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Realistic Mathematics Education for Logical Reasoning of Primary Students

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Abstract: Primary school students are inadequate in using logical reasoning. Meanwhile, primary school students need logical reasoning to solve problems based on reasonable facts. The realistic mathematics education (RME) approach is thought to improve the logical reasoning of primary school students. The study aimed to examine the effect of the RME approach on the logical reasoning of primary school students. A quasi-experimental design with one group pretest-posttest was applied as the research design. Meanwhile, the research sample was taken from a randomly selected public primary school in Sidoarjo. Data analysis techniques used descriptive and inferential. The results showed a difference in the average pretest and post-test scores on logical reasoning. Meanwhile, the paired t-test result of 0.000 <0.05 provides evidence that there is indeed a relationship between implementing the RME approach and the improvement of logical reasoning of elementary school students. Thus, the RME approach significantly affects the logical reasoning of primary school students..

Keywords: Logical reasoning; RME approach; primary students.

Pendidikan Matematika Realistis untuk Penalaran Logis Siswa Sekolah Dasar

Abstrak: Siswa sekolah dasar belum memadai dalam menggunakan penalaran logis. Sementara, siswa sekolah dasar membutuhkan penalaran logis untuk menyelesaikan masalah berdasarkan fakta-fakta yang masuk akal. Pendekatan realistic mathematics education (RME) diduga dapat memperbaiki penalaran logis siswa sekolah dasar. Tujuan penelitian adalah untuk memeriksa adanya pengaruh pendekatan RME terhadap penalaran logis siswa sekolah dasar. Desain kuasi-eksperimental dengan *one group* pretes-postes diterapkan sebagai desain penelitian. Sementara, sampel penelitian diambil dari salah satu sekolah dasar negeri di Sidoarjo yang dipilih secara random. Teknik analisis data menggunakan deskriptif dan inferensial. Hasil penelitian menunjukkan perbedaan rata-rata hasil nilai pretes dan postes mengenai penalaran logis. Sementara, hasil uji-t berpasangan sebesar 0,000 < 0,05 memberikan bukti bahwa memang terdapat hubungan antara penerapan pendekatan RME dengan peningkatan penalaran logis siswa sekolah dasar. Dengan demikian, pendekatan RME berpengaruh signifikan terhadap penalaran logis siswa sekolah dasar.

Kata Kunci: Penalaran Logis; pendekatan RME; siswa sekolah dasar.

INTRODUCTION

Logical reasoning can be seen as a skill that underlies high-order thinking (Seif, 2023; Thompson et al., 2017; Thuneberg et al., 2018). The experts argue that through a strong foundation of logical reasoning, high-order thinking can be achieved including critical thinking (Heard et al., 2020), creative thinking (Hidajat, 2021), analogical reasoning (Supratman et al., 2023), computational thinking (Moschella & Basso, 2020), analytical thinking (Odina & Stavicka, 2022), decision-making (Chang et al., 2020), and metacognition (Hamzah et al.,

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2022). In addition, logical reasoning is needed to understand mathematical ideas meaningfully (Albay, 2019; Lestari & Jailani, 2018). Therefore, students generally need logical reasoning to solve problems reasonably based on assumptions, principles, and facts in daily life (Dos Santos, 2021; Khotimah & Masduki, 2019). Thus, logical reasoning can be viewed as an essential yet complicated thinking skill that underlies mathematical making sense.

The importance of logical reasoning for primary school students is focused on problem-solving, making sense of relationships, and understanding patterns (Lin, 2023; Md, 2019). Problem-solving means that students draw reasonable conclusions based on appropriate premises to solve problems (Saleh et al., 2018). Making sense of relationships and understanding patterns is helpful for primary students to identify and extend patterns sensibly, to observe sequences and relationships, for example, numbers that repeat in certain patterns using numerical or figural forms (Devi & Amir, 2021; Lin, 2023; Yildiz, 2022).

Although primary students need logical reasoning, primary students often experience difficulties or obstacles (Smit et al., 2023; Szabo et al., 2020). Difficulties or obstacles of logical reasoning primary students are influenced by several factors: weak making sense (Singh et al., 2020a), mathematics performance (Morsanyi, 2020), and mathematical anxiety (Latip et al., 2023). According to O'Ijayevna (2020), primary students' development of logical reasoning is more determined by the abstract nature of mathematical objects, so primary students have difficulties understanding mathematics concepts. As a result, primary students only memorize formulas and do not use them in a making sense (Singh et al., 2020b).

The results of empirical preliminary studies also show similar logical reasoning obstacles or problems. When primary students are asked to check the truth of the following statements verbally and visually, how do you think about the truth of the statement "non-solid cubes (having all sides, without base and top sides) will have less volume than solid cubes (having all sides, including base and top sides)"?. Primary students generally answered "less volume" and could not draw it. This shows that primary students cannot use logical reasoning due to obstacles regarding concept understanding and abstract mathematical objects. Therefore, a learning environment is needed, and a supportive learning approach should be implemented according to the needs of primary students to eliminate primary students' obstacles (Sun, 2024). Learning should facilitate primary students in building and using meaningful concepts so that students can use informal logical reasoning and make the right decisions in solving problems (Bronkhorst et al., 2022).

Learning that can facilitate primary students reasonably in the formation and use of concepts is Realistic Mathematics Education (RME). RME as an approach has a real problem setting that is a source of learning for primary students. Real means that primary students can imagine the problems presented because they are close to their lives and knowledge (Lerman, 2020). Specifically, the RME approach facilitates primary students in the process of horizontal mathematization to vertical mathematization. In other words, abstract mathematical knowledge concepts are formed through the association of concrete models (Üredi & Doğanay, 2023). Therefore, we suspect that the RME approach can stimulate the formation of meaningful and make-sense knowledge for primary students.

Previous research has been conducted on RME experimentally on logical reasoning for primary students (Cindyana et al., 2022; Ekowati et al., 2021; Febrian & Astuti, 2018; Purnamatati et al., 2023; Saleh et al., 2018). The experimental implementation of RME positively impacts primary students' logical reasoning. However, these existing researches have not elaborated on the need for logical reasoning informally with the formation of mathematization horizontally. This is because primary students need a horizontal mathematization process to vertical mathematization through RME to get abstract and reasonable knowledge based on real life or their closest knowledge (Lerman, 2020; Üredi & Doğanay, 2023). In addition, logical reasoning informally for primary students is built on logic that makes sense and is meaningful (Tum, 2024). Thus, to cover the gap and the need for research, it is necessary to experimentally research RME on logical reasoning for primary students by elaborating the process of horizontal mathematization to vertical mathematization. Therefore, this research aims to examine the effect of RME on logical reasoning for primary students.

METHOD

This research used a quantitative quasi-experimental method with a one-group pretest-post-test control design. This research was conducted to determine whether the RME affects the logical reasoning of primary school students. This research test instrument is in the form of a test given on the pretest and post-test. The pretest was conducted by providing learning with a conventional approach. While the post-test was given using the RME approach.

The steps of the RME approach are adopted based on the learning steps from Ekowati et al. (2021), which are: (1) Understanding contextual problems. At this stage, students are asked to understand the given problem based on the context; (2) Explain contextual problems. At this stage, students and teachers conduct question-and-answer activities, (3) Solving contextual problems. Students understand the problem; the teacher gives problems in groups; (4) Comparing answers. Students are then directed to discuss with other group members to find the correct answer. (5) Conclude. At this stage, students are expected to be able to conclude the material presented by the teacher.

The following research was conducted at SDN Kalisampurno 3 Tanggulangin. The research population was all fourth-grade students of SDN Kalisampurno 3 Tanggulangin in the 2023-2024 school year. The sample of this research was 23 students of class IV-A. Meanwhile, the research sample was taken at one of the public primary schools in Sidoarjo and was selected using a random sampling technique. The data collection technique used a logical reasoning test totalling five essay questions. The five items are presented in Table 1. The test refers to the indicators of logical reasoning: collecting facts, determining assumptions, checking assumptions, determining generalizations, and drawing conclusions (Pamungkas & Masduki, 2022). Validators, a requirement for a study, have validated the test instrument. Logical reasoning indicators are presented in Table 2.

Table 1. Logical Reasoning Test

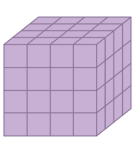
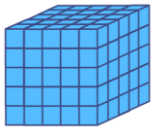
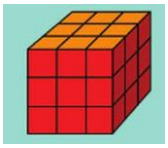
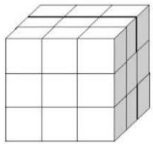
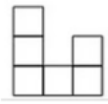
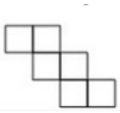
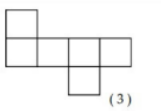
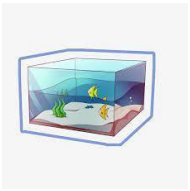
No	Questions
1	Based on your knowledge, determine the length of the ribs of the cube below without measuring!    Picture 1. Picture 2. Picture 3.
2	Rudi has a medium-sized dice with unit length below!  ▼  Picture 4. Picture 5. Help Rudi find the volume of the dice with the length of the unit cube provided!
3	Budi : Sir, I want to make a wooden tool cube. Pak Didin : Yes, how long is the tool? Budi : The tool length is 75cm sir Pak Didin : Okay good sir, I'll make it Budi : Please side the tooling can be given an iron plate, sir. Pak Didin : Good sir, for the process, about 2 weeks. Budi : Yes, sir. Based on the estimation from the dialogue above, calculate the area of the iron plate that will be installed on Budi's tool!
4	Here's a picture of the mesh of a cube!    Picture 6. Picture 7. Picture 8. - Decide which one is the mesh of the cube! - Determine which parts include the lid and base of the cube by marking with a pencil!
5	Mika has a cube-shaped aquarium with a rib of 15 cm..  Help Mika measure the volume of her aquarium!

Table 2. Logical Reasoning Indicator Question Grid

No	Logical Reasoning Indicator Question Grid
1	Presented with a problem in the form of a picture of a cube, students can write the number of ribs with the help of unit cubes based on facts.
2	Given a problem, students can calculate a cube's volume with a unit cube's help
3	Presented with a story dialog, students are asked to calculate the surface area of a cube
4	Presented with a picture of a cube mesh net, students can determine which one includes a Cube mesh net.
5	Presented with a picture, students are asked to calculate the volume of a cube.

The question grid based on logical reasoning indicators can be seen in Table 2. The questions given are appropriate in the context of daily life. Students can solve the problems well according to the indicators. As can be seen in Table 1, the logical reasoning test consists of five essay questions. The test is used as a reference to determine whether students can work using good logical reasoning.

Data analysis techniques in this research are using descriptive analysis and inferential analysis. Descriptive analysis can be described based on mean and standard deviation. As for the inferential analysis to test whether or not the RME approach affects logical reasoning, Inferential analysis has three prerequisite tests. The first is the normality test, which determines whether the data is normally distributed. The second prerequisite test is the homogeneity test, which is carried out to determine whether the data is homogeneous. The homogeneity test was conducted using the Levene test. The last test, the t-test, was used with a paired sample T-test.

RESULT AND DISCUSSION

The results of the research that was carried out on fourth-grade students at SDN Kalisampurno 3 include descriptive and inferential analysis. The descriptive analysis aims to explain the data obtained, including the average score and standard deviation. These results are obtained from the calculation of pretest and post-test in Table 3.

Table 3. Data on Pretest and Post-test Results

	No	Mean	Std. Deviation
Pretest - posttest	23	36,09–66,09	6,735-7,971
Valid(N)	23		

Table 3 shows that the mean value of the pretest is 36.09 with a standard deviation of 6.375 and the mean value of the post-test is 66.09 with a standard deviation of 7.971. Based on the average score, there is a considerable difference between the pretest and post-test

results, which is 30 percent. This descriptively shows that the use of the RME approach in mathematics learning has a positive influence on logical reasoning. The data description is presented as a diagram of the logical reasoning pretest and post-test scores in Figure 1.

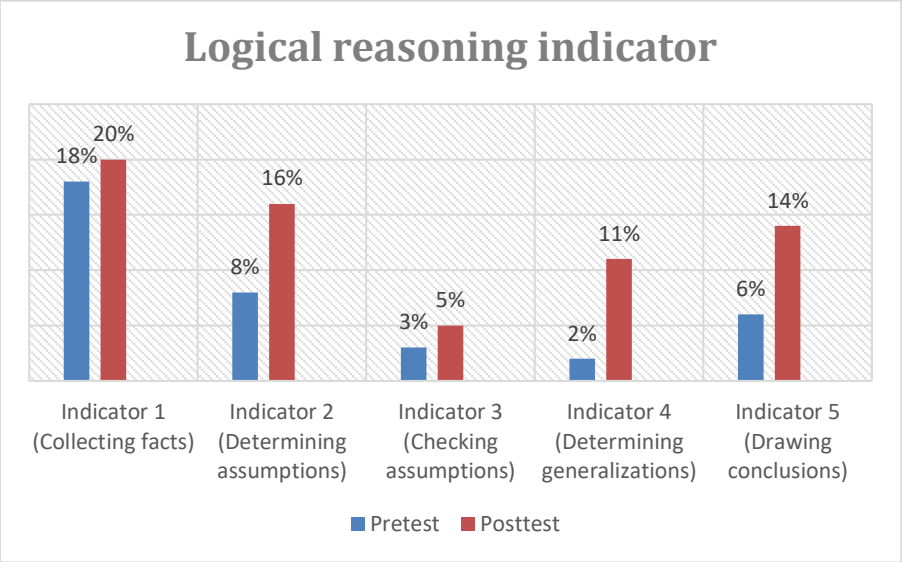


Figure 1. Average logical reasoning indicators

The results shown in Figure 1 on logical reasoning for primary students show that the post-test data is better than the pretest data. However, the statement was not said to be valid before hypothesis testing. Before testing the hypothesis, a prerequisite test is first carried out, namely the normality test using Shapiro-Wilk to prove whether the data is normal so that the next test can be carried out. The results of the normality test are in Table 4.

Table 4. Data Output of Shapiro-Wilk Normality Test

	Sig	Criteria	Status
Pretest - posttest	0,56–0,98	Sig. >0,05	Normal

Based on Table 4 regarding the results of the normality test using the Shapiro-Wilk test conducted on 23 students, the significance value for the pretest was 0.056> 0.05, while in the post-test, it was 0.098> 0.05. So, it can be concluded that the pretest and post-test data are normally distributed. Furthermore, the homogeneity test was carried out to determine whether the two data were homogeneous or not using the Leavene test. The results of the homogeneity test can be seen in Table 5.

Table 5. Leavene's Test Data

	Levene Test	Sig	Criteria	Status
Pretest - posttest	0,244	0,624	Sig. >0,05	Homogen

Based on the results of the homogeneity test in Table 5 using the Levene test, the significance value is 0.624> 0.05. It is known that the significance value must be > 0.05, which means that the data will be homogeneous. It can be concluded from these results that the

data above is homogeneous and can be continued with the next test, namely the paired sample t-test. The results of the paired sample t-test can be seen in Table 6.

Table 6. Data of Paired Sample t-Test

	Sig	Criteria	Status
Pretest - posttest	0,000	Sig. <0,05	Effect

Based on Table 6, the 2-tailed significance value is 0.000 (0.000 <0.05), therefore, $H0$ is rejected and $H1$ is accepted. H_0 : μ = μ $_0$ shows that there is no significant difference between logical reasoning using RME. Meanwhile, H_1 > μ = μ $_1$ shows that there is a difference between RME and logical reasoning. Therefore, it can be concluded that RME significantly affects primary students' logical reasoning. The results of this research are similar to previous research that the implementation of RME has a positive impact on logical reasoning for primary students (Cindyana et al., 2022; Ekowati et al., 2021; Febrian & Astuti, 2018; Purnamatati et al., 2023; Saleh et al., 2018).

Improving students' primary logical reasoning can be explained by the fact that RME optimizes students' mathematization. Mathematization can be a powerful weapon in developing students' activeness in learning. These results are obtained from a context that reflects ideas and concepts that eventually return to the real world so that primary students have a better understanding (Da, 2022; Duyen & Loc, 2022; Ekowati et al., 2021). In addition, the process of horizontal to vertical mathematization in RME makes primary students get knowledge that is abstract and makes sense based on their real-life or immediate knowledge (Lerman, 2020; Üredi & Doğanay, 2023).

CONCLUSION AND RECOMMENDATION

The research results show that RME significantly impacts primary students' logical reasoning. However, the positive impact was obtained only in the sample involving grade four primary students and only in one school. Therefore, suggestions for further research are given, namely the need to implement RME in primary students by involving other grades besides grade four and a wider research site in primary schools.

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