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Implementation of a realistic mathematics learning approach (RME) and analytical thinking: The impact on students' understanding of mathematical concepts in Indonesia

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Abstract

Understanding of concepts is a fundamental ability to learn mathematics in a more meaningful way. Understanding concepts is one of the goals to be achieved in learning mathematics. This study aims to determine the impact of a realistic mathematics learning approach (RME) and analytical thinking on students' understanding of mathematical concepts. This experimental research uses a posttest-only control design. The population in this study included students XI in Kasui sub-district, Way Kanan district, Lampung, Determination of the sample using cluster random sampling technique. The research sample was 72 students (36 in the experimental class and 36 in the control class). Hypothesis testing using ancova test. Based on the research results, it can be concluded that the realistic mathematics learning approach (RME) has an influence on students' understanding of mathematical concepts by controlling analytical thinking, analytical thinking has an influence on students' understanding of mathematical concepts, and there is a simultaneous influence between the RME approach and analytical thinking on understanding mathematical concepts student.

INTRODUCTION

Understanding is a process that involves the ability to explain and interpret something, to provide descriptions, examples, and adequate explanations, and to offer creative descriptions and explanations. On the other hand, a concept is an idea or understanding that is formed in the mind (Mawaddah & Maryanti, 2016; Susanto, 2013). One of the goals of learning mathematics, as stated in Permendikbud number 58 of 2014 (Fitriani et al., 2018), is to achieve a deep understanding of mathematical concepts. This ability to understand concepts requires practice in solving problems related to them. Therefore, teachers are required to provide assignments and exercises, and students must be willing to do them (Sodikin & Hartatiana, 2015). Since the majority of mathematics learning involves learning concepts, it is important to pay attention to how educators teach concepts and how students can best understand them (Agustiana et al., 2019). Students who have a strong grasp of mathematical concepts are generally able to solve various types of mathematical problems proficiently (Gardenia, 2016). This statement is supported by the findings of several researchers who have suggested that a good understanding of mathematical concepts not only leads to improved problem-solving abilities, but also enhances fundamental skills such as reasoning (Munasiah et al., 2020), communication (Gardenia, 2016), and problem-solving strategies, including making connections between different concepts (Lisnani & Pranoto, 2020).

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The low mathematical ability of students is further evidenced by the results of a survey conducted by Sari et al. (2022), which shows that the majority of students have not met the minimum passing grade (KKM) due to suboptimal understanding of mathematical concepts. Additionally, it was found that the conventional teaching approach used in the classroom was perceived as uninteresting, resulting in low student engagement (Arifin, 2019). Therefore, an appropriate and engaging teaching approach that actively involves students in the learning process is necessary. One such approach is the realistic mathematics education (RME) approach. RME is a learning approach developed by a group of mathematicians from the Freudenthal Institute, Utrecht University in the Netherlands in 1971 (Afriansyah, 2016). As noted by Herwanto et al. (2020), RME emphasizes a process of involving students holistically to help them discover and relate mathematical concepts to real-life situations, thereby encouraging them to apply these concepts to problems encountered in daily life. The purpose of RME is to provide opportunities for students to rediscover and construct mathematical concepts in the context of the real world, leading to a deeper understanding of mathematical concepts (Ulfah, 2022). Additionally, RME fosters students' understanding of the relevance and applicability of mathematics in everyday life (Jeheman et al., 2019; Lestari & Surya, 2017).

The RME approach is oriented towards making the learning process relevant to students' lives, which encourages high curiosity and active participation in finding suitable solutions (Firdaus et al., 2022). Through this process, students can create a comfortable study space by collaborating with peers, their environment, and subject teachers (Firdaus et al., 2022). The realistic mathematics approach is a learning approach that allows students to actively discover, develop, and construct mathematical concepts into formulas (Gravemeijer & Doorman, 1999).

Numerous studies have been conducted on the RME approach, such as those by Firdaus et al. (2022), Herwanto et al. (2020), Jeheman et al. (2019), and Kusumaningrum & Nuriadin (2022), which found that the use of a realistic mathematics learning approach can enhance students' understanding of mathematical concepts and their mathematical representations. However, these studies mainly focused on elementary and junior high school students, and it remains unclear whether this approach can improve the cognitive abilities of high school students. Additionally, Nopiyani et al. (2010) found that mathematical communication skills can be enhanced with the GeoGebra-assisted RME approach, while Herzamzam (2018) discovered that the RME approach can increase student interest in learning. However, these studies did not specify the evaluated learning outcomes. A significant limitation of these studies is that they did not control external variables, so they only focused on cognitive abilities. Furthermore, no previous studies have examined the impact of realistic mathematics learning approaches and analytical thinking on students' understanding of mathematical concepts.

The realistic mathematics learning approach in this study follows the syntax proposed by De Lange (1996), which includes five stages: (1) understanding contextual problems, where students are given contextual problems and asked to comprehend them; (2) explaining contextual problems, where the teacher acts as a facilitator and provides necessary explanations or suggestions for certain parts that students have not yet understood; (3) solving contextual problems, where students work individually or in groups to solve problems in their own way; (4) viewing and discussing answers, where the teacher gives students time and opportunity to see and discuss their answers in groups, and students are required to express their opinions; and (5) providing conclusions, where the teacher guides students to draw conclusions from the information obtained (Sohilait, 2021). The syntax for realistic mathematics learning is illustrated in Figure 1.

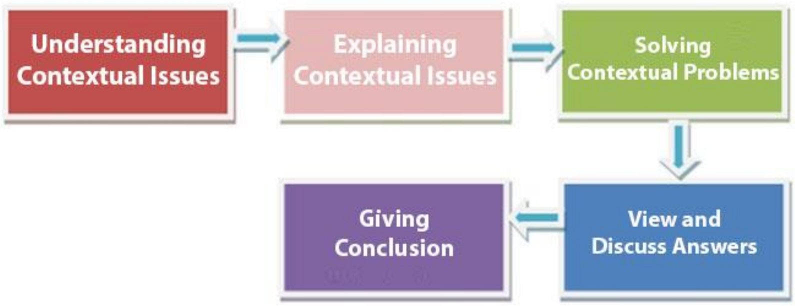

Figure 1. Cycle Realistic Mathematics Learning Approach

Besides the approach, students' understanding of mathematical concepts is also correlated with analytical thinking (Majeed, 2017). Thinking is a cognitive activity that occurs in one's mind by using the information available to produce a decision in solving a problem. According to the standard content of mathematics subjects in the Regulation of the Minister of National Education Number 22 of 2006, the ability to think logically, analytically, systematically, critically, and creatively is essential (Ilma et al., 2017). One of the thinking skills in mathematics that students must have is the ability to think analytically (Mahyastuti & Hidayanto, 2020). Analytical thinking means that students are able to identify various problems, describe them, separate unrelated problems, form links between problems that have the same concept, and find solutions to these problems (F. Fitriani et al., 2021). The ability to think analytically consists of the aspects of sorting, organizing, and attributing or connecting (Annisa et al., 2016; Annizar et al., 2021).

According to Yuwono et al. (2020), the ability to think analytically by using the problem-based learning model has an influence on learning outcomes in the realm of knowledge. However, the resulting effect is not significant. Although there have been many studies on analytical thinking, only a few have researched using a sample of high school students, especially in learning mathematics. Several previous researchers have never examined the effect of a realistic mathematics learning approach (RME) and analytical thinking on students' understanding of mathematical concepts. Therefore, this research will reveal the effect of a realistic mathematics learning approach (RME) and analytical thinking on students' understanding of mathematical concepts.

METHODS

Design

This study uses a quantitative approach with a quasi-experimental research design. This study consists of independent variables, namely the realistic mathematics learning approach (RME), analytical thinking covariate variables, and understanding of mathematical concepts as the dependent variable. The selection of samples was carried out randomly using the cluster random sampling technique (area sampling), and two samples were obtained, namely the experimental class, which was treated with a realistic mathematics learning approach (RME), and the control class, which was given treatment with a conventional approach. The research design uses a 1 x 2 factorial design.

Table 1. Factorial Design

Group			
Eksperimen		Kontrol	
X_1	Y_1	X_2	Y_2
$X_{1.1}$	$Y_{1.1}$	$X_{2.1}$	$Y_{2.1}$
$X_{1.2}$	$Y_{1.2}$	$X_{2.2}$	$Y_{2.2}$
…	…	…	…
…	…	…	…
$X_{1.n}$	$Y_{1.n}$	$X_{2.n}$	$Y_{2.n}$

Instrumens

The instrument used in this study is a description test to measure analytical thinking and understanding of mathematical concepts. The analytical thinking test consisted of 6 questions representing 3 indicators, which were then tested on 30 students and found 4 valid and reliable essay questions with a Cronbach's alpha value of 0.712. The mathematical concept understanding test consisted of 10 essay questions representing 5 indicators and was then tested on 30 students, finding 6 valid and reliable questions with a Cronbach's alpha value of 0.717. So that the questions used to measure analytical thinking are 4 questions and the understanding of mathematical concepts is 6 questions.

Participans

Participants in this study were 72 students in the age range of 16–17 years, with details of 36 students who studied with a realistic mathematics learning approach (RME) and 36 students who studied with a conventional approach. The 72 students are class XI students in Kasui District, Way Kanan Regency, Lampung Province, Indonesia. The demographics of the participants in this study are listed in Table 2.

Table 2. Sample Demographic Characteristics

Demographic		**Frequency**	**Persentation (%)**
Gender	Male	36	50%
	Female	36	50%
Residence	Village	72	100%
Ethnic group	Jawa	12	17%
	Semendo	40	56%
	Ogan	20	27%

Note, N = 72; rata-rata usia 16,5 tahun (*SD = 0,49863 S.E =0,05876)*

Data Collection

The data collection technique used in this study is a description test to measure analytical thinking and understanding of mathematical concepts. In this study, the test applied was the final test (posttest). The posttest was used after the application of a realistic mathematics learning approach to see if there were any differences between the experimental group and the control group. The analytical thinking indicators used in this study can be seen in Table 3.

Table 3. Indicator Analytical Thinking

No	Indicator	Deskripsion
1	*Differentiating*	Sort out the relevant parts of the problem
2	*Organizing*	Build ways or strategies to solve problems
3	*Attributing*	Determine the purpose or conclusion of the results of the problem

Based on Table 3, it can be seen that there are three indicators of analytical thinking used in making essay tests: Differentiating, organizing, and attributing (Ad'hiya & Laksono, 2018). The indicators of understanding the mathematical concepts used in this study can be seen in Table 4.

Table 4. Indicator of Understanding of Mathematical Concepts

No	Indicator
1	Restate a concept that has been learned
2	Classify objects based on whether or not the requirements are met to form a particular concept
3	Apply the concept logarithmically
4	Presenting concepts in various forms of mathematical representation
5	Associating several concepts (internal and external mathematics)

Based on Table 4 above, it can be seen that there are five indicators of understanding the mathematical concepts used in this study: restating a concept that has been studied, classifying objects based on whether or not the requirements are fulfilled to form a certain concept, applying the concept in a logarithmic manner, presenting the concept. in various forms of mathematical representation, and linking several concepts (internal and external to mathematics) (Jeremy & Jane, 2005).

Data Analysis

The analysis technique used in this study is the analysis of covariance test (one-way ancova). The one-way ancova test is a hypothesis test that is carried out after fulfilling the four prerequisite tests. The four prerequisite tests are the normality test, the homogeneity test of data variation, the regression linearity test, and the regression coefficient homogeneity test. Hypothesis test and prerequisite test in this study using SPSS 26 for Windows software.

RESULTS AND DISCUSSION

Analysis of Covariance Prerequisite Test *(One-Way Ancova)*

The first test performed was the norm test. The normality test was carried out to find out whether the results of the research in the form of questions in the experimental and control classes were normally distributed or not. The data used for the prerequisite test is posttest data. The calculation of the normality test in this study used *Kolmogorov-Smirnov* with the help of SPSS 26 software. The following normality test results can be seen in Table 5.

Table 5. Normality Test Results

Test of Normality							
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Kelas	Statistic	df	Sig.	Statistic	df	Sig.
Analytical Thinking	Eksperiment	.140	36	.071	.941	36	.053
	Control	.129	36	.137	.946	36	.079
Understanding of Mathematical Concepts	Eksperiment	.106	36	.200	.961	36	.225
	Control	.101	36	.200	.962	36	.247

The results of Table 5 show that the results of the normality test for analytical thinking and students' understanding of mathematical concepts at level α = 0.05 can be concluded that the data obtained in the control and experimental classes are normally distributed because $p - value$ > α. The next prerequisite test is the homogeneity test. The following results of the homogeneity test for data variation can be seen in Table 6.

Table 6. Homogeneity Test Results

Levene's Test of Error Variances[a] Dependent Variable: Understanding of Mathematical Concepts			
F	df1	df2	Sig.
.474	1	70	.493

Table 6 shows that the results of the homogeneity test of analytical thinking and understanding of mathematical concepts come from the same or homogeneous variance, because $p - value$ 0.493 > α(0.05). The next prerequisite test is the regression linearity test. The regression linearity test is fulfilled if there is a linear relationship between the covariates and the dependent variable. The following results of the regression linearity test can be seen in Table 7.

Table 7. Linearity Test Results

Tests of Between-Subjects Effects

Dependent Variable: Understanding of Mathematical Concepts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5171.250[a]	2	2585.625	49.860	.000
Intercept	2191.277	1	2191.277	42.255	.000
X1	461.606	1	461.606	8.901	.004
X2	2512.830	1	2512.830	48.456	.000
Error	3578.200	69	51.858		
Total	435914.695	72			
Corrected Total	8749.450	71			

a. R Squared = .591 (Adjusted R Squared = .579)

The results of Table 7 show that the covariate Sig value (X2) is less than α or 0.00 <0.05. This shows that there is a linear relationship between the covariate variables (analytical thinking) and the dependent variable (understanding of mathematical concepts). The last prerequisite test is the regression coefficient homogeneity test. The assumption test of the homogeneity of the regression coefficients in this study is fulfilled if there is no linear relationship between the covariate variables and the independent variables. The following results of the regression coefficient homogeneity test can be seen in Table 8.

Table 8. Results of Homogeneity Regression Coefficient

Tests of Between-Subjects Effects

Dependent Variable: Understanding of Mathematical Concepts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5189.066[a]	3	1729.689	33.035	.000
Intercept	2207.880	1	2207.880	42.168	.000
X1	59.934	1	59.934	1.145	.288
X2	2495.370	1	2495.370	47.659	.000
X1 * X2	17.816	1	17.816	.340	.562
Error	3560.384	68	52.359		
Total	435914.695	72			
Corrected Total	8749.450	71			

a. R Squared = .593 (Adjusted R Squared = .575)

Table 8 shows the results of the regression coefficient homogeneity test showing that the value of Sig = 0.562 > 0.05. It can be concluded that there is no linear relationship between the covariate variables and the independent variables, so the assumption test is fulfilled.

Hypothesis Test Analysis of Covariance *(One-Way Ancova)*

Hypothesis testing using analysis of covariance (one-way ancova). The one-way Ancova test is a different test or comparative test with the independent variable consisting of a mixture of factor data and numerical data, while the dependent variable is an interval or ratio (quantitative) data scale. The ancova technique is used to adjust the score of the dependent variable by eliminating the bias of the treatment impact (Apriyanah et al., 2018). The aim of eliminating treatment impact bias is to reduce the error variance by controlling for the influence of covariate variables that are believed to be biased on the analysis results. Statistical analysis of covariance can be used to equate groups based on the influence of variables outside the treatment variables. The one-way Ancova test in this study used SPSS 26 software. The following results of the one-way Ancova test can be seen in Table 9.

Table 9. *One-Way Ancova* Result

Tests of Between-Subjects Effects

Dependent Variable: Understanding of Mathematical Concepts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5171.250[a]	2	2585.625	49.860	.000
Intercept	2191.277	1	2191.277	42.255	.000
X2	2512.830	1	2512.830	48.456	.000
X1	461.606	1	461.606	8.901	.004
Error	3578.200	69	51.858		
Total	435914.695	72			
Corrected Total	8749.450	71			

a. R Squared = .591 (Adjusted R Squared = .579)

Table 9 in row X1 shows that the value of Fcount = 8,901 with $p - value$ = 0.004 at a significance degree of 0.05. This means that $p - value$ < 0.05 So H0 is rejected and H1 is accepted. The conclusion is that there is a better effect of the realistic mathematics learning approach (RME) on students' understanding of mathematical concepts by controlling analytical thinking Table 9 in line X2 can be seen that the value of Fcount = 48,456 with $p - value$ = 0.000 at a significance degree of 0.05. This shows that $p - value$ < 0.05. So that H0 is rejected and H1 is accepted. The conclusion is that there is an influence of analytical thinking covariate variables on students' understanding of mathematical concepts. The results of the corrected model in Table 9 can be seen that the value of Fcount = 49,860 with a p-value = 0.000 at a significance degree of 0.05. This shows that $p - value$ < 0.05. So that H0 is rejected and H1 is accepted. The conclusion is that there is a simultaneous influence of realistic mathematics learning approaches (RME) and analytical thinking on students' understanding of mathematical concepts.

The findings on the one-way Ancova test, namely the realistic mathematics learning approach (RME), have an influence on students' understanding of mathematical concepts. This can be seen from the students who were treated with a realistic mathematics learning approach (RME) having a higher posttest score on understanding mathematical concepts compared to students who were taught with a conventional approach, especially in the indicator of restating a concept that had been learned and applying the concept logarithmically. This is because the realistic mathematics learning approach (RME) has several advantages. The advantages of the RME approach are as follows: it provides clear and operational understanding to students about the relationship between mathematics and everyday life and about the use of mathematics in general. Provide a clear and operational understanding to students that mathematics is a field of study that they can construct and develop themselves, so that they can develop their imagination, train their analytical thinking skills, and understand their mathematical concepts. The learning process is the main thing, and in order to learn mathematics, students must go through the process themselves and try to develop their own concepts and teaching materials for mathematics. This is intended so that students are active in learning, not only accepting what is given by the teacher, so they can develop their way of thinking. Teachers can also provide information to students about the material being studied in a language that is easily understood by students.

In addition, researchers also apply a problem-based learning model. This model can be said to be suitable when applied to the RME approach because the problem-based learning model is a learning model that requires students to be active and independent when learning (Herutomo et al., 2020). Likewise, with analytical thinking, students also have a positive influence on understanding mathematical concepts. Students who are able to develop their analytical thinking tend to have a good understanding of concepts. This can be seen from the results of the posttest understanding of mathematical concepts, where students who have good analytical thinking skills can solve questions about understanding concepts in an appropriate and orderly manner. This is because analytical thinking has a positive relationship with understanding mathematical concepts. Based on this, the realistic mathematics learning approach (RME) and analytical thinking simultaneously influence students' understanding of mathematical concepts. Then a further test was carried out with the t-statistic in Table 10.

Table 10. Further Test Results

Parameter Estimates

Dependent Variable: Understanding of Mathematical Concepts

					95% Confidence Interval	
Parameter	B	Std. Error	t	Sig.	Lower Bound	Upper Bound
Intercept	40.285	6.267	6.428	.000	27.783	52.787
X2	.534	.077	6.961	.000	.381	.687
[X1=1]	-5.758	1.930	-2.984	.004	-9.608	-1.908
[X1=2]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

Table 10 in line $[X1 = 1]$ can be seen that the value of t_0 = -2.158 with a p-value = 0.004 at a significance degree of 0.05. This shows that the *p-value* < 0.05 so that H0 is rejected and H1 is accepted. The conclusion is that students' understanding of mathematical concepts taught by a realistic mathematics learning approach (RME) is better than students taught by a conventional approach after controlling students' analytical thinking. This is because the RME approach emphasizes the principle of interaction which states that learning mathematics is a human activity which is also seen as a social activity (Yuanita et al., 2018). Students who previously interpreted mathematics as a difficult subject, so this RME invites students to interact with various ideas and student activities (Herzamzam, 2018; Lestari & Surya, 2017). This is also in line with (K. Fitriani & Maulana, 2016) who found that the RME approach can improve understanding and solving mathematical problems. Based on the description above, it can be concluded that the realistic mathematics learning approach (RME) is better than the conventional approach

CONCLUSIONS

Based on the research results and discussion, it can be concluded that the realistic mathematics learning approach (RME) has a significant positive influence on students' understanding of mathematical concepts when controlling for their analytical thinking. Specifically, the use of the RME approach in teaching sequences and series has a positive impact on students' understanding of mathematical concepts. This implies that teachers should consider implementing RME in their mathematics teaching practices to support students' comprehension of mathematical concepts and foster their enthusiasm for learning. The full involvement of students in the RME approach can also promote a sense of responsibility and hard work among students. Furthermore, students' analytical thinking skills also have a positive impact on their understanding of mathematical concepts. The results of the hypothesis test indicate that students who develop their analytical thinking skills tend to have a better understanding of mathematical concepts, and vice versa. Therefore, it is important to foster analytical thinking skills among students alongside the use of the RME approach in teaching mathematics. Overall, the findings suggest that the combination of the realistic approach to learning mathematics and analytical thinking has a positive effect on students' understanding of mathematical concepts.

Although understanding mathematical concepts is important in mathematics lessons, it can be seen that this research still focuses on the subject matter of sequences and series. Based on this, approaches, models, and analytical thinking are very important to note in the learning process. Applying a realistic mathematical approach to learning that is able to activate students and increase student cooperation in solving mathematical problems is an effort to improve students' understanding of mathematical concepts. Therefore, researchers are to conduct further research by examining other factors that influence the ability to understand mathematical concepts so as to add broader insights.

AUTHOR CONTRIBUTIONS STATEMENT

NS as research coordinator who contributed to developing ideas and methods. RWY and FF are responsible for developing theory, designing instruments, and collecting and analyzing data.

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