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Original Research Article

Developing Mathematical Modeling Competency for Elementary Students through Teaching the Topic of "Fractions"

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Abstract: Mathematical modeling competence plays a crucial role in the development of mathematical thinking and problem-solving skills for elementary students. This study explores the theoretical foundations of competence, the framework of mathematical modeling competence, and the significance of the topic "Fractions" in fostering students' mathematical abilities. The research presents a structured approach to developing mathematical modeling competence in elementary students through the teaching of fractions, outlining key stages in the model-building process. Additionally, the study provides illustrative examples that demonstrate the practical application of the proposed framework. The findings contribute to enhancing teaching strategies that promote mathematical reasoning and problem-solving skills in elementary education.

Keywords: mathematical modeling competence, elementary education, fractions, problem-solving, mathematical thinking.

I. INTRODUCTION

Mathematics is a fundamental science with many applications in real life. One of the important goals of Mathematics is: "To form and develop mathematical competencies, which include the following core components: the ability to think and reason mathematically; the ability to model mathematically; the ability to solve mathematical problems; the ability to communicate mathematically; the ability to use tools and resources for learning mathematics" (Ministry of Education and Training, 2018). Among these, the ability to model mathematically is one of the important specific competencies in Mathematics that needs to be formed and developed in each student. In teaching, to develop the modeling ability for students, one needs to know how to "translate" and describe situations (with mathematical significance) posed in various real-world problems into a suitable mathematical problem or model, find ways to solve the mathematical problems within the established model, and then compare and address the posed real-world issues (Ministry of Education and Training, 2018). However, in actual teaching practice, teachers generally do not fully understand the competencies, nor are they clear about the methods and objectives needed to develop the modeling ability in particular and competencies in general for students.

The topic of fractions is a new content area for fourth-grade students; therefore, guiding students on how to translate situations into mathematical operations, rules, and formulas to solve problems is very important. In this article, we clarify some theoretical issues regarding competencies, mathematical modeling abilities, some modeling processes, and the application of modeling processes in teaching the topic of fractions in fourth grade to develop students' mathematical modeling abilities.

II. THEORETICAL BASIS

2.1. Theoretical Framework on Competence and Mathematical Modeling

Competence is "understood in a broad sense as the psychological characteristics of an individual that regulate their behavior and are the living conditions of the individual" (Philosophical Dictionary, 1986). Competence (NL) is a set of psychological traits or qualities of an individual that serve as internal conditions, facilitating the effective execution of a specific type of activity (Vu Dung, 2000). Competence is "the ability that is formed and developed, allowing individuals to achieve success in a physical, intellectual, or professional activity. Competence is manifested in the ability to perform an activity and carry out a task" (Bui Hien, 2000). "Competence is a personal attribute formed and developed through inherent qualities and the process of learning and training, enabling individuals to mobilize a combination of knowledge, skills, and other personal attributes such as interest, belief, willpower... to

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successfully perform a specific activity and achieve desired results under specific conditions" (Ministry of Education and Training, 2018).

Mathematical competence is a specific type of competence closely related to the subject of mathematics. There are various definitions of mathematical competence. The National Council of Teachers of Mathematics (NCTM) describes it as: "Mathematical competence is the way of grasping and using mathematical knowledge content" (National Council of Teachers of Mathematics, 2000). According to Blomhøj & Jensen (2007): "Mathematical competence is the readiness to act in response to mathematical challenges in specific situations."

The Southeast Asia Primary Learning Metric (SEA-PLM, 1991) program has defined mathematical competence as follows: "An individual's mathematical competence is understood as the ability of a person, when faced with a problem that is relevant or significant to them, to understand the problem and translate it into an appropriate mathematical formula, apply knowledge and skills in the field of mathematics to find solutions, and interpret mathematical results in relation to the context while considering the value or limitations of those results."

Thus, it can be understood that: *"Mathematical Literacy (ML) is the ability to mobilize knowledge, skills, and personal attributes to successfully solve mathematical and practical problems."*

Mathematical modeling: According to Barreto (2010), mathematical modeling (MM) is an abstract model that uses mathematical language such as graphs, equations, functions, symbols, etc., to represent and describe the characteristics of an object, phenomenon, or real subject being studied. Edwards and Hamson (2001) argue that MM is a process of transforming real-world problems into mathematical problems by establishing mathematical models, then solving, presenting, and evaluating the solutions in a real-world context, improving the model if necessary. According to Nguyen Danh Nam (2016), mathematical modeling encompasses the entire process of converting real-world problems into mathematical problems and vice versa, starting from reconstructing the real situation, selecting an appropriate mathematical model, working within a mathematical environment, interpreting and evaluating results related to the real situation, and sometimes needing to adjust the models, repeating the process multiple times until a reasonable result is achieved.

From the above perspectives, we believe that "*mathematical modeling is the process of transforming real-world problems into mathematical form and vice versa through the establishment of mathematical models (such as operations, drawings, tables, functions, graphs, equations, systems of equations, diagrams, charts, symbols, etc.) and solving those problems. In this process, the cognitive operations may be repeated multiple times, adjusting the models until a reasonable result is achieved*." Mathematical modeling allows students to connect school mathematics with the real world, highlighting the applicability of mathematical ideas. Modeling provides students with a broader and richer picture of mathematics, facilitating the transmission of mathematical information more easily and helping students see the relationship between mathematics and reality, and vice versa.

Mathematical modeling competency: There are many research works on mathematical modeling competency (MMC), and here are some perspectives from notable authors: Henning and Keune (2004) argue that "*MMC is a combination of the attributes of the individual learner, such as knowledge, skills, attitudes, and the willingness to engage in mathematical modeling activities to ensure that these activities are effective."* According to Blomhoj and Jensen (2007), MMC is the ability to fully carry out all stages of the mathematical modeling process in a given situation. Nguyen Danh Nam (2016) states that MMC is considered the readiness of an individual to perform all parts of the mathematical modeling process in a specific situation.

Mathematical modeling process: Many studies have proposed the MM process, which is primarily represented through steps and stages that connect practical situations with mathematics through models. The MM process by Blum and Leiss (2007) consists of 7 steps: - Step 1: Understand the given real-world situation, build a model for that situation, explore the situation, and establish the problem's objectives; - Step 2: Simplify the situation and introduce appropriate variables to obtain the actual model of the situation, identify the variables in the situation, and select the important variables that describe the situation; - Step 3: Transition from the real model to the mathematical model, establish the model by creating and selecting geometric representations, tables, statistics, and diagrams that describe the relationships between the variables; - Step 4: Work within the mathematical environment to achieve mathematical results, analyze and express relationships to draw conclusions; if the model has not been established, reselect the variables used; - Step 5: Interpret (understand) the results in the context of reality; - Step 6: Review the validity of the results or conduct a second iteration; - Step 7: Apply the model to similar situations. The MM process by Swetz & Hatler (1991) consists of 4 stages: - Stage 1: Model the real-world simulation: Select and identify the important factors and data of the real-world problem and their relationships; - Stage 2: Establish the mathematical model: Create a mathematical model that describes the initial situation, meaning using mathematical language to represent the relationships between the factors identified in step 1; - Stage 3: Solve the mathematical problem established in step 2: Use appropriate mathematical tools

to address the mathematical issue in the established model; - Stage 4: Compare and test the results in reality: Examine the rationality and relevance of the results just found in the context of reality and draw conclusions.

2.2. The Role of Teaching the Topic of Fractions in Developing Mathematical Modeling Skills

Teaching the topic of fractions plays an important role in developing mathematical modeling skills for elementary school students, as fractions are not only a fundamental mathematical concept but also the foundation for many other mathematical knowledge and skills, particularly abstract thinking and modeling abilities.

First, mathematical modeling skills require students to identify, analyze, and use mathematical elements to solve real-world problems. The topic of fractions, with its high applicability in everyday life such as measurement, resource sharing, or data analysis, helps students form a connection between mathematics and reality. According to NCTM (2000), mathematical modeling skills encompass not only building models but also the ability to analyze, adjust, and evaluate the reasonableness of those models. The topic of fractions provides opportunities for students to practice these skills through real-world problems such as "dividing a cake" or "analyzing ratios."

Second, teaching fractions in an active manner, using methods such as project-based learning, group activities, or technology applications, creates opportunities for students to develop teamwork skills, mathematical communication, and analysis. Research by Cai & Lester (2005) indicates that learning fractions through real-life situations not only improves mathematical abilities but also enhances students' creativity in constructing and validating models.

Finally, the topic of fractions helps students form concepts of abstraction and relativity—essential elements in mathematical modeling. For example, students can understand that 1/2 is not just a number but also a model representing division, ratios, or units of measurement.

In summary, teaching the topic of fractions is a crucial foundation for developing mathematical modeling skills in elementary school students. When combined with active teaching methods and real-world situations, it will promote students' thinking, creativity, and application of mathematics.

III. RESEARCH METHOD

The study was conducted with a sample of 115 third-grade students from Vinh University Practice School. A quantitative research method was used to evaluate the effectiveness of teaching the topic of "Fractions" in developing students' mathematical modeling abilities.

We developed a mathematical modeling process for teaching the topic of fractions to third-grade students, consisting of four steps. Based on this, we created examples for teaching and assessing the level of student development.

Data were collected through Likert scales designed to measure students' mathematical modeling abilities based on specific criteria, including the ability to identify real-world problems, construct mathematical models, and verify solutions. The Likert scale was constructed on a range from "Very Poor" to "Excellent," facilitating a detailed assessment of student progress.

IV. RESEARCH RESULTS

4.1. The MHHTH Process in Teaching Mathematics in Primary Schools

Based on the processes of the aforementioned authors, we have developed the MM process for teaching mathematics in primary schools, consisting of 4 steps:

Step 1: Construct real-life situations, simplifying real-life situations into mathematical situations;

Step 2: Use mathematical tools and language to express real-life content as mathematical models;

Step 3: Utilize mathematical models to solve problems;

Step 4: Evaluate mathematical results in context.

Manifestation of Modeling Competence in Teaching the Topic of Fractions in Primary School.

For primary school students, teachers can view mathematical modeling as a guide and a means to assist students who encounter difficulties during problem-solving. Summarizing the problem is also a form of modeling, helping students find solutions more easily. The mathematical modeling competence in primary education is specifically manifested through various criteria, indicators, and requirements outlined in the following table:

Components of mathematical competence	**Criteria, indicators**	**Requirements to be met**
Mathematical modeling capability	Demonstrated through the execution of actions: - Using mathematical models (operations, formulas, equations, tables, graphs, etc.) to describe situations presented in real-world problems.	- Select appropriate operations, arithmetic formulas, diagrams, tables, and drawings to present and express (verbally or in writing) the contents and ideas of the situations arising in simple practical problems.

	- Solving mathematical issues within the established model. - Presenting and evaluating solutions in a real-world context and improving the model if the solution approach is not suitable.	- Solve the problems that arise from the above selection. - Provide answers to the situations presented in the practical problems.

From the concepts of mathematical modeling competence and the criteria, indicators; the requirements for achieving MM competence as stipulated in the 2018 General Education Program, we believe that MM competence manifested in teaching the topic of "fractions" in elementary school includes:

+ Describing real-life problems in the form of mathematical language;
+ Using diagrams and drawings to represent objects as equal parts, taking a part from a total of b parts represented by the fraction a/b;
+ Using diagrams and operations to represent situations in the form of calculations, formulas, and properties of fractions;
+ Stating answers and solving mathematical problems within established fraction models;
+ Evaluating solutions and results in real-life contexts.

4.2. Applying the mathematical modeling process in teaching the topic of "fractions" in elementary school

Step 1: Constructing situations linked to reality, simplifying real-life situations into mathematical situations

Mathematics originates from reality and then applies mathematical knowledge to solve real-life problems; therefore, teachers need to research and develop problems based on real-life situations that can exploit various models and then guide students to transition from real-life situations to mathematical situations, specifically:

+ Teachers guide students to read and clarify the meaning of the text, objects, images, and tasks to be solved… to understand the situation;
+ Teachers guide students to simplify the problem by focusing on important content related to mathematical knowledge and expressing it in mathematical language.

Step 2: Use tools and mathematical language to express practical content as mathematical models.

The teacher guides students on how to choose mathematical models to represent situations; the teacher assists students in constructing models, drawings, tables, diagrams, calculations, etc., to accurately represent real-world models. At this stage, the teacher requires students to produce a summary, simulation, or sketch, helping them demonstrate their ability to use symbols, drawings, diagrams, charts, tables, etc. It is essential to maximize students' creativity, allowing them to express the practical situation in various ways and represent it with different models. The teacher should prepare prompts to help students feel less confused with this type of task and enable them to engage effectively.

Step 3: Use mathematical models to solve problems.

In the situations that have been developed into mathematical models, the teacher guides students to rely on the model, connect, transform, and apply relevant knowledge to solve problems and complete tasks. This helps students see that using mathematical models is an inseparable part of mathematics. The teacher needs to cultivate the skill of using models in all stages of the learning process: in exploration, practice, application, review, knowledge systematization, and in solving math problems, etc.

Step 4: Evaluate mathematical results in real-world contexts.

This is the final but very important step of the process: understanding the solution to the problem in practice and reconsidering the model (or accepting the model), rephrasing the original problem (or reporting the results), and exploring the limitations and difficulties encountered when applying the results of the problem to real-world situations. This step helps students develop the skill of translating mathematical results into practical outcomes and reflecting on the limitations.

4.3. Some illustrative examples of applying the mathematical modeling process in teaching the topic of fractions in elementary school

Example 1: During the experience of making mooncakes, an made 3 square mooncakes of the same size but with different flavors. An eagerly brought them home and shared the mooncakes equally among 4 family members so that everyone could enjoy all the flavors. Please help an describe the ways to share the mooncakes and indicate how many pieces of each mooncake each family member receives.

Step 1: Build situations connected to reality, simplifying real-life situations into mathematical situations

From the real-life situation constructed above, the teacher guides students to carefully examine the problem, focusing on the information related to mathematics to clarify the data provided in the problem and the tasks to be performed.

Mathematical data given in the problem: There are 3 mooncakes, shared equally among 4 people.

Tasks to be performed: Describe the ways to share the mooncakes; How many pieces of each mooncake does each person get?

Step 2: Use mathematical tools and language to express real-life content as mathematical models

The teacher guides students to choose materials to simulate the mooncake: paper, cardboard... in square shape.

The teacher guides students on how to share the mooncakes on the model to ensure that the 3 mooncakes are shared equally among 4 people.

The teacher divides the class into groups, guiding students to create 3 squares to represent the 3 mooncakes, with each square divided into 4 equal parts, encouraging students to find different ways to share, where each group can either share all three mooncakes in the same way or share the 3 mooncakes in 3 different ways.

Step 3: Use a mathematical model to solve the problem

From the division model above, each cake is shared among 4 people, with each person receiving $\frac{1}{4}$ of each cake.

Thus, for each cake, each person receives $\frac{1}{4}$ of the cake. Since there are 3 cakes, the total amount of cake each person receives is:: $\frac{1}{4} + \frac{1}{4} + \frac{1}{4} = \frac{3}{4}$ of the cake.

Step 4: Evaluate the mathematical result in a real-world context

After the students have built the model and found the solution to the problem, the teacher guides them to compare the result with the requirements of the problem statement and the appropriateness of the result in practice. According to the problem's requirements, an wants all four family members to enjoy different flavors of the cake. With the division method described, each cake is evenly shared among the 4 people, so everyone gets to enjoy 3 different flavors. All three cakes are completely shared among the 4 people, with each person receiving an equal portion of $\frac{3}{4}$ of the cake. He way of dividing the candy as above is appropriate to reality and easy to implement.

Example 2. Mother has a bag of candy; she gives you $\frac{1}{3}$ of the total candy in the bag and gives your brother $\frac{1}{4}$ of the total candy in the bag. Please represent the amount of candy each person receives through a model to compare who received more candy from mother.

Step 1: Build situations linked to reality, simplifying real-life situations into mathematical situations.

From the above real-life situation, the teacher needs to guide the students to read the problem carefully, identify the given data, and the requirements to be fulfilled. Bring it back to mathematical elements.

Students state: Given data: younger sister: $\frac{1}{3}$ of the total candy in the bag

Brother: $\frac{1}{4}$ of the total candy in the bag

The requirement is: to represent the amount of candy through a model and compare.

Step 2: Use mathematical tools and language to express real-life content into mathematical models.

The teacher guides students to choose ways to create models that describe the situation, which may include drawing, cutting shapes, creating tables, etc. The teacher encourages students to express their ideas about the models to be established and to represent the model such that for the brother: each bag of candy is divided into 4 equal parts, and then 1 part is taken from the total of 4 parts, and for you: the bag of candy is divided into 3 equal parts, and then 1 part is taken from the total of 3 parts; the amount taken by you and your brother can be compared.

Step 3: Use mathematical models to solve problems

From the established models, the teacher asks students to compare and articulate their reasoning for the different comparison methods. Groups present their models and explain their comparison methods.

From the above models, students will conclude that $\frac{1}{3}$ > and the teacher guides them to comment on the characteristics of the two fractions (same numerator, different denominators) and derive the rule for comparing two fractions with different denominators.

Step 4: Evaluate mathematical results in real-life contexts

The teacher asks students to review the proposed models, identifying which model clearly illustrates the comparison of the fractions $\frac{1}{3}$ và $\frac{1}{4}$; In the models, methods such as dividing using a number line, paper strips, and pie charts will easily allow for the comparison of parts belonging to "you" and "him." The method of describing the number of candies in groups, as in the fourth method, may not be clearly represented in the model, but in practice, if one manipulates a set of candies, the comparison as described in the fourth method will also clearly show the results of comparing $\frac{1}{3}$ and $\frac{1}{4}$.

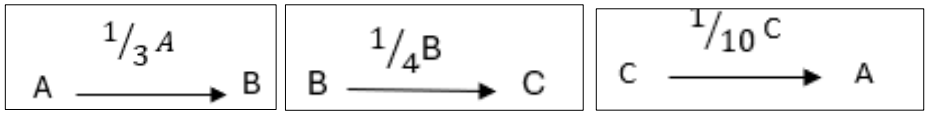
Example 3: Nam has 3 containers with a total of 54 liters of water, but the amount of water in each container is not equal. Nam wants the amount of water in each container to be equal, so he does the following: first, Nam $\frac{1}{3}$ liters of water from container A into container B, then $\frac{1}{4}$ sliters of water from container B into container C, and finally $\frac{1}{10}$ liters of water from container C back into

container A. After these three pours, the amount of water in the three containers is equal. Can you find out how many liters of water each container had initially and how Nam performed the pouring?

Step 1: Create real-life scenarios, simplifying real-life situations into mathematical problems

From the real-life scenario constructed above, the teacher guides students to thoroughly understand the problem, focusing on clarifying the important content of the given problem, including:

+ The process of pouring water from one container to another:



The total amount of water in the 3 buckets remains unchanged after pouring from one bucket to another. After pouring, the three buckets have equal amounts of water, so the amount of water in each bucket afterward can be calculated as: 54: 3 = 18 (liters).

Task: + Calculate the initial amount of water in each bucket

+ Restate the method of pouring that Nam performed

Step 2: Use mathematical tools and language to express practical content as mathematical models.

This problem is quite complex, so the teacher guides the students to simplify and clarify the content of the problem into the following summary table:

Instance	Transfer	Result after transfer
1	A → B	$A_1 = A - \frac{1}{3}A = \frac{2}{3}A$ (1) $B_1 = B + \frac{1}{3}A$ (2)
2	B_1 → C	$B_2 = B_1 - \frac{1}{4}B_1 = \frac{3}{4}B_1 = 18$lít (3) $C_1 = C + \frac{1}{4}B_1$ (4)
3	C_1 → A_1	$A_2 = A_1 + \frac{1}{10}C_1 = 18$lít (5) $C_2 = C_1 - \frac{1}{10}C_1 = \frac{9}{10}C_1 = 18$ lít (6)

Step 3: Use a mathematical model to solve the problem

From the table above, students will calculate the data in reverse order from the end up.

From (6), we find C1= 18: $\frac{9}{10}$ = 20 (liters)

From (5): A1=18 - $\frac{1}{10}$ C1= 18- 20x$\frac{1}{10}$ = 16(liters)

From (1): A= A1: $\frac{2}{3}$ =16: $\frac{2}{3}$ = 24 (liters)

From (3): B1= 18: $\frac{3}{4}$= 24 (liters)

From (2): B = B1- $\frac{1}{3}$A = 24 - $\frac{1}{3}$x24 = 18 (liters)

From (4): C = C1- $\frac{1}{4}$ B_1 = 20 - $\frac{1}{4}$ x 24 = 14 (liters)

After deriving the results based on the table, the teacher guides the students to write the solution and present the detailed steps to find the initial amount of water in each container and the amount of water Nam poured each time.

Step 4: Evaluate the mathematical results in a real-world context

The teacher asks the students to verify the established model, checking the results obtained against the information provided in the problem. Are the initial amounts of water in the three containers equal? Describe the method Nam used to pour the water to achieve three containers with equal amounts of water, and illustrate that pouring method.

4.4. DISCUSSION

The results of the pilot implementation of the teaching topic "Fractions" for 115 third-grade students at Vinh University Practice School have confirmed the effectiveness of using active teaching methods to develop mathematical modeling skills. Through Likert scales, most students achieved good results, showing significant progress in their ability to identify real-world problems, construct, and validate mathematical models.

An important factor contributing to this success is the integration of real-life problems into the teaching content. Problems such as "dividing a cake evenly" or "analyzing ratios" have helped students connect mathematics with everyday life while also developing abstract thinking. This aligns with the research of Cai & Lester (2005), which asserts that learning mathematics through real-life situations will enhance students' modeling abilities and creativity.

However, the implementation process also posed some challenges. Some students struggled with transitioning between real-world problems and mathematical models. This indicates a need for additional time to guide students in analyzing and simplifying complex issues.

Overall, the teaching of the topic "Fractions" has yielded positive results, laying the groundwork for broader application in the primary education curriculum.

V. CONCLUSION

Elementary students, with their concrete visual thinking, still dominate, and constructing problems based on real-life situations while guiding students to build mathematical models through the four steps mentioned above helps them develop clear representations of mathematical content. Additionally, it helps them understand the relationship between mathematics and reality. Teaching that develops modeling skills not only enhances their modeling abilities but also fosters cognitive operations and creativity, meeting the educational goals of developing competencies according to the current 2018 General Education Program.

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