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Realistic Mathematics Education to Improve Student's Numeracy Literacy on Social Arithmetic Topics

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Abstract:
Numeracy literacy is one of the abilities that students need to have today. Numeracy literacy skills require critical thinking skills. This study aims to describe the RME model and see its effectiveness in developing students' numeracy literacy in social arithmetic learning. This study used a quasi-experimental design with a non-equivalent control group design. The instrument used was a numeracy test consisting of pretest and posttest questions. Observation sheets and field notes were used to obtain qualitative data on the implementation of the RME model. The results of data analysis with an independent sample t-test showed that students' numeracy literacy in learning with the RME model was better than that of students in learning with the conventional model. In learning with the RME model, students can be actively involved in the critical thinking process to solve contextual problems.

Keywords: Realistic Mathematics Education (RME), Numeracy Literacy, Social Aritmethic

1. Introduction

Numeracy literacy is a fundamental competency that encompasses the ability to understand and utilize information in various forms, as well as to comprehend and apply mathematical concepts in everyday life. It is an essential skill for students today, requiring critical thinking abilities. Numericy literacy involves using a range of numbers and symbols related to basic mathematics to solve practical problems across diverse contexts (Cao et al., 2022; Iswara et al., 2022; Singh et al., 2023). Numeracy literacy is useful for analyzing information presented in various forms, such as graphs, tables, and charts, and for using the results of this analysis to make predictions and informed decisions (Iswara et al., 2022).

The numeracy literacy ability of students in Indonesia remains relatively low, as evidenced by the PISA (Programme for International Student Assessment) survey results. From 2006 to 2022, the ranking of Indonesian students in numeracy literacy has not shown significant improvement. In the 2022 PISA results, Indonesian students achieved a mathematics score of 366, which is still below the OECD average of 472 (OECD, 2023). Based on the ranking, Indonesia is ranked 70th out of 81 participating countries (Wijaya et al., 2024). Previous research showed that students' numeracy literacy skills were not satisfactory, with scores of 55.3%, 54.4%, and 39.4% in content, cognitive processes, and context, respectively. This analysis highlights the need for students to practice and improve their skills in the contextual dimension (Aini et al., 2024).

The low level of numeracy literacy is influenced by various factors, including a lack of student independence in tackling and solving math problems, a limited ability to comprehend problems, insufficient attention and support from parents, and a deficiency in teachers' skills to create engaging learning models and media for students. (Hazimah & Sutisna, 2023). The research conducted by Setiyani found that students are still not accustomed to numeracy literacy questions, which typically include preceding texts. They often do not comprehend what is being asked or known in the questions, leading them to guess answers without a logical basis for their thinking. Additionally, students lack an understanding of the prerequisite material necessary to tackle these questions effectively (Setiyani et al., 2024). Based on existing problems, improvements must be made to equip students with the skills needed to adapt to the times and solve problems in daily life.

Social arithmetic is a subfield of mathematics that studies the relationships between numbers and various economic activities, such as banking, buying, and selling (Rahayu et al., 2021; Risdiyanti et al., 2019). The grade 7 social arithmetic curriculum covers mathematical computations in social activities and their applications in everyday life, including banking and commerce (price, discount, profit and loss, valuation, gross, net, and buying and selling) (Azzahra & Herman, 2022). Despite the material's strong connection to everyday life, many find it challenging. Social arithmetic issues are typically tale problems, which are thought to be more challenging than other kinds of problems. This is due to the fact that students must comprehend challenges, find solutions, and analyze the results (Rahayu et al., 2021).

One effective way to enhance students' understanding of social arithmetic is through the use of a context-based learning model. The Realistic Mathematics Education (RME) approach employs contextual problems derived from students' daily environments as a starting point for learning. This method translates complex problems into more comprehensible forms, facilitating better understanding. RME emphasizes active student participation, allowing learners to construct their own understanding rather than relying solely on teacher-led instruction (R. I. I. Putri et al., 2022). This self-directed learning fosters deeper comprehension and retention of mathematical concepts. RME is a learning approach centered on problems that are both authentic and relevant to students' lives. This approach has the potential to significantly improve students' mathematical literacy. Numeracy literacy is an indispensable component of mathematics, as mathematics involves not only formulas but also strong mathematical reasoning abilities. Social arithmetic, a mathematical topic with direct connections to daily life, offers a practical context for applying RME and strengthening students' numeracy literacy.

2. Objectives

The objectives of this study are to:

1. describe the implementation of the Realistics Mathematics Education (RME) model in developing students' numeracy literacy.

2. see the effectiveness of the Realistic Mathematics Education (RME) model on students' numeracy literacy.

3. Literature Review

Numeracy Literacy

The term "numeracy" describes not only numerical skills but also their practical application in various situations, particularly in problem-solving. Researchers have observed that numeracy, while emphasizing numerical concepts, is one component of a broader mathematical literacy. This literacy includes three distinct but interconnected areas: numeracy, quantitative literacy, and spatial literacy(Asmara & Purnomo, 2023). Rahmawati asserts that the application of numeracy literacy to other mathematical literacy is also included. Numeracy, then, is the capacity to identify and analyze mathematical problems with multiple contexts, process information, and then make and assess sound decisions to resolve these challenges (Rahmawati et al., 2023).

In PISA 2012 (OECD, 2013), the ability to formulate, apply, and interpret mathematics in a range of circumstances is known as numeracy. This covers mathematical reasoning as well as the description, explanation, and prediction of phenomena using mathematical ideas, methods, data, and instruments. Numeracy helps individuals to recognize the role of mathematics in daily life as well as make the judgments and decisions needed by constructive, engaged, and reflective citizens. According to Ojose (Ojose, 2011), mathematical literacy is the ability to understand and apply the fundamentals of mathematics in day-to-day situations. In this way, someone with strong mathematical literacy abilities is sensitive to which mathematical ideas apply to the issue or situation they are dealing with. Following this sensitivity, problem-solving techniques utilizing mathematical ideas are applied.
In numeracy assessment, there are three interrelated aspects, namely:

1. *The mathematical processes*
   The mathematical process includes 3 stages, namely: 1) formulating the situation mathematically, 2) using mathematical concepts, facts, procedures, and reasoning, and 3) interpreting, applying and evaluating mathematical results
2. *The mathematical content*
   In numeracy literacy, there are four mathematical contents used, namely: 1) change and relationships; 2) space and shape; 3) quantity ; and 4) uncertainty and data.
3. *The context*
   An important aspect of mathematical literacy is that mathematics is involved in solving problems set in context. The context is an aspect of the individual's world in which the problem is placed.

Realistic Mathematics Education (RME)

RME was conceptualized and developed in the Netherlands. The learning strategy known as realistic mathematics education (RME) was founded on Freudenthal's (1905–1990) mathematical theories. Freudenthal believes that rather than being treated as passive recipients, pupils ought to be given the chance to reimagine mathematics through practical encounters with their teachers (Armiati et al., 2022; Kusumaningsih et al., 2018; Sahara et al., 2024; Sumirattana et al., 2017; Tong et al., 2022). Students can learn mathematics and develop their own mathematical concepts at the end of the RME process. As a result, pupils acquire formal mathematical knowledge. (Sahin & Gurbuz, 2022).

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A realistic approach to math education starts with a real-life problem, allowing students to learn math while solving these problems. Mathematization involves achieving mathematical concepts through experiences acquired from everyday life, where formal information is the final step. The first step, horizontal mathematization, involves transitioning from everyday life to the world of symbols. The second step, vertical mathematization, involves navigating within the world of symbols (Akbas & Yildirim, 2024)

Understanding the problem, articulating it mathematically, solving the problem, and interpreting the result are all necessary steps in the mathematization process. The initial step is to comprehend real-world issues and identify the key elements of modeling procedure-related issues. Creating mathematical representations of real-world issues is the next stage. Finding pertinent variables, relationships, and restrictions may be necessary for this, as well as describing the problem's constituent parts using mathematical symbols and equations. The next step is to use mathematical ideas and procedures to solve a real-world problem after it has been formally represented. Lastly, it is necessary to comprehend the answer to a mathematical problem in light of the equivalent real-world difficulty. This comprises converting a mathematical solution back to a real-world format and evaluating its accuracy and applicability to the initial problem (Suparatulatorn et al., 2023).

RME has five characteristics, including: (1) using real-world contexts, (2) developing models to turn real situations into mathematical problems, (3) students reproducing the formation of guided mathematical concepts, (4) student-teacher interaction, and (5) views mathematics as an integrated subject (Laurens et al., 2018; Nurmasari et al., 2024; Tong et al., 2022).

4. Methods

Research design

The study employed a quasi-experimental design featuring a non-equivalent control group. In this design, two sample groups were formed: an experimental group and a control group, which served as the research subjects for comparison. Pre-tests were utilized to ensure group equivalence. The quasi-experimental design used in this study can be schematically illustrated as follows:

$$O_1 \quad X \quad O_2$$
....
$$O_3 \qquad O_4$$

Figure 1. Desain *Non-equivalent Control Group Design*
(Sugiyono, 2017)

Population and research sample

The study involved all Grade VII students of SMP Negeri 1 Mejobo located in Kudus Regency. Sampling was conducted using a random sampling technique, resulting in the selection of two classes: one designated as the experimental group (E) and the other as the control group (K).

Instruments and Data Collection

The instrument used was a numeracy test, comprising pretest and posttest questions. The pretest questions assessed numeracy literacy related to the prerequisite material for social arithmetic and were administered before the treatment. The posttest questions, administered after the treatment, assessed numeracy literacy related to social arithmetic material. These questions were previously validated by experts to ensure they met the necessary criteria and were suitable for use. The test questions were designed according to numeracy aspects and indicators of learning objective achievement. In addition to the test instruments, observation sheets and field notes were employed to gather qualitative data on the implementation of the Realistic Mathematics Education (RME) model. This aimed to determine whether the learning implementation aligned with the established learning provisions and to observe student activities during the learning process.

Data analysis technique

The data analyzed quantitatively in this study were obtained from the students' numeracy ability tests, which were conducted at both the beginning and the end of the learning process. Data processing in this study involved the following steps: 1) conducting prerequisite tests; 2) if the data are normally distributed, using the T-test to compare the means of the two groups; and 3) if the data are not normally distributed, applying a nonparametric statistical method, such as the Wilcoxon test or the Mann-Whitney test, to compare the averages of the two samples.

5. Results

Pretest Results

Before the experimental and control classes began, students were given pretest questions on numeracy literacy to assess their numeracy abilities in both classes prior to receiving treatment. The results of the analysis of the pretest scores are presented in Table 1.

Table 1. Independent T-test of Scores Before Treatment

Group statistics					
Group	N	Mean	Std. Deviation	Std. Error Mean	
Experimental group	28	45.32	12.626	2.386	
Control Group	26	44.88	12.068	2.367	
Kolmogorov Smirnov Test for Normality					
Sig.			0.200		
Levene’s Test for Equality of Varians					
F			Sig.		
0.000			0.992		
t-test for Equality of Means					
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	0.130	52	0.897	0.437	3.366

Based on Table 1, it can be observed that the average pretest scores in both classes show a not-so-significant difference. The normality test yielded a value of 0.200 (above 0.05), leading to the conclusion that the data is normally distributed. The homogeneity test produced a figure of 0.992 (above 0.05), indicating that the variance of the data is homogeneous. Furthermore, the t-test results showed a significance level of 0.897 (above 0.05), allowing us to conclude that there is no significant difference in numeracy literacy between students in the experimental class and those in the control class. Therefore, prior to receiving treatment, students in both classes exhibit similar levels of numeracy literacy ability.

Posttest Results

To determine the impact of the treatment, a post-test was conducted to measure students' numeracy literacy. The findings from the post-test data analysis are summarized in Table 2.

Table 2. Independent T-test of Scores After Treatment

Group statistics					
Group	N	Mean	Std. Deviation	Std. Error Mean	
Experimental group	28	70.39	16.269	3.075	
Control Group	26	60.23	11.877	2.329	
Kolmogorov Smirnov Test for Normality					
Sig.			0.200		
Levene's Test for Equality of Varians					
F			Sig.		
2.211			0.143		
t-test for Equality of Means					
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	2.604	52	0.012	10.162	3.902

Based on Table 2, the average post-test scores of both classes show a difference that is not statistically significant, although students in the experimental class achieved higher post-test results than those in the control class, with a difference of 10.16. The normality test yielded a value of 0.200 ($p > 0.05$), indicating that the data was normally distributed. The homogeneity test showed a value of 0.143 ($p > 0.05$), confirming that the variance of the data was homogeneous. The t-test results indicated a significance level of 0.012 ($p < 0.05$), leading to the conclusion that there is a significant difference in numeracy literacy between the experimental and control classes. Therefore, the numeracy literacy of students in the experimental class was significantly better than that of students in the control class.

The achievement of students' numeracy literacy from the indicators of formulation, employing, and interpreting can be seen in figure 2.

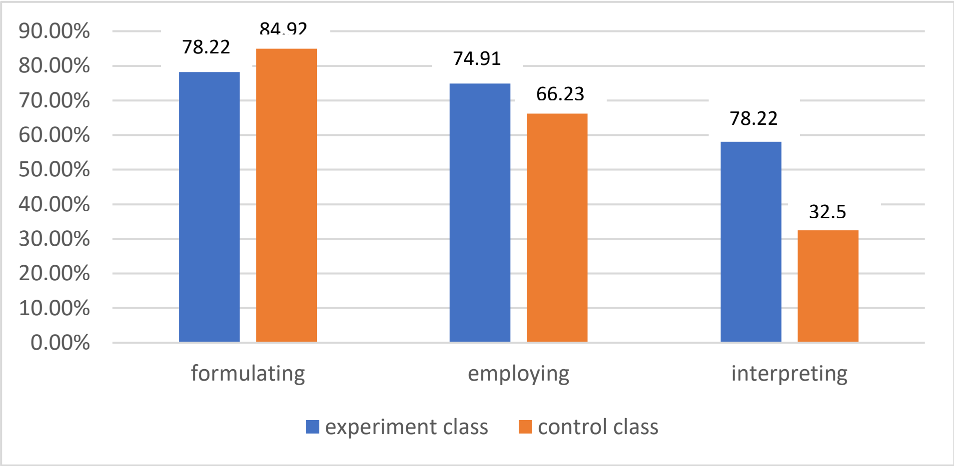

Figure 2. Achievement of students' numeracy literacy

Based on Figure 2, it can be seen that the control class shows better abilities than the experimental class in the formulating indicators. Both classes have obtained excellent results, exceeding 75%. However, in the employing indicator, the experimental class demonstrated slightly better abilities than the control class, although the difference is not significant. Both classes performed well during the employing stages. A significant difference was observed in the interpreting stage, where the experimental class achieved much higher results than the control group.

RME Model Implementation Analysis

To observe the implementation of the RME model in learning, it is essential to monitor the teacher's activities during the learning process. Observations were conducted by two observers, who assigned a value on a scale of 1 to 5 for each aspect observed. The results of these observations related to the implementation of learning steps using the RME model are presented in Table 3.

Table 3. Learning observation results with the RME model

Teacher Activities according to RME Steps	**Meeting 1**	**Meeting 2**	**Meeting 3**	**Meeting 4**	**Average**
Phase 1 understands contextual issues					
1. Provide contextual problems about the material being studied	4	5	5	5	4.75
2. give students time to understand the problem given	5	5	5	5	5
Phase 2 describes contextual issues					
explain the situation and condition of the questions by providing hints/suggestions as necessary (limited) to certain parts that students do not understand	4	4	5	5	4.5

Phase 3. Solving contextual problems					
1. Give learners time to solve contextual problems individually in their own way	5	5	5	5	5
2. motivate students to solve problems in their own way by providing questions/hints/suggestions	3	4	4	5	4
Phase 4. Compare and discuss answers					
1. provide time and opportunities for students to compare and discuss the answers to the questions in groups	4	5	5	5	4.75
2. guide students to compare and discuss answers in group discussions	3	3	4	5	3.75
3. facilitate group discussions on the material at the student worksheet	4	4	5	5	4.5
Phase 5. Conclude the results of the discussion					
1. provide opportunities for students to explain the results of group discussions	5	5	5	5	5
2. direct students to draw conclusions about a procedure or concept about the material being studied	4	4	4	5	4.25
3. giving students time to solve contextual problems individually	4	5	5	5	4.75

Based on Table 3, it can be observed that at the initial meeting the teacher did not provide motivation and direction to students in problem solving and group discussion processes. However, at the next meeting, the teacher's ability increased significantly so that he was able to carry out the stages of Realistic Mathematics Education (RME) learning effectively.

The observation results indicate that students initially struggled with individual problem-solving in a Realistic Mathematics Education (RME) model. During the first meeting, students faced difficulties addressing contextual problems, and despite teachers' efforts to provide guidance and stimuli, group discussions were ineffective as students felt embarrassed about sharing answers with peers. The teacher's role was crucial in motivating students to engage more enthusiastically in discussions, often monitoring group progress and assisting those in need.

When presenting their discussion outcomes, students exhibited a lack of confidence, tending to read from notes rather than interacting with the audience. The teacher encouraged them to improve their presentation skills and reminded classmates to pay attention. In the conclusion phase, the teacher effectively guided students to summarize what they learned, resulting in increased enthusiasm for providing conclusions.

The learning session concluded with an evaluation where students completed questions individually. They appeared calm while working on these tasks, with some seeking clarification from the teacher on questions they found challenging. Overall, the RME model's implementation showed potential for enhancing student engagement and understanding in mathematics through contextual learning experiences.

Based on the observation results, the quality of teachers in implementing the learning steps of the RME model has improved. Field records indicate that student activities during learning with the RME model have also increased. However, student boredom was observed ahead of the last meeting, as students appeared less enthusiastic about working on the questions provided, particularly when it came to individual tasks. To address this issue, teachers introduced distractions in the form of games to keep students engaged while solving problems. Additionally, teachers offered rewards to students who successfully solved problems correctly, aiming to enhance motivation among learners.

6. Discussion

The Realistic Mathematics Education (RME) learning model has been shown to positively impact students' numeracy literacy skills. This model effectively maximizes various aspects of mathematical numeracy literacy at each stage, allowing students to become familiar with the stages of mathematical numeracy literacy during the learning process. Literacy and numeracy skills are crucial for students as they enable them to understand, analyze, and make informed decisions based on relevant information and data. In line with Winarno's statement, a student's level of literacy proficiency significantly influences their numeracy abilities, which encompass identifying known information, understanding questions, formulating concepts, and applying procedures (Winarno et al., 2024).

Numeracy literacy refers to the ability to apply mathematical principles, basic knowledge, and processes in everyday life. In the Realistic Mathematics Education (RME) model, students learn mathematics in a contextual manner, making the material easier to comprehend. At the beginning of the learning process, students are given the opportunity to explore their abilities in solving contextual problems they frequently encounter in their lives. By the end of the learning experience with the RME model, students are guided to independently discover the mathematical concepts they have learned. This approach emphasizes understanding through real-life applications, fostering deeper engagement and comprehension of mathematical concepts (A. D. Putri et al., 2024). Utilizing the Realistic Mathematics Education (RME) approach allows students to discover their own knowledge and correctly master the results of their findings. In this model, the teacher's role is to guide students by providing directions, encouraging them to think independently and derive general principles based on prompts or questions. The nature of the questions posed by the teacher and the level of guidance provided depend on the students' skills and the material being studied. This realistic approach aids students in understanding concepts and applying them effectively to solve mathematical problems (Manurung et al., 2020; Nugraheni & Marsigit, 2021; Zakaria & Syamaun, 2017).

The implementation of RME has been shown to positively impact students' mathematical literacy, leading to demonstrable improvements in their mathematical problem-solving skills (Ariati et al., 2022). This is consistent with the findings of Nugraheni's study, which demonstrates that instructional materials derived from the realistic mathematics education approach can positively impact students' learning mastery, particularly their ability to solve mathematical problems (Nugraheni & Marsigit, 2021). Considered an alternative to blending math language with real-life situations, RME can help students to focus on problems, question problems, and think. RME also gives students the opportunity to use mathematical devices to organize and solve problems (Akbas & Yildirim, 2024).

Social arithmetic is frequently applied in daily life, particularly in buying and selling activities familiar to students. Students often encounter challenges in determining purchase price, selling price, loss, or profit. Mangelep's research explored social arithmetic learning using monopoly games and found that a designed learning trajectory using monopoly games helped students solve social arithmetic problems by using their knowledge and experience at situational, referential, and general levels (Mangelep et al., 2023). A similar study by Hardini investigated social arithmetic learning using snacks and money as the context3. The findings indicated that students with lower abilities could effectively engage with the learning process and solve social arithmetic problems when the Indonesian Realistic Mathematics Education approach was used (Hardini et al., 2021).

Steen underlined that numeracy encompasses more than just numbers and how they are used. Belief in mathematics, appreciation of mathematics, including its history and the significance of understanding real-world problems, the capacity for logical thought and decision-making, the application of mathematics to everyday problems in a variety of contexts, comprehension of mathematical numbers and symbols, data reasoning, and the capacity to draw on a variety of sources and mathematical knowledge are all aspects of numeracy that must be taken into account (Pramesti & Sari, 2024). The activities of students in RME learning emphasize their active involvement in the critical thinking process to solve contextual problems. By understanding problems, exploring different solutions, using mathematical models, and analyzing and reflecting on results, students can develop critical thinking skills that are useful not only in mathematics but also in everyday life.

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