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Identifying Learning Obstacles in Junior High School Students: A Diagnostic Study on the Topic of Integer Multiplication

Inggrid Sitanala, Rizky Rosjanuardi*, & Tia Purniati
Mathematics Education Study Program, Universitas Pendidikan Indonesia, Indonesia

*Corresponding email: rizky@upi.edu

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Abstract: Integer multiplication is one of the important materials in mathematics. However, material on integer multiplication often becomes a problem for junior high school students' learning. This study aims to determine the learning barriers experienced by junior high school students in the integer multiplication material and to identify the characteristics of these barriers (ontogenic, epistemological, and didactic). This study used a qualitative method with a diagnostic study design. The research participants were 14 eighth-grade students at a public junior high school in Bitung City, North Sulawesi, with 3 students selected as subjects for exploration based on the types and patterns of errors and the diversity of levels of understanding observed in learning integer multiplication. The research procedure began with the preparation of a diagnostic test instrument consisting of three abstract questions and story problems related to the multiplication of integers, as well as an interview guide. The instruments used comprised two types: a learning-obstacle diagnostic test and a semi-structured interview guide, while the researcher served as the analytical instrument. Data collection in this study was carried out using triangulation, namely observation, interviews, and documentation of textbooks and student notebooks. The research data analysis was conducted in three stages, namely data reduction, data presentation, and conclusion drawing. The study found three interrelated types of learning obstacles: ontogenic, epistemological, and didactical. Based on the results of the research and discussion on the identification of learning obstacles, it can be concluded that the characteristics of learning obstacles in learning integer multiplication in junior high school are ontogenic obstacle in the form of memorization without understanding the rules of multiplication of signs, epistemological obstacle in the form of misunderstanding of the definition and characteristics of integers, misconceptions about the rules of multiplication of signs, difficulties in understanding the relationship between real contexts and integer operations, and didactic obstacle in the form of design and implementation of learning. Based on the results of this study, it is necessary to create a learning design to overcome students' learning obstacles in junior high school integer multiplication.

Keywords: learning obstacle, integer multiplication, diagnostic study, junior high school students.

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INTRODUCTION

Integers are a topic covered in seventh-grade mathematics in junior high schools or equivalent. This material covers the comparison of integers and the operations on them, such as addition, subtraction, multiplication, and division (Faznur & Rohim, 2020). The concept of an integer is fundamental and needs to be taught to establish a strong foundation for students (Alfarisi et al., 2022). Decree of the Head of the Education Standards, Curriculum, and Assessment Agency of the Ministry of Education, Culture, Research, and Technology No. 032/H/KR/2024 emphasizes the importance of conceptual understanding in learning numbers.

Mathematics learning positions conceptual understanding as crucial, as a solid understanding impacts students' ability to analyze problems, find solutions, and solve real-world problems relevant to mathematical concepts (Mulyatna et al.,

2023). Wibowo et al. (2021) also stated that understanding mathematical concepts is an important skill for students, as it makes it easier for them to learn and master these concepts.

Arithmetic operations on integers, namely addition, subtraction, multiplication, and division, are very important in students' daily lives, both at school and in the community and within their families. The relationship between integer concepts and other mathematical concepts is crucial, as integer concepts are prerequisites students must master before understanding subsequent concepts (Ramadhani, 2022). However, the main obstacle to learning mathematics at the junior high school level is students' limited ability to perform basic operations with integers (Hernadi et al., 2020). Conceptual understanding is also related to students' ability to solve math problems. The better a student's conceptual understanding, the fewer errors they make, and vice versa (Paut et al., 2025)

Students still face many obstacles to understanding mathematical concepts due to limited conceptual explanations in the learning process (Muin & Fatma, 2021). Conceptual understanding of integer multiplication is still lacking (Ernawati et al., 2022). This is evident in students' inability to answer questions and their lack of conceptual understanding of questions on integer multiplication. Similarly, Widyasari & Lestari (2023) stated that students still struggle to understand the concept of multiplication and numeracy, especially when performing arithmetic operations involving integers. Rumajar et al (2024) also noted that many students remain confused about understanding the basic concepts of integers. Furthermore, Arum (2025) explained that students' mathematics learning outcomes, particularly in integer multiplication, remain suboptimal.

Multiplication of integers involving negative numbers is generally challenging. Students still have difficulty interpreting negative numbers and performing operations involving them (Alfarisi et al., 2022). Swintari (2016) also observed the errors made by students when dealing with dissimilar numbers and involving positive and negative integers.

Research conducted by Purniati & Suhaedi (2025) found that mathematics learning in schools is often poorly connected to students' real-life contexts, resulting in many students having difficulty understanding mathematical concepts. However, connecting mathematics to everyday life is essential for students to understand its relevance and benefits. Faznur & Rohim (2020) also noted that students struggle to translate word problems into mathematical concepts. Furthermore, teachers often emphasize procedural skills, such as introducing multiplication, without fully utilizing concrete objects or visual aids. Instead, they emphasize memorization techniques (Baharuddin, 2024).

Many students still encounter obstacles in learning this material (Kurniasi, 2023). Hidayat (2020) also explained in his research that integer multiplication is a fundamental concept for students in reaching the next level of concepts. Therefore, multiplication is important for students to master. However, during the process, students encountered obstacles in understanding integer multiplication operations. The study found that the concept of integer multiplication is among the integer arithmetic operations that pose learning obstacles for students when solving problems related to this material.

Problems that arise in the multiplication of integers include a lack of understanding of the definition of integers, a suboptimal mastery of basic multiplication, a weak understanding of positive and negative multiplication, and difficulty solving mathematical word problems. Even students who can solve multiplication problems often rely solely on procedures without a deep understanding of the concepts. Interviews indicate

that students tend to memorize formulas without understanding their underlying meaning.

These problems arise because teachers fail to explain the definition of integers, directly provide multiplication formulas with signs without explanation, and lack a variety of examples, including those from everyday life. Consequently, students cannot name integers, do not understand word problems, especially those involving negative signs, and cannot solve them correctly. These factors can be classified as learning obstacles.

Brousseau (2002) proposed three types of learning obstacles: ontogenic, epistemological, and didactic obstacles that can occur in the learning process. Ontogenic obstacles are difficulties related to students' readiness to learn. Epistemological obstacles are difficulties arising from the limited context in which a concept is first learned. This means that students actually possess knowledge, but it applies only within a narrow context. Therefore, when faced with a broader or different context, students experience difficulties and even errors. Meanwhile, didactic obstacles are difficulties caused by the didactic design used.

Unlike previous studies that identified learning obstacles generally in integer operations, such as the study conducted by Malau et al. (2022) or other materials such as the Pythagorean theorem in the study conducted by Ifada & Ruli (2024), the material on exponents in the study conducted by Sumirat (2022), statistics in the study conducted by Saputri (2024), and circles in the study conducted by Marlena (2021), this study provides a new contribution through a diagnostic study focused on the material on integer multiplication in junior high school, by identifying and grouping the characteristics of learning obstacles experienced by students.

Identifying learning obstacles in junior high school students' understanding of integer multiplication is crucial for preventing them from failing to master it, as this could affect their ability to understand more complex mathematical topics. The diagnostic study not only identifies the types of learning obstacles but also analyzes their causes from ontogenetic, epistemological, and didactic perspectives. This study employed data triangulation using diagnostic tests, interviews, and documentation to identify barriers to student learning.

Based on the background outlined above, the research question is: "What are the characteristics of learning obstacles (ontogenic, epistemological, and didactic) experienced by junior high school students in integer multiplication?" The purpose of this study was to determine the characteristics of learning obstacles (ontogenic, epistemological, and didactic) in integer multiplication among junior high school students.

This research is expected to contribute to teachers in schools by emphasizing conceptual understanding rather than simply providing formulas in integer multiplication lessons. Teachers can also conduct diagnostic tests before the lesson begins to assess students' understanding.

METHOD

Participants

The research subjects were eighth-grade students at a public junior high school in Bitung City, North Sulawesi. Fourteen students participated in the diagnostic test, and three were then selected as research subjects for interviews. The research subject selection technique used was purposeful sampling with the following inclusion criteria: students who had studied integer multiplication in seventh grade, students who had varied answers, both correct and incorrect, to identify learning obstacles, students who demonstrated conceptual, procedural, or technical errors in solving problems, and students who were willing to be interviewed to explore the reasons behind their answers. The three

students were coded S1, S2, and S3. This limited number of subjects was intended to allow for a more in-depth and detailed analysis of the error patterns and learning obstacles experienced by each individual. The research was conducted in October 2025 to identify learning obstacles related to integer multiplication.

Research Design and Procedures

This study employed a qualitative, diagnostic design to identify and analyze obstacles to learning integer multiplication among junior high school students. A qualitative approach was chosen because it allowed researchers to explore in depth the learning obstacles students experienced by analyzing answer errors, thought patterns, and conceptual understanding. This study identified learning obstacles, classified into three categories according to Brousseau (2002): ontogenic, epistemological, and didactic, that can occur during the learning process.

The research procedure began with the development of a diagnostic test instrument consisting of three questions, one abstract and one story problem, related to integer multiplication, and the preparation of an interview guide. Fourteen students took the written test, and three were selected for interviews. The study was conducted over two weeks.

Data collection in this study was conducted through triangulation, namely observation, interviews, and documentation. Observations were conducted to identify the sources of teaching materials used and to gather information on students' understanding of the material. Interviews were conducted with students who had taken the diagnostic test and teachers who taught in Grade 7. Documentation was conducted to obtain data and information through textbooks used by students and teachers, as well as student notebooks.

Data analysis was conducted in three stages, referring to Miles and Huberman (1992): data reduction, data presentation, and conclusion drawing. In the data reduction stage, the data obtained from the data collection results were summarized. Then, the data were presented as narrative text, figures, and tables. Conclusions were then drawn to clarify the findings.

Instruments

The instruments used consisted of two types, namely: (1) A diagnostic learning obstacle test consisting of three descriptive questions to identify learning obstacles in the concept of integer multiplication. The indicators measured were the definition of integers, multiplication signs, and story problems. Based on these indicators, questions were created covering: understanding the definition of integers (question number 1), multiplying integers with various combinations of positive and negative signs (question number 2), and applying integer multiplication through story problems involving temperature drops. The diagnostic test in question was a retrospective assessment of material retention. (2) A semi-structured interview guide was designed to delve deeper into students' understanding, the reasons behind their answers, the problem-solving strategies used, and to identify learning obstacles not revealed through the written test.

The instrument was validated through the following steps: describing the instrument, validating it with an expert, namely an algebra lecturer, revising it based on expert advice, and determining the final instrument. In addition, the researcher acted as an analytical instrument.

Data Analysis

Data analysis was conducted using triangulation of written tests, interviews, and student notebook documentation. The first stage was administering a diagnostic test to 14 students. Students were asked to work on three descriptive questions individually, writing down all the steps for solving them in detail. Students were given

sufficient time to complete the test so they could express their understanding to the fullest. Second, interviews were conducted. Of the 14 students who took the diagnostic test, three students were selected for interviews. Interviews were conducted individually, lasting approximately 30-45 minutes per student. Aspects explored during the interviews included initial conceptual understanding, problem-solving steps, the rationale behind answers, error locations, and obstacles students encountered while learning. During the interviews, the researcher represented the students' answers and asked about their reasons, strategies, and understanding of each question. Third, students' notebooks for integers were reviewed in Grade VII.

■ RESULT AND DISCUSSION

Students took a diagnostic test, and three students were selected to have their answers taken and interviewed. The diagnostic test questions an their answers are shown in Table 1.

Table 1. Diagnostic test questions and their answers

QUESTIONS	ANSWERS		
	S1	S2	S3
1. Which of the following numbers are integers? $1;\ \frac{1}{2};\ 0;\ -4;\ 0{,}8;\ 3\frac{2}{5};\ 7.39$	0 and 7.39	$3\frac{2}{5}$	0.8
2. What is the result of:			
a). $3 \times 5 =$	15	15	15
b). $7 \times (-4) =$	-28	-24	-28
c). $(-8) \times 6 =$	48	48	48
d). $(-13) \times (-9) =$	277	-117	-117
3. The temperature in the Arfat Mountains of Papua drops 2°C every hour at night. If the initial temperature is 10°C, what will the temperature be 6 hours later?	126	4°C	20°C

The three students' diagnostic test and interview answers are explained in detail below.

Question 1: Definition of Integers

Question 1 tests students' understanding of the definition of integers and their ability to identify numbers within the set of integers, as shown in Figure 1 below:

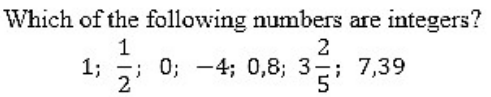

Figure 1. Question 1

The answer to S1 shown in Figure 2 below.

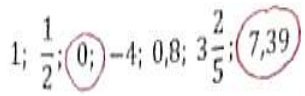

Figure 2. S1's answers

In Figure 2, S1 answered 0, which is an integer, and 7.39 is not an integer. Based on the interview results, S1 answered 0 because it is round, while the answer 7.39 was a guess.

Next, the answer to S2 is shown in the following Figure 3.

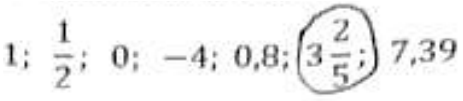

Figure 3. S2's answers

In Figure 3, S2 answered 3 2/5, which is not an integer. Based on the interview results, S2 only guessed the answer. Next, the answer to S3 is shown in the following Figure 4.

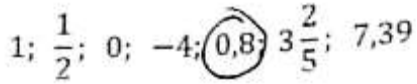

Figure 4. S3's answers

In Figure 4, S3 answered 0.8, which is not an integer. Based on the interview results, S3 only guessed the answer. Based on the answers and interviews from the three students, it shows that they do not know the definition of integers, so they cannot correctly name the numbers that are integers and can only guess. Students cannot distinguish between integers, decimals, and fractions. The results of interviews with the Grade VII teacher also showed that the teacher did not explain the definition of integers during the previous Grade VII lesson. This obstacle is fundamental because understanding integers is a prerequisite for learning integer multiplication operations. The relationship between error types and learning obstacle categories is presented in the concept map in Figure 5 below:

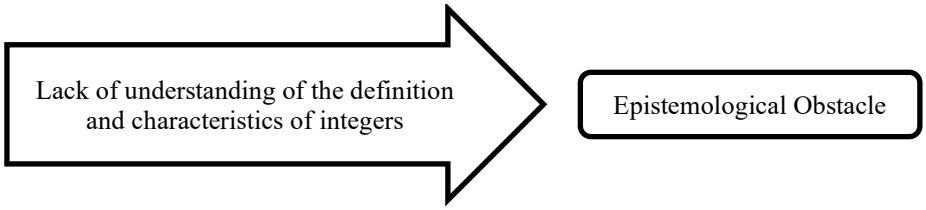

Figure 5. Flowchart of error categorization

Question 2: Multiplication of Integers

Question 2 consists of four sub-questions (2a, 2b, 2c, 2d) that test students' ability to perform multiplication operations with integers with various combinations of positive and negative signs. Question 2 is shown in Figure 6 below:

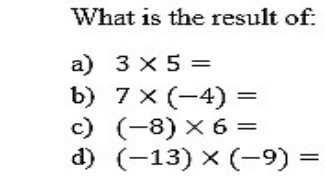

Figure 6. Question 2

The answer to S1 is shown in Figure 7 below.

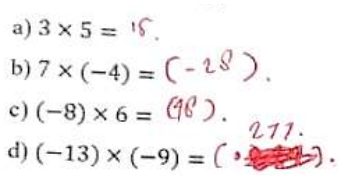

Figure 7. S1's answers

In Figure 7, S1 answered questions 2a and 2b correctly, but answered 2c incorrectly because it did not include a negative sign, and 2d was also answered incorrectly in the multiplication calculation, although the positive sign was correct. Based on the interview, S1 felt that his first answer to question 2d was incorrect, so he crossed it out and replaced it with 277. So S1 can calculate multiplication but is not careful when multiplying 2 numbers by 1 number, so the result is wrong, and he is still wrong in including the sign when multiplying negative numbers by positive numbers.

Next, the answer to S2 is shown in the following Figure 8.

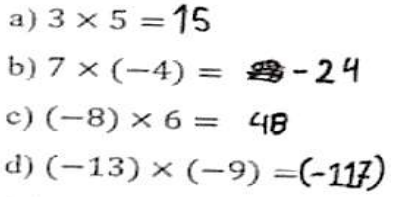

Figure 8. S2's answers

In Figure 8, it can be seen that S2 answered question 2a correctly, but answered 2b incorrectly because the negative sign was correct. However, the multiplication result was wrong; number 2c was also wrong because it did not include a negative sign even though the multiplication result was correct. Number 2d was also wrong because the sign was negative even though the multiplication result was correct. Hence, S2 has not mastered basic multiplication, so he made a mistake in answering the question and in applying the sign rules for multiplying negative and positive numbers, as well as for multiplying negative numbers.

Next, the answer to S3 is shown in the following Figure 9.

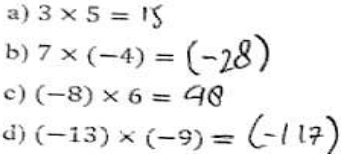

Figure 9. S3's answers

In Figure 9, S3 correctly answered questions 2a and 2b. Number 2c is still incorrect because it does not include a negative sign even though the multiplication result is correct. Number 2d is also still incorrect because the sign is negative even though the multiplication result is correct. So, S3 can perform multiplication operations but is still incorrect in handling negative numbers. Based on the interview results, S3 answered using basic multiplication calculations, while the positive and negative signs were determined by the sign of the second number in the question.

Question number 2 consists of four sub-questions (2a, 2b, 2c, 2d) that test students' ability to perform multiplication operations of integers with various combinations of positive and negative signs. Student answers show varying error patterns. Based on interviews, some students did not master basic multiplication, while others memorized the rules for multiplication signs without understanding the underlying concepts. Some students tended to solve problems by using negative numbers, resulting in negative answers. This indicates a misconception about the rules for multiplication signs. The relationship between error types and learning obstacle categories is presented in the concept map in Figure 10 below:

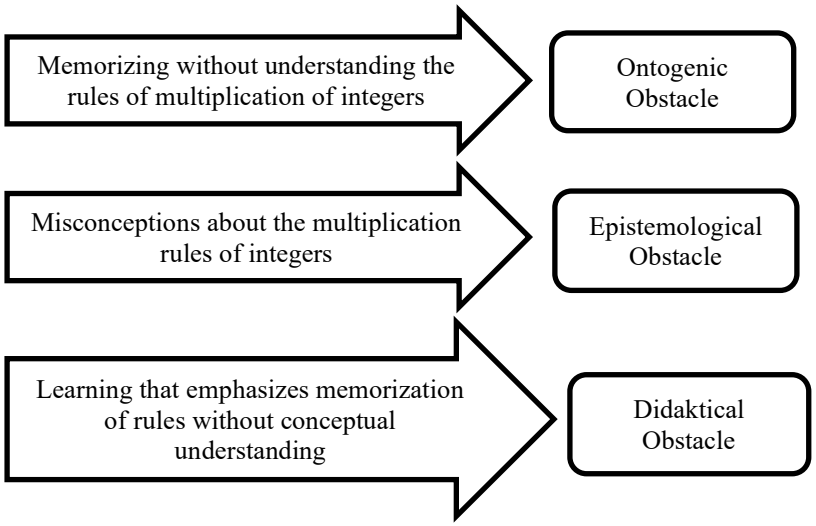

Figure 10. Flowchart of error categorization

Question 3: Word Problem

Question 3 uses the context of decreasing temperature. This question tests students' understanding of negative numbers. Question 3 is shown in Figure 11 below:

The temperature in the Arfat Mountains of Papua drops 2°C every hour at night. If the initial temperature is 10°C, what will the temperature be 6 hours later?

Figure 11. Question 3

The answer to S1 is shown in Figure 12 below:

Figure 12. S1's answers

In Figure 12, it can be seen that S1 was wrong in answering question number 3; S1's answer was 126. Based on the interview results, S1 worked by multiplying the temperature drop of 2°C by the initial temperature of 10°C, but then he forgot how to do it and got the result 126. While, S2 incorrectly answered question 3; S2's answer was 4°C. Based on the interview results, S2 worked by reducing the initial temperature by 10°C over 6 hours to obtain an answer of 4°C, and ignored the 2°C decrease per hour at night. S3 incorrectly answered question 3; S2's answer was 20°C. Based on the interview results, S3 worked by multiplying the temperature drop of 2°C by the initial temperature of 10°C to obtain the answer 20°C, and did not know how to work out the temperature 6 hours later.

The answers from the three students show that they were unable to solve the problem correctly. The results of interviews with students indicate that students do not understand the concept of decreasing or repeated subtraction represented as multiplication by negative numbers. Students cannot interpret the context of a 2°C decrease every hour for 6 hours and cannot correctly calculate the initial temperature of 10°C. This obstacle indicates difficulty in understanding the relationship between real contexts and mathematical model representations, as well as difficulty in understanding the meaning of negative numbers in the context of decreasing, rather than due to difficulties in reading literacy. The relationship between error types and learning obstacle categories is presented in the concept map in Figure 13.

Overall, these barriers are interrelated, from basic to contextual application, indicating the need for learning interventions that focus on conceptual understanding, visualization of real-world contexts, and correction of specific misconceptions to address students' developmental potential.

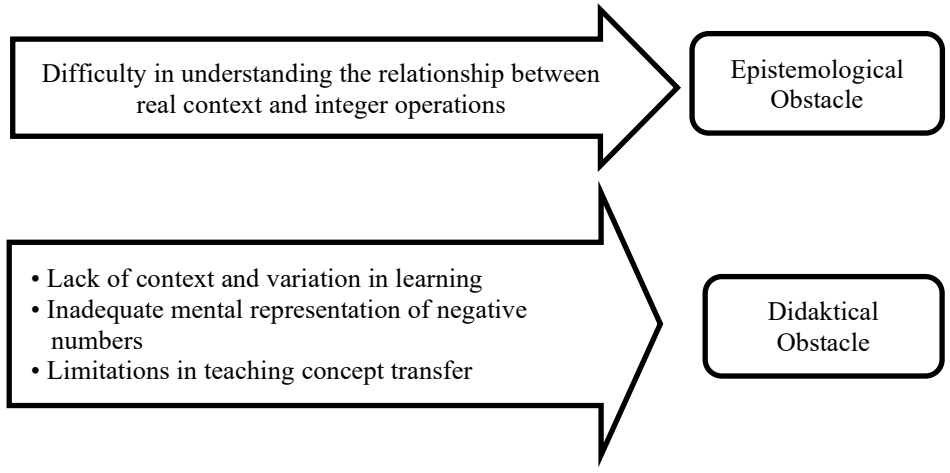

Figure 13. Flowchart of error categorization

Based on the analysis of diagnostic test and interview results, the learning obstacles identified in this study were classified into three categories according to Brousseau (2002): ontogenic, epistemological, and didactic. The characteristics of the learning obstacles identified in this study are shown in Table 2 below:

The characteristics of learning obstacles indicate that integer multiplication is difficult to grasp because it relies solely on memorization

Table 2. The characteristics of learning obstacles

No	Learning obstacle	Characteristics of Learning Obstacles
1	Ontogenic Obstacle	Memorizing without understanding the rules of multiplication signs
2	Epistemological Obstacle	• Lack of understanding of the definition and characteristics of integers • Misconceptions about the rules of multiplication of signs • Difficulty in understanding the relationship between real-world contexts and integer operations
3	Didactical Obstacle	• Learning that emphasizes memorization of rules without conceptual understanding • Lack of context and variety in learning • Inadequate development of mental representations of negative numbers • Limitations in teaching concept transfer

rather than conceptual understanding and lacks real-life context, making it difficult for students to understand story problems. The findings of this study demonstrate the complexity of the obstacles junior high school students experience in learning integer multiplication.

These results align with research by Malau et al. (2022), who found that learning obstacles can be identified through errors made in solving problems. Oktavia & Kertiyani (2025) also explained in their study that emerging learning obstacles can disrupt students' learning processes. Ontogenic obstacles include students' unpreparedness during learning, lack of interest and motivation to learn, and a lack of understanding of prerequisite material. Epistemological obstacles include misconceptions, an inability to understand, identify, and analyze problems, inaccuracies, and limitations in problem-solving. Didactic obstacles include teacher-centered learning, a fast pace of learning, inappropriate instructional materials, and inadequate school facilities. Research by Fuadiah (2016) also indicates that most problems in integer arithmetic operations involve negative numbers. Several studies have suggested that students' difficulties in understanding negative numbers are largely due to their inherently abstract nature. Therefore, teaching aids are needed to help students understand negative numbers.

A common misconception among students is that the sign of a multiplication result is determined by the second term. Kurniati et al. (2018) explain that misconceptions in mathematics can become serious problems if not addressed promptly, as they can lead to ongoing errors. Their research findings indicate that one misconception students encounter when solving integer problems concerns the multiplication of integers.

Didactic barriers identified primarily involve instruction that emphasizes memorizing rules

without conceptual explanation. Interviews revealed that teachers directly provide multiplication formulas without explanation, indicating ineffective teaching practices. This confirms the importance of a more constructivist approach to learning, in which students are guided to understand concepts through exploration and discovery rather than passively accepting rules.

Students' difficulties in translating the context of word problems into mathematical representations demonstrate a gap between procedural and application skills. Maharani et al. (2024) explained that one of the difficulties in learning mathematics is solving word problems. A common problem is that students are unable to master mathematics learning, especially word problems. This is because solving word problems cannot be done in a single step; students must go through several stages that require a good understanding of the problem, the ability to perform calculations, and the ability to draw conclusions. If students do not master one of the stages in solving word problems, they will have difficulty or even fail to solve math word problems.

■ CONCLUSION

Based on the research results and discussion on identifying learning obstacles, it can be concluded that the obstacles experienced by students include ontogenetic, epistemological, and didactic obstacles. Furthermore, the characteristics of learning obstacles in learning integer multiplication in junior high school are identified: ontogenic obstacles in the form of memorization without understanding the rules of multiplication signs; epistemological obstacles in the form of misunderstanding the definition and characteristics of integers, misconceptions about the rules of multiplication signs, difficulties in understanding the relationship between real-world contexts and integer operations; and didactic obstacles in the form of learning design and implementation.

The implications of this study are the validation of the learning obstacle framework in the context of learning integer multiplication. The three types of learning obstacles (ontogenic, epistemological, and didactic) were found to be interrelated and influence student learning in a complex manner. The findings of this study indicate that ontogenic obstacles tend to exacerbate students' epistemological obstacles, which are further reinforced by didactic obstacles in the mathematics learning process.

Suggestions based on the results of this study are the need to redesign integer multiplication learning that: (1) ensures mastery of prerequisites (basic multiplication) before teaching integer multiplication; (2) builds a conceptual understanding of negative numbers; (3) teaches the rules of multiplication signs with conceptual justification, not just memorization; (4) provides a variety of word problem contexts; and (5) uses a continuous diagnostic approach to identify and address misconceptions early on.

■ DECLARATION OF GENERATIVE AI USAGE IN THE WRITING PROCESS

During the writing of this manuscript, the author(s) employed Perplexity AI to assist with searching for articles supporting the research and to find definitions of unclear words and phrases. The author(s) have reviewed and edited the content generated by this tool and assume full responsibility for the content of the published article.

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