthen more than one mathematical concept simultaneously, even though there is a concept that may be more dominant. For example, multiplication material can be linked to the concept of flat shapes to provide students with a more holistic understanding (Anas et al., 2019)

According to de Lange dalam (Rahman Johar, et al., 2021), mathematics learning using the PMR approach includes the following aspects:

a. Begin the lesson by presenting 'real-world' problems or questions that align with students' experiences and knowledge levels, ensuring immediate and meaningful student engagement.
b. Ensure that the given problems are aligned with the lesson's intended objectives.
c. Have students develop or create informal symbolic models to represent the posed problems or issues.
d. Teaching takes place interactively; students explain and give reasons for the answers they give, understand their friends' answers (other students), agree with their friends' answers (Johar et al., 2021)

The core principle of PMR is the active involvement of students in the learning process. Students need to be given opportunities to build their own knowledge and understanding. Abstract mathematical concepts need to be transformed into a real context for students (Miftakhul Khasana, et. al 2023). By making math problems relevant to students' daily lives, they will be more likely to generate various alternative answers creatively, which in turn can improve their creative thinking abilities

Students' creative thinking abilities will be more meaningful when they are faced with mathematical problems that are relevant to real life and presented in the form of open-ended problems (Yayuk et al., 2020). Open-ended problems are problems that have multiple correct answers. Thus, presenting mathematical problems through open-ended problems will stimulate students to develop their creative abilities in solving problems. This is because open-ended problems provide students with the opportunity to find many correct answers with various alternative solutions (Halimsyah et al., 2022).

Open ended activities consider three characteristics, namely student learning activities must be open, mathematics activities are open diversity and student activities and mathematics activities are one activity (Integrative) (Utami et al., 2020). By presenting mathematical problems in open-ended form, it stimulates students to develop their creativity in solving problems. This is because open-ended problems provide opportunities for students to find many valid solutions with a variety of different approaches (Salsabila & Suparni, 2022). Good problems with creativity in mathematics can be measured with open ended questions that provide more than one answer, involve students in developing creative thinking skills and provide opportunities for students to gain knowledge, obtain, understand and find solutions to problems in different ways (Syaban, 2004).

Based on the explanation above, it is essential to conduct research on students' creative mathematical thinking abilities. This study will investigate the impact of an open-ended, realistic mathematics learning approach on students' creative thinking skills (Arrahim et al., 2022). The research aims to determine which of the four creative thinking indicators are more or less dominant, as preferred by students when engaged with the open-ended creative mathematics-based realistic learning approach. The Open-Ended Based Realistic Mathematics Learning Approach is expected to improve students' creative thinking abilities, especially in developing indicators of students' creative thinking abilities. To gain a comprehensive understanding of the impact of the Open-Ended Based Realistic Mathematics Learning Approach on students' mathematical creative thinking abilities, a research was conducted entitled "Open-Ended Based Realistic Mathematics Learning Approach on Class V Students' Mathematical Creative Thinking Abilities". This research aims to measure the extent to which this approach can facilitate students in developing their creative thinking through open and contextual mathematical activities, so that it is hoped that it can make a positive contribution to the learning process and improve overall student learning outcomes.

METHODS

Type and Design

The method used in this research is a quantitative method. Quantitative research is an approach to gaining knowledge that uses data in numerical form as a means of obtaining information about what we want to know (Sugiyono, 2017). The data collection techniques utilized in this research include several methods. Initially, questionnaires were distributed to gather preliminary observation data. Additionally, tests were administered to assess the research outcomes. To complement these methods, documentation was also employed to provide further supporting information and context to the findings.

To gain a comprehensive understanding of the impact of Open-Ended Based Realistic Mathematics Education on students' mathematical creative thinking abilities, a study titled "Open-Ended Based Realistic Mathematics Learning Approach on Class V Students' Mathematical Creative Thinking Ability" was conducted. The purpose of this research is to assess the significant influence of each indicator of mathematical creative thinking abilities on elementary school students using an Open-Ended Based Realistic Mathematics Learning approach:

Table 1**.** *Desaign non equivalent posttest only control grup design*

Class	***Treatment***	***Post-test***
E	X	O1
K	-	O2

Information:

KE = experimental class

KK = control class

O1 = post-test on the experimental class

O2 = post-test on the control class

X = treatment of the experimental class (open-ended based PMRI approach)

\- = did not provide treatment to the control class

In collecting data on creative thinking ability, the test method was used, namely with a total of 10 questions. Of the 10 questions, the researcher included 2 indicators of creative thinking ability as measuring tools in this research, namely indicators of fluency and originality/novelty. Giving a post test is a data collection technique about the creative thinking abilities in mathematics of class V students at SD Negeri 105346 Aras Kabu. The test is carried out at the end of learning which aims to measure students' abilities. Test the validity of reliability, level of difficulty and differentiating power using the SPSS 25 program.

RESULTS AND DISCUSSION

The data analyzed in this research are the creative thinking abilities in mathematics of fifth grade students who are divided into experimental groups and control groups. Data regarding creative thinking abilities in mathematics were obtained from the results of the post-test given at the end of the research. Data analysis was carried out separately for each class, namely the experimental class and the control class.

The results of data analysis are described in the following table:

Table 2. Data analysis with descriptive statistics

Statistics	Results of creative thinking abilities	
	Experiment	Control
Maximum score	96	56
Minimum score	60	20
Mean	80,4	31,5
Mode	90	40
Median	81,5	37,5
Variance	119	110

From the results of data analysis with descriptive statistics above, the experimental group's creative mathematical thinking ability is mean = 80.4, mode = 90, median = 81.5, and variance (s2) = 119. Meanwhile, the control group's mathematical creative thinking ability data is the mean. = 31.5, mode = 40, median = 37.5, and variance (s2) = 110. The maximum scores of the experimental group and control group are 96 and 56. Meanwhile, the minimum scores of the experimental group and control group are 60 and 20. To see the tendency of scores obtained by students, then the post test data on the creative thinking ability of experimental group students is presented in the following histogram:

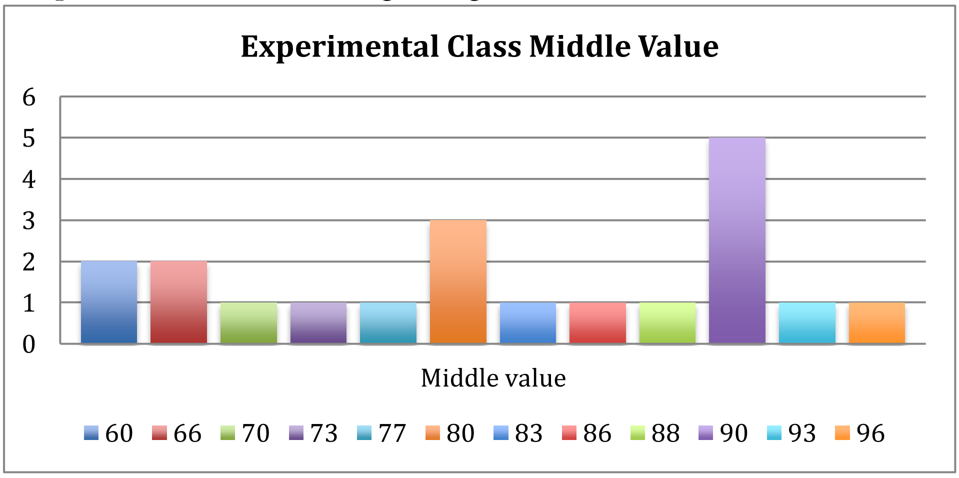


Figure 02

Histogram of experimental class students' mathematical creative thinking ability scores

In the control group, data on mathematical creative thinking abilities can be described with an average value (Mean) of 31.5, mode of 40, median of 37.5, and variance of 110. The tendency of the scores obtained by students in the control group shows the spread of scores which can be further interpreted through data visualization. To facilitate analysis and provide a clearer picture of the score distribution, post-test data on students' creative thinking abilities in the control group is presented in the form of a histogram. This histogram, seen in Figure 2, shows the frequency distribution of scores achieved by students, allowing us to observe the distribution of scores and general trends within the group. Through histograms, we can identify distribution patterns, such as whether scores are more concentrated in a certain range or widely spread, thereby providing deeper insight into the level of mathematical creative thinking abilities among control group students.

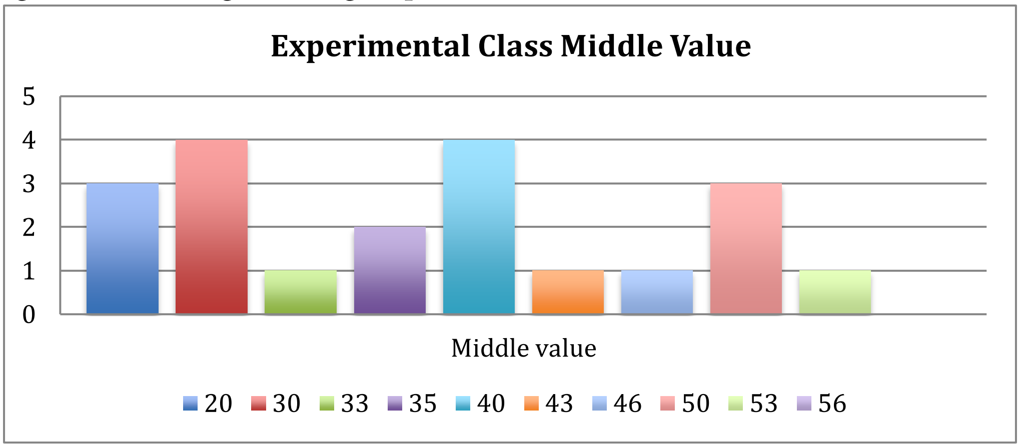


Figure 02

Histogram of scores on creative thinking abilities in mathematics for students in the Control class

To determine the variable quality of mathematical creative thinking abilities in the control class, five scale assessment criteria were used. Based on the results of conversion into these criteria, the average creative mathematical thinking ability of students in the control group is M = 31.5, which is in the range 41.66 < X < 58.34 in the "Low" category. The post-test results showed that the average score on the creative thinking ability test in the experimental group was higher than in the control group. The arithmetic average of the experimental group's post-test results was 80.4, while the control group had an arithmetic average of 31.5, which was significantly lower.

Before carrying out a hypothesis test, several prerequisite tests must be carried out on the post-test results, including the normality test of data distribution and the homogeneity of variance test. The normality test was carried out to ensure that the data distribution in the experimental group and control group was normally distributed. This test was carried out using SPSS version 25 software. Data is considered normally distributed if the significance value is greater than $\alpha = 0.05$.

In addition, a homogeneity of variance test is necessary to ensure that the variances between the two groups are the same, which is an important prerequisite for a valid hypothesis test. The results of the normality test and homogeneity of variance test provide a strong basis for proceeding to the hypothesis testing stage, ensuring that the basic statistical assumptions have been met. Below are presented the results of the normality test of students' creative mathematical thinking abilities in the experimental group and control group, which will be the basis for further analysis..

Table 3. Normality Test Results for Creative Thinking Ability

Tests of Normality							
Class		*Kolmogorov-Smirnov*[a]			*Shapiro-Wilk*		
		Statistic	df	Sig.	*Statistic*	Df	Sig.
student scores	experiment_class	0,154	20	.200*	0,913	20	0,073
	control class	0,108	20	.200*	0,953	20	0,407

Based on the results of normality test calculations using SPSS 25, the sig. in the experimental class posttest it was 0.073 > 0.05, while the control class posttest data was 0.407. So based on these results it can be concluded that in the experimental class and control class the data is normally distributed.

then a homogeneity of variance test was carried out to determine whether the data from the experimental and control groups had a homogeneous distribution or not. The results of the homogeneous variance test with SPSS are presented in the following table:

Table 4. Results of the Homogeneity of Variance Test

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
student scores	*Based on Mean*	0,057	1	38	0,813
	Based on Median	0,056	1	38	0,815
	Based on Median and with adjusted df	0,056	1	37,961	0,815
	Based on trimmed mean	0,057	1	38	0,813

Based on the results of the homogeneity test carried out via SPSS 25, a significant value (sig.) Based on trimmed mean was found to be 0.813 < 0.05 so it can be concluded that the variance of the experimental class and control class posttest data was found to be the same or had a homogeneous variance.

After carrying out normality tests and homogeneity tests in the experimental class and control class, the data was then tested using hypothesis testing to determine the effect of an open-ended based realistic mathematics learning approach. Hypothesis testing H0 and H1 was carried out by t-test using SPSS. number of students in the experimental group and control group (n_1=n_2), so using the seprated variance formula. The hypothesis criteria used are H0 accepted if tcount is smaller or equal to ttable t_{table} ($t_{count} \leq t_{table}$), and H0 is rejected if t_{count} is greater than t_{tabel} ($t_{hitung} > t_{tabel}$)) with df.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
student scores	Equal variances assumed	0,057	0,813	12,493	38	0,000	43,350	3,470	36,325	50,375
	Equal variances not assumed			12,493	37,937	0,000	43,350	3,470	36,325	50,375

Based on the calculation results in the table above, seen from the results of the sig. (2-tailed) is 0.000 < 0.05, t_{count} is 12.493, while t_{table} with df 38 is at a significant level of 1.68595. This means that tcount is greater than ttable (tcount > ttable) so that H_0 is rejected and H_1 is accepted. Thus, it can be interpreted that there is a significant influence of the implementation of an open-ended based realistic mathematics learning approach on the mathematical creative thinking abilities of fifth grade students at SD 105346 Aras Kabu, Beringin District, academic year 2023/2024.

This research is supported by research that has been conducted (Febrianingsih, 2022), that the realistic mathematical approach and the conventional approach have different influences on students' mathematical understanding abilities. Research from Rizky, Dantes and P. Aditya, 2020 states that learning using an open-ended based PMR approach shows high effectiveness on students' problem solving abilities compared to students learning without using an open-ended based PMR approach. The role of the teacher is also very necessary in the open-ended PMR approach as a facilitator and providing opportunities for students to explore more deeply about mathematics in everyday life to be active together in carrying out the mathematics learning process (Oktapia et al., 2022).

In learning mathematics, it is important to develop students' creative thinking abilities by understanding its characteristics, such as fluency, flexibility, originality and elaboration. Teachers can design assessment instruments to measure students' creative thinking processes, or implement learning models that support the development of students' creative thinking abilities, especially in the context of mathematics (Putri et al., 2024). The ability to think creatively in mathematics trains students to see problems from various points of view and relate them to the knowledge they have. In accordance with Livne's view, creative thinking in mathematics refers to the ability to produce new and varied solutions to open-ended mathematical problems (Utami et al., 2020).

Learning activities using an open-ended based PMR approach were applied to the experimental group and conventional learning to the control class group at SD 105346 Aras Kabu, Beringin District. This research shows that there are differences in students' mathematical creative thinking abilities. This can be seen from the data on students' creative mathematical thinking abilities. Descriptively, students' creative mathematical thinking abilities in the experimental group were higher than those in the control class group. So this research shows that there is an influence of the open-ended PMR approach on students' creative mathematical thinking abilities.

CONCLUSION

Berdasarkan hasil penelitian dan diskusi, dapat disimpulkan bahwa kemampuan berpikir kreatif matematis siswa yang diajarkan dengan pendekatan pembelajaran matematika realistik berbasis open-ended memiliki pengaruh signifikan, dengan rata-rata hasil post-test sebesar 80,4. Sebaliknya, kemampuan berpikir kreatif matematis siswa yang diajarkan dengan pembelajaran konvensional cenderung lebih rendah, dengan rata-rata 31,5. Hasil uji hipotesis menggunakan t-test dengan SPSS menunjukkan nilai sig. (2-tailed) 0,000 < 0,05, t-hitung sebesar 12,493, sedangkan t-tabel dengan df 38 pada tingkat signifikan 1,68595. Ini berarti t-hitung lebih besar dari t-tabel (t-hitung > t-tabel) sehingga H0 ditolak dan H1 diterima. Dengan demikian, terdapat pengaruh signifikan dari penerapan pendekatan pembelajaran matematika realistik berbasis open-ended terhadap kemampuan berpikir kreatif matematis siswa kelas V di SD 105346 Aras Kabu, Kecamatan Beringin, tahun ajaran 2023/2024.

For future research, it is recommended to expand the research sample to include various grade levels and various school backgrounds to increase the generalizability of the findings. In addition, further research can consider the use of other learning methods as a comparison with the Open-Ended Based Realistic Mathematics Learning approach.

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