

A Descriptive qualitative analysis of junior high school students' ability to understand mathematical concepts in fractional materials

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Abstract

The focus of this research is to examine junior high school (Grade VII) students' ability to understand mathematical concepts when solving fraction problems, using a qualitative, descriptive design. The analysis focuses on three abilities: restating concepts, presenting concepts in different forms of mathematical representation, and applying concepts or algorithms to obtain solutions. The novelty of this study lies in combining tiered categorization (high, medium, low) with an in-depth qualitative description of each ability group, enabling identification of students' achievement characteristics on each indicator in greater detail than in previous similar studies. The research was conducted at a public junior high school in Metro City, based on pre-survey results showing a low completion rate among students in solving fraction problems. Six of the 26 students in Class VII A were selected through purposive sampling, taking into account variation in pre-survey scores to ensure proportional representation of the high-, medium-, and low-ability groups. Data were obtained through a written test on fraction material that mathematics teachers and lecturers had validated, then analyzed through the stages of data reduction, data presentation, and conclusion drawing. The results place students' concept understanding in the medium category, with an average score of 52 and an average ability percentage of 61.1%. Students in the high group were able to meet all three indicators; the medium group was able to use mathematical representations and problem-solving algorithms, but was not yet consistent in restating concepts; while the low group had not shown achievement on any of the three indicators. These findings are specific to the research subjects and are not intended to be generalized broadly. This study provides a diagnostic picture of students' patterns of understanding of fraction concepts that can inform teachers in designing instruction that places greater emphasis on the meaning of concepts before students move on to related material, such as ratio and proportion, with the limitation that the subjects were drawn from a single school.

Keywords: Fractions; Concept Understanding; Mathematical Representation

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INTRODUCTION

Mathematics learning is not limited to mastering the material but also to developing students' ways of thinking. Through mathematics, students are trained to use logical, critical, systematic, and analytical reasoning when facing difficulties (Masrurah & Apriyono, 2025; Nurrahmah et al., 2026; Ulzana et al., 2026). Therefore, the success of mathematics learning cannot be assessed solely by students' ability to obtain final answers, but also by how students understand information, identify the necessary concepts, and apply those concepts in problem-solving.

Understanding concepts is one of the important bases for determining students' success in learning mathematics. With this understanding, students can recognize a concept's meaning, connect it to their existing knowledge, and apply it to find the right solution. Learning mathematics does not only stop at remembering formulas or procedures but includes the ability to understand and use concepts meaningfully (Atiqoh et al., 2026; Fitri et al., 2022; Nurrahmah et al., 2026; Prihastari et al., 2026; Solaiman, 2026).

The National Council of Teachers of Mathematics (NCTM, 2014) explained that understanding concepts is related to the development of various mathematical processes, including problem-solving, reasoning and proof, connections, communication, and representation. Understanding concepts is an important component of learning. Students are expected to understand and explain how concepts relate to one another when solving problems (Halawa et al., 2025).

In this study, the understanding of the concept uses indicators that refer to Permendikbud No. 59 of 2014, as operationalized by Safriati (2021): (1) the ability to restate a concept, (2) the ability to present a concept through various forms of mathematical representation, and (3) the ability to use a concept or algorithm in problem-solving. These three indicators were selected because they represent the core cognitive processes required to demonstrate conceptual understanding in mathematics, from recognizing a concept to translating it into different representations and, finally, applying it procedurally. Furthermore, they have been used in prior studies of concept understanding in comparable school-level contexts (Rismen et al., 2021; Rohmah et al., 2024). This study adapts, rather than adopts wholesale, the broader set of indicators in Permendikbud No. 59 of 2014, restricting the analysis to these three dimensions to keep the assessment focused and manageable within a single written instrument.

Fraction material was chosen because its completion requires mastery of fundamental knowledge (Bhoy et al., 2025; Tiningsih et al., 2026). Students need to understand integers and the operations of addition, subtraction, multiplication, and division that form the basis for solving fraction problems. Mastery of fraction concepts is also foundational because it underlies subsequent mathematical topics, one of which is ratio and proportion; students who understand fraction concepts conceptually, rather than

only procedurally, are better positioned to transfer that understanding to related material (Björkhammer et al., 2025; Brahier et al., 2014; Merkel et al., 2025).

Initial findings supporting this study were obtained through a preliminary test administered to students at the research site in September 2025. The results indicated that many students still had difficulty solving fraction problems and were often unable to represent the underlying mathematical concepts correctly when working through the given tasks. A summary of the preliminary test results is presented in Table 1; the test administration procedure is described in the Research Methods section.

Table 1. Preliminary Survey Test Results of Mathematical Concept Comprehension

Ability			
Criteria	Number of Students	Percentage	Remarks
Pass	4 Students	15,38%	Complete
Not Passing	22 Students	84,62%	Incomplete
Total	26 Students	100%	

In Table 1, students are categorized as "Pass" if their preliminary test score met the school's minimum mastery criterion, and "Not Passing" if it fell below this threshold. Using an institutional benchmark, rather than a criterion set by the researcher, keeps the classification consistent with the school's own assessment standard. The results in Table 1 show that most students had not reached this completeness criterion, indicating that the difficulties students faced were not only computational but also related to understanding the concepts and information embedded in the questions. Students who do not understand the meaning of a problem tend to have more difficulty determining which concept to apply to begin solving it.

This condition is consistent with findings from previous research. Rismen et al. (2021) found that students' understanding of mathematical concepts is relatively moderate. Meanwhile, Gaspersz et al. (2023) found limitations in several indicators of understanding the concept of fractions specifically. Furthermore, recent studies highlight that strengthening understanding of mathematical concepts requires appropriate pedagogical strategies, such as problem-based learning or technology-assisted realistic mathematics education, tailored to students' varying cognitive abilities (Rasidi, 2024; Sari et al., 2024). However, these earlier studies either did not separate findings by both ability group and indicator simultaneously or did not focus on fraction material under the current curriculum. This points to a research gap: there is limited empirical evidence on how

concept-understanding indicators are distributed among high-, medium-, and low-ability Grade VII students under the *Merdeka* curriculum, specifically for fraction material. The present study addresses this gap by combining indicator-level and ability-group-level analyses of Grade VII students working on fraction material within the *Merdeka* curriculum context.

Based on this research gap, this study formulates the following research question: "How is the ability of Grade VII students to understand mathematical concepts in fraction material, viewed across ability groups?" The purpose of the study is to describe students' ability levels in fulfilling the three concept-understanding indicators used, as well as to examine differences in answer characteristics among the high-, medium-, and low-ability groups.

METHODS

This study applies a qualitative approach with a descriptive design. The research was conducted at SMP Negeri 10 Metro, Jalan Wolter Mongisidi, East Hadimulyo, Metro City. Six students were selected as research subjects from the 26 students of class VII A using a purposive sampling technique, based on their preliminary test scores (Table 1) classified into high, medium, and low ability categories following the criteria in Table 4 (adapted from Arham & Adirakasiwi, 2022): two subjects were purposively selected from each category. Selecting two subjects per category, rather than one, allows the researcher to check whether the characteristics observed in one subject's answer are also reflected in the other subject from the same category, which supports the credibility of the qualitative description without requiring a larger sample; six subjects is therefore considered adequate because the goal of this study is an in-depth description of understanding within each ability group rather than statistical generalization to a wider population. According to Sugiyono (2014), the purposive sampling technique allows researchers to determine samples based on certain considerations so that the subjects chosen are in accordance with the needs of the research; in this study, the consideration used was each student's ability category, so that the data analyzed could represent the high, medium, and low ability groups relevant to the research question.

The measurement of concept-understanding ability was carried out using two written-description questions on fractional material. The questions were prepared with

reference to the three indicators used in this study: the ability to restate a concept, present a concept through various forms of mathematical representation, and use a concept or algorithm in problem solving; each item was mapped to at least one indicator so that scoring could be broken down per indicator, as shown in Table 5. The instrument has been checked and validated by teachers and lecturers of mathematics education, using a validation sheet covering three aspects: construction, content, and language, each rated on a 1–5 scale. The mathematics teacher gave a score of 48 out of a maximum of 50 (96%), and the mathematics education lecturer gave a score of 42 out of 50 (84%); the average validity score was 90%, which falls into the "very valid" category (a validity percentage above 80%). The full results are presented in Table 2.

Table 2. Instrument Validation Results by Expert Validators

No	Validator	Institution	Score	Percentage	Category
1	Validator 1	Mathematics Teacher, SMP Negeri 10 Metro	$\frac{48}{50}$	96%	Very Valid
2	Validator 2	Mathematics Education Lecturer, Universitas Muhammadiyah Metro	$\frac{42}{50}$	84%	Very Valid
Average				90%	Very Valid

(Source: Instrument Validation Sheets, 2025)

Based on this result, the instrument was judged suitable for use without requiring substantive revision and was administered to the research subjects as is. An example of the research instrument is shown in Table 3.

Table 3. Instrument Test

1. The younger sibling's age is $\frac{1}{4}$ of the father's current age, while the grandfather's age is 7 times the younger sibling's age. If the father is currently 36 years old, how old is the grandfather?
2. Father uses his cellphone for 2.5 hours a day, while Mother uses her cellphone for 1 hour and 40 minutes a day. If the cellphone can only be used for 5 hours a day, how long can the younger sibling use it?

Each subject's answer sheet was examined using a four-level analytical scoring rubric per indicator. Although this study follows a qualitative approach, the rubric scores are converted into percentages here only as a descriptive device to summarize and compare achievement across indicators and ability groups; the percentages are not used for inferential statistical testing or for generalizing beyond the subjects studied, and every

percentage reported is followed by a qualitative explanation drawn from the students' actual written answers. This is consistent with a qualitative descriptive design that uses simple descriptive statistics to organize findings before they are interpreted. Rismen et al. (2021) describe the analytical rubric as an assessment guideline that scores responses against defined criteria. After all answers are scored, each indicator's achievement was calculated as a percentage; these calculations form the basis for describing students' concept-understanding ability both overall and per indicator. The percentage formula used is as follows:

$$\text{Percentage Score} = \frac{\text{Total scor obtained}}{\text{Maximum number of score}} \times 100$$

To capture variation in subjects' ability, test results were divided into three groups: high, medium, and low. This grouping follows the score-range criteria used by Arham & Adirakasiwi (2022), as shown in Table 4, so that the boundaries between categories are based on criteria established in prior research rather than by the researcher. The category of the level of students' ability to understand mathematical concepts in each group is presented below.

Table 4. Categories of Mathematical Comprehension Ability Levels

Score	Category
66 < x ≤ 100	High
45 < x ≤ 65	Medium
0 ≤ 44	Low

In this study, the high category is owned by students who have a test result score of more than equal to 66, while the medium category is owned by students who have a test result score between 45 to 65, and the low category is owned by students who have a test result score less than equal to 44. After the grouping is carried out, the data is analyzed through the process of data reduction, presentation of findings, and drawing conclusions or verification.

To strengthen the credibility and trustworthiness of these findings, the verification stage was supported by three procedures. First, source triangulation was carried out by cross-checking each subject's written test answers against the researcher's field notes taken while the test was administered, second, member checking was conducted by returning the researcher's provisional interpretation of each subject's answer to that

subject, third, a qualitative peer review was carried out by discussing the coding of student answers against the three concept-understanding indicators in data collection.

RESULTS AND DISCUSSION

The research data were obtained from 6 subjects in class VII A who worked on the fractional material test described above. Each subject's score is then used to determine their ability group, following the criteria in Table 4, and forms the basis of the analysis presented in the following table.

Table 5. Research Results Data

No	Name	Value	Groups
1.	MFF	75	Height
2.	AIP	75	Height
3.	MFD	62,5	Medium
4.	LALE	62,5	Medium
5.	VA	37,5	Low
6.	RS	0	Low

In Table 5, the subject's average score is 52. This value is included in the medium category according to the criteria in Table 4. The range of subject scores is between 0 (the lowest score) and 75 (the highest score).

Table 6. Results of Student Answer Percentage by Indicator

No	Indicator	Many Subjects	Presentase
1.	Restating concepts	3	50%
2.	Presenting concepts in a variety of mathematical representations	5	83,3%
3.	Using a concept or problem-solving algorithm	3	50%

Table 6 shows differing achievements across the three indicators. As many as 3 of 6 students (50%) were able to restate concepts, 5 students (83.3%) were able to present concepts using various mathematical representations, and 3 students (50%) were able to apply a concept or algorithm to solve problems. Although the three indicators differ in their individual percentages, the average of the three (61.1%) is reported only as a single summary figure of overall concept-understanding achievement, consistent with the average score reported in Table 5; it is not intended to imply that the three indicators are equivalent, and the discussion below deliberately treats each indicator separately to

capture these differences rather than relying on the average alone. The students' answers were then further analyzed to characterize the extent of each indicator's fulfillment.

The following section presents a qualitative, indicator-by-indicator description of the answers of students with high, medium, and low ability, based on their actual written work rather than on the percentages alone. Errors and patterns found in students' answers are used as evidence of whether students understood the concepts being tested and are discussed in relation to each indicator below.

a) Ability to Understand High Category Mathematical Concepts

diketahui:
 umur Adik = $\frac{1}{4}$
 umur Ayah = $\frac{3}{4}$
 umur kakak = ?
 $\frac{1}{4} \times 2 = \frac{2}{4}$
 $\frac{2}{4} \times \frac{3}{4} = \frac{25}{4} = 6 \frac{1}{4}$
 Jadi selang umur kakak adalah: $6 \frac{1}{4}$ tahun.

diketahui:
 Ayah meminjam HP = 2.30
 ibu meminjam HP = 1.40
 Adik : ?
 $5 - 2.30 = 2.30$
 $2.30 - 1.40 = 50 \text{ menit}$
 Jadi Adik meminjam HP selama: 50 menit //

Figure 1. Sample of Students' Responses on High Category

Based on Figure 1, the researcher examined the answer sheet for subject MFF, which represents the high-ability category (score 75). On the rubric, MFF's answer reached the highest scoring level on all three indicators: the student correctly restated the meaning of the fraction concept in their own words (Indicator 1), represented the fraction problem using more than one form of mathematical representation that was consistent with the requested solution (Indicator 2), and applied the correct procedure or algorithm to reach a correct final answer through a clear, logically ordered working process (Indicator 3). This condition is in line with the opinion of (Nurhangesti & Seruni, 2024; Kase et al., 2023; Hatisaru, 2023; Jäder & Johansson, 2025), who state that students with strong conceptual mastery find it easier to connect between concepts, explain the reasoning behind each step of their solution, and adapt their solution strategy to a new context; in MFF's work this was reflected in the coherence between the concept restated at the beginning of the answer and the procedure used to arrive at the solution. Students in this category appear to have constructed their own understanding of fractions, enabling them to solve the given problems appropriately.

This is reflected in the interview excerpts with subject MFF on both test items:

First question

- P : *"What do you understand from this problem?"*
- MFF : *"It's about finding the younger sibling's age, which is not yet known."*
- P : *"What information do you know?"*
- MFF : *"I know that the younger sibling's age is $\frac{1}{4}$ [of the father's age], and the father's age is 36 years."*
- P : *"After understanding the problem, what steps did you think of to solve it?"*
- MFF : *"I wrote down what is known and what is asked first, then I multiplied the fraction by 36."*
- P : *"What mathematical concept or representation did you use? Why did you choose that method?"*
- MFF : *"I used fractions and multiplication or division to find the result, because what was being asked was the younger sibling's age."*
- P : *"After getting the answer, did you check it again?"*
- MFF : *"Yes, I checked my calculation again."*

Question two

- P : *"What information do you know?"*
- MFF : *"Father used his phone for 2 hours 30 minutes, and Mother for 1 hour 40 minutes."*
- P : *"What steps did you take?"*
- MFF : *"I found the remaining time first by subtracting the time used by Father, then subtracting again the time used by Mother."*
- P : *"Why did you use subtraction?"*
- MFF : *"Because the time already used by Father and Mother had to be subtracted from the total time to find out how much time was left for the younger sibling."*
- P : *"Did you check your answer again?"*
- MFF : *"Yes, I checked the subtraction again so I wouldn't miscalculate the time."*

These responses show that MFF was able to identify the information given in each problem, explain the reason for choosing a particular operation, and verify the result, which together support the highest rubric level reached on all three indicators.

b) Medium Category Mathematical Concept Comprehension Ability

① $\frac{1}{4} \times \frac{7}{1} = \frac{7}{4} \times \frac{36}{1} = \frac{252}{4} = 63$
 diketahui
 usia adik $\frac{1}{4}$ usia ayah 36 tahun
 ditanya
 berapa usia kakak
 jawab
 $\frac{1}{4} \times 7 = \frac{7}{4} \times \frac{36}{1} = \frac{252}{4} = 63$
 jadi umur kakak 63 tahun

② $5 - 2,5 = 2,5$
 $\begin{array}{r} 5,00 \\ - 2,50 \\ \hline 2,50 \end{array}$
 jadi adik 50 menit

Figure 2. Sample of Students' Responses on Medium Category

Based on Figure 2, the researcher examined the answer sheet for subject MFD, which represents the medium-ability category (score 62.5). MFD met the scoring criteria for Indicators 2 and 3: the student was able to represent the fraction problem using an appropriate mathematical representation and apply the correct procedure or algorithm to reach a correct final answer. On Indicator 1, however, MFD's restatement of the concept was incomplete: the student could name the term used in the problem, but did not fully explain what the concept means or why the chosen procedure follows from that meaning, so the answer did not reach the highest rubric level for this indicator. This pattern, being able to apply a concept procedurally while only partially explaining its meaning, indicates that at this stage, MFD's mastery of the concept is more procedural than conceptual: the student can execute the steps but has not yet fully internalized the underlying idea well enough to articulate it independently. This is consistent with (Hudiyagama & Farahsanti, 2026; Schulz, 2023; Mangarin et al., 2024; Phuong, 2020) who discuss students' difficulties in understanding and using mathematical concepts as a whole, particularly the gap between procedural fluency and conceptual explanation.

This is reflected in the interview excerpts with subject MFD on both test items:

First question

P : "What do you understand from this problem?"

MFD : "It's about finding the younger sibling's age, which is not yet known."

P : "What information do you know from the problem?"

MFD : *"I know the father's age is 36 years and the fraction for the younger sibling's age given in the problem."*

P : *"After understanding the problem, what steps did you think of to solve it?"*

MFD : *"I wrote down what is known and what is asked, then I multiplied the given fraction by the father's age."*

P : *"You reached the final answer on this problem. Can you explain what the fraction concept you used actually means?"*

MFD : *"The fraction shows a part of the age."*

P : *"Why did you go straight to writing the solution steps without explaining your strategy first?"*

MFD : *"Because I'm more familiar with how to calculate it."*

P : *"Did you check your answer again?"*

MFD : *"Yes, I checked my calculation again."*

Question two

P : *"What information do you know?"*

MFD : *"Father's phone-use time was 2 hours 30 minutes, and Mother's was 1 hour 40 minutes."*

P : *"After understanding the problem, what steps did you think of?"*

MFD : *"I subtracted the time already used by Father and Mother, and the remainder was for the younger sibling. The result was 50 minutes."*

P : *"Why did you use subtraction?"*

MFD : *"Because I was looking for the remaining time."*

P : *"Have you checked your answer?"*

MFD : *"Yes, I checked my calculation again."*

These responses show that MFD was able to carry out the correct procedure and verify the result on both items, but when asked to explain the meaning of the fraction concept itself, they could only name what it represents without elaborating further, consistent with the partial achievement on Indicator 1 described above.

c) Ability to understand low-category mathematical concepts

jawab

1. using = 25
 using = 36
 $\frac{1}{4} \times 36 = \frac{36}{4} = 9$
 45,36; 7 x 7 = 63

2. 30 x 50 = 50 menit
 jadi, jadi menitnya 50

jadi 50 menit

Figure 3. Sample of Students' Responses on Low Category

Based on Figure 3, the researcher examined the answer sheet of subject RS, representing the low-ability category (score 0). On the rubric, RS did not meet the criteria for any of the three indicators: the student left the restatement of the concept blank or gave an unrelated statement (Indicator 1), did not produce any mathematical representation of the problem, whether numeric, symbolic, or visual (Indicator 2), and did not carry out a recognizable procedure or algorithm toward a solution (Indicator 3). In other words, RS did not yet have a sufficient conceptual basis to translate the information given in the problem into a solution step. This condition is in line with the opinion of (Darwani et al., 2023; Maskar & Herman, 2023; Ningrum et al., 2022; Abdullah et al., 2024), who state that students' low concept understanding is caused by a tendency to merely record concepts presented by the teacher without understanding them, as well as by an inability to use concepts appropriate to the problem given.

This is reflected in the interview excerpts with subject RS on both test items:

First question

P : "Did you find it difficult to understand this problem?"

RS : "Yes, I was a bit confused."

P : "Which part confused you?"

RS : "I was confused about how to use the fraction and how to calculate it."

P : "Why did you write the calculation this way?"

RS : "I thought the fraction should be multiplied by 36."

P : "Are you confident in your answer?"

RS : "Not really confident."

P : "After finishing, did you check it again?"

RS : "I looked at it again, but I was still unsure whether the calculation was correct."

Question two

- P : *"How did you work on this problem?"*
- RS : *"I just tried calculating from the times given."*
- P : *"Can you explain why you wrote 30 times 50?"*
- RS : *"I thought that was how you were supposed to calculate it."*
- P : *"Do you know why it should be multiplied?"*
- RS : *"I don't know."*
- P : *"So while working on this problem, were you actually still confused about which method to use?"*
- RS : *"Yes."*
- P : *"Why did you still write 50 minutes as the answer?"*
- RS : *"So that there would be an answer."*
- P : *"Do you think 50 minutes is definitely correct?"*
- RS : *"I'm not very sure."*
- P : *"After writing the answer, did you check your calculation again?"*
- RS : *"No."*

These responses show that RS could not explain why a particular operation was chosen and openly admitted to guessing, writing an answer merely to have one rather than out of confidence in the procedure, and did not verify the result, consistent with the failure to meet any of the three indicators described above.

Overall, students' obstacles in solving problems are related to mastery of the material and thoroughness in their work. In some of the answers, it can be seen that steps were taken in a hurry, so basic mistakes still appear. On the other hand, the achievement on the mathematical representation indicator is the highest, while the other two indicators remain lower. These results are in line with Aisyah & Marlina (2025), who also reported learning habits that focus on recording theories without ensuring understanding of the material.

CONCLUSION

This study shows that grade VII students' understanding of mathematical concepts in fraction material falls into the medium category, with an average score of 52 and an average indicator fulfillment percentage of 61.1%. The most dominant indicator was the

ability to present concepts through various mathematical representations (83.3%), while the ability to restate concepts and to use concepts or algorithms in problem-solving each reached only 50%. Subject MFF, representing the high-ability group, was able to meet all three indicators; subject MFD, representing the medium-ability group, was able to use mathematical representations and problem-solving algorithms but was not yet able to consistently restate concepts; and subject RS, representing the low-ability group, had not met any of the three indicators. These findings show that mastery of the concept of fractions among the students studied is uneven across indicators, with procedural and representational skills outpacing conceptual understanding.

This pattern carries several implications for classroom practice: teachers may need to allocate more explicit instructional time to having students verbalize and justify concepts in their own words, rather than relying primarily on procedural practice, and could use varied representations as a scaffold toward, rather than a substitute for, conceptual explanation. This study also has several limitations: the subjects were limited to six students from a single class at one school, so the findings describe the characteristics of these subjects and should not be generalized to a wider population; and the instrument covered only two written items on fraction material. While source triangulation, member checking, and qualitative peer review were used to strengthen the credibility of the findings, these procedures were applied within a single class rather than across multiple schools or raters. Future research is recommended to involve a larger, more diverse sample across schools, to extend these credibility procedures to independent raters, and to explore instructional interventions that specifically target the concept-restatement indicator identified as the weakest in this study.

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