The effect of a Realistic Mathematics Education (RME) approach and reasoning ability on students' conceptual and procedural understanding

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Abstract

This research aimed to test the conceptual understanding and procedural understanding of mathematics in groups of students who have high reasoning abilities and low reasoning abilities by following the RME approach and lecture method. This research used a 2X2 factorial quasi-experimental design with the independent variables being the RME approach and the lecture method. Data collection was carried out using tests of reasoning ability, conceptual understanding, and procedural understanding instruments. The pretest and posttest data were analyzed using the MANCOVA test. Based on the results of the research there is a significant difference in the conceptual understanding and procedural understanding of mathematics in groups of students who have high reasoning abilities and low reasoning abilities by following the RME approach and lecture method. Based on the results of this research, it was concluded that using the RME approach and high reasoning abilities can improve the conceptual understanding and procedural understanding of mathematics for class VII students. This research implies that the RME approach can be used as a way to improve students' conceptual understanding and procedural understanding of mathematics.

Keywords: Conceptual understanding; mathematics; procedural understanding; reasoning ability; RME approach.

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1. Introduction

Mathematics is one of the main subjects in elementary school. It is hoped that mathematics taught to elementary school students can provide life skills that will be needed in children's daily lives. It is the teacher's job to transfer this knowledge to students so that students understand it. The score in mathematics is still very far from ideal requirements and has the lowest score compared to several other subjects. In general, children have difficulty understanding mathematics subject matter. They tend to memorize without understanding the material. So, they will easily forget if the material is replaced with other material. Students' lack of understanding in mathematics lessons will cause a decrease in students' conceptual understanding. Therefore, there needs to be efforts from researchers, as teachers, to improve learning outcomes in Mathematics subjects.

Based on observations in Surabaya city schools, most students are weak in conceptual understanding and procedural knowledge. Students' weak conceptual understanding is reflected when students successfully solve mathematical problems that are the same as those demonstrated by the teacher, but when given problems that are slightly changed, students have difficulty solving them. This demonstrates that students are only able to memorize and remember the formulas and processes involved without understanding mathematical concepts. Meanwhile, students' weak procedural knowledge is reflected when students succeed in solving mathematical problems that are the same as those exemplified by the teacher, but when given a problem, whether it is the same as the example or slightly modified, students always ask the teacher about the order of each step taken to solve the problem. This demonstrates that students do not understand the techniques or procedures for solving problems correctly and students still have a dependency on the teacher to solve problems. This problem is one of the causes of students' learning difficulties, especially in mathematics subjects.

Efforts to increase conceptual understanding and procedural understanding of Mathematics subjects certainly require active participation not only from teachers but also active participation from students (Arifin & Herman, 2017; Gunawan et al., 2019; Zineb et al., 2022; Yohannes & Chen 2024; Morris et al., 2023). For this reason, there is a need for learning capital that involves students directly, so that learning becomes meaningful. Because meaningfulness will impress students the lesson will have a longer memory period (retention spam) compared to rote learning. The learning that can lead to this is Realistic Mathematics Education (RME) learning (Darto, 2021; Nurjamaludin et al., 2021; Septia, 2021).

RME learning must be linked to reality and mathematics is a human activity. This means it must be close to children and relevant to everyday situations (Nuraina et al., 2021; Rahmawati Suwanto & Wijaya, 2021; Sevinc, 2023). Mathematics as a human activity means that humans must be allowed to rediscover mathematical ideas, concepts, and procedures. The RME approach is an approach that assumes the need for a connection between mathematics and reality that exists and can be found in everyday life. These realistic problems do not mean problems that are always concrete and can be seen by the eye but include things that are easy for students to imagine. In addition, students must be allowed to rediscover and construct mathematical concepts and procedures with the guidance of adults or teachers (Ahadi et al., 2021; Dewi & Izzati, 2020). Problems like this need to be resolved, solutions need to be found so that students can act, behave better, and implement their understanding in their daily activities. Furthermore, it is a shared responsibility to do so, however, teachers have the opportunity to teach teaching material and implement it in students' daily lives or activities through a learning design in a good and positive direction.

Another factor that must be considered in learning mathematics is students' reasoning abilities. Students' reasoning abilities play an important role in the smooth running of a learning activity because it describes students' readiness to receive the lessons that will be delivered (Kollosche, 2021). Teachers need to know students' reasoning abilities before starting learning because in this way it can be seen whether students have reasoning abilities that are a prerequisite for participating in learning, students know what material will be presented (Bai et al., 2023). Good input is expected to produce good output, so having adequate reasoning skills will support the learning process and students' achievement of conceptual understanding and procedural

understanding of mathematics. The inclusion of student characteristic variables in this research as moderator variables is also intended to increase the internal validity of this research design.

Several studies have been conducted on RME Learning (Darto, 2021; Nuraina et al., 2021; Nurjamaludin et al., 2021; Pakhrurrozi, 2021; Rahmawati Suwanto & Wijaya, 2021; Sulastri et al., 2021; Supriyanto et al., 2020; Witha et al., 2021; Zubaidah Amir et al., 2021). The research researched so far has only been on the RME Learning approach in improving mathematics learning outcomes on one type of learning outcome. Research on the RME Learning approach in increasing students' achievement of conceptual understanding and procedural understanding of mathematics has not been widely researched, even though conceptual understanding and procedural understanding in abstract mathematics are arranged in stages and sequentially starting from the basic level, conceptual understanding and procedural understanding (Mulyono et al., 2018; Sari et al., 2020). This is also by the RME and Lecture Learning approach model which is applied through reasoning skills.

1.1. Purpose of study

Based on the problems above, none of the research conducted has been tested to apply the RME and Lecture Learning approach which is applied through reasoning abilities to students' conceptual understanding and procedural understanding of mathematics in class VII in the city of Surabaya.

2. Methods and materials

This research is quasi-experimental research using a Pretest-Posttest, Non-Equivalent Control Group Design research design. In this design, there is a pretest before the treatment is given and a posttest after the treatment is given (Sugiono, 2021; Creswell, 2015).

2.1. Participants

In this study, two treatment classes were taken, namely class VII H as the experimental class and class VII F as the control class. The experimental class was subjected to certain treatment variables within a certain period, and subjected to the same measurements, namely through a written test with the same questions as the control class. To find out more clearly the research design in this study can be seen in Table 1.

Table 1
Research design

Group	Treatment	Description
Experiment	X_1	RME Approach
Control	X_2	lecture method

Sampling is a process of selecting and determining the type of sample and calculating the size of the sample that will be the subject or object of research. The sample that will be studied must represent the population both in characteristics and in number.9 In this research the sampling technique used is purposive sampling technique. Purposive sampling is a sampling technique by taking subjects not based on strata, random, or area but based on a specific objective. The purposive sampling technique is a technique for determining samples with certain considerations.

2.2. Data collection instrument

One of the data collection techniques in this research is using test questions and reasoning ability questionnaires to collect data regarding students' conceptual understanding procedural understanding and reasoning abilities. Before the test questions and reasoning ability questionnaires are created, it is necessary to prepare an instrument grid which is a guide or guide in formulating the instrument questions used. Apart from that, it is necessary to create a grid for this instrument so that the preparation of the instrument is more systematic so that it is easy to control, correct, and consult with experts. The grid of test instruments and questionnaires is as follows (tables 2 & 3).

Table 2

RME approach instruments

No	Variable	Indicator		No. Items	Number of Items
A	Reasoning Ability	1)	Ability to present mathematical statements verbally, in writing, drawings, sketches, or diagrams	1,2,	2
		2)	Ability to make allegations	3,4,5	3
		3)	Ability to determine patterns	6,7,8	3
		4)	Ability to perform mathematical manipulation	9,10,11	3
		5)	Ability to provide reasons for several solutions	12,13	2
		6)	Ability to check the validity of an argument	14	1
		7)	Ability to draw conclusions or make generalizations	15	1
Total Item					15

Table 3

Instrument test grid for reasoning ability

No	Variable	Aspect	Indicator	No. Items	Number of Items
A	RME Approach	Ask a contextual problem	The teacher can pose problems regarding the material to be studied in everyday life.	1,2,3	3
		Resolve contextual problems	Teachers can help direct students in solving problems	4,5,6,7	4
		Compare and discuss	The teacher can compare the results of the student's answers and discuss them with the students.	8,9,10	3
		Make conclusions	The teacher can direct students to conclude the learning that has been carried out	11,12,13,14,15	5
		Total Item			15

Hypotheses testing in this study used the MANOVA test. Manova is an abbreviation for multivariate analysis of variance, meaning it is a multivariate form of analysis of variance (MANOVA). Manova is a statistical test used to measure the influence of independent variables on a categorical scale on several dependent variables as well as quantitative data scales. Imam. The Manova test is used to determine whether there are statistically significant differences in several variables that occur simultaneously between two levels in one variable. Based on the hypothesis, the criteria used to determine assumptions are if Sig. in the table <0.05 then H0 is rejected, and if Sig. > 0.05 then H0 is accepted.

The interaction profile of the independent variables (RME approach and lecture method) and the reasoning ability of the independent variables' conceptual understanding and procedural understanding are presented in Figure 1 and Figure 2.

Figure 1

The interaction effect of the RME approach and lecture method and reasoning ability on students' conceptual understanding
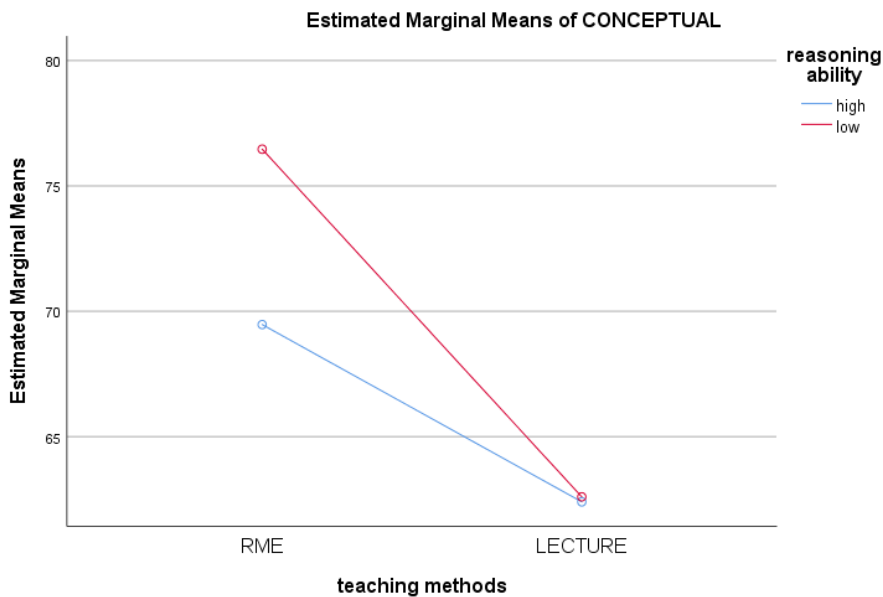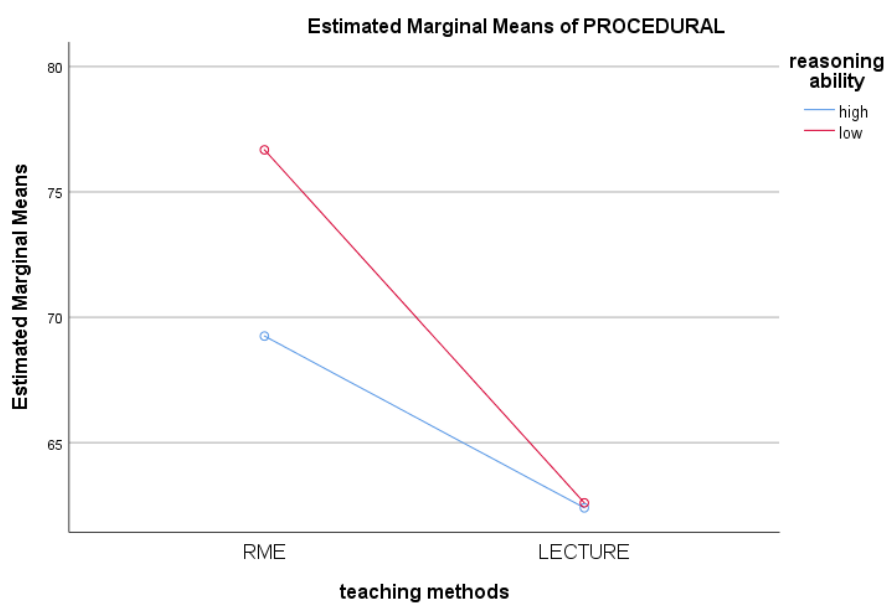

Estimated Marginal Means of CONCEPTUAL

Figure 2

The interaction effect of the RME approach and lecture method and reasoning ability on students' procedural understanding

Estimated Marginal Means of PROCEDURAL

Based on Figure 1, it appears that the difference in the average value of understanding the concept of the RME approach group is higher than that of the RME approach group. This is caused by differences in learning model treatment. So, the RME approach is better at achieving conceptual understanding compared

to the lecture method. In examining the impact of the reasoning ability variable on conceptual understanding, it appears that the average value of conceptual understanding for the group of students who have high reasoning ability is higher than those with low reasoning ability.

Based on Figure 2, it appears that the difference in the average value of understanding the concept of the RME approach group is higher than that of the RME approach group. This is caused by differences in learning model treatment. So, the RME approach is better at achieving procedural understanding compared to the lecture method. In examining the impact of the influence of the reasoning ability variable on procedural understanding, it appears that the average value of procedural understanding for the group of students who have high reasoning ability is higher than those with low reasoning ability.

3. Result

Based on Table 4, shows that the average score for conceptual understanding and procedural understanding for the group of students who have high reasoning abilities and follow the RME approach after controlling for covariate variables is 70%. The average value of conceptual understanding and procedural understanding for the group of students who have high reasoning abilities and follow learning using the lecture method, after controlling for covariate variables, is 62%. Meanwhile, the average score for conceptual understanding and procedural understanding for the group of students who have low reasoning abilities and follow the RME approach after controlling for covariate variables is 77%. The average value of conceptual understanding and procedural understanding for the group of students who have low reasoning abilities and follow the lecture method, after controlling for covariate variables, is 62%. Descriptive statistical values with the percentage increase in procedural understanding can be seen in Figure 3 below.

Figure 3
Description of the RME approach and lecture method as well as reasoning abilities on students' conceptual understanding
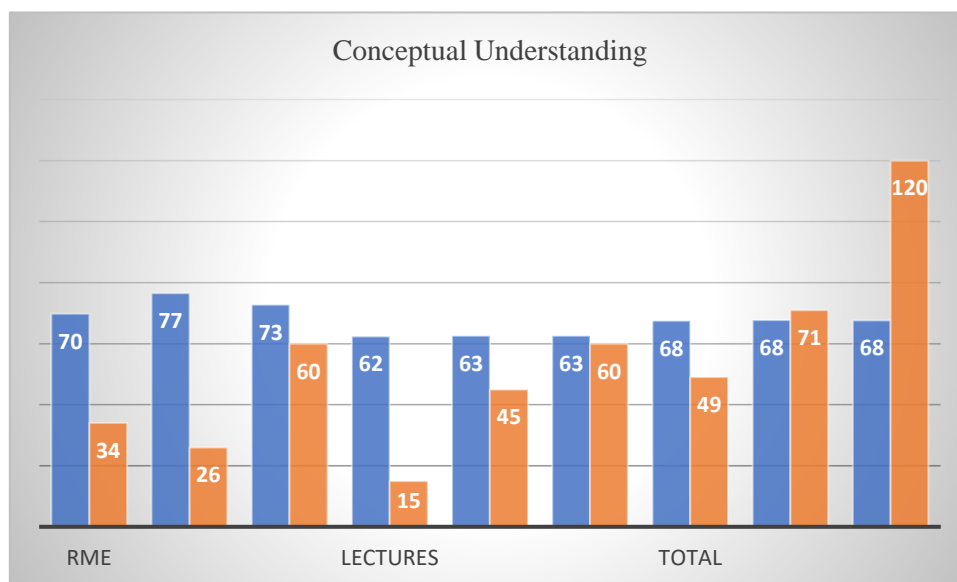

Based on Table 4, shows that the average procedural understanding score for the group of students who have high reasoning abilities and follow the RME approach after controlling for covariate variables is 70%. The average procedural understanding score for the group of students who have high reasoning abilities and follow learning using the lecture method, after controlling for covariate variables, is 62%. Meanwhile, the average procedural understanding score for the group of students who have low reasoning abilities and follow the RME approach after controlling for covariate variables is 77%. The average procedural understanding score

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for the group of students who have low reasoning abilities and follow the lecture method, after controlling for covariate variables, is 63%. The complete test results are presented in Figure 4 as follows.

Figure 4

Description of the RME approach and lecture method as well as reasoning abilities on students' procedural understanding
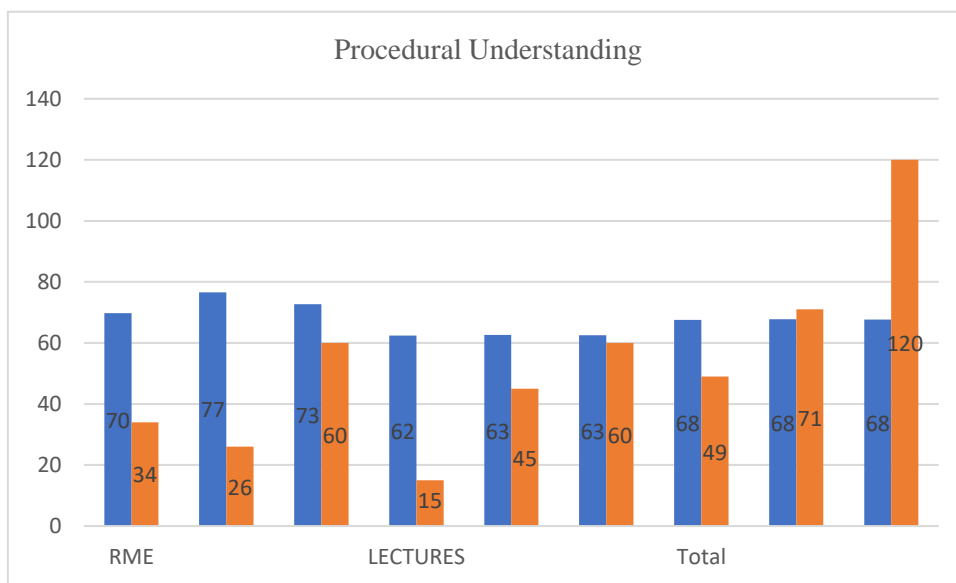
The MANOVA test in this study aims to determine the effect of all independent variables on all dependent variables together. Based on the table of multivariate test results, the results show that there is an influence and interaction between the RME approach and reasoning ability on conceptual understanding and procedural understanding. To find out more, see table 4.

Table 4

Results of tests of between-subjects effects

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	CONCEPTUAL	3842.259[a]	3	1280.753	68.109	.000
	PROCEDURAL	3925.360[b]	3	1308.453	70.122	.000
Intercept	CONCEPTUAL	470986.299	1	470986.299	25046.341	.000
	PROCEDURAL	470970.777	1	470970.777	25240.208	.000
methods	CONCEPTUAL	2811.569	1	2811.569	149.515	.000
	PROCEDURAL	2810.370	1	2810.370	150.613	.000
reasoning_ability	CONCEPTUAL	332.208	1	332.208	17.666	.000
	PROCEDURAL	373.397	1	373.397	20.011	.000
methods * reasoning_ability	CONCEPTUAL	296.300	1	296.300	15.757	.000
	PROCEDURAL	335.266	1	335.266	17.968	.000
Error	CONCEPTUAL	2181.333	116	18.805		
	PROCEDURAL	2164.507	116	18.660		
Total	CONCEPTUAL	555071.000	120			
	PROCEDURAL	555002.000	120			
Corrected Total	CONCEPTUAL	6023.592	119			
	PROCEDURAL	6089.867	119			

a. R Squared = .638 (Adjusted R Squared = .629)

b. R Squared = .645 (Adjusted R Squared = .635)

4. Discussion

The calculation results show that the probability is 0.000, which is smaller than the real level of 0.05. Thus, it can be said that there is a difference in conceptual understanding and procedural understanding of Mathematics between learning using the RME approach and Class VII students' lectures, accepted at a significance level of 5%.

The research results showed that the application of the RME Approach was proven to provide a difference in student's conceptual understanding and procedural understanding of mathematics compared to the application of lecture method learning. Based on theoretical and operational empirical comparisons of the learning strategies implemented, it appears that both learning approaches provide the same facilities, namely the application of students' conceptual understanding and procedural understanding of mathematics. Students' conceptual understanding and procedural understanding of mathematics require students to build a logical understanding by connecting what they already know and have learned, and starting from what is asked (Claudia, 2017; Susiloningsih, 2019; Zahroh et al., 2022).

To build a logical conceptual understanding and procedural understanding of students' mathematics, it is necessary to apply the RME Approach which supports students' mathematics learning which will be carried out later (Mulyati, 2021; Rizqi et al., 2021; Wesna et al., 2021). For students to be able to build a logical application of the RME Approach, students must be able to connect the schemata of related concepts by re-exploring knowledge about previous concepts related to the problem to be solved (Hasunah, 2021; Lestari & Syafri, 2021; Sukmaningthias et al., 2021). Based on theoretical studies regarding students' conceptual understanding and procedural understanding of mathematics by applying the RME Approach, it can be concluded that it is better than applying the lecture method learning in this research. Students who are accustomed to the RME Approach in this way will be able to remember and connect related mathematical concepts completely (Ariningsih et al., 2023; Laurens et al., 2018; Ridha et al., 2021).

Understanding mathematical concepts requires sufficient prior mathematical knowledge. For example, to understand the characteristics of mathematical concepts, students are required to understand the previous material, because mathematics lessons are tiered. To be able to understand this mathematical concept, students need good knowledge of mathematical concepts. Thus, students who have good conceptual readiness and procedural understanding will be able to connect the problems they face with previous knowledge (Putri & Prihatnani, 2020; Rizal et al., 2022).

Another factor that influences the results of students' conceptual understanding and procedural understanding of mathematics is not yet optimal is the lecture method. The lecture method is a habit of students who often follow conventional learning, namely receiving lots of explanations from the teacher. Usually, students will find it easier to understand conceptual material and procedural understanding from detailed teacher explanations. This can be obtained by students from the RME Approach, not from lecture method learning, and not from group learning.

Apart from that, based on the nature of mathematics lessons, it is still suitable to be taught using the lecture method. Several conceptual and procedural understandings of mathematics still require detailed explanations from the teacher so as not to give rise to wrong interpretations from students. Learning mathematics requires students' ability to connect one concept with another concept and requires students' skills in balancing reaction equations and mathematical operations. This demand needs constant guidance and attention from the teacher.

The level of concept understanding when viewed from indicators of concept understanding includes the ability to interpret, provide examples, classify, summarize, draw inferences., compare (comparing), and explain (explaining). According to Alawiya et al., (2022), and Izzah & Fitriyani (2019), supporting factors can be used as a reference for a student's learning achievement through understanding concepts. Students who have low conceptual understanding and procedural understanding, experience difficulties in learning in schools that still use traditional methods.

Based on the results of research on conceptual understanding and procedural understanding of mathematics with Reasoning Ability, there are still some students who actively learn independently or with Reasoning Ability to find their respective conceptual and procedural understanding of mathematics. This is because students have not been able to understand and discover concepts in conventional ways and are guided and directed from the initial process of the problem to solving the problem to get the correct conclusion. Apart from that, some students with good conceptual understanding and procedural understanding of mathematics are more likely to have high reasoning abilities. Apart from that, in the Reasoning Ability indicator, students rarely evaluate the material they have studied or themselves. After learning is complete, students tend to think that learning the material has been completed even though the material is the basic material for the next material (Alawiya et al., 2022; Izzah & Fitriyani, 2019; Midun, 2022; Solihah et al., 2021; Liu et al., 2024).

Students lack self-confidence and only rely on information from lecturers and friends who have high reasoning abilities to explain and find solutions to mathematical problems in the material being studied (Aprilia, 2022; Indah & Nuraeni, 2021; Saputra & Rahman, 2022). Therefore, students are less responsible for solving the problems that have been given. Students study if there are exams or quizzes given. Apart from that, the influence of Reasoning Ability with the RME Approach on conceptual understanding and procedural understanding of mathematics is visible because students do not have difficulty understanding mathematical material. Some mathematical materials have their methods for solving them so if there are problems that are different from the examples, students will have difficulty solving the problems.

Students are no longer used to the teacher's explanation of concepts so they feel that they have no difficulty in finding concepts with real situation patterns, so that for learning using the RME Approach students still have no difficulty adapting to this learning model (Mafidah, 2021; Ndiung et al., 2021; Yulianti & Yulianti, 2021). Students must use their reasoning abilities to discover a concept through observation or make a guess to reach the correct conclusion (Indriastuti et al., 2021; Munir, 2020). For this reason, students need exercises with a variety of different types of questions so that students can understand the concepts well and learning outcomes can improve.

Reasoning ability is one of the most important abilities in thinking which is very necessary both in learning activities and in everyday life (Aprilia, 2022; Indah & Nuraeni, 2021; Indriastuti et al., 2021; Khoerunnisa et al., 2020; Munir, 2020; Puspita et al., 2020; Putri & Masriyah, 2022; Saputra & Rahman, 2022; Sutrisno, 2020) formulated that reasoning in mathematics is part of the way to gain an understanding of mathematical concepts which includes making formulations and drawing valid conclusions about ideas and how these ideas are related. Rahman et al., (2019) opine that reasoning is central to learning in achieving conceptual understanding and procedural understanding of mathematics. In other words, reasoning abilities are used to think about the properties of a set of mathematical objects and develop formulations that apply to them.

If the RME Approach is applied with high reasoning abilities, it will improve Conceptual Understanding and procedural understanding. The views of Claudia (2017) and Mulyono et al. (2018), hold that for learning to take place, students must apply the new knowledge and make connections between their procedural and conceptual understanding and their reasoning skills, that is, the RME Approach, reinforce this.

RME learning aims to equip students with knowledge that can be flexibly applied (transferred) from one problem to another and from one context to another. Defining transfer is the ability to think and argue about new situations through the use of prior knowledge. It can have a positive connotation if learning or problem-solving is enhanced through the use of prior knowledge. It can have a negative connotation if prior knowledge significantly interferes with the learning process. Transfer can also occur in one context by giving assignments that are closely related to the subject matter, or certain situations, and then used in other contexts (Lady et al., 2018; Perwira Negara et al., 2021; Qoiriah et al., 2021).

If RME learning is applied with high reasoning, it will be able to improve learning outcomes. This is reinforced by Nurjamaludin et al. (2021), that: For learning to occur, students must take action on the new

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information and connect the new information with the initial knowledge, namely with a coding process strategy which is often called a repetition strategy. From the opinion above, it can be concluded that for learning to occur that can improve learning outcomes, there needs to be a real approach, namely RME (Mafidah, 2021; Ndiung et al., 2021; Yudianto et al., 2021). The research results show that the realistic mathematics learning process has shown satisfactory results.

5. Conclusion

Based on the results of the research and discussion carried out above, conclusions can be drawn. There is a significant difference in the conceptual understanding and procedural understanding of mathematics in groups of students who have high reasoning abilities and low reasoning abilities by following the RME approach and lecture method.

The research currently being conducted still has many shortcomings and limitations, including the following: in this research, the data produced is only from questionnaire instruments, so the conclusions drawn are only based on the data collected. The research suggestion is the importance of collecting all triangulation data in investigating similar research in the future.

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