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THE INFLUENCE OF REALISTIC MATHEMATICS EDUCATION ON YEAR 8 STUDENTS' SPATIAL ABILITY OF CUBOIDS AND CUBES

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ABSTRACT

This study aims to determine the effect of RME on the spatial abilities of Year 8 students concerning cuboids and cubes. Geometry problems often experienced by junior high school students, such as difficulty knowing the difference between cuboids and cubes, difficulties showing elements of cuboids and cubes, and difficulty imagining cuboids and cubes in the case of rotation. The teacher should not underestimate it because it will impact the next level of learning. Besides, spatial abilities are closely related to other mathematical concepts. One alternative is using RME. This research employed the quasi-experimental method, and samples were selected using purposive sampling techniques. The two classes were selected as samples in this study: the experimental and the control classes. Before conducting the main analysis test, the pre-test score students were tested with the t-test. The initial conclusion was that there was no difference in the spatial ability of the experimental class and the control class. The main analytic test in the post-test was done using U-test. The post-test results show that the average score of the experimental class is higher than the control class; RME positively influences students' spatial abilities.

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INTRODUCTION

Mathematics learning is taught to students from kindergarten to college level. Each level of education that students' study has its characteristics. Students' mathematics learning is adjusted to their development (Nasaruddin, 2013). Mathematics lessons are knowledge with many interrelated concepts, showing the importance of early understanding of mathematical concepts. Many mathematicians state that mathematics is abstract. Mathematics consists of abstract ideas with symbols arranged hierarchically and has deductive reasoning so that learning mathematics requires high mental activity (Hasratuddin, 2014). Because of its abstract nature, many students have difficulty, especially in geometric concepts requiring good visualization and understanding of spatial concepts. Therefore, teachers need to improve students' spatial abilities from an early age to resolve geometry problems.

The expected goal of learning mathematics is for students to improve their logical, rational, and critical thinking skills and develop a consistent, independent, and honest attitude (Sujadi, 2018). Thus, it is hoped that students can master the above abilities at the primary school level to prepare them for the next level. However, junior high school students experience difficulties understanding or participating in mathematics learning, especially in geometry (Deshinta et al., 2015). Among the subjects in geometry are cuboids and cubes. The analysis that has been carried out by Mutiah (2017) and is strengthened by the analysis of Maryanih et al. (2018) suggest that Junior high school students still have difficulty distinguishing between cuboids and cubes, mentioning the elements, and distinguishing these shapes in everyday life because they are abstract. Hence, students find it difficult to imagine and visualize.

Geometry learning is critical to be taught to elementary school students to instill visualization skills and teach them to build space from an early age so that their spatial abilities can be developed and useful for the next level (NCTM, 2000). In addition, students can use geometric modeling in problem-solving. The government syllabus stated that cuboids and cubes are one of the geometry subjects and must be taught to elementary school students and junior high school students. Cuboids and cubes have been taught at the elementary school level, but the difficulties in the learning process affect the next level, namely at the junior high school level. Most obstacles experienced by students in the learning process are the abstract material and using many concepts, so many students have not mastered the concept and have difficulty working on the problems on the related topic. Students are also weak in recognizing polyhedron and how it differs from other forms or have difficulty recognizing the shape (Suwaji, 2008).

This obstacle was strengthened by interviews with several junior high school students and teachers regarding problems in learning geometry. They said students had difficulty imagining, contemplating, thinking, and realizing ideas in their way regarding the shape of the space. The analysis can be seen from the low scores of students on spatial materials, about 70% below the minimum criteria of mastery learning. Furthermore, based on the Program for International Student Assessment (PISA) results, Indonesia experienced a significant decline, especially in mathematics; in 2018, Indonesia's score was lower than 2015. Apart from a decline in ranking, when compared to neighboring countries, Indonesia is far below, for example, Thailand. In 2018, Indonesia scored 379 in mathematics while Thailand scored 419.

One of the reasons PISA is used as a problem analysis material in geometry learning is because the assessment in PISA includes geometric shapes, location, movement, and spatial (OECD, 2018). These problems indicate that Indonesia is a country where mathematics achievement is lower. One of the factors is the lack of preparation and debriefing from an early age, especially during elementary school (Fauzi & Arisetyawan, 2020). Therefore, the teacher should not belittle students with difficulty understanding geometry, especially polyhedron, because it will affect the next level of learning. Based on the problems above, the researcher wants to contribute to providing alternative knowledge that can be a solution starting from the environment and where the researcher lives first so that it can become a picture for educational practitioners.

Difficulty in learning geometry, especially spatial, requires a high level of imagination and good spatial abilities. Cuboids and cubes are abstract geometrical subjects that require imagination and good visualization skills (Chintia et al., 2021). Marliah (2006) argued that spatial ability is one aspect of cognition, which functions as a person's adaptation to the environment, namely how a person copes with the environment and organizes his thoughts and actions (Marliah, 2006). Meanwhile, Dearing et al. (2012) argued that spatial ability could determine a child's future, determining a child's chances of success. Being less math-ready at the start of school is associated with lower achievement in mathematics, less literacy, an increased chance of failing to graduate from high school, and increased future unemployment

(Duncan et al., 2007). Furthermore, in long-term research, it is stated that spatial ability can be a predictor of mathematical ability at the next level and in the future (Wolfgang, C. H., Stannard, L. L., & Jones, 2001).

Students must have spatial abilities, such as the ability to imagine objects from abstract to real in mind, being able to compare one shape to another, predicting and determining the solution to problems related to polyhedron, constructing understanding, representing, and finding information from visual stimuli in a spatial context (Lestari, K. E., & Yudhanegara, 2015). Cognitive development in children must go through the object media used so that they have a perception and manipulation of objects in their minds and can be imagined. Spatial representation is not just an image of what the student sees but an image recorded in his/her mind, images from the environment or daily activities. The spatial representation will lead to spatial concept (Marliah, 2006).

This study used the indicators based on Maier (1994), including: 1) Spatial Perception, namely the ability to predict the location of an object observed from all directions; 2) Visualization, namely the ability to visualize an object with different forms; 3) Mental Rotation, namely the ability to predict a rotated object; 4). Spatial Relation is the ability to connect parts of a spatial structure; even if there are changes, you can still predict them; 5). Spatial Orientation is the ability to predict the state of an object from various conditions.

Spatial ability is necessary, especially for elementary school and junior high school students in learning geometric geometry, because the spatial ability is closely related to other mathematical abilities. Developing and improving spatial abilities can be done through learning models used and implemented by educators. Teachers need to think about suitable learning models and meet students' problems or characteristics to achieve the expected educational goals. The learning model describes the activities conducted by educators in the class from beginning to end, presented uniquely (Helmiati, 2012).

The development of various learning models shows the growing conception of learning technology in line with the development of learning and learning theories. In the new paradigm of education, learning is to change student behavior and shape the character and mental attitude of professionals oriented to a global mindset. The focus of learning is on learning how to learn and not just studying the subject's substance (Helmiati, 2012).

Gravemeijer (2006) argued that mathematics is an activity carried out by humans. Mathematics is not only about logical thinking, certainty, accuracy, and consistency. However, mathematics is very close to human activities. In RME, learning mathematics means doing mathematics to solve the most important daily life problems (contextual problems). The teacher gives freedom to students to try to find their understanding of mathematical concepts. Learning becomes more meaningful if there is interaction between students and students, teachers and students, which becomes learning that affects the achievement of goals.

Learning in mathematics, in addition to gaining knowledge, must also be relevant to reality or related to the child's experience in his daily life, close to the culture and circumstances of society, and will become the child's experience in his life. The goal is that learning has a deep meaning in life in society (Heuvel-panhuizen, 2000). Therefore, RME can be used as an alternative to overcoming problems in learning mathematics. RME can be an alternative for teachers to improve teaching and change the habits of students who usually passively receive knowledge to find their understanding independently.

Learning with RME is a learning model based on real-life, meaning that learning is based on real-world situations. The reality in question has a wider scope; students are given a problem that occurs or is experienced by the student, or students are given something imaginable. So the emphasis is on making mathematics that is considered abstract to be real in students' minds (Heuvel-Panhuizen, Van Den M. & Drijvers, 2014).

RME is part of learning mathematics taught in schools (Lestari & Yudhanegara, 2015). The prioritized principle is reality or problems that make sense in students' lives or according to the student experience as a source of learning. Whether they happen or are just shadows, real-life problems will be realistically used as sources to construct students' understanding and bring up mathematical concepts. So that activities in the learning process become effective, students are encouraged to solve problems independently, identify existing problems, and process the main issues to find conclusions. The RME steps are 1) Understanding contextual issues, 2) Explain contextual issues; 3) Resolve contextual problems; 4) Compare and discuss student answers, and 5) Conclude (Hobri, 2009).

RME is one way to bring students closer to mathematics because mathematics is a form of human activity, so it has a deep meaning for students (Wulandari & Sulasmono, 2020). An effective strategy is needed to help students understand and visualize their shadows in cuboids and cubes, one of which is the learning model and the presentation of the material presented by the teacher (Basiran et al., 2021). The ability to master geometry also requires spatial ability, so spatial ability has an important role in achieving mathematics learning goals; the teacher's role is needed to overcome problems in geometry, one of which is the use of learning strategies (Syahputra, 2013).

RME connects mathematics with everyday life so that students understand the meaning of mathematics. It also trains students to be independent by going through the process of finding their understanding and inviting students into an active learning process. However, RME also has some challenges; raising students' awareness to learn independently may be hard or take a long time, and finding realistic or contextual questions (Hobri, 2009). RME is one model that can be used to improve students' spatial abilities. The principles and steps in RME are related to students' problems in learning geometry, especially cuboids and cubes, RME learning can solve these problems, training students to think realistically, logically, and imaginatively. To support the above theory, the researchers want to scientifically prove the impact of using RME learning on Grade 8 students' spatial abilities on cuboids and cubes.

METHODS

This study is quantitative research using a quasi-experimental method. Meanwhile, the appropriate design is a non-randomized control group pretest-posttest (non-randomized control group pretest-posttest design). The population used in this study was all eighth-graders, while the technique for taking samples was using the purposive sampling technique because cuboids and cubes are studied in the eighth grade, so the sample used is the eighth grade. The design in this study used two classes from the selected sample of about 36 students, the experimental and control classes. The experiment class was treated using RME, while the control class was taught using the expository model. The research design is shown in Table 1.

Table 1. Research design non-randomized control group pretest-posttest design

Group	*Pre-test*	Dependent Variable	*Post-test*
Experiment	Y_1	X	Y_2
Control	Y_1	-	Y_2

Description:
Y_1 = pre-test for experimental and control classes
Y_2 = post-test for experimental class and control class
X = Treatment

Data collection was done by a spatial ability test. There are five questions, each corresponding to an indicator of spatial ability. The test used in this study is a description test;

Students are given more than one answer choice and must be accompanied by logical reasons. The researchers used a short answer test because the spatial ability test is usually in the form of multiple choice. In addition, students are also required to provide reasons for the answers they have chosen. Thus, the results obtained are more reliable to measure students' spatial abilities.

Before the data collection, these instruments were tested in another school to examine the validity, reliability, discriminating power, and difficulty index. The next step is to analyze the data used, namely the homogeneity test and normality test on the pre-test value of the two samples to determine the initial spatial ability. Next, a hypothesis test was performed (T-test if the data is normal and homogeneous/U-test or Mann Whitney if the data is not normal but homogeneous). The same analysis was done for the post-test scores. Pre-test and post-test scores were analyzed using SPSS 21.

The main goal of data analysis in this study is to determine whether there are significant differences in students' spatial abilities between students taught using the RME learning model and those taught using the expository learning model on the subject of cuboids and cubes. From these differences, we can conclude whether there is an effect of RME learning on students' spatial abilities.

RESULTS AND DISCUSSION

First, the acquisition of students' initial spatial ability results in cuboids and cubes will be explained and the students' learning activities during learning using RME. Next, the spatial ability test scores of students taught with the RME learning model in the experimental class and those taught by the expository model or in the control class are presented.

The initial hypothesis was carried out to determine the students' spatial ability before being given treatment. The class that has been selected as the sample class was given a pre-test. Then, the prerequisite test was carried out, namely the homogeneity of the students' pre-test scores. The homogeneity test aims to determine the variance of the two samples is homogeneous or not. Homogeneity test determines their initial spatial ability before the treatment. The data were tested using One-Way ANOVA. The data is said to be homogeneous if the P-value > 0.05; otherwise, if the P-value is 0.05, the data is not homogeneous.

The analysis of the pre-test value and the results of the homogeneity test output will be presented in Table 2.

Table 2. The results of the analysis of the pre-test homogeneity test

Levene's Statistic	df1	df2	Sig.
.054	1	51	0.818

Based on Table 2 the homogeneity test results, the p-value was 0.818, indicating that the variance in the two samples was homogeneously distributed. Next, the normality test was carried out on the pre-test data to examine whether the two classes were normally distributed. In this study, the normality test was carried out using SPSS, namely Shapiro-Wilk, because the sample in this study was classified as a small sample. The data is normal if the p-value > ($\propto$=0.05); Otherwise, the data is not normally distributed.

Table 3. Normality Test of Pretest

Spatial Ability Study Result Test (Class)	Shapiro Wilk		
	Statistic	df	Sig.
Post-test Experiment (RME)	.924	26	.055
Post-Test control (Expository)	.933	27	.080

Based on Table 3, it can be seen that the statistical test results of the Shapiro-Wilk p-value from the experimental pre-test was 0.055, so the experimental pre-test data is normally distributed. The pre-test in the control class obtained p-value of 0.08, showing that the pre-test data in the control class was normally distributed.

After the prerequisite test was carried out, namely the homogeneity test and normality test for the pre-test scores, the pre-test hypothesis was tested using the t-test. It is inadequate if the pre-test score was only tested by homogeneity test. Homogeneity determines the initial mathematical ability, while a t-test is necessary to determine the students' initial spatial ability.

H_0 : There is no difference in students' initial spatial ability between the experimental and the control classes based on the pre-test results.

H_1 : There. Is a difference in students' initial spatial ability between the experimental and the control based on the pre-test results.

The following are the results of the t-test of the pre-test scores for the experimental and the control classes, the data obtained are as shown in table 4 below.

Table 4. Independent Sample t-Test test results of the pre-test

	F	df	Sig. (2-Tailed)
Spatial Ability Study Result Test	0.054	51	0.934

From the Table 4, it can be seen that the p-value is 0.934, thus H_0 is accepted. This means that when viewed from the pre-test results, the spatial abilities of students in both experiment and control classes were homogeneous or have the same variance. Thus, it can be concluded that there was no difference in initial spatial ability in the sample class. A cluster random sampling technique was used to determine the control and the experimental classes.

After the experimental and control classes were treated, both classes were given a post-test. The main hypothesis test is carried out if the prerequisite tests have been carried out, namely homogeneity and normality tests on students' post-test scores.

Table 5. Results of the analysis of the post-test homogeneity test

Levene Statistic	df1	df2	Sig.
1.247	1	51	.269

Based on table 5, the homogeneity test results, the significance value obtained is 0.269; it can be stated that the post-test variance in the two samples is homogeneously distributed ($p=0.269$).

Table 6. Normality test results

Spatial Ability Study Result Test (Class)	Shapiro Wilk		
	Statistic	df	Sig.
Post-test Experiment (RME)	.888	26	.008
Post-Test control (Expository)	.927	27	.060

Based on table 6, the post-test data in the control class obtained a p-value of 0.06, indicating the post-test data in the control class was normally distributed. Meanwhile, the distribution was not normal for the post-test of the experiment class ($p=0.008$).

The main hypotheses to be tested in this study are as follows.

H_0 : There is no significant effect on the spatial ability of students who are taught using RME

H_1 : There is a significant effect on the spatial ability of students taught using RME

The test used for the main hypothesis is the U-test or the Mann-Whitney test using SPSS 21.

Table 7. Mann-Whitney test results of post-test

	Spatial Ability test result
Mann-Whitney U	66.000
Wilcoxon W	444.000
Z	-5.114
Asymp. Sig. (2-tailed)	.000

Table 7 shows that the p-value is 0.000 and thus H_0 is rejected, and H_1 is accepted. This means that between the sample classes, there were differences in the spatial abilities of students taught using RME and those taught using expository approach. Likewise, the post-test scores in the experimental class were higher than in the control class. The highest score in the experimental class was 90, while in the control class was 75, the lowest score in the experimental class was 50, while in the control class was 20. The average post-test score of students was higher in the experimental class (75.58) than the control class (55.19). Thus, it can be concluded that there is an effect of using RME on students' spatial abilities.

The positive effect is shown by learning using the RME model. This can be proven from the post-test results of students with RME learning their test results are better than those taught by expository classes. In this study, each class was held three times, both in the experimental and control classes. The material taught at the first meeting was about the elements of cuboids and cubes, their differences, and similarities. The second meeting discussed the volume of cuboids and cubes, and the third meeting discussed the surface area of cuboids and cubes. The learning process in the experimental class is in accordance with the lesson plans prepared by the researchers, using RME learning and sources of knowledge using problems that are in accordance with the circumstances or conditions of students. In comparison, the learning process in the control class uses a learning model that teachers usually use, namely material explanations, sample questions, and discussions to do practice questions.

This study is supported by research conducted by (Rohati, 2015), stating that one of the causes of less meaningful learning is the absence of a relationship between mathematics and everyday life. Therefore, students are not eager to learn it because they think there is no benefit. RME learning can change mathematics learning from two-way learning; the teacher explains to students only in all directions, namely teacher-student and student-student. While Wahyuni, et al. (2015) concluded that some students' efforts to construct their knowledge independently and find knowledge and understand it well on the material being studied volume and surface area of cuboids and cubes can encourage and train students to bring up spatial abilities. Students are invited to explore their abilities and be directly involved in finding the formula for the volume or surface area of cuboids and cubes. Where in each activity, students are required to work together and be able to communicate their ideas so that students can always share and exchange the information they have. Based on these statements, the model suitable for developing students' spatial abilities at the elementary level is RME.

Learning with RME can train students to develop their spatial abilities. RME is learning by relating mathematics to everyday activities, based on students' experiences, or even their logical imagination. So that students train their minds and logic to imagine or think about a wake correctly. Learning with RME is also carried out with various activities with the aim that students can construct their understanding of the material. This is also supported by another study of Rohman, S., Susanto, & Hobri (2019) that the implementation of mathematics learning can foster students' attitudes to dare to ask questions, express opinions, dare to present the results of discussions and dare to answer questions and respect the opinions of others. In terms of emotion, students experience interest in learning, so the material is easy to understand and happy with group learning.

The learning process in the experimental class is more effective because students are given the responsibility to find their understanding, and the teacher always provide support and motivation (Nasir & Sari, 2019). Students conduct discussions with their friends and share opinions, suggestions, and input; the teacher directs students by walking around the class to monitor the discussion. The discussions carried out in each group were well established, helping each other's friends who did not understand. Student activities in the discussion can be shown in the Figure 1 below (The illustration of student group discussion in class).

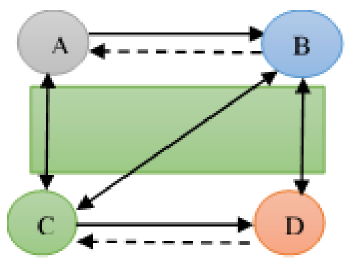

Figure 1. Illustration of a group in class

Description:

Students ask

Students give opinions

Students answer questions

Student interaction in the group went well. Student A asked student B, then student B answered student A's questions. Student C gave his opinion, and student B also added opinions from student C. Each student played an active role in the discussion. So that all members in the group can understand and find their understanding. The students' post-test results also evidence that the class using RME is better than the class that uses the expository model that teachers usually use every day.

Many other researchers have carried out experimental research. Still, in this study, researchers are interested in finding a link or relationship between RME and students' spatial abilities, which are rarely discussed in schools, even though students' problems related to geometry are very complex. The problems presented in this study are also in accordance with students' experience and the questions that exist in students' lives. So, students can imagine the problem and put it into mathematical concepts. The relationship between RME and spatial ability can be seen in Figure 2. The figure shows the flow of the RME learning process using the RME steps and the problems presented in the lives of students to achieve learning objectives on geometry so that students' spatial abilities are expected to increase.

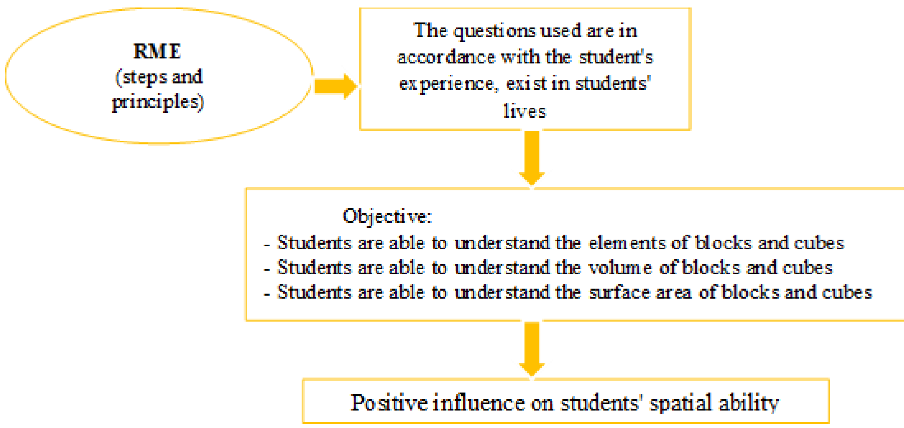

Figure 2. The relationship between RME learning and students' spatial abilities on block and cube material

CONCLUSIONS

This study showed no difference in the students' initial spatial abilities before the treatment. Thus, the sample was done by cluster sampling technique. The Mann-Whitney test conducted on the students' post-test showed that the use of RME positively influences students' spatial abilities. Students taught using RME obtained a higher post-test score than those experiencing the expository model. The learning in the experimental class is also more engaging and efficient because students are directed to carry out discussions to understand the concepts independently. The teacher acts as a motivator and directs students.

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