

Study on Applying Realistic Mathematics Education Theory in Teaching and Learning Fractions – Grade 4

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ABSTRACT: Realistic Mathematics Education (RME) is an educational theory that emphasizes the close relationship between mathematics and reality. In this perspective, mathematics is not regarded as a system of abstract rules transmitted directly by teachers, but as a human activity constructed by learners through meaningful contexts, modeling, guided reinvention, interaction, and application. Fractions are an important topic in Grade 4 mathematics in Vietnam because they mark students' transition from natural numbers to a new form of number representing part-whole relationships. However, many Grade 4 students still encounter difficulties in understanding the meaning of numerators, denominators, equivalent fractions, comparison of fractions, and operations with fractions. This study proposes the application of Realistic Mathematics Education in teaching fractions for Grade 4 students. Based on theoretical analysis, curriculum requirements, and a survey of primary teachers, the paper presents pedagogical principles and instructional measures for designing fraction lessons according to RME. The proposed approach emphasizes starting from realistic contexts, using visual models to support mathematization, encouraging students to construct solutions, enhancing mathematical interaction, and applying fraction knowledge in new situations. An illustrative example of teaching addition of fractions with the same denominator is provided to clarify the instructional process.

KEYWORDS: Realistic Mathematics Education, RME, fractions, Grade 4, primary mathematics, mathematization.

I. INTRODUCTION

In the Vietnamese primary mathematics curriculum, fractions play an important role in developing students' mathematical thinking. The topic of fractions helps students expand their understanding from natural numbers to rational numbers and provides a foundation for later learning of decimals, ratios, proportions, and other mathematical concepts. In addition, fractions frequently appear in real-life situations such as sharing objects, measuring quantities, comparing parts, dividing work, using materials, and solving everyday problems. Therefore, teaching fractions in Grade 4 is significant not only for helping students acquire mathematical knowledge but also for developing their ability to apply mathematics in practical contexts.

However, in classroom practice, many Grade 4 students still have difficulties when learning fractions. They may confuse the numerator and denominator, fail to understand the relationship between the selected part and the whole, or mechanically apply rules for operations with fractions without understanding their meaning. For example, when adding two fractions with the same denominator, some students may incorrectly add both the numerators and denominators. This indicates that if fraction teaching mainly relies on symbols and computational rules, students may find it difficult to understand the nature of fractions. One reason for these difficulties is that the teaching of fractions sometimes focuses mainly on transmitting knowledge and practicing calculation techniques, while paying insufficient attention to organizing opportunities for students to observe, manipulate, model, discuss, and discover knowledge through meaningful situations. When students are not introduced to fractions through realistic contexts and visual models, they may regard a fraction merely as two natural numbers separated by a line, rather than as a number expressing a relationship between a part and a whole.

The 2018 General Education Curriculum in Vietnam emphasizes the development of students' qualities and competencies. In mathematics, students are expected to develop mathematical thinking and reasoning, mathematical modeling, problem-solving, mathematical communication, and the ability to apply knowledge in real-life situations (Ministry of Education and Training, 2018). This orientation requires innovation in mathematics teaching methods, especially at the primary level, in order to promote students' active participation and connect mathematical knowledge with practical contexts. Realistic Mathematics Education (RME), initiated by Hans Freudenthal in the Netherlands, provides a suitable theoretical foundation for renewing the teaching of fractions in Grade 4. According to Freudenthal (1991), mathematics should be understood as a human activity. Mathematical knowledge should not be presented to students as ready-made rules but should be constructed through solving meaningful problems, using models, interacting with others, generalizing, and applying knowledge back to reality.

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From the RME perspective, learning mathematics should begin with realistic or imaginable situations that are meaningful to learners. These situations create a need for students to use mathematics. Through the process of mathematization, students gradually move from a realistic context to visual models, from models to mathematical symbols, and from symbols to formal concepts and rules. This approach is particularly appropriate for teaching fractions because fractions are abstract for primary students but strongly connected to real-life activities such as sharing, measuring, and comparing parts of a whole.

International studies have shown that RME can support students' understanding of fractions. Warsito et al. (2019) designed fraction learning activities based on RME using contexts such as circles, pizza, and bar models to help students understand fraction values and addition of fractions. Shanty (2023) studied fifth-grade students' learning of multiplication of fractions based on RME and highlighted the role of models such as number lines, ratio tables, and area models in supporting students' mathematization, symbolization, generalization, and formalization.

In Vietnam, several studies have also emphasized the relevance of RME to the orientation of competency-based education. Nguyen et al. (2020) analyzed the development of RME in Vietnam in terms of policies, curriculum, textbooks, assessment, and teacher education. Pham Thi Hai Chau (2021) emphasized the importance of exploiting realistic contexts in primary mathematics teaching, while Luu Tra My (2024) discussed the application of RME principles in teaching Grade 4 mathematics in Vietnam.

Based on the above theoretical and practical background, this paper focuses on applying Realistic Mathematics Education in teaching fractions for Grade 4 students. The paper aims to propose pedagogical principles and instructional measures that help students understand the meaning of fractions, reduce mechanical learning, and develop mathematical competencies through realistic contexts and visual models.

II. CONTENT

A. The Purpose of Applying Realistic Mathematics Education in Teaching Fractions in Grade 4

The purpose of applying Realistic Mathematics Education in teaching fractions in Grade 4 is to organize the teaching and learning process so that students construct fraction knowledge through meaningful contexts rather than passively receiving abstract rules. In traditional teaching, students are often introduced directly to definitions, formulas, and procedures. Although this approach may help students perform calculations, it does not always ensure a deep understanding of the nature of fractions.

By contrast, RME begins with realistic situations that are familiar to students. Through these situations, students recognize the need to use fractions to represent, compare, calculate, and solve problems. For example, when students see a chocolate bar divided into eight equal parts and three parts are shaded, they can understand the fraction $\frac{3}{8}$ as a representation of three parts out of eight equal parts of a whole. Thus, the fraction is not introduced as a purely symbolic object but as a meaningful mathematical representation derived from a realistic situation.

Applying RME in teaching fractions aims to help students understand the part-whole relationship, the meaning of numerators and denominators, equivalent fractions, comparison of fractions, and operations with fractions. It also aims to develop students' mathematical modeling competence, problem-solving competence, reasoning competence, and mathematical communication competence. In this process, the teacher acts as an organizer and guide, while students actively participate in observing, manipulating, discussing, explaining, and generalizing mathematical knowledge.

Furthermore, applying RME helps students realize the relevance of fractions in daily life. Fractions appear in many familiar contexts such as sharing food, measuring ingredients, dividing ribbons, coloring parts of a figure, planning study time, or calculating the remaining part of a task. When students are able to connect fraction knowledge with such contexts, their learning becomes more meaningful and sustainable.

B. The Scientific Basis for Applying RME in Teaching Fractions in Grade 4

The theory of Realistic Mathematics Education was developed from the idea that mathematics is a human activity (Freudenthal, 1991). In this view, students should learn mathematics by doing mathematics. They need to be placed in situations where mathematical ideas arise naturally and where they can gradually reinvent mathematical knowledge under the teacher's guidance.

In RME, a realistic context is not limited to a situation that actually happens in real life. It may also be an imaginable situation that students can understand and consider meaningful. Therefore, in teaching fractions, teachers may use real situations, simulated situations, or reasonable hypothetical situations, as long as they are close to students' experiences and contain clear mathematical potential.

Another important concept in RME is mathematization. Treffers (1987) distinguished between horizontal mathematization and vertical mathematization. Horizontal mathematization refers to the process of transforming a real-life problem into a mathematical representation, such as a drawing, diagram, model, table, or expression. Vertical mathematization refers to the process of developing mathematical ideas further within mathematics, moving from informal representations to formal concepts, rules, and symbols.

In teaching fractions, horizontal mathematization may occur when students transform a situation such as "a wall divided into eight equal parts, three of which have been painted" into a bar model or a fraction $\frac{3}{8}$. Vertical mathematization occurs when students

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use several such models to generalize that when adding fractions with the same denominator, the denominators remain unchanged while the numerators are added.

Visual models play an essential role in this process. According to Gravemeijer (1994), models in RME can develop from “models of” specific situations into “models for” mathematical reasoning. In fraction teaching, a paper strip, a rectangular bar, a circular model, or a number line may first represent a real object such as a cake, a wall, or a ribbon. Gradually, these models become tools for students to reason about fractions, equivalent fractions, comparison, and operations.

The characteristics of Grade 4 students also support the application of RME. Students at this age still need visual support and concrete manipulation to understand abstract mathematical ideas. Fractions require students to shift from thinking about discrete natural numbers to thinking about part-whole relationships. Therefore, teaching fractions through realistic contexts and visual models is consistent with students’ cognitive characteristics and with the orientation of competency-based teaching in the 2018 General Education Curriculum.

A preliminary survey conducted with 30 primary teachers also shows the necessity of applying RME in teaching fractions. The results indicate that teachers are aware of the importance of connecting fraction teaching with realistic contexts. However, many teachers still face difficulties such as a lack of reference materials on RME, limited time for organizing RME-based activities, and a shortage of visual teaching materials. These findings suggest the need to develop clear instructional measures and illustrative examples to support teachers in applying RME effectively in Grade 4 fraction lessons.

C. Principles for Applying RME in Teaching Fractions in Grade 4

1. Using realistic contexts as the starting point of learning

In RME, realistic contexts serve as the starting point for students’ mathematical learning. In teaching fractions, teachers should select or design contexts that are familiar to students, such as sharing cakes, dividing ribbons, coloring parts of a picture, measuring water, preparing materials, or completing a part of a class task. These contexts should not simply decorate the lesson; they must contain mathematical problems that create a genuine need for students to use fractions. For example, a situation in which a class decorates a wall divided into eight equal parts and has completed three parts can help students understand the meaning of $\frac{3}{8}$. If students need to find how much of the wall remains to be decorated, the situation naturally leads to subtraction of fractions.

2. Using visual models to support mathematization

Fractions are abstract for Grade 4 students, so visual models are necessary. Teachers may use paper strips, fraction bars, rectangular models, circular models, number lines, or real objects. These models help students identify the whole, equal parts, the selected part, and the relationship between different fractions. A model must be mathematically accurate. The parts of the same whole must be equal. If the model is unclear or inaccurate, students may misunderstand the meaning of fractions. Therefore, teachers should design models that are simple, visible, and directly related to the mathematical content of the lesson.

3. Encouraging students to construct solutions

RME emphasizes guided reinvention. Students should not merely receive rules from the teacher; they should have opportunities to propose solutions, use models, compare strategies, and explain their reasoning. In fraction lessons, students may solve problems through drawings, paper strips, diagrams, or symbolic calculations. Through discussion and teacher guidance, they gradually move toward formal mathematical knowledge.

4. Strengthening interaction and mathematical communication

Interaction is an important feature of RME. Through interaction, students express their ideas, listen to others, compare different solutions, and adjust their understanding. In teaching fractions, teachers should ask guiding questions such as: What is the whole in this situation? What does the denominator show? Why does the denominator remain unchanged when adding fractions with the same denominator? What does the result mean in the original context? These questions help students go beyond calculation and develop mathematical reasoning and communication.

5. Connecting fraction knowledge with application in new situations

RME emphasizes that mathematics should start from reality and return to reality. Therefore, after students have constructed new fraction knowledge, teachers should provide opportunities for them to apply it in new situations. Such tasks may involve measuring, sharing, calculating the completed part of a task, finding the remaining part, or creating their own realistic fraction problems. This helps students consolidate their knowledge and recognize the value of mathematics in daily life.

D. Instructional Measures for Teaching Fractions Based on RME

Measure 1: Applying RME in designing introductory activities

The introductory activity should be designed to create a cognitive need for students to learn new fraction knowledge. Instead of beginning the lesson by announcing a rule, the teacher introduces a realistic situation that contains a mathematical problem. Students observe, discuss, predict, and propose initial solutions. When their existing knowledge is insufficient, the teacher guides them toward the new lesson. For example, in a lesson on equivalent fractions, the teacher may present a situation in which two cakes of the same size are shared by two groups. The first cake is divided into two equal parts and one part is eaten. The second cake is divided into

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four equal parts and two parts are eaten. Students discuss whether the two groups have eaten the same amount of cake. This situation creates a need to learn about equivalent fractions.

Measure 2: Using visual models in forming new knowledge

Visual models should be used not only for illustration but as tools for students to explore and construct knowledge. In teaching fractions, models help students see the whole, equal parts, and the selected parts. They also support students in understanding operations with fractions. For example, when teaching addition of fractions with the same denominator, the teacher may use a chocolate bar divided into eight equal parts. Students first shade three parts, then shade two more parts. By counting the total number of shaded parts, students recognize that $\frac{3}{8} + \frac{2}{8} = \frac{5}{8}$. From several similar examples, students generalize that to add two fractions with the same denominator, they add the numerators and keep the denominator unchanged.

Measure 3: Designing realistic exercises and questions

Exercises and questions should not only require students to calculate but also encourage them to analyze situations, choose appropriate operations, explain results, and connect answers with reality. Teachers can design exercises involving familiar contexts such as preparing orange juice, dividing study time, transporting goods, taking care of a school garden, or decorating the classroom. For example, a problem may state: “To make a glass of orange juice, An pours $\frac{1}{4}$ cup of orange concentrate and $\frac{1}{2}$ cup of water into a jug. What fraction of a cup is the mixture in total?” This problem requires students to add fractions with different denominators and interpret the result in a real context.

E. An Illustrative Example of Implementation

Lesson: Addition of Fractions with the Same Denominator – Grade 4

The following example illustrates how the RME-based teaching process can be applied to the lesson “Addition of Fractions with the Same Denominator” in Grade 4. This content is selected because it is a fundamental topic in the fraction strand and often causes difficulties for students if it is taught only through formal rules. Some students may mechanically add both numerators and denominators, for example writing $\frac{3}{8} + \frac{2}{8} = \frac{5}{16}$. Therefore, it is necessary to organize the lesson in a way that helps students understand the meaning of the operation before formalizing the rule.

Objectives:

After the lesson, students are expected to understand the meaning of adding two fractions with the same denominator through a realistic context and a visual model. They are able to perform addition of fractions with the same denominator and explain why the denominator remains unchanged. In addition, students are expected to develop mathematical modeling competence, reasoning competence, mathematical communication competence, and the ability to apply fraction knowledge to familiar situations.

Step 1. Starting from a realistic situation

The teacher presents the following situation:

During a class activity, the teacher gives a group of students a chocolate bar divided into eight equal parts. At first, the students eat 3 parts of the chocolate bar. After that, they eat 2 more parts. The teacher asks: “How many parts of the chocolate bar have the students eaten altogether?”

The teacher may use a real chocolate bar model, a picture, or a paper strip representing the chocolate bar. Students are asked to observe the situation and answer guiding questions such as:

What is the whole in this situation?

Into how many equal parts is the chocolate bar divided?

How many parts were eaten at first?

How many more parts were eaten later?

What do we need to find?

This situation is familiar and easy for Grade 4 students to imagine. More importantly, it contains a clear mathematical problem: students need to combine two parts of the same whole. Thus, the realistic context is not used merely as an illustration but as the starting point for mathematical thinking.

Step 2. Initial modeling – Horizontal mathematization

After students understand the situation, the teacher gives each group a paper strip divided into eight equal parts. Students shade 3 parts to represent the amount eaten at first, then shade 2 more parts in another color to represent the amount eaten later.

Through this activity, students transform the real-life situation into a mathematical model. The chocolate bar becomes a paper strip, the eaten parts are represented by shaded parts, and the problem is gradually expressed in mathematical language:

The whole chocolate bar is divided into 8 equal parts.

The first amount eaten is $\frac{3}{8}$.

The second amount eaten is $\frac{2}{8}$.

The total amount eaten is the number of shaded parts out of 8 equal parts.

At this stage, students are not asked to memorize a rule. Instead, they use a model to represent the situation and begin to recognize the relationship between the context and the fraction expression. This is the stage of horizontal mathematization, in which students

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move from a realistic situation to a visual mathematical representation.

Step 3. Guided reinvention – Vertical mathematization

The teacher asks students to observe the shaded paper strip and discuss the following questions:

How many parts are shaded altogether?

Does the whole chocolate bar change?

Is the chocolate bar still divided into 8 equal parts?

Why do we count 5 parts out of 8 parts?

Through group discussion, students realize that there are 5 shaded parts altogether. The whole has not changed, and the chocolate bar is still divided into 8 equal parts. Therefore, the total amount eaten is $\frac{5}{8}$ of the chocolate bar.

The teacher then guides students to express the result using a mathematical calculation:

$$\frac{3}{8} + \frac{2}{8} = \frac{5}{8}$$

At this stage, students begin to move from the visual model to a more formal mathematical expression. They recognize that when two fractions have the same denominator, the denominator shows the way the whole is divided. Since the whole is still divided into 8 equal parts, the denominator remains 8. Only the number of selected parts changes, so the numerators are added.

This process reflects guided reinvention in RME. The teacher does not give the rule immediately. Instead, students are guided to discover the rule through observation, manipulation, discussion, and reasoning.

Step 4. Generalization and formalization of knowledge

After students have explained the result based on the model, the teacher asks them to state the rule in their own words. Some students may say: “We add the shaded parts together, but the total number of equal parts of the whole stays the same.”

The teacher then helps students formalize the rule:

To add two fractions with the same denominator, we add the numerators and keep the denominator unchanged.

For example:

$$\frac{3}{8} + \frac{2}{8} = \frac{(3 + 2)}{8} = \frac{5}{8}$$

The teacher emphasizes that this rule is not simply a procedure to remember. It comes from the meaning of the model: the whole is divided in the same way, so the denominator does not change. What changes is the number of parts being selected or combined.

Step 5. Application in new situations

To help students apply the learned knowledge, the teacher gives several new problems connected with familiar contexts.

Problem 1: A class decorates a wall divided into 8 equal parts. In the morning, students decorate $\frac{3}{8}$ of the wall. In the afternoon, they decorate $\frac{2}{8}$ more. What fraction of the wall has been decorated?

Problem 2: Mai reads $\frac{4}{10}$ of a book on Monday and $\frac{3}{10}$ of the book on Tuesday. What fraction of the book has she read in total?

Problem 3: Create your own real-life problem involving addition of two fractions with the same denominator. Draw a model and explain your solution.

In these tasks, students are required not only to calculate but also to interpret the result in the original context. For example, in Problem 1, the answer $\frac{5}{8}$ means that 5 out of 8 equal parts of the wall have been decorated. This helps students connect the symbolic calculation with its real meaning.

Analysis of the Illustrative Example

The example above shows the five main phases of an RME-based learning process: starting from a realistic situation, initial modeling, guided reinvention, formalization, and application. The lesson begins with a familiar context, a chocolate bar divided into equal parts. This context is appropriate for primary students because it is simple, easy to visualize, and directly related to the part-whole meaning of fractions. It also creates a natural need for students to use addition of fractions: they need to find the total number of parts eaten.

The paper strip model plays an important role in the process of mathematization. At first, the model represents the chocolate bar in the situation. Students use it to shade, count, and compare parts. Gradually, the model becomes a tool for mathematical reasoning. Through the model, students can see that $\frac{3}{8}$ and $\frac{2}{8}$ refer to the same whole and the same division of that whole. This helps them understand why the denominator remains unchanged when adding two fractions with the same denominator.

The example also reflects the principle of guided reinvention. Students are not given the formal rule at the beginning of the lesson. Instead, they are encouraged to observe the model, discuss with classmates, explain their reasoning, and discover the rule under the teacher's guidance. This process helps students build conceptual understanding rather than only memorizing a procedure.

In addition, the example supports the development of mathematical communication. Students have opportunities to answer questions, describe the whole, explain the meaning of the numerator and denominator, and interpret the result in the original context. These activities help students express mathematical ideas more clearly and strengthen their reasoning.

The application tasks at the end of the lesson show that fraction knowledge can be transferred to new situations. Students apply the same mathematical idea to contexts such as decorating a wall or reading a book. This is consistent with the spirit of RME, in which mathematics begins from reality and returns to reality. Through this process, students understand that adding fractions is not only a

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calculation in the textbook but also a useful tool for solving familiar problems in daily life.

Overall, the example demonstrates that teaching addition of fractions with the same denominator according to RME can help Grade 4 students understand both the procedure and the meaning of the procedure. The realistic context, visual model, guided discussion, formalization, and application are closely connected, forming a coherent learning process that supports students' conceptual understanding and mathematical competence development.

F. Some Pedagogical Considerations in Implementing the Approach

In applying RME to teaching fractions in Grade 4, several pedagogical issues should be considered. Realistic contexts need to be familiar to students and directly connected to the mathematical content of the lesson. For fraction teaching, a suitable context should make clear what the whole is, how it is divided into equal parts, and why fractions are needed to solve the problem. Contexts such as sharing objects, measuring ribbons, coloring parts of a figure, or finding the remaining part of a task are useful only when they lead students to model and reason mathematically.

Visual models should also be used with care. Paper strips, fraction bars, rectangular models, circular models, and diagrams can help students move from a real situation to mathematical symbols. However, these models must be accurate: the whole must be clearly identified and the parts must be equal. Otherwise, students may misunderstand the meaning of the numerator, denominator, or the operation being learned.

Teachers should give students enough time to observe the situation, manipulate models, discuss their ideas, and explain their reasoning before formal rules are introduced. For example, when learning addition of fractions with the same denominator, students should first see that the whole is divided in the same way and only the number of selected parts changes. From this, the rule becomes more meaningful rather than something to memorize.

Classroom interaction is also important. Students should be encouraged to explain what a fraction represents, why a model is appropriate, and what the result means in the original context. This helps them connect the realistic situation, the visual model, and the mathematical expression. Since teachers may face limitations in lesson time and teaching materials, RME-based activities should be simple, focused, and closely related to the lesson objectives. Reusable models such as paper strips, fraction bars, and diagrams can make the approach more practical in Grade 4 classrooms.

III. CONCLUSIONS

The study shows that Realistic Mathematics Education is a relevant and feasible theoretical orientation for teaching fractions in Grade 4. Fractions are one of the first mathematical topics in which primary students move beyond natural numbers and begin to work with part-whole relationships. For this reason, teaching fractions only through symbols, definitions, and calculation rules may lead to mechanical learning. RME offers a more meaningful approach by helping students begin with familiar contexts, represent those contexts through visual models, gradually construct mathematical ideas, and apply the learned knowledge to new situations. Based on the analysis of the Grade 4 fraction content and the characteristics of primary students, this paper proposes several principles and instructional measures for applying RME in fraction teaching. These include selecting realistic contexts as the starting point of learning, using visual models to support mathematization, encouraging students to construct and explain their own solutions, strengthening interaction in the classroom, and connecting fraction knowledge with practical applications. These principles are closely related to the requirements of competency-based mathematics education, especially the development of mathematical modeling, reasoning, communication, problem-solving, and application competencies.

The illustrative lesson on addition of fractions with the same denominator demonstrates how the RME process can be organized in a Grade 4 classroom. Through the use of a familiar situation, a visual model, guided discussion, and formalization of the rule, students are supported in understanding why the numerators are added while the denominator remains unchanged. This example suggests that RME can help students understand not only how to perform fraction operations, but also why these operations are mathematically meaningful.

The findings also indicate that the successful application of RME requires careful instructional preparation. Realistic contexts must be appropriate, mathematically focused, and connected to students' experiences. Visual models need to be accurate and easy to manipulate. Teachers should guide students gradually from informal reasoning to formal mathematical knowledge, while ensuring that classroom activities remain manageable within lesson time.

In conclusion, applying RME in teaching fractions in Grade 4 can contribute to improving students' conceptual understanding, reducing rote learning, and enhancing their ability to use mathematics in real-life contexts. Future studies may develop a more complete system of RME-based lesson plans for different fraction topics, conduct classroom experiments with larger student samples, and evaluate the impact of this approach on students' mathematical understanding, learning motivation, and competency development.

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