Riemann: *Research of Mathematics and Mathematics Education*
Volume 8, Issue 1, 429-442, April 2026
e-ISSN: 2721-883X|p-ISSN: 2721-8848
https://journal.sanagustin.ac.id/index.php/reimann

Analysis of Junior High School Students' Multiple Mathematical Representation (MMR) Ability in Solving Fraction Problems

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Received: February 2026 | Revised: March 2026 | Accepted: April 2026 | Published: April 2026

***Abstract*:**
This study aims to analyze the multiple representations of mathematics (MMR) of junior high school students with high, medium, and low abilities in solving fraction problems. This study uses a descriptive qualitative method. The subjects of this study were 6 students taken from 32 seventh-grade students of SMP Negeri 2 Sukodadi. The research instrument consisted of a problem-solving test and a semi-structured interview guide (task-based) that refers to the aspects of multiple representations, namely (1) symbolizing; (2) describing (visually, verbally, and symbolically); and (3) referring to the answer. Data were analyzed through data condensation, data presentation, and drawing conclusions, with time triangulation to ensure the validity of the findings. The results of the study show that, based on student scores and data obtained, students are in the high category; there are 11 students (34.375%), with an average score of 100. There are 10 students in the medium category (31.25%), with an average score of 62.5. And 11 students in the low category (34.375%), with an average score below 50. Based on the multiple representations used, 12.5% of students in the high category meet all indicators of multiple representations. 12.5% of students in the medium category meet 3 indicators, with 2 representations. 75% of students in the low category only meet 1 indicator (describing visually/verbally). These findings indicate the need for us to achieve success in solving mathematical problems.

Keywords: Multiple Representations of Mathematics (MMR), Problem Solving.

Introduction

Representation is one of the process skills required in mathematics learning. Kalathil & Sherin (2000) argue that representation is everything students do to represent and demonstrate their work. The ability to represent problems mathematically plays a crucial role for students in the mathematics learning process, as it helps them understand and apply mathematical ideas when solving various challenges (Sari et al., 2023). According to Goldin (1996), to organize and make situations more meaningful, individuals can use representations. These representations can be in the form of pictures, diagrams, graphs, or other forms of representation that teachers and students can use during learning. Arianti (2021) states that good mathematical representation skills build a strong foundation for students in

facing more complex problems in the future. This study indicates that the use of various representations is very important in mathematics learning.

The use of multiple representations in mathematics learning is crucial to helping students build mathematical understanding and achieve success in solving mathematical problems. Key points on why multiple representations are so important: (1) Deeper Conceptual Understanding: The use of multiple representations (such as illustrations, diagrams, graphs, and equations) helps students transform abstract mathematical ideas into more concrete ones, making them easier to understand and remember. (2) Facilitates Problem Solving: Students who have strong multiple-representation skills tend to be better able to solve complex mathematical problems, especially non-routine ones. (3) Improves Mathematical Communication Skills: Representations provide students with opportunities to organize, record, and communicate their mathematical ideas, both through text and visuals. (4) Connecting Mathematical Ideas: Multiple representations encourage students to connect various mathematical concepts (mathematical connections), such as converting a word problem into an equation and then into a graph. (5) Addressing Learning Difficulties: Students often experience confusion when relying solely on symbolic representations (numbers/formulas). Multiple representations provide additional options, particularly through visual representations, to visualize problems before solving them.

These multiple representations can support students in developing a more profound understanding of concepts. These representations can take the form of images, diagrams, graphs, or other types of representations that can be utilized by teachers and students in the learning process. Effective representations are needed to convey information. A problem that is considered complex and complicated will be easier to solve with representation. Hutagaol (2013) stated that "effective representations are needed in the process of abstract mathematics education so that abstract mathematical concepts can be more easily understood." Ainsworth & Shaaron (2006) explain that "multiple representations can serve as tools that help and support meaningful learning and/or deep learning. The application of multiple representations is very useful for teaching scientific concepts that are not concrete." Conveying an idea or event by utilizing various diverse representations can make the idea or event easier to understand and interesting for students. Waldrip et al. (2006) stated that "multiple" means showing the same idea in various ways, such as using words, images, and numbers, and giving students many chances to engage with the same idea. This can be interpreted as meaning that "multiple representations mean conveying the same concept through different forms, which can be words, pictures, graphs, and numbers." Meanwhile, Adu-Gyamfi K. (1993) stated, “Multiple representations means using various forms (such as graphs, tables, equations, and diagrams) simultaneously." This shows that multiple representations require the use of various forms of representation (such as graphs, tables, equations, and diagrams) simultaneously. Ozgun-Koca (1998) stated that “Several representations can be described as external mathematical

expressions of thoughts and concepts to convey the same information in various formats." Multiple representations can be described as external mathematical forms of ideas and concepts that convey similar information in multiple formats. In addition, Vault (2019) states, "Multiple representations are ways to symbolize, to describe, and to refer to the same mathematical entity." This shows that multiple representations serve as a method for explaining, describing, and referring to similar mathematical entities. Symbolizing occurs when a student is able to record or represent, convey, or describe information in the form of letters, numbers, or symbols that represent a value or other operation. Describing occurs when a student can name, differentiate, generate, categorize, evaluate, construct, and apply information in visual, verbal, or symbolic form. Referring occurs when a student can align, adjust, and interpret the information that has been obtained. Students can show one form of representation and may also be able to generate more than one representation of the same idea in different variations.

Several studies indicate that to improve conceptual understanding, students need support through the use of multiple representations in the learning process (Adadan et al., 2009). Hwang & Chen (2007) stated that the ability to develop ideas when solving problems through various explanations and illustrations is an element that impacts multiple representation skills in problem solving. (Oylum Akkus, 2010) explained that learning that focuses on representations has a significant impact on algebraic abilities when compared to traditional teaching methods. Research by Panasuk & Beyranevand (2010) showed that there is a relationship between student achievement and their ability to recognize and solve problems involving linear equations of one variable presented in various representation models (text, diagrams, and symbols).

Furthermore, this study also shows that students who can recognize the same pattern even in different forms demonstrate better conceptual understanding, which ultimately contributes to higher academic achievement. However, academic achievement is not a strong indicator of conceptual understanding. This study also indicates that the more diverse students' knowledge of various representations, the greater their chances of developing accurate solutions to problems. Representations play an important role in helping students deepen their mathematical knowledge. This is in line with the findings obtained by Faridah et al. (2022), which found that the use of multiple representations has a significant impact on students' problem-solving abilities.

In this research, mathematical multiple representation (MMR) is defined as the process of mental imagery/expression of a person's ideas to symbolize, describe, and refer to the same mathematical entity in different visual, verbal, and symbolic forms. Visual representations can be images, diagrams, graphs, or tables. Verbal representations can be written text and words. Symbolic representations can be mathematical equations or symbols. The aspects of mathematical multiple representation (MMR) in this research are the following: a) Symbolizing, which

involves manipulating mathematical symbols and language to convey a concept. b) Describing, which involves explaining through illustration or imagination. c) Referring, which involves assessing the appropriateness of the representation to information in the problem.

Fractions, a common mathematical topic encountered in everyday life, are often considered difficult by students. However, a good understanding of the concept of fractions is very useful in supporting subsequent mathematics learning, such as fractions in algebra, ratios in geometry, and other mathematical topics.

On average, students in many countries rarely have a good conceptual understanding of fractions (Fazio et al., 2016). Students often make errors in determining the results of operations with fractions, even though they have learned about them since elementary school. This phenomenon is due to a lack of understanding of the concept of fractions among students from elementary school. Consequently, this has an impact on their subsequent education, especially in junior high school.

This is supported by various studies, including research conducted by Cahyadi F and Suryani E D (2021), which found that many students still experience difficulties in understanding fraction problem solving, determining strategies, performing calculations, and drawing conclusions. Meanwhile, research conducted by Manjani et al. (2024) found that, in general, about 50% of students are still confused about fractions. Because of the many ways to work on this material, students easily forget and are confused about how to work on it. Research by Bhoy & Palobo (2025) showed that students' ability to convert simple fractions into decimals was very minimal, with percentages of 14.70% and 5.88%, respectively.

Based on observations conducted by researchers at SMP Negeri 2 Sukodadi Lamongan in seventh grade, students experienced difficulty understanding the concept of fractions, particularly in arithmetic operations with fractions, with many students still not meeting the Minimum Completion Criteria.

The above research indicates that fractions are a difficult and complex topic for students to understand. Students' lack of understanding of fractions is one factor contributing to their low mathematical mastery. Another factor is that students rarely use representations (pictures) or other representations to solve problems. Consequently, representations are not considered a means of problem-solving or a way of thinking. This demonstrates students' lack of mathematical representation.

Research Methods

This qualitative study aims to analyze the multiple mathematical representations (MMR) of junior high school students with high, medium, and low ability in solving fraction problems. The subjects were six students drawn from 32 seventh-grade students at SMP Negeri 2 Sukodadi. These six students were selected using a purposive sampling technique, selecting representatives from the high-, medium-, and low-ability groups (two students each) to obtain a comprehensive picture.

Furthermore, the researchers selected communicative students. This step was done because they wanted students who could convey ideas, concepts, or reasons so that they could explore more about students' multiple mathematical representations in solving fraction problems.

This research was conducted by administering a problem-solving test on fractions. Students were asked to answer questions, and the results were then analyzed qualitatively to determine their level of understanding of concepts related to fractions and the representations used. Data sources were obtained from problem-solving tests, task-based interviews, and documentation. Meanwhile, to verify the validity of student data, time triangulation was used, namely checking with written tests and task-based interviews, at different times and in different situations. This study was conducted twice. The interval between the first and second data collection was one week. Data or information obtained in the first data collection was compared with data or information obtained in the second data collection. In this case, the researcher checked and compared the accuracy of the written test results with the interview results. Data or information is considered valid if there is consistency or similarity of views, opinions, or thoughts in the first and second data collections. If the data obtained is invalid, it is repeated until valid data is obtained. Then, valid data is used in this study.

The classification and indicators of Multiple Representations (Faridah et al., 2024a) are presented in Tables 1 and 2.

Table 1. Mathematical Multiple Representation Indicators

No	Multiple Representation Aspect	Description	Indicator
1.	Symbolize (Waldrip et al., 2006; Adu-Gymfi K, 1993; Vault, 2019)	Manipulating mathematical symbols and language	1. Record or describe existing data and questions arising from the problem presented. 2. Define or convey information in this problem using letters, numbers, or symbols that represent a number or other operation.
2.	Describe (Waldrip et al., 2006; Ozgun-Koca, 1998; Vault, 2019)	Explaining through illustration or imagination	1. Constructing or creating a visual, verbal, or symbolic representation of data. 2. Using data to solve problems.
3.	Refer (Waldrip et al., 2006; Adu-	See the suitability	1. Check the representations you have created. 2. Adjust and align the results of the representations you have obtained.

No	Multiple Representation Aspect	Description	Indicator
	Gymfi K, 1993; Vault, 2019)		

Table 2. Classification of Mathematical Multiple Representation (MMR) Capabilities

No	Mathematical Multiple Representation Aspect	Description	Level
1.	Symbolize, Describe, Refer	- Meets all indicators MMR, dan - Meets 3 representations (visual, verbal, symbolic)	High
2.	Symbolize, Describe, Refer	- Meets 2 or 3 indicators MMR, but only - Meets 2 representations (visual, verbal, or symbolic)	Medium
3.	Symbolize, Describe, Refer	- Meets 1 or 2 indicators MMR, and only - Meets 1 representation (visual/verbal/symbolic)	Low

Data collection was conducted using three techniques, including:

1. Tests: in the form of essays designed based on indicators of multiple mathematical representation (rhematics), including: (1) symbolizing, (2) describing (visual, verbal, symbolic), and (3) referring to answers.
2. Interviews (task-based): conducted in a semi-structured manner to delve deeper into students' responses to each indicator of multiple mathematical representation (rhematics).
3. Documentation: consisting of photographs, interview recordings, and archives of students' answers from written tests.

The test instrument was validated before use by two mathematics teachers from SMP Negeri 2 Sukodadi and one mathematics teacher from SMP Negeri Tuban. This validity test was conducted to ensure that the questions were in accordance with the criteria being measured. The validation aspects reviewed were material, construction, and language. The results of the validation conducted by the validators indicated that the instrument was suitable for use, provided that several changes were made based on their suggestions; specifically, the instructions for answering the questions were clarified to better align with the indicators of multiple mathematical representations.

Results and Discussions

In the high category, there are two students: AEPZ (coded T1) and IAP (coded T2). These two students were selected because they have a deeper understanding of fraction concepts and communication skills than other students. The middle category is also represented by two students: AWA (coded S1) and DSL (coded S2). These two students have intermediate abilities, which gives insight into students with average abilities. Meanwhile, in the low category, there are SGA (coded R1) and CAA (coded R2). These two students were selected because their understanding of fraction concepts is lower than the other categories, providing insight into the difficulties faced by low-ability students, such as challenges in grasping basic operations and applying fraction concepts in problem-solving situations.

Therefore, the selection of subjects in this study encompassed all variations of student skill categories, ensuring more comprehensive information for examining multiple mathematical representations based on varying ability levels.

The following data presents the results of the multiple mathematical representation ability test. In the high category, subjects T1 and T2 successfully met all indicators. Both subjects provided descriptions using visual, verbal, and symbolic representations. In the intermediate category, subjects S1 and S2 met three indicators, with two representations. The representation used by S1 was visual and verbal, while S2 used visual and symbolic. In the low category, subjects R1 and R2 met one indicator (describing). The representation used by R1 was verbal, and R2 was visual.

In this section, we will discuss each indicator based on the results. The discussion is presented as follows:

1. Symbolizing

In the first indicator, subjects T1 and T2 were able to write down what was known and what was asked and present it in numerical form to represent a number or other operation by symbolizing/using symbols. In the symbolizing aspect, T1 used examples such as the perimeter of land (K), girls (Pr), boys (Lk), the width of land (l), and the length of land (p). Meanwhile, T2 is symbolized by using examples such as K = circumference, L = area, P = length, Le = width, LL = area of the section for boys, and LP = area of the section for girls. Similarly, subjects S1 and S2 wrote down what was known and asked using symbols. Meanwhile, subjects R1 and R2, in the symbolizing indicator, both directly wrote down what was known and asked without symbolizing. The results showed that T1, T2, S1, and S2 were able to read problems well, identify information, write mathematical symbols completely, and write different mathematical symbols. This means that the subject understands the problem given. Meanwhile, R1 and R2 do not. Students with low ability often have difficulty shifting from concrete thinking (real objects) to abstract thinking (symbols, numbers, letters, formulas). Symbolization (mathematical representation) is considered complex because one must translate word problems into mathematical language. Amir et al.

(2022) also stated that students have difficulty in concretizing fraction learning materials. Meanwhile, Faridah et al. (2024b) in her study revealed that the use of symbols as representations is often ignored during the mathematics learning process, especially in discussions about fractions. In the same context, research conducted by Khoerunnisa & Maryati (2022) shows that students still have difficulty in transforming problems from the real world into appropriate mathematical problems. Research by Pramesti et al. (2025) states that students who have limited abilities encounter it difficult to describe mathematical concepts in written form and cannot translate these ideas into mathematical models or expressions. (Faridah et al., 2024b)

2. Describing

In this indicator, T1 and T2 use three representations: visual, verbal, and symbolic. T1 first sketches the land and writes down what is known. Then, he finds its length and width.

Subject T1 made a sketch of the land first. Writing down what was known, namely pr $= \frac{1}{2} \times$ lk, $k = 280$, $l = \frac{3}{4}$ from p. Then find the length and width so that the area is known. The subject got the answer that the portion of land for boys is 1,200 m^2 and the portion of land for girls is 600 m^2. The subject wrote the answer and explained it in words. The subject wrote the answer using symbols, for example: K (perimeter of land) = 280 m, l (width of land) = $\frac{3}{4}$ from p (length). Subject T2 The subject draws the garden. Then finds the length and width so that the area is known. After that, divide it into 4 parts, 3 for men and 1 part for 2 women because they only get half the share of men. The subject gets the answer that the men's share of land is 1200 m^2 and women's is only 600 m^2. The subject writes the answer and explains it in words. The subject writes the answer using symbols, for example: K (land perimeter) = 280 m, l (land width) = $\frac{3}{4}$ from p (length).

In this indicator, S1 and S2 use 2 representations. S1 uses visual and verbal representations. S1 draws the land by entering what is known so that the length and width of the land can be found. Land area = 4800 m^2, then divided by 4 = 1200 m^2 (for boys). Then for girls (300 : 2 = 150). S1 writes the answer and explains it in words. While S2 uses verbal and symbolic representations. S2 in describing the solution by finding the length and width first through what is already known, namely: yaitu: $k = 280$, $l = \frac{3}{4}$ from p. So that later the length and width will be known. The subject applies the information to solve the problem. S1 gets the answer that the portion of land for boys is 1,200 m^2 and the portion of land for girls is 600 m^2. S2 writes the answer using symbols, for example: K (land perimeter) = 280 m, l (land width) = $\frac{3}{4}$ from p (length).

In this indicator, R1 and R2 used one representation. R1 used a verbal representation, describing his answer in words without using symbols. For example: Given: Perimeter of the plot = 280 m, Width of the plot = $\frac{3}{4}$ of the length, Width and length of the plot are multiples of 10, Female portion = = $\frac{1}{2}$ of Male portion. The

question is: What is the area of the plot for the female? Meanwhile, R2 wrote his answer by drawing it first. He entered the known information to find the length and width of the plot. He then divided it into four parts: three for the male and one for the female, as they only received half the male portion. However, both subjects' answers were inaccurate.

These findings align with a study by (Lestari & Palupi, 2023) which found that high-ability students can meet all representation indicators. (Cahyadi F, Suryani E D, 2021) also reported that high-ability students can meet three representation indicators, moderate-ability students can meet two, and low-ability students only meet one. The ability to reformulate ideas indicates a good basic understanding of the material (Hanggara et al., 2022). Without understanding the problem at hand, there will be no strategy to address it, and without the right strategy, problem-solving will not proceed effectively (Damayanti, 2022)**.** Research by (Hartini & Setyaningsih, 2023) showed that low-ability students often experience difficulty switching between representation types. Furthermore, research by (Putri et al., 2025) found that students face challenges in representing fractions both visually and symbolically. In fact, research (Marina & Susanti, 2025) found that 63.6% of low-ability students were unable to meet visual representation indicators, such as drawing pictures to explain problem-solving strategies, resulting in inability to provide correct answers. Students with very low mathematical representation ability category cannot draw completely and accurately to solve problems, cannot create mathematical expression models, and can only answer questions using incomplete words or written text (Sari et al., 2023)**.**

3. Refer

The third indicator shows that T1 and T2 are able to check the representation and align/adjust the results obtained. T1 can complete and re-explain the problem solving that has been done well and provide reasons and can state the conclusions obtained, namely: the area of the daughter's land. T2 can explain the suitability of the answer to what is asked in the question and provide reasons. The subject can state the conclusion obtained/wanted to be done using various methods, the results will always be the same if the method is correct. Likewise, S1 did it according to/aligned with the information provided, and the results were the same between answers using words and pictures/done in different ways the results were the same. S2 did it according to what was known. S2 was sure that the answer was in accordance with the information provided. Meanwhile, subjects R1 and R2 did not check the answers, due to a lack of understanding of a problem. Characteristics of low-ability children Generally, they are only able to understand the problem but have difficulty in planning, implementing, and re-checking the answers. They focus on the final result, not on the logical solution process. This is supported by research by (Cahyadi F, Suryani E D, 2021) which states that most students have difficulty checking their answers. Research by (Nuraini., Yuanita P., 2023) found that students with low abilities lacked understanding of a

problem and rechecked the answers they had obtained. This is in line with research by (Muharani et al., 2025) which states that students verify 10% of their results.

Conclusions and Suggestions

Based on the results of tests and interviews, it can be concluded that 11 students (34.375%) are in the high category with an average score of 100, 10 students (31.25%) are in the medium category with an average score of 62.5, and 11 students (34.375%) are in the low category with an average score below 50. Therefore, it can be stated that most students have good mathematical multiple representation abilities, as indicated by 11 students in the high category and 10 students in the medium category. Furthermore, based on the indicators of mathematical multiple representation, it was found that 4 students (12.5%) were in the high category, 4 students (12.5%) in the medium category, and 24 students (75%) in the low category. Students in the high category were able to solve test questions accurately and completely, fulfilling all indicators of multiple representation aspects, namely symbolizing, describing, and referring to answers. They used three types of representations: visual, verbal, and symbolic. Meanwhile, students in the medium category also solved the questions properly and correctly, meeting three indicators but using only two forms of representation, either visual and verbal or visual and symbolic. Students in the low category, however, were only able to meet one of the three indicators of mathematical multiple representation ability.

The following suggestions are proposed by the researchers based on the results of this study. Junior high school teachers are encouraged to use these findings to evaluate the effectiveness of multiple mathematical representations in solving mathematical problems, thereby providing a sound basis for designing effective learning strategies. In addition, future researchers are advised to develop studies that apply multiple mathematical representations to different topics and explore them from other perspectives, such as student learning styles.

Acknowledgements

The author would like to thank the community of SMP N 2 Sukodadi Lamongan.

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