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Exploring Fifth Graders' Learning Obstacles in Multiplication and Division of Fractions

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ABSTRACT

Fractions serve as a critical foundation in mathematics education, preparing students for more advanced topics such as algebra and probability. Despite their importance, fractions are often difficult for elementary school students to grasp due to their abstract nature, especially when not taught within meaningful contexts. This study investigates the learning obstacles faced by fifth-grade students in understanding the multiplication and division of fractions. Utilizing a qualitative case study approach, data were collected through tests, interviews, classroom observations, and documentation at Lempuyangwangi Elementary School in Yogyakarta. The analysis revealed three primary categories of learning obstacles: (1) Ontogenic obstacles, including students' inability to simplify fractions correctly, frequent computational errors, and low motivation in learning mathematics; (2) Didactical obstacles, such as difficulties in interpreting word problems and applying appropriate procedures; and (3) Epistemological obstacles, particularly in understanding and applying the inverse concept required for dividing fractions. These findings highlight the need for more contextually relevant and cognitively aligned instructional strategies. Addressing these obstacles can support the development of more effective teaching approaches to enhance students' conceptual understanding of fraction operations.

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1. INTRODUCTION

In the 21st century, mathematics is one of the most important subjects to be taught (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). From elementary school to university level, students study mathematics. One of the essential materials contained in mathematics is fractions (Unaenah et al., 2023). Fractions are essential because they are an important topic of complex principles and concepts (Roesslein & Codding, 2019). Empson in Diputra added that fraction material is very influential in understanding mathematical concepts at an advanced level, especially algebra and opportunity

material (Diputra, Suryadi, Herman, & Jupri, 2023). In addition, the concept of fractions is also important because it is widely used in everyday life, for example, to divide a certain amount of food into equal parts or the quantity of a group divided into several equal parts (Muharram, Prabawanto, & Jupri, 2019). However, considering the importance of fraction material for students, especially at the elementary school level, this has not been matched by the findings in previous studies, which state that many students still have difficulty applying concepts and calculating fractions (Wulandari & Amir, 2022).

The term obstacle in student learning is commonly known as a learning obstacle. Learning obstacles are difficulties in learning and misunderstanding of material in students (Hidayah & Maemonah, 2022). When students make mistakes, it shows that they are having difficulty learning. Teachers should look at the subject's context to see what is possibly causing these difficulties (Sulistyani et al., 2024). Brousseau in Purnomo (2022) explains three types of learning obstacles based on the didactic relationship between teacher-student-material: ontogenic, didactic, and epistemological (Purnomo, Y. W., 2022). Ontogenic obstacles are based on learners' self-limitations related to learners' readiness and mentality. For example, learners have difficulty understanding fraction-counting operations if they cannot count integers (Fauzi & Suryadi, 2020). Didactic obstacles are caused by using teacher learning strategies, methods, models, and approaches in teaching; the presentation of material in teaching materials can also cause this type of obstacle. For example, when students complete fraction calculation operations with the wrong procedure, it is because the learning strategy used does not align with the characteristics of elementary school students. While epistemological obstacles are obstacles related to the nature of mathematical concepts themselves. For example, when students complete fraction calculation operations with the form and context previously exemplified, they have limitations in building their knowledge (Rosid et al., 2022).

Fractions have several meanings: part-whole, measurement, division, operator, and ratio (Walle, Karp, & Williams, 2013)*; textbooks* and teaching in Indonesia are dominated by the concept of part-whole, which raises the problem of the limited meaning of fractions for students holistically (Simon, M. A., et al., 2018). Besides that, in their research, Wulandari & Amir (Wulandari & Amir, 2022) suggested that students' obstacles in learning fractions are that they cannot represent images into fractions and are still confused about the meaning of numerators and denominators. Problems or obstacles in learning material can cause obstacles in new material, affecting the student's learning process (Ulfa et al., 2021). When students are constrained in understanding the concept of fractions and these obstacles are not resolved immediately, this will hurt further material, such as fraction counting operations. Despite being one of the basic materials, there are still many students who have difficulty in understanding and solving problems related to fraction material, especially multiplication and division of fractions (Anugraheni & Sartono, 2022).

Multiplication and division of fractions are challenging materials for students, where teachers often focus on procedural rather than conceptual (Sukarma, Isnawan, & Alsulami, 2023). Analysis of students' learning difficulties in fraction materials, especially the calculation operations of multiplication and division of fractions, is very important so that teachers can take didactical steps to overcome these difficulties. Although many studies have been conducted to analyze student learning obstacles in fraction material, few discuss fraction calculation operations, especially multiplication and division (Martin A Simon, Placa, Avitzur, & Kara, 2018). Therefore, based on the description above, the researcher will examine students' learning obstacles in the multiplication and division of fractions more deeply.

Based on the explanation above, this research aims to discover fifth-grade students' learning obstacles in fractions' multiplication and division at SD Negeri Lempuyangwangi, Yogyakarta. The formulation of this research problem is how the obstacles are categorized into three groups: ontogenic obstacle, didactic obstacle, and epistemological obstacle.

2. METHODS

The method used in this research is qualitative with a case study approach. It aims to obtain data from the field conditions regarding learning obstacles encountered when students learn fraction multiplication and division materials. The number of research subjects involved in this study was grade V students of SD Negeri Lempuyangwangi, totalling 27 students. Data collection techniques used in this research were test questions, interviews, observation, and documentation. Test questions about multiplication and division of fractions with various contexts were given to detect learning obstacles encountered by students, then deepened with students' answers in an interview session using semi-structured interviews. The test questions to identify learning obstacles consisted of 6 essay questions with different meanings of multiplication and division of fractions for each question. Problem number 1 presents multiplication and division of fractions procedurally; problem number 2 presents multiplication of fractions as repeated addition; problem number 3 presents multiplication of fractions as partitive interpretation; problem number 4 presents multiplication of fractions as a rectangular area; problem number 5 presents division of fraction as measurement, and problem number 6 presents division of fractions as partitive interpretation. Experts have validated this test instrument.

The test data collected were then analyzed using a rubric, as shown in Table 1 (Purnomo, Widowati, & Ulfah, 2019). The maximum score for each indicator is 2, and the minimum score for each is 0. The highest score for question number 1 is 16 points, which is a direct calculation problem of four sub-problems, and the highest score for questions 2 to 6 is 6 points, which is a story problem. So, the total score for all questions is 46 points.

Table 1. Learning Obstacle Test Assessment Rubric (Purnomo et al., 2019)

Scoring Criteria	Indicator	Score
Problem-Solving	Comprehensive and organized understanding	2
	There is an attempt to organize understanding, yet some issues cannot be understood	1
	Does not understand the problem and is unable to organize understanding systematically	0
Planning strategy	The strategies used are relevant and well-explained	2
	Some strategies are relevant but not well-explained	1
	The strategy used is irrelevant, unclear, and struggles to earn points	0
Calculation accuracy	Using the right procedure to get the right answer	2
	Some of the algorithms applied were correct, but there were still errors, so the answer was not correct	1
	No answer	0

The assessment rubric used in this study refers to the research of Purnomo, Widowati, and Ulfah (2019), validated by mathematics education experts and tested for reliability through previous trials. The content validity of the rubric was carried out by matching the assessment indicators to the learning objectives on the multiplication and division of fractions material. Reliability was tested using the consistency test with an average coefficient of 0.85. Other studies have also used this rubric to reveal similar student learning obstacles.

The results were then used to select six students to interview for further study related to difficulties when working on problems. From the test results, interviews, and observations, the learning obstacles found were classified into ontogenic, didactic, and epistemological obstacles. Then, the data that has been analyzed is presented descriptively, and conclusions are drawn.

3. FINDINGS AND DISCUSSION

3.1 Finding

Based on the Learning Obstacle test results given to 27 fifth-grade students at SD Lempuyangwangi Yogyakarta, the average score is 26.29, with a total score of 46 points. There are 40% students above the class average, 30% at the class average, and 30% below the class average. The following are details of the data on the number of questions that students can answer:

Table 2. Details of Fraction Multiplication and Division Test Results

Student	Number of Items Answered					
	Correct Answer	Percentage	Partially Correct Answer	Percentage	No answer / Wrong answer	Percentage
S1	5	83%	0	0%	1	17%
S2	4	66%	1	17%	1	17%
S3	3	50%	1	17%	2	33%
S4	4	67%	0	0%	2	33%
S5	4	67%	0	0%	2	33%
S6	3	50%	1	17%	2	33%
S7	5	83%	1	17%	0	0%
S8	0	0%	3	50%	3	50%
S9	4	67%	0	0%	2	33%
S10	3	50%	2	33%	1	17%
S11	5	83%	0	0%	1	17%
S12	1	17%	2	33%	3	50%
S13	1	17%	3	50%	2	33%
S14	0	0%	3	50%	3	50%
S15	0	0%	3	50%	3	50%
S16	2	33%	1	17%	3	50%
S17	6	100%	0	0%	0	0%
S18	0	0%	4	67%	2	33%
S19	2	33%	1	17%	3	50%
S20	0	0%	3	50%	3	50%
S21	4	67%	0	0%	2	33%
S22	0	0%	2	33%	4	67%
S23	1	17%	2	33%	3	50%
S24	0	0%	1	17%	5	83%
S25	0	0%	3	50%	3	50%
S26	0	0%	1	17%	5	83%
S27	0	0%	5	83%	1	17%
Average		35%		27%		38%

Of the 6 questions given to 27 students, 35% of the average correct questions were answered by students, 27% of the average questions were partially correct, and 38% of the average answered wrong or did not write the answer at all.

A statistical analysis of student test results was conducted to strengthen the analysis of research findings. This analysis includes the percentage of answers per item to identify error patterns and types of learning obstacles. Table 3 presents the results of the item-by-item analysis based on student responses.

Table 3. Percentage of Item Answerability

Question	Correct Answer	Percentage	Partially correct	Percentage	Wrong Answer	Percentage
1	11	41%	16	59%	0	0%
2	0	0%	2	7%	25	93%
3	10	37%	7	26%	10	37%
4	13	48%	11	41%	3	11%
5	12	44%	6	22%	9	33%
6	9	33%	4	15%	14	52%

Based on data collected from test data, interviews, observations, and documentation of student answer sheets, researchers found several learning obstacles in the multiplication and division of fractions material.

3.1.1 Ontogenic obstacle

The researcher identified several students who had ontogenic obstacles. This can be seen in the students' answer sheets, where some students made mistakes in calculating fractions' multiplication and division operations. The following are the findings on students' answers:

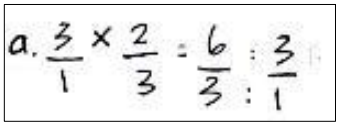

Figure 1. Student 1's answer to question number 1a

In Figure 1, student 1 (S1) made a mistake when simplifying the fraction form. The answer $\frac{6}{3}$ is correct, but when continuing the work, S1 looks like it is dividing $\frac{6}{3}$ by $\frac{3}{1}$. After an interview with S1, it turns out that the meaning of $\frac{3}{1}$ is the result, not the divisor.

P: Why does the answer, after simplifying, become $\frac{3}{1}$ *?*
S1: Because it is divided by 2
P: What is 6 divided by 2?
S1: 3
P: Then, 3 divided by 2?
S1: I think that is wrong, ma'am

Based on the interview above, S1 was not careful in determining the quotient of simplifying fractions. If examined further, the concept that should be used in simplifying fractions is to divide the numerator and denominator by the GCF (Greatest Common Factor) of the number. It can be seen in the answer above that S1 has not applied the concept.

P: How should you simplify the fraction $\frac{6}{3}$*?*
S1: Equally divided by 3, ma'am, so the answer is $\frac{2}{1}$

Students seem to be able to simplify fractions after being asked again; this happened because when working on the problem, S1 was not careful in carrying out the procedure for multiplying fractions, especially at the stage of simplifying fractions. This inaccuracy is also seen in other answers, as follows:

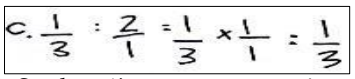

Figure 2. Student 1's answer to question number 1c

In Figure 2, S1's answer to the problem of division of fractions, S1 reverses the divisor number and converts the operation into a form of multiplication. This procedure is common, but it requires accuracy. S1 was less careful in writing the numbers in the problem, which should have reversed $\frac{2}{1}$ to $\frac{1}{2}$, but S1 wrote $\frac{1}{1}$. However, in the next step, S1 multiplied the numbers correctly, but the result was incorrect due to errors in writing numbers.

The results of observations when working on problems show that S1 was not careful because he was in a hurry to solve the problem. Also, based on the results of interviews with class teachers who teach math, S1 is often unfocused and unmotivated when learning math in class. The results of interviews with S1 also show S1's low motivation and interest in learning math.

P: Does S1 like math?
S1: Not so much
P: Why doesn't S1 like math?
S1: Because there are complicated calculations

3.1.2 Didactic obstacle

Furthermore, obstacles related to didactics or didactical obstacles. According to the learning obstacle test results, most students had difficulty answering questions in the form of word problems, questions 2 to 6. From the data in Table 3, most students can do problem number 1 correctly, which is a direct calculation problem. Meanwhile, it is inversely proportional to questions 2 to 6, which are multiplication and division story problems with various meanings. The following is the answer of student 2 (S2) in working on the fraction multiplication story problem number 2:

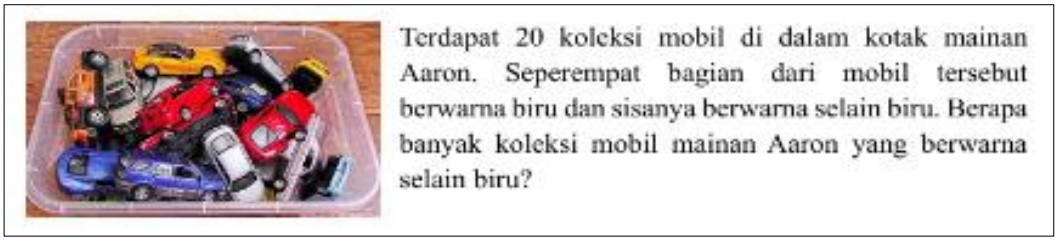

Figure 3. Question Number 2

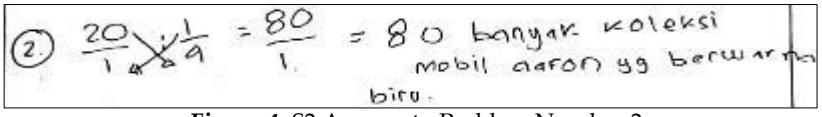

Figure 4. S2 Answer to Problem Number 2

Problem number 2 is a story problem of multiplying fractions with the meaning of part of quantity interpretation of multiplication (Purnomo, Pasri, Aziz, Shahrill, & Prananto, 2022). The answer of student 2 (S2) in Figure 4 does not allow for understanding the story problem because it works by division. The following is an excerpt of the interview text between the researcher and the student:

P: What does S2 think question number 2 asks?
S2: The total collection of blue cars

Based on the interview conversation's text, S2 does not understand what the problem asks or requests. After the researcher asked to reread the problem more carefully, S2 could finally correctly mention what was asked in the problem. After that, the interview conversation continued regarding the problem-solving steps in the problem that S2 applied as follows:

P: S2 got the final answer, 80. Can you tell me where you got this number?
S2: Number 2 I was confused, ma'am, so I thought it was division.
P: What made S2 think it was division?
S2: (Looks confused and cannot answer the question given)

Due to not understanding the story problem given, S2 could not determine that the work on the problem was using the concept of multiplication. The researcher suspected that S2 only guessed between multiplication and division without logical reasoning, so when asked the reason for doing this step, S2 could not explain.

In addition, the next finding regarding didactical obstacles is contained in the procedure for working on less precise problems, as in the following answer:

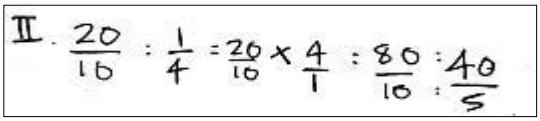

Figure 5. S1's answer to question number 2

S1 added the number 10 as the fraction's denominator in the answer above. This is not by the information presented in the problem, where the total number of cars is 20, while S1 wrote $\frac{20}{10}$. Improper application of procedures can cause errors in the result. The following are the results of the researcher's interview with S1:

P: In the problem, it is written that there are 20 toy cars. Why did S1 write it as 20/10 on the answer sheet?
S1: Because the number in the problem is more than 10, ma'am.
P: Is there any reason for adding 10 as the denominator?
S1: No ma'am

3.1.3 Epistemological obstacle

The data on students' answers to the learning obstacle test questions found that obstacles included epistemological obstacles, namely students' difficulties when performing fraction division procedures. The following questions and student answers are related to these obstacles:

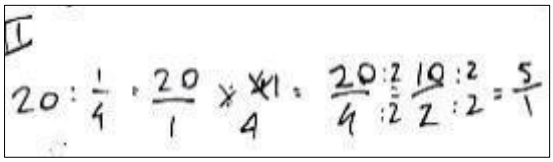

Figure 6. S3's answer to Problem Number 2

In the answer above, S3 tries to solve the division by the inverse method, which is multiplying by the opposite of $\frac{1}{4}$. However, there is a mistake made, namely when the counting operation has changed to multiplication, but S3 does not write the inverse of $\frac{1}{4}$, $\frac{4}{1}$, but still writes as in the question. This happened to the students, and many others wrote the same thing. Not a few students did not answer because they did not know how to answer the question. The following is an excerpt of the text of the researcher's interview with S3:

P: Why did answer number 2 change the divide sign to a times sign?

S3: I forgot how to do it ma'am
P: What about the way you were taught before?
S3: It should be reversed
P: Does S3 know why dividing can be reversed?
S3: I do not know ma'am

3.2 Discussion

Based on the results of the previous research data analysis, three categories of students' learning disabilities in multiplication and division of fractions were found, namely:

Ontogenic Obstacle

There are three types of ontogenic obstacles, namely psychological ontogenic, instinctual ontogenic, and conceptual ontogenic (Suryadi, 2019). So, based on the findings in the test answers, interviews, and observations, the learning obstacles found are categorized into psychological ontogenic obstacles. Students' unpreparedness causes this obstacle to receiving lessons psychologically, so it impacts focus and accuracy when working on problems. Lack of motivation and interest in the subject from the start is also a trigger in bringing up this type of obstacle. This is from previous research that psychological ontogenic obstacles arise due to students' unpreparedness to learn from psychological aspects such as motivation and disinterest in the subject (Ruli et al., 2021). In addition, this type of obstacle can be caused by problematic mastery of prerequisite material, such as understanding the concept of fractions as division, multiplication, and division of integers, the Greatest Common Factor, addition and subtraction of fractions, mixed fractions, and fractions worth. This is in line with the results of previous research (Fauzi & Suryadi, 2020), which explains that students' weak understanding of prerequisite material will trigger the emergence of new obstacles in the material that will be taught next. This can be seen in the students' weak understanding of the meaning of fractions, which are part of the whole, so they are unable to work on multiplication and division of fractions related to this concept. This obstacle can be anticipated by strengthening students' readiness for the prerequisite material for multiplication and division of fractions. This aligns with previous research that strengthens prerequisite material andan help students understand the concepts of multiplication and division of fractions (Permata, Wijayanti, & Masriyah, 2019).

Didactical Obstacle

One example of a didactic obstacle is students not understanding the meaning of word problems. For students to understand story problems well, good teaching regarding problem-solving strategies, language understanding, good reading skills, and habituation from teachers is needed. In their book, Van de Walle, Karp, and Bay-Williams explained that teaching approaches focusing on problem-solving and active learning can help overcome students' difficulties in understanding story problems (Walle et al., 2013). Based on the results of interviews with students, S2 said that he did not know how to use lessons on multiplication and division of fractions in everyday life. This finding is also in line with research conducted previously that didactic obstacles can increase if, in the presentation of the lesson material, the teacher does not relate to contexts that are close to everyday life and are not structured in a sequence according to the cognitive level of elementary school students (Hendriyanto et al., 2024). To overcome this obstacle, teachers can design learning using everyday contexts suitable for students (Salim Nahdi & Gilar Jatisunda, 2020).

Furthermore, in this type of obstacle, students were found to apply the procedure of multiplying and dividing fractions inappropriately. Based on the interview results, the researcher suspected that S1 did not understand how to work on multiplication and division of fractions, so the steps on the answer sheet were not based on clear reasons. Weak concept understanding can lead to procedural errors because students only memorize steps without understanding the meaning of multiplication and division of fractions (Purnomo et al., 2022). In learning fractions in Indonesia, especially the arithmetic

operations of multiplying and dividing fractions, teaching is often focused on working procedures rather than understanding the concept of the material. Therefore, researchers suspect that students experience didactical obstacles due to didactical systems, such as the education system and the selection of unsuitable learning strategies for students or the subject (Nurani et al., 2021). Previous research has shown that balancing procedural and conceptual emphasis together can overcome this obstacle so that learners understand the procedural meaning of what is being done (Purnomo et al., 2019).

Epistemological Obstacle

The findings on this type of obstacle come from the characteristics of this fraction multiplication and division material, which triggers the emergence of obstacles. Based on the interview results, students who are used to working on multiplication of fractions work on division similarly so that multiplying fractions is mixed with the procedure for dividing fractions. If not understood thoroughly and only relies on memorization, dividing fractions by multiplying the inverse can cause obstacles when working on problems. This aligns with previous research, where this epistemological obstacle occurs due to students' limited understanding of new concepts and procedures, so understanding old concepts and procedures becomes an obstacle (Ulfa et al., 2021). Solving this obstacle can be done by designing learning using manipulative media. This is in line with previous research that the use of manipulative media can bridge abstract fraction material with the cognitive development stage of elementary school students (Braithwaite & Siegler, 2021; Mills, 2019; Milton, Flores, Moore, Taylor, & Burton, 2019).

This study was conducted on 27 grade 5 elementary school students in Yogyakarta with certain characteristics, such as geographical location, the curriculum used, namely the Merdeka curriculum, and students' backgrounds. Therefore, the results of this study may have limitations in terms of generalization to a wider population. However, the findings can provide meaningful and relevant insights for elementary schools with similar characteristics, especially in teaching fraction operations. For future research, it is recommended to involve a larger and more diverse sample to improve the generalizability of the results.

4. CONCLUSION

Based on the results of the research and data analysis, it can be concluded that there are several learning obstacles experienced by fifth-grade students of Lempuyangwangi Elementary School, Yogyakarta on the material of multiplication and division of fractions, among others: 1) Ontogenic obstacle, where students have not been able to simplify the form of fractions, not careful in calculating the product and quotient, and low motivation to learn mathematics 2) Didactic obstacle, where students have not been able to understand the story problem, have not been able to determine what is asked about the problem so that the selection of problem-solving strategies is also inappropriate, and students have not been able to apply the working procedures appropriately 3) Epistemological obstacle, where students have difficulty applying the concept of inverse to the division of fractions which is still often mixed up in the calculation operation of fraction multiplication.

From the findings of these learning obstacles, some practical strategies teachers can implement to overcome these obstacles are suggested. Teachers can provide gradual practice for ontogenic obstacles with a focus on prerequisite material. The prerequisite material that can be delivered is the simplification of fractions using Least Common Multiple (LCM) and Greatest Common Factor (GCF) and strengthening the concept of fractions as parts of a whole. Teachers are advised to use the context of everyday lessons for didactic obstacles. Manipulative media or relevant stories can be used to make it easier for students to understand the context of story problems. For epistemological obstacles, teachers can utilize visual aids and manipulatives, such as fraction diagrams or interactive games, to help students understand the concept of division as the inverse operation of multiplication.

The findings of this study can be used as a basis for teachers in designing didactical learning to overcome these learning obstacles in the multiplication and division of fractions material, so that the learning process can be improved.

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