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Understanding the Concept of Fractions through the Integration of the Realistic Mathematics Education Approach and Metacognition: A Descriptive Study of Second-Grade Elementary School Students in Indonesia

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ABSTRACT

This study aims to analyze elementary school students' understanding of fractional numbers through the application of a metacognitive-based Realistic Mathematics Education (RME) approach. The study employed a qualitative, descriptive approach and was conducted with second-grade students at SDN Banjarwangi. Research subjects were selected using purposive sampling. Data were collected through concept comprehension tests, observations, interviews, and documentation. Data analysis was performed using the Miles and Huberman interactive model, which includes data reduction, data presentation, and drawing conclusions, and its validity was tested through triangulation of techniques and sources. The research results indicate that students' understanding of fraction concepts falls into the "good" category, with an average score of 79.4%, an increase from the pre-test score of 61.2%. Most students were able to restate the concepts, classify, and represent fractions, but still had difficulty explaining the solution procedures systematically. Results from interviews and observations indicate that the use of real-world contexts in the RME approach helped students understand the concepts more concretely, while metacognitive strategies encouraged students to plan, monitor, and evaluate their thinking processes. Thus, RME- and metacognition-based mathematics learning is effective in improving students' understanding of fraction concepts, although reinforcement is needed in the area of mathematical communication. This study recommends the integration of real-world contexts and reflective activities in learning to enhance the quality of students' conceptual understanding.

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INTRODUCTION

Mathematics plays a crucial role in developing students' logical, critical, and problem-solving skills. However, various studies indicate that mathematics instruction in elementary schools still faces challenges in fostering a deep conceptual understanding. Students tend to be able to perform computational procedures but do not yet fully understand the underlying concepts. In fact, conceptual understanding is a fundamental aspect that enables students to connect various mathematical ideas and apply them in different situations (Hiebert & Carpenter, 1992).

One of the topics that most frequently causes difficulty is fractions. Research findings indicate that elementary school students still hold misconceptions regarding fractions, primarily due to a tendency to apply whole-number thinking when solving fraction problems (Clements & Sarama, 2014). Furthermore, these difficulties are also influenced by instruction that remains procedure-oriented and lacks real-world context, preventing students from gaining meaningful learning On the other hand, metacognitive skills also play a crucial role in mathematics learning. Students with strong metacognitive skills tend to be better able to plan, monitor, and evaluate their thinking processes when solving mathematical problems (Zimmerman, 2002). Research indicates that the use of metacognitive strategies can enhance students' conceptual understanding and mathematical problem-solving skills (Schneider & Artelt, 2010; Mulyatna & Kusumah, 2020). This suggests that metacognitive aspects need to be integrated into instruction to support students' thinking processes more effectively.

Although various studies have demonstrated the effectiveness of the RME approach and metacognitive strategies separately, a review of the literature indicates that research integrating both approaches remains limited, particularly regarding fraction content in elementary school. Most studies focus solely on one approach without considering the importance of students' awareness in controlling their thinking processes during learning. This limitation indicates a research gap, namely the suboptimal integration of the contextual approach and metacognitive strategies within a single integrated learning design.

Based on this gap, this study offers a novelty in the form of integrating the Realistic Mathematics Education approach with metacognitive strategies in fraction learning. This integration is expected to create more meaningful learning, as students not only construct concepts through real-world contexts but are also trained to reflect on and independently control their thinking processes. Thus, the objective of this study is to analyze students' understanding of fraction concepts through the application of a metacognitive-based Realistic Mathematics Education approach among elementary school students.experiences (Nurjanah & Suryadi, 2019). This situation indicates that students' conceptual understanding of fractions has not yet developed optimally.

Various studies have examined efforts to improve mathematical concept understanding, one of which is through the Realistic Mathematics Education (RME) approach. This approach emphasizes the use of real-world contexts as the starting point for learning and encourages students to construct their own knowledge through the process of mathematization (Gravemeijer, 1994; van den Heuvel-Panhuizen & Drijvers, 2014). Research findings indicate that the implementation of RME can improve conceptual understanding, student engagement, and mathematical thinking skills (Fitriani et al., 2018; Putri & Zulkardi, 2019). Thus, RME is a promising approach for addressing students' difficulties with fractions.

METHOD

This study employs a qualitative, descriptive approach aimed at analyzing students' understanding of fractional numbers through the application of a metacognitive-based Realistic Mathematics Education (RME) approach. This approach was chosen to gain an in-depth understanding of students' thought processes and how they construct conceptual understanding during learning in a natural context (Creswell, 2014). Data analysis was conducted systematically following the interactive model of Miles, Huberman, and Saldaña (2014), which allows for a comprehensive interpretation of the data.

Table 1 Research Design

Component	Description
Research Approach	Qualitative
Type of research	Descriptive
Research Focus	Analysis of Conceptual Understanding of Fractions
Learning approach	Metacognitive-based Realistic Mathematics Education

The study was conducted among Year 2 pupils at SDN Banjarwangi during the second term of the current academic year. Subjects were selected using purposive sampling, taking into account the pupils' characteristics and the suitability of the learning material. This technique was used to identify subjects who could provide relevant information regarding the focus of the study.

Table 2. Research Subjects

Component	Description
Research location	SDN Banjarwangi
Research subjects	Year 2 pupils
Teaching materials	Fractions
Subject selection method	Second semester of the
Research timeline	current academic year

Data collection was carried out using four techniques to obtain comprehensive data, namely:

Table 3. Data Collection Techniques

Technique	Objective	Data Source
Tests	Assessing students' understanding of fractions	Students
Observation	Observing students' activities and engagement	The learning process
Interviews	Exploring students' thinking processes and strategies	Students
Documentation	Supporting research data	Archives & work samples

The use of these various techniques aims to enhance the depth and validity of the data through methodological triangulation (Moleong, 2018). The instruments used include a concept comprehension test, observation sheets, interview guidelines, and documentation. The test was designed based on concept comprehension indicators covering: (1) explaining the concept, (2) classifying objects according to the concept, and (3) applying the concept in problem-solving.

Table 4. Research Instruments

Instrument	Function	Data
Tests	Assessing conceptual understanding	Student scores and answers
Observation	Observing learning activities	Field notes
Interviews	Exploring thought processes	Transcripts
Documentation	Supporting data	Photos and work samples

Data Validity
The validity of the data in this study was tested through:
a. Methodological triangulation (tests, observation, interviews, documentation)
b. Source triangulation (multiple students)
c. Member checking to ensure the consistency of interview results with the respondents
These steps were taken to enhance the credibility and validity of the research findings.
Data analysis utilised the interactive model proposed by Miles, Huberman, and Saldaña (2014), which comprises three stages:

Table 5. Data AnalysisTechniques

Stage	Activity
Data reduction	Selecting, focusing on, and simplifying data
Presentation of data	Organising data in narrative and tabular form
Drawing conclusions	Interpreting data and formulating findings

The analysis was conducted on an ongoing basis from data collection through to the drawing of conclusions, thereby providing a comprehensive picture of the pupils' understanding of fractions.

RESULTS

The research findings were obtained through concept comprehension tests, interviews, observations and document analysis. The research subjects comprised 20 Year 2 pupils, with 6 pupils selected for in-depth interviews based on variations in ability (high, medium, low).

A. Conceptual Understanding Test Results
1. Comparison of Pre-test and Post-test

Table 6. Comparison of Pre-test and Post-test

Stage	Average Score	Category
Pre-test	61,2	Fair
Post-test	79,4	Good

There was an increase of 18.2 points, indicating a change in conceptual understanding following the implementation of metacognitive-based RME learning.

2. Distribution of Student Scores

Table 7. Distribution of Student Scores

Score Interval	Frequency	Percentage
90–100	3 student	15%
80–89	7 student	35%
70–79	6 student	30%
60–69	3 student	15%
<60	1 student	5%

The majority of students (80%) fall into the 'good' and 'very good' categories.

3. Performance by Indicator

Table 8. Performance by Indicator

Indicator	Percentage	Category
Stating concepts	86%	Good
Classifying	82%	Good
Representation	79%	Good
Problem-solving	76%	Fair
Explaining procedures	74%	Fair

4. Individual Performance Patterns

a) High-achieving students: able to meet all indicators, including explaining procedures in a logical sequence
b) Average students: able to understand concepts, but less systematic in their explanations
c) Low-achieving students: understand intuitively, but struggle with representation and communication

B. Interview Results

Interviews were conducted with 1 teacher and 6 pupils.

Table 9. Interview Results

Respondent	Code	Direct Quote	Interpretation
Teacher	G1	"Pupils grasp fractions more quickly when using real-life examples such as sharing food."	Real-life context aids understanding
Teacher	G1	"Discussions encourage students to explain their thought processes."	RME is improving communication
High-achieving pupils	S1	"I imagine fractions as being like sharing a cake."	Concrete representation
Average pupils	S2	"I know the answer, but it's hard to explain."	Metacognitive difficulties
Low-achieving pupils	S3	"It's easier with a picture."	Visualsaid understanding

C. Results of the Classroom Observation

The observation revealed an increase in pupils' learning activity during the lesson.
Specific Findings:

1) Pupils actively discussed in groups
2) Pupils used concrete objects to understand fractions
3) There was interaction between pupils when explaining their answers

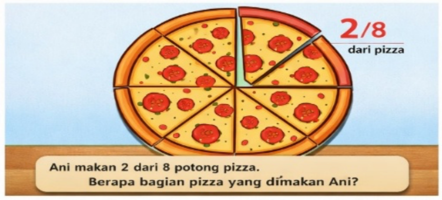
Table 10. Results of the Learning Observation

Aspect	Observed Behaviour	Field Note	Interpretation
Student activities	Active group discussion	"The pupils are discussing how to divide a slice of pizza"	Increased collaboration
Conceptual understanding	Using concrete objects	"The pupils divide the paper into equal parts"	Conceptual understanding
Metacognition	Checking answers	"A pupil said: 'This is wrong; it should be divided equally'"	Reflective thinking
Interaction	Asking questions of classmates	"Why are the answers different?"	Knowledge construction

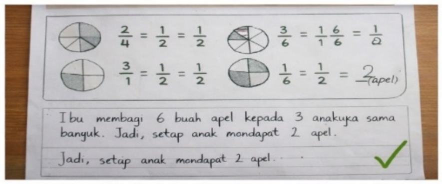
D. Results of the Document Review

Table 11. Results of the Document Review

Aspect	Findings
Textbook	Procedurally dominant
Old worksheets	Not contextual
Metacognitive activities	Not available



Gambar 1. *Contoh masalah kontekɛsual pevibolajavan pecahan berbasis RME*



Gambar 2. *Contoh hasil pelenjaan siswa dalam menyelesaikan masalah pecahan*

Gambar 3. *Aklivitas siswa dalam pevibalajavan RME berbasis metakognitif*

DISCUSSION

The research findings indicate that pupils' understanding of fractional concepts improved following the implementation of a metacognitive-based RME approach. This improvement is evident from a comparison of pre-test and post-test scores, as well as the predominance of pupils in the 'good' category.

These findings are consistent with previous research indicating that the RME approach is effective in enhancing mathematical conceptual understanding because it utilises real-life contexts as the basis for learning (Gravemeijer, 1994; van den Heuvel-Panhuizen & Drijvers, 2014). In this study, the use of contexts such as food sharing proved to help students build a more concrete understanding, as evidenced by the results of interviews and observations.

Furthermore, the integration of metacognition also contributed to the improvement in students' understanding. Students demonstrated the ability to monitor and evaluate their thinking processes, although this was not yet fully optimal. These findings are consistent with research stating that metacognition plays a crucial role in enhancing problem-solving skills and understanding of mathematical concepts (Zimmerman, 2002; Schneider & Artelt, 2010).

However, the results of this study also indicate limitations in students' ability to explain problem-solving procedures. This suggests that although students have intuitively understood the concepts, they still face difficulties in communicating their thought processes systematically. These findings differ from some studies showing significant improvements in mathematical communication, thus indicating that this aspect requires special attention in the implementation of learning.

The results of this study provide important implications, both theoretically and practically, for mathematics learning in primary schools. Theoretically, the findings of this study reinforce the notion that the integration of the Realistic Mathematics Education (RME) approach with metacognitive strategies can support the construction of a more meaningful conceptual understanding. Learning that begins with real-world contexts and is supplemented with reflective activities has been shown to help pupils not only understand the concept of fractions but also to become aware of and control their thinking processes.

In practical terms, this study offers recommendations to teachers to develop lessons that focus not only on problem-solving but also on the students' thought processes. Teachers can design learning activities based on everyday contexts and provide space for students to reflect, such as reviewing their answers and explaining their solution steps. Furthermore, the development of teaching materials such as worksheets based on RME and metacognition can serve as alternatives to improve the quality of mathematics learning, particularly regarding fractions.

This study has several limitations that must be considered when interpreting the results. Firstly, the limited number of research subjects restricted to a single class with a relatively small number of pupils means the generalisability of these findings remains limited. Secondly, this study focused solely on a single topic, namely fractions, and therefore cannot yet demonstrate the effectiveness of the metacognition-based RME approach in other areas of mathematics. Thirdly, the relatively short duration of the study meant that the development of pupils' metacognitive skills was not yet optimal, particularly regarding the systematic communication of thought processes. Furthermore, as this study employed a qualitative approach, it has not provided robust quantitative measures regarding the level of effectiveness of the learning intervention.

Given these limitations, future research is recommended to expand the scope of the study by involving a larger and more diverse sample of participants so that the findings can be generalised more widely. Furthermore, future research could test the application of a metacognitive-based RME approach to various other mathematics topics to determine the consistency of its effectiveness. Research using experimental or mixed-methods designs is also recommended to obtain stronger empirical evidence regarding the impact of this approach on students' conceptual understanding and thinking skills.

Furthermore, future research could develop more structured learning tools, such as RME- and metacognition-based learning models or worksheets, equipped with more specific indicators of reflective activity. Research could also focus on strengthening students' mathematical communication skills, particularly in explaining problem-solving procedures, which in this study still showed suboptimal results.

CONCLUSION

Based on the research findings and discussion, it can be concluded that primary school pupils' understanding of the concept of fractions through learning using a metacognitive-based Realistic Mathematics Education (RME) approach falls into the 'good' category, with an average percentage of 79.4%. These results indicate that the majority of pupils have been able to understand basic concepts of fractions, represent these concepts in various forms, and apply them to solve simple problems. Findings from interviews and observations also reinforce that the use of real-life contexts in learning helps pupils build more meaningful understanding, whilst the integration of metacognitive strategies encourages pupils to plan, monitor, and evaluate their thinking processes.

Nevertheless, students' ability to explain problem-solving procedures remains relatively low, so more systematic efforts are needed to develop students' mathematical communication skills. Therefore, teachers are advised to: (1) design contextual problem-based learning activities that are relevant to students' lives, (2) provide metacognitive prompting questions such as "why" and "how" at every stage of learning, and (3) provide broader opportunities for students to explain and discuss their thinking processes both orally and in writing.

More broadly, this study has implications for curriculum developers to explicitly integrate contextual and metacognitive approaches into learning materials, and for teacher training institutions to equip prospective teachers with the competence to design learning that emphasises students' thinking processes. For future researchers, it is recommended to test the effectiveness of this approach on a larger sample, with different subject matter, and to use quantitative or mixed-methods research designs to obtain stronger empirical evidence.

However, these conclusions must be understood in light of the study's limitations, namely the limited number of participants, the focus on a single learning subject, and the relatively short duration of the study. Consequently, the metacognitive-based RME approach retains its potential as an effective learning alternative, but requires further development and testing to yield more comprehensive results.

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AUTHOR CONTRIBUTION STATEMENT

RS contributed to the conceptualisation, methodology, investigation, data curation, formal analysis, and original draft writing. Karlimah was involved in the methodology, validation, and writing revision & editing.

AI DISCLOSURE STATEMENT

The author declares that, in the preparation of this manuscript, limited use has been made of artificial intelligence (AI), specifically for the improvement of grammar, sentence clarity and the neatness of the writing structure. The use of AI did not extend to the formulation of research ideas, data collection and analysis, or the drawing of conclusions. The author takes full responsibility for the entire content, accuracy, and scientific integrity of this manuscript.

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