Development of Teaching Materials Based on Realistic Mathematics Education to Improve Understanding of Fractions in Fourth-Grade Elementary School Students

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Abstract
Students' understanding of fractions in fourth-grade elementary school remains low due to the lack of contextual and engaging teaching materials. This study aims to develop teaching materials based on Realistic Mathematics Education (RME) to enhance students' understanding of fractions. The research method used is Research and Development (R&D) with the 4D model (Define, Design, Develop, Disseminate), though it was limited to the Develop stage due to time constraints. Expert validation results indicate that the teaching material has a very high level of validity. A limited trial conducted on 10 fourth-grade students showed an improvement in understanding by 45%-54%. Additionally, teacher feedback revealed that this teaching material is highly practical and easy to use in learning. The RME approach, which emphasizes the mathematization of real-world situations, has proven to help students grasp fraction concepts more effectively than conventional methods. Thus, RME-based teaching materials can serve as an innovative alternative to improving the quality of mathematics learning in elementary schools.

INTRODUCTION

Mathematics is a fundamental discipline essential for solving social, economic, and scientific problems (Aras, 2012). It is not just an abstract concept but a practical tool used in various aspects of life. Due to its significance, mathematics is taught from elementary to higher education levels. However, some mathematical topics, such as fractions, remain particularly challenging for elementary school students (Januarti, 2017). This difficulty necessitates the development of effective teaching strategies to improve students' understanding.

Mathematics education aims to cultivate logical, critical, and systematic thinking skills essential for problem-solving (Surat, 2016). According to the Indonesian Ministry of Education and Culture Regulation No. 22 of 2016, mathematics learning in elementary schools should be interactive and engaging. Ideally, students should actively discover and understand mathematical concepts rather than rely on passive learning. However, in practice, achieving these learning objectives remains challenging, particularly in the topic of fractions. Many students struggle to grasp fractions due to the abstract nature of the concepts and ineffective teaching methods.

Fractions pose greater challenges than whole numbers because they require both arithmetic skills and an understanding of division and proportion (Utari et al., 2019). Unlike whole numbers, which students encounter in daily life, fractions are more abstract and less intuitive. Many traditional teaching methods emphasize rote memorization and repetitive exercises, which do not promote deep conceptual understanding. As a result, students often learn how to manipulate fractions mechanically without

comprehending their meaning. This gap in understanding makes it difficult for students to apply fractions to real-world situations.

Numerous studies indicate that students' understanding of fractions remains low. International assessments such as the Programme for International Student Assessment (PISA) reveal that Indonesian students' mathematics proficiency is below the global average, particularly in fraction-related problems (Benu et al., 2024). This finding highlights the need for improved instructional strategies that foster a deeper understanding of fractions. Without effective intervention, students will continue to struggle with fractions, which are foundational for more advanced mathematical concepts. Therefore, addressing this issue is crucial to improving mathematics education at the elementary level.

One major issue in teaching fractions is the lack of engaging and contextual teaching materials (Ermayani et al., 2018). Many textbooks present fraction concepts in an abstract manner without linking them to real-life applications. According to Piaget's theory of cognitive development, children aged 7-11 learn best through concrete experiences (Rosmala, 2021). If fraction concepts are not made tangible and relatable, students will have difficulty understanding them. Thus, integrating contextual and meaningful learning experiences is essential for improving fraction comprehension.

Observations at SDIT Al-Akhyar Bungo reveal that fraction lessons remain teacher-centered and heavily dependent on textbooks. Teachers mainly provide theoretical explanations on the board, while students passively take notes and complete exercises. This traditional approach limits students' engagement and prevents them from developing a deep conceptual understanding of fractions. Consequently, many students rely on memorization rather than truly understanding how fractions work. To address this, a shift towards more interactive and student-centered teaching methods is needed.

Realistic Mathematics Education (RME) is an approach that emphasizes the application of mathematics in real-world contexts (Gravemeijer in Purwati, 2020). It allows students to construct their understanding through exploration, discussion, and problem-solving. Key characteristics of RME include using real-life contexts, progressively developing mathematical models, and encouraging active student-teacher interactions. This method helps students connect abstract mathematical concepts to tangible experiences, making learning more meaningful. As a result, students develop a deeper and more lasting understanding of mathematical concepts.

Research findings indicate that RME-based teaching materials significantly improve students' mathematical comprehension (Febriana, 2023; Verlina, 2020; Wulandari et al., 2019). Students who learn fractions through RME can relate the concepts to real-life situations, such as dividing food or measuring objects (Ananda, 2018). This approach not only enhances conceptual understanding but also boosts students' motivation to learn mathematics. Additionally, RME encourages collaborative learning, where students actively discuss and explore mathematical problems together. This interactive learning process makes mathematics more accessible and enjoyable for students.

Beyond improving students' understanding, RME-based teaching materials also encourage teachers to adopt more innovative instructional strategies. By designing engaging and problem-based activities, teachers can foster deeper learning experiences for students (Sastrika et al., 2013). The use of contextual teaching materials makes learning more meaningful and helps students develop critical thinking skills. Additionally, RME-based materials offer flexibility, making them suitable for both face-to-face and technology-assisted learning environments (Rahmasantika & Prahmana, 2022). Thus, RME has the potential to improve not only student comprehension but also teaching effectiveness.

Given these challenges and needs, this study aims to develop RME-based teaching materials for teaching fractions to fourth-grade elementary school students. The research will assess the validity and practicality of the developed materials through content evaluation and field trials. By incorporating real-life applications, these materials are expected to enhance students' conceptual understanding and problem-solving abilities. Furthermore, the findings of this study will contribute to improving the quality of mathematics education at the elementary level. Ultimately, the development of RME-based teaching materials can serve as a valuable reference for educators in designing more effective learning strategies.

METHODS

This study employs the Research and Development (R&D) method using the 4D development model (Define, Design, Develop, and Disseminate). However, due to time limitations within the academic calendar and situational constraints, such as the need for extended field trials and administrative approvals for broader implementation, this research was conducted only up to the Develop stage. The Disseminate stage requires long-term observation and extensive data collection across multiple schools, which was not feasible within the study's timeframe. The 4D model is widely used in the development of teaching materials as it produces valid, practical, and effective materials for learning (Gustiawati et al., 2020).

The subjects of this study included fourth-grade elementary school students, fourth-grade teachers, and expert validators. The expert validators consisted of two content experts, two language experts, and two design experts from a teacher education institution. Additionally, teacher feedback on the developed teaching materials was obtained from three elementary school teachers from schools with different accreditation levels. A limited trial was conducted with 10 fourth-grade students, consisting of five students from class IVA and five students from class IVB, to measure the effectiveness and practicality of the developed teaching materials.

The data collection instruments in this study consisted of expert validation sheets, teacher response questionnaires, and student comprehension tests. The expert validation sheets were used to assess the content, language, and design aspects of the teaching materials. The teacher response questionnaires were used to gather feedback regarding the feasibility, clarity, and suitability of the teaching materials. Meanwhile, the student comprehension test was administered during the limited trial phase to evaluate how well the Realistic Mathematics Education (RME)-based teaching materials improved students' understanding of fractions.

This study utilized qualitative descriptive analysis and statistical descriptive analysis. Qualitative descriptive analysis was used to process comments and suggestions from expert validators as well as teacher responses to the developed teaching materials. The feedback from experts was used as the basis for revising the materials before conducting the student trials. In addition, statistical descriptive analysis was used to process the data obtained from the validation scores and limited trial results. The validity of the teaching materials was assessed using a rating scale, and the results were converted into categories of very good, good, sufficient, or less good, based on predefined standards.

After the validation and revision process, the developed teaching materials were tested on a small group of students to assess their effectiveness in improving fraction comprehension. The findings from expert validation, teacher feedback, and student trials served as the basis for determining the feasibility and practicality of the RME-based teaching materials for teaching mathematics in fourth-grade elementary school classrooms.

RESULTS AND DISCUSSION

Development Stages

Definition Stage (Define)

The definition stage aims to identify the needs in developing instructional materials based on Realistic Mathematics Education (RME) for the topic of fractions in 4th-grade elementary school. This stage involves analyzing the current learning conditions, student needs, and the curriculum used.

a. Preliminary Analysis : The preliminary analysis was conducted through classroom observations in IVA and IVB at SDIT Al-Akhyar Bungo, as well as interviews with 4th-grade teachers. The observations revealed several challenges in teaching fractions, particularly in students' conceptual understanding. The learning process primarily relied on textbooks and lacked connections to students' real-life experiences. Teachers generally used lecture methods and problem-solving exercises without further exploration of fraction concepts in everyday contexts. Additionally, students struggled with fraction operations due to a lack of concrete visual representations.

b. Student Analysis: Student analysis was carried out to understand the characteristics of 4th-grade elementary school students as research subjects. Based on Piaget's cognitive development theory, children aged 9-11 are in the concrete operational stage, meaning they grasp mathematical concepts more easily when presented with real-world visualizations or direct experiences. However, existing instructional materials are mostly text-based with minimal illustrations or contextual relevance to students' daily lives.

c. Curriculum Analysis: The curriculum analysis refers to the 2013 Curriculum used in elementary schools. In the second semester of 4th grade, fraction material covers basic concepts, arithmetic operations with fractions, and real-life applications. The relevant Basic Competencies (Kompetensi Dasar, KD) for developing these instructional materials are KD 3.6 and KD 4.6, which focus on understanding and solving problems related to fractions. The school textbooks present fractions in an abstract manner with limited real-life examples.

d. Task Analysis: Task analysis was conducted to determine activities that can help students comprehend fractions. The instructional materials based on RME emphasize contextual problems, mathematical modeling, and conceptual exploration through various visual and manipulative approaches. This approach allows students to construct their understanding of fractions through direct experiences and interactive learning.

Design Stage

The design stage is carried out after obtaining the results of the needs analysis and student characteristics assessment. At this stage, an initial design of the RME-based instructional materials is developed, covering the structure of content presentation, learning models, and design elements that support readability and student comprehension. The structure of the instructional materials is based on the principles of Realistic Mathematics Education (RME), which emphasize several important aspects. The first is the use of real-life contexts, where fraction concepts are linked to everyday situations such as dividing food, measuring fabric length, and comparing quantities. The second is mathematical modeling, which involves various representations of fractions, including area models, number lines, and other visual aids, to help students grasp the concepts concretely. The third is interaction and discussion, where students are encouraged to collaborate and discuss mathematical problems, allowing them to exchange ideas and develop more effective solutions. Lastly, reflection and generalization are emphasized, guiding students to reflect on their learning process, summarize key concepts, and apply them in different contexts.

The visual design and learning media of the instructional materials are developed with engaging and student-friendly elements tailored to 4th-grade learners. Special attention is given to color usage, illustrations, and clear typography to enhance comprehension. Additionally, the materials are supplemented with exploratory exercises and educational games that incorporate mathematical manipulatives to reinforce learning and make the process more interactive.

Development Stage

The development stage is the phase where the instructional material design is realized. At this stage, validation by experts, limited trials, and revisions based on evaluation results are conducted to ensure the quality and effectiveness of the materials. Expert validation is carried out by three groups of validators: subject matter experts, language experts, and design experts. Each validator assesses the aspects within their area of expertise. The following are the validation results:

Table 1. Expert validation scores

Validation Aspect	Score Stage 1	Score Stage 2	Final Category
Content	56.5	87.9	Very Good
Language	74.7	84.7	Very Good
Design	67.6	88.6	Very Good

Next, A limited trial was conducted with 10 students from classes IVA and IVB at SDIT Al-Akhyar Bungo. The results of the trial are presented in the following table:

Table 2. Limited group trial scores

Class	Number of Students	Average Score Before	Average Score After
IV A	5	65.8	83.6
IV B	5	53.0	81.5

The average understanding of fractions among students increased by 45% to 54% after using the RME-based instructional materials. These results indicate the effectiveness of the materials in enhancing students' comprehension of fraction concepts. The last, teacher feedback, three teachers involved in the study provided feedback on the developed instructional materials. Their responses are summarized in the following table

Table 3. Teacher Response to the Product

Teacher	Class	Response Score	Category
Teacher 1	Grade IV	90	Very Good
Teacher 2	Grade IV	93	Very Good
Teacher 3	Grade IV	91	Very Good

Based on the questionnaire results, the instructional materials received an average score of 91.3, which falls into the "Very Good" category. Teachers stated that these materials help students understand fraction concepts more easily and enjoyably, making learning more engaging and effective.

The teaching materials based on Realistic Mathematics Education (RME) developed in this study have high levels of validity, practicality, and effectiveness. Expert validation indicates that these teaching materials are highly suitable for use in learning, while limited trials show that they significantly improve students' understanding of fraction concepts. Additionally, these materials received positive feedback from teachers as they help in teaching fractions in a more engaging and interactive way.

The development of RME-based teaching materials has proven to be an effective approach in enhancing students' understanding of fraction concepts in fourth-grade elementary school. This method focuses on using real-world contexts relevant to students' lives, enabling them to grasp fractions more intuitively. Many students struggle with understanding fractions due to their abstract nature, which contrasts with whole numbers that are easier to manipulate.

This study employed the Research and Development (R&D) method using the 4D development model, consisting of Define, Design, Develop, and Disseminate. However, due to time and situational constraints, only the first three stages were conducted. The Define stage was carried out to identify students' needs and analyze the current learning conditions in elementary schools. The Design stage aimed to create teaching materials suitable for students in the concrete operational stage according to Piaget's theory. The Develop stage involved expert validation, material revisions, and limited trials with students and teachers to assess their effectiveness in learning.

The validation of teaching materials was conducted by three groups of experts: subject matter experts, language experts, and design experts. Each group evaluated aspects relevant to their expertise to ensure the developed materials were suitable for use. The subject matter aspect was assessed based on content alignment with the curriculum and coherence of the taught concepts. Meanwhile, the language aspect was evaluated to ensure readability and appropriateness for elementary students' comprehension levels. The design aspect was reviewed to determine whether the materials' visual presentation was engaging, clear, and supportive of students' conceptual understanding.

The first-stage validation results indicated that while the teaching materials were generally good, they required some improvements for optimal use. Language experts suggested simplifying certain sentences for better student comprehension. Design experts recommended adding illustrations to support students' understanding of fraction concepts. Subject matter experts advised incorporating more varied examples by linking fraction concepts to different real-life situations. Based on these inputs, the teaching materials were revised to be more communicative, engaging, and easy for fourth-grade students to understand.

After revisions, the second-stage validation showed an increase in scores across all aspects assessed by the experts. The subject matter aspect scored 87.9, the language aspect scored 84.7, and the design aspect scored 88.6, all categorized as "excellent." These results indicate that the developed RME-based teaching materials meet high validity criteria. Consequently, they were deemed suitable for further trials to assess their effectiveness in improving students' understanding of fraction concepts. A limited trial was conducted as the next step to gather empirical data on the impact of these materials in learning.

The limited trial involved 10 students from two different fourth-grade classes to evaluate the extent to which RME-based teaching materials could enhance their understanding of fraction concepts. Before using the materials, students took a pre-test to measure their initial comprehension of fractions. After learning with the RME-based materials, they took a post-test to assess their learning outcomes. The results showed a significant increase in students' understanding, with average scores improving by 45% to 54%. This improvement suggests that the RME approach helps students comprehend fraction concepts better than conventional teaching methods.

In addition to student trials, this study also gathered teachers' feedback on the practicality and effectiveness of the RME-based teaching materials. Three teachers from SDIT Al-Akhyar Bungo evaluated these materials based on their ease of use in classrooms and their impact on students' comprehension. The questionnaire results showed an average score of 91.3, categorized as "excellent." Teachers found the materials more engaging than conventional textbooks and more effective in helping students understand fraction concepts deeply. They also noted that the materials could be flexibly used according to classroom learning needs.

The main advantage of RME-based teaching materials lies in using real-world contexts as a starting point for learning (Fiangga et al., 2022). Instead of learning fractions merely through symbols and numbers, students relate them to everyday situations such as sharing food, measuring fabric, or comparing object sizes. This approach helps students see fractions as more than just abstract concepts, but as having real-life applications. Consequently, their understanding becomes more concrete, making it easier for them to remember and apply these concepts.

Furthermore, RME-based teaching materials emphasize mathematical modeling as part of the learning strategy (Septian et al., 2019). Students are introduced to various representations of fractions, such as area models, number lines, and tangible objects they can manipulate. This approach allows students to gradually develop their understanding from concrete experiences to abstract concepts. Modeling enables them to comprehend relationships between different fraction representations and apply them in various situations.

Interaction and discussion are also crucial components of RME-based teaching materials (Dinar, 2019). In these materials, students not only learn individually but also through group work, discussions, and explorations with peers. Teachers act as facilitators, guiding students in discovering concepts independently through discussion and reflection. This approach enhances students' deeper understanding while also developing their social skills and critical thinking abilities.

From a design perspective, these teaching materials are designed to be visually appealing to students by incorporating colors, illustrations, and easy-to-read typography. The content is systematically structured with diagrams, visual examples, and graphic elements to clarify concepts. This attractive design aims to increase students' interest in learning and help them focus on understanding the material. With a more interactive presentation, students can enjoy the learning process more and become more motivated to understand fractions (Apriani, 2024).

The exercises in these materials are also designed to be more exploratory and challenging. Students are not only given basic arithmetic problems but also problem-based challenges that require critical thinking and logic. Some problems encourage students to find multiple ways to solve a single question, reinforcing the idea that mathematics offers various approaches to problem-solving. With a diverse range of exercises, students can develop a more flexible understanding of fraction concepts (Mytra & Christi, 2024).

The practicality of these teaching materials is another key factor in their success. Teachers can easily adapt them to various learning models, whether in face-to-face classes or technology-based learning. With this flexibility, RME-based teaching materials can be implemented in different learning conditions, including project-based or problem-based learning (Jufri et al., 2023). Thus, these materials provide teachers with an easier way to deliver lessons in a more engaging and meaningful manner.

Based on this study's findings, it can be concluded that RME-based teaching materials are highly effective in improving students' understanding of fraction concepts. In addition to enhancing conceptual comprehension, these materials encourage students to think more creatively, critically, and actively in the learning process. By using more contextual teaching materials, students become more motivated to learn and gain a better grasp of fraction concepts. Through the RME approach, students explore fractions through direct experiences that closely relate to their daily lives (Sofia, 2024).

However, further research is needed for broader implementation. One aspect that can be further developed is testing the materials on a larger scale to evaluate their effectiveness in different learning conditions. Additionally, adapting the RME concept to other mathematical topics could be the next step in improving elementary school learning quality.

With the various advantages discussed, RME-based teaching materials are expected to serve as a reference for developing mathematics teaching materials at the elementary level. A broader implementation of this approach could positively impact the overall quality of mathematics education and help students understand mathematical concepts more effectively and meaningfully.

CONCLUSION

The teaching material based on Realistic Mathematics Education (RME) has proven effective in enhancing fourth-grade elementary students' understanding of fractions. Expert validation indicates that the material has a high level of validity in terms of content, language, and design. A limited trial involving 10 students showed a 45%-54% improvement in understanding, demonstrating its effectiveness in learning. Additionally, teachers' feedback highlighted that the material is practical and easy to implement in the classroom. The RME approach, which utilizes real-life contexts, helps students grasp fractions more intuitively and applicatively. The use of mathematical models and active interaction in learning also enhances student engagement and motivation. Therefore, RME-based teaching materials can serve as an innovative solution for improving the quality of mathematics education at the elementary level.

Future research should focus on completing the *Disseminate* stage of the 4D model by implementing RME-based teaching materials in a wider range of schools with different accreditation levels to evaluate their broader effectiveness. Additionally, further studies could explore the integration of digital technology into RME-based materials to enhance student engagement and provide more interactive and adaptive learning experiences.

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