



Learning through a realistic mathematics education approach towards critical thinking and logical intelligence



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ABSTRACT

This study aims to analyze the effectiveness of the Realistic Mathematics Education (RME) approach on students' critical thinking skills and logical mathematical intelligence in the material of quadratic equations and functions. The background of this study is the low level of both abilities due to teacher-centered learning and the lack of active student involvement, especially in abstract quadratic material. RME was chosen because it emphasizes real contexts and mathematization processes that are believed to develop students' thinking skills. This study used a quasi-experimental method with a posttest-only control group design. The subjects were grade X students of SMAN 1 Gurah who were divided into experimental and control classes. The research instruments were 5 essay questions to measure critical thinking and 15 multiple-choice questions for logical mathematical intelligence that were valid and reliable. Data were analyzed using descriptive and inferential statistics through linear regression tests. The results showed that the implementation of RME learning was very good with a score of 3.67. The average critical thinking score of the experimental class (41.35) was higher than that of the control class (25.59), while the logical mathematical intelligence of the control class (41.91) was slightly higher than that of the experiment class (41.18). Regression tests showed a significant effect of RME, with a negative effect on critical thinking and a positive effect on logical-mathematical intelligence. Consequently, RME needs to be combined with strategies that explicitly train critical thinking to ensure balanced development of both abilities.

1. Introduction

Education is a fundamental field that forms the basis for all aspects of human life. Education is understood as a lifelong process that prepares individuals to live meaningful lives [1]. One of the important elements in education is the learning of mathematics, as it contributes significantly to the development of human thinking skills. Mathematics is present in various daily life activities, as civilization and technology develop [2].

Mathematics learning is closely linked to skill mastery. These skills include critical thinking, problem-solving, communication, and collaboration, which students need to face global challenges [3]. The Partnership for 21st Century Learning emphasizes that education demands higher-order thinking skills, innovation, and a learning process that fosters creativity and conceptual understanding. This aligns with the goal of mathematics learning, which is to equip students with critical, logical, systematic, analytical, and

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creative thinking skills to equip them for everyday life [4].

In line with these demands, Indonesia is currently implementing the Independent Curriculum, which focuses on developing critical thinking skills and student learning independence. This curriculum emphasizes the importance of contextual, innovative, and real-life learning to better prepare students to face the challenges of the 21st century [5]. However, observations of tenth-grade mathematics lessons at SMAN 1 Gurah indicate that the implementation of this learning approach is still suboptimal. The learning process tends to be teacher-centered using conventional methods, resulting in students being less active in constructing knowledge and developing critical thinking skills. This condition results in low critical thinking skills and low logical-mathematical intelligence.

Low critical thinking skills and logical-mathematical intelligence can be influenced by various factors, one of which is the use of less interactive learning methods [6], shows that teacher-centered learning contributes to low critical thinking skills and mathematical logical intelligence of students, so that mathematics learning outcomes do not reflect optimal mastery of competencies.

Logical-mathematical intelligence includes the ability to understand patterns, think inductively and deductively, and use logical reasoning in solving problems [7]. When these skills develop alongside critical thinking skills, students will be better able to analyze, evaluate, and make logical decisions when solving mathematical problems. Therefore, a learning approach is needed that can stimulate both skills simultaneously. One learning approach considered relevant is Realistic Mathematics Education (RME). This approach, developed by the Freudenthal Institute, emphasizes the use of contextual problems as a starting point for mathematics learning [8].

However, based on a review of previous research, most studies still examine critical thinking skills and logical-mathematical intelligence separately. For example, research by [9] emphasizes the importance of critical thinking skills in learning, while research related to logical-mathematical intelligence refers more to the theory of multiple intelligences by [10]. Through Realistic Mathematics Education RME, students are guided to carry out the process of mathematization, discussion, collaboration, and discovering mathematical concepts independently [11]. In addition, several studies on the Realistic Mathematics Education (RME) approach show that

this approach is effective in improving students' critical thinking skills, reasoning, and logical mathematical intelligence [12] in understanding mathematical concepts and problem-solving skills [13]. However, not many have studied its simultaneous relationship with critical thinking skills and logical mathematical intelligence, and the implementation of the Realistic Mathematics Education (RME) approach in the context of the Independent Curriculum is also still relatively limited, especially at the high school level.

Research related to the Independent Curriculum focuses more on developing Pancasila student profiles and project-based learning [14], so that studies that specifically integrate the RME approach with these two cognitive variables are still rarely found.

Based on this description, it is important to examine the effectiveness of the Realistic Mathematics Education (RME) approach in mathematics learning, particularly in terms of students' critical thinking skills and logical mathematical intelligence. Therefore, this study aims to analyze mathematics learning using the Realistic Mathematics Education (RME) approach for 10th-grade students. This is expected to contribute to the development of mathematics learning that is in line with the demands of the Independent Curriculum and 21st-century skills.

2. Method

2.1 Research Design

This study used a quantitative approach with a quasi-experimental design. The design involved an experimental class and a control class. The experimental class received instruction using the Realistic Mathematics Education (RME) approach, while the control class received instruction using a conventional approach. The study was conducted on the topic of quadratic equations and functions, with the purpose of comparing students' outcomes after the learning process.

2.2 Instruments and Data Collection

Data on logical-mathematical intelligence were collected using a test consisting of 15 multiple-choice items, while critical thinking skills were measured using five essay questions. The data were analyzed using statistical procedures with the assistance of IBM SPSS Statistics 25. The analysis included descriptive statistics, prerequisite tests, and hypothesis testing through linear regression.

2.3 Learning Implementation Observation

To ensure that the RME approach was implemented according to the planned learning syntax, observations were conducted using a lesson-plan implementation assessment scale. The research was carried out over three meetings. The observation results were used to determine the quality of learning implementation and to support the interpretation of the quantitative findings.

Table 1
Learning Implementation Assessment Scale

No	Average Score	Category
1	$0,00 \leq \bar{x} < 1,50$	Not good
2	$1,50 \leq \bar{x} < 2,50$	Pretty good
3	$2,50 \leq \bar{x} < 3,50$	Good
4	$3,50 \leq \bar{x} \leq 4$	Very good

Source :[15]

3. Results and discussion

3.1 Implementation of the RME Approach

The learning activities were implemented according to the lesson plan that had been prepared and validated. Observations across three meetings in the experimental class produced an average score of 1.5, which was categorized as very good. This result indicates that the RME approach was implemented consistently and in accordance with the planned instructional stages [16].

3.2 Descriptive Statistics of Learning Outcomes

Descriptive analysis of the posttest data was conducted using IBM SPSS Statistics 25. The analysis was intended to identify the mean scores and standard deviations of students' critical thinking skills and logical-mathematical intelligence in both the experimental and control classes. The results are presented in Table 2.

Table 2
Descriptive statistics of posttest of critical thinking ability and logical mathematical intelligence

Posttest	Approach	Mean	Standard Deviation	N
Critical thinking	Experimental class	41.35	4.48	34
	Control class	25.59	10.73	34
Total		33.47	7.61	68
Logical Intelligence	Experimental class	41.18	3.27	34
	Control class	41.91	6.96	34
Total		41.55	5.12	68

Table 2 shows that the experimental class obtained a higher mean score in critical thinking than the control class. This indicates that students who learned through the RME approach demonstrated better descriptive achievement in critical thinking than students who learned through a conventional approach. The contextual problems used in RME may have encouraged students to analyze situations, formulate strategies, and justify mathematical ideas [12], [17].

In contrast, the mean score for logical-mathematical intelligence in the control class was slightly higher than that of the experimental class. This finding suggests that the RME approach did not immediately produce a higher descriptive score for logical-mathematical intelligence. The result may be related to students' familiarity with formal and symbolic exercises, which are commonly emphasized in conventional instruction.

Previous research indicates that logical-mathematical intelligence is influenced not only by contextual learning but also by the intensity of symbolic practice, algorithm mastery, and familiarity with formal logical problems [8]. Therefore, contextual learning through RME needs to be balanced with structured procedural exercises so that students can connect real-world contexts with formal mathematical reasoning.

3.3 Prerequisite Tests

Before testing the research hypotheses, prerequisite tests were conducted to ensure that the data met the assumptions for regression analysis. The prerequisite analysis indicated that the residual data were normally distributed, the relationships between variables were linear, and no heteroscedasticity problem was found. Therefore, the data were considered suitable for further hypothesis testing.

The residual normality test results for critical thinking and logical-mathematical intelligence are presented in Table 3. The values indicate that the residuals were normally distributed and that the assumption of normality was fulfilled.

Table 3
Results of the residual normality test

		Critical thinking	Logical Intelligence
N		34	34
Normal Parameters a,b	Mean		
		.0000000	-.1562560
Most Extreme Differences	Std. Dev	4.14002439	3.62646521
	Absolute		
		.137	.150
	Positive	.066	.116

	Negative	-.137	-.150
Test Statistics		.137	.150
Asymp. Sig. (2-tailed)		.108	.051

Table 4
Linearity test results

Data	Deviation from linearity	df	Mean Square	F	Sig.
Critical thinking	275,747	11	25,068	1,816	.115
Logical Intelligence	142,456	11	12,951	1,671	.150

Table 5
Results of heteroscedasticity test

Data	Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
Critical thinking	.100	.112	.156	.893	.379
Logical Intelligence	-.423	.246	-.291	-1,719	.095

3.4 Regression Analysis and Hypothesis Testing

After the prerequisite tests confirmed that the classical assumptions were met, hypothesis testing was conducted using linear regression analysis with IBM SPSS Statistics 25. The regression results were used to determine the influence of the RME approach on critical thinking skills and logical-mathematical intelligence.

Table 6
Linear regression test results

Data	Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
Critical thinking	-.421	.181	-.381	-2,332	.026
Logical Intelligence	.297	.133	.368	2,238	.032

Based on Table 6, the regression results indicate that the RME approach had a significant relationship with both critical thinking skills and logical-mathematical intelligence. However, the direction of the effect differed: the coefficient for critical thinking was negative, whereas the coefficient for logical-mathematical intelligence was

positive. This result requires careful interpretation because statistical direction may be influenced by measurement characteristics, learning adaptation, and classroom implementation conditions.

The negative coefficient for critical thinking may be explained from several perspectives. First, differences in measurement scale and students' responses to contextual learning may have affected the regression direction. Students who were not yet accustomed to RME may have required additional time to interpret contextual problems, discuss strategies, and express mathematical reasoning in written form.

Second, innovative learning approaches such as RME require an adaptation period [18], [19]. At the initial stage, students may experience cognitive load because they must understand the context, engage in discussion, construct models, and connect informal reasoning with formal mathematical concepts. This condition may temporarily affect students' performance on critical thinking tests.

Nevertheless, RME provides opportunities for students to discover patterns, generalize ideas, and draw logical conclusions from contextual problems. This is consistent with the concept of logical-mathematical intelligence, which emphasizes reasoning, classification, pattern recognition, and problem solving. The positive regression coefficient for logical-mathematical intelligence suggests that RME has potential to support the development of students' logical reasoning when implemented appropriately.

This finding is consistent with previous research showing that Realistic Mathematics Education can improve students' reasoning and mathematical logic when implemented consistently and supported by reflective activities [20-24]. The use of real contexts allows students to move from informal strategies toward formal mathematical models, which is a key principle of RME.

3.5 Discussion and Learning Implications

Overall, the findings indicate that the RME approach was effective in terms of learning implementation and showed different characteristics of influence on the two cognitive variables. RME supported students' critical thinking descriptively, while its statistical relationship with logical-mathematical intelligence was positive. These results suggest that learning effectiveness should be interpreted comprehensively by considering implementation quality, students' adaptation, and the characteristics of each measured variable [25-27].

The regression findings also indicate that the effectiveness of RME cannot be evaluated through a single indicator. A contextual approach may improve students' engagement and reasoning processes, but its impact on test performance can depend on students' readiness, the duration of implementation, and the balance between

contextual exploration and formal practice [28].

The implication is that RME can be used as an alternative mathematics learning approach to support critical thinking within the Independent Curriculum. However, its implementation should be accompanied by clear scaffolding, sufficient adaptation time, and exercises that strengthen logical and procedural understanding [29].

These findings strengthen the view that learning effectiveness needs to be reviewed from multiple perspectives, including learning implementation, student responses, learning outcomes, and statistical relationships among variables. In this way, the contribution of RME to mathematics learning can be understood more accurately and applied more effectively in classroom practice [30-33].

4. Conclusion

This study shows that mathematics learning on quadratic equations and functions using the Realistic Mathematics Education approach was implemented in the very good category according to the validated lesson plan. Descriptive analysis indicated that the experimental class achieved a higher mean score in critical thinking than the control class, although the control class obtained a slightly higher mean score in logical-mathematical intelligence.

The regression analysis showed that RME had a significant relationship with both critical thinking and logical-mathematical intelligence, with different directions of influence. The negative relationship with critical thinking may have been influenced by instrument characteristics, students' adaptation to contextual learning, and the relatively short implementation period. Meanwhile, the positive relationship with logical-mathematical intelligence suggests that RME can support reasoning when contextual activities are connected with formal mathematical structures.

This study has several limitations, including the short duration of implementation, the limited sample size, and the possibility of instrument bias. Future studies are recommended to use a longer intervention period, broader samples, and more diverse instruments to obtain a more comprehensive understanding of the effectiveness of RME.

The practical implication is that RME can be used as an alternative approach for developing critical thinking skills in line with the Independent Curriculum. However, teachers need to provide structured scaffolding, combine contextual problems with procedural exercises, and allow sufficient time for students to adapt to the learning process.

Based on the findings, the implementation of RME should be supported by activities that strengthen logical reasoning, symbolic manipulation, and procedural fluency. This balance is important so that students can

connect real-life contexts with formal mathematical concepts and improve both critical thinking and logical-mathematical intelligence.

Further research is recommended to examine the effects of RME over a longer duration and to combine analysis of group differences with predictive analysis using more diverse methodological approaches. Such research can provide stronger evidence regarding the contribution of RME to students' cognitive development in mathematics learning.

CRedit authorship contribution statement

Hanizyah **Quswatul** **Khasanah:**
Conceptualization, Methodology, Software,
Investigation, Formal analysis, Writing - original
draft. **Darsono:** Validation, Writing - review.
Dian Devita Yohanie: Validation, Writing -
review.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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