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Students' learning obstacle in operations of integer

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ABSTRACT

This study aims to describe the learning obstacles faced by students in the operation of integers. The research method used is a qualitative method with a case study design. The data was taken from 16 students in grade 7, a junior high school in Batang Hari, Jambi. The data collection technique used was triangulation data. There are written tests, interviews with both students and the teacher, and document analysis. The data collection instrument used was a test of integer operations, interview guidelines, and documents (lesson plan and textbook). The results of the research showed that there are learning obstacles in the operations of integers, namely, ontogenic obstacles (difference in knowledge between natural number operations and integer operations), epistemological obstacles (limited understanding), and didactical obstacles (obstacles that come from the didactic system). Other researchers can create lesson plans based on the obstacles found in this research.

INTRODUCTION

Integer arithmetic operation competence is one of the basic material that is very important for students. This competency will always be used in the next material. In accordance with one of the characteristics of mathematics material, namely between materials in mathematics learning has a spiral-shaped relationship. Soyke stated that the spiral-shaped characteristics of mathematical material make basic material very important for students to master (Soyke, 2016). These characteristics make the basic concept of a material will always be used in the next material. The material will be repeated and deepened at the next levels. The material for integer operations in grade 7 SMP semester 1 will continue to be used in subsequent materials such as power numbers, algebra, linear equations and inequalities and other materials.

In addition to being essential, the material for integer operations is also strategic. That is, the material is widely applied in everyday life as well as applied to other sciences. As'ari stated that one of the characteristics of mathematics is that it is widely used in other knowledge (As'ari et al., 2017). Integer material is applied to the fields of chemistry, physics, biology, technology, and so on. Integration between knowledge is needed to solve real problems. Makonye and Fakude stated that real problems in science require students to apply knowledge of science and mathematics to solve them (Makonye & Fakude, 2016). If students do not understand mathematical concepts, students may be able to solve problems in the science section but when it comes to mathematics they fail. They often fail to manipulate calculations, especially those involving positive and negative integers.

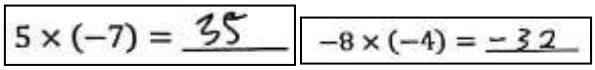
Based on the description above, it is illustrated that the material for integer operations is very important to pay attention to. However, many students have difficulty learning about integer. This research aims to find out the obstacles faced by students in learning about integer. Researchers conducted preliminary observations on 16 students in one of the junior high schools in Batang Hari Regency, Jambi Province. The researcher gave 10 questions about integer operations to students. Based on the results of student answers 93.75% still make errors in operating integers, there is only one person

who answers all questions correctly. Here are some of the results of the student worksheets that have been done.

(a) (b)

Figure 1. Preliminary Study Worksheet

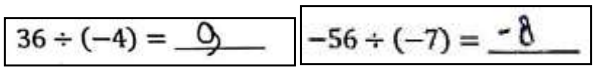
Figure 1 shows student worksheets on the addition and subtraction of two integers, there are still students who have not been able to operate correctly. The operation of addition and subtraction of integers has been studied and is often used in elementary school. In the picture it can be seen that students add 10 and 12 first, then students add a negative sign to the result of the operation. Meanwhile, in the subtraction operation, it can be seen that students consider the results of 12-10 to be the same as 10-12.



(a) (b)

Figure 2. Preliminary Study Worksheet 2

Students also have not been able to understand the rules for multiplication of integers. In Figure 2, students answer positive integers multiplied by negative integers to produce positive integers. Meanwhile, in the next question, students answered that the product of two negative integers resulted in a negative integer too.



(a) (b)

Figure 3. Preliminary Study Worksheet 3

The same is true for the division operation. Figure 3 shows that students divide a positive integer by a negative integer to produce a positive number. Students also answer that the quotient of two negative integers produces negative integers too.

Based on the preliminary study, it can be seen that there are student errors in answering integer operations questions. Some of the errors in the student's answers above indicate that students do not understand the concept of integer operations. Al-Mutawah mentions that understanding mathematical concepts helps students avoid mistakes in learning mathematics (Al-Mutawah & Thomas, 2019). Students' failure to understand math material can indicate learning obstacles. There are three types of learning obstacles that may occur, namely ontogenic obstacles (mental readiness), epistemological obstacles (limited understanding), and didactical obstacles (obstacles that come from the didactic system).

Based on the research background above, this study aims to describe the learning obstacle faced by students in the operation of integers. The results of this study are expected to be able to help students understand the rules of integer operations and avoid errors in solving problems related to integer operations.

RESEARCH METHODS

This research was conducted in one of the junior high schools in Batang Hari Regency, Jambi Province. The research method is a case study in qualitative method. Yin stated that qualitative research provides the authors with an overview of the views and perspectives of respondents (Yin, 2015). This is in line with the research objective, which is to obtain a description of the learning obstacles that students face when learning integer operations. The data collection instrument used was the researcher himself. There are several additional instruments including written tests and interview guidelines. Collecting data in this study using triangulation techniques. The triangulation technique was chosen to

increase the validity of the data obtained (Nieveen & Folmer, 2013; Yin, 2015). The triangulation technique intended in this research is a written test, student and teacher interviews, as well as document analysis such as lesson plans and textbooks used when learning integer operations.

The written test consists of questions filled with integer operations. The written test was conducted to see the students' ability to answer questions about integer operations. After the written test and obtaining the written test results, several selected students will be interviewed. Students are selected based on answers that represent several students. Interviews were conducted to obtain information about students' learning experiences in studying integer operations. Interviews were conducted to find out more deeply what was in the minds of the participants (Creswell, 2016; Nieveen & Folmer, 2013). Interviews will be conducted with open-ended and developing questions with all selected participants. Creswell stated that the questions in the interview were open, general, and focused on understanding the main phenomenon in research (Creswell, 2016). The author will also conduct interviews with mathematics teachers who teach in the class concerned. Teacher interviews were conducted to obtain an overview of the learning process that had been carried out by the teacher. Furthermore, the author will also analyze documents such as lesson plans and textbooks used in the learning process. Document analysis was conducted to see whether learning resources and didactic situations were able to help students achieve learning objectives.

The next step is to carry out three steps of qualitative data analysis according to Creswell (2016) namely:

a. Preparing and organizing the data. This stage is data collection. The data collected in this study were written test results, transcripts of teacher and student interviews, lesson plans, and textbooks.
b. Reducing the data. After all the data is collected the next step is to reduce the data. Data reduction is carried out through data selection and centralization. At this stage the data is coded to be grouped based on the research objectives. So there is an allowance for data that is not included in the research objectives.
c. Representing the data. The last stage is presenting the data. The reduced data is presented in the form of pictures, tables, or discussions. At this stage the data is described so that a research conclusion can be drawn.

The flow of this research can be summarized in a flow chart as follows:

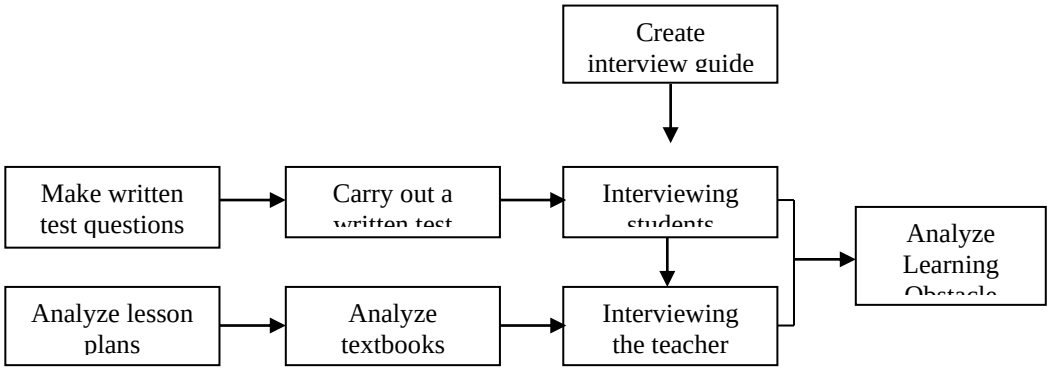


Figure 4. Research Flow

RESULTS AND DISCUSSION

The study was conducted on 16 seventh-grade students in one of the junior high schools in Batang Hari Regency, Jambi Province. This study uses data triangulation to obtain a description of the learning obstacle in learning integer operations in class VII SMP. The data triangulation includes student and teacher interviews, analysis of documents such as lesson plans and textbooks, and written tests.

Interviews were conducted with 3 students. Interviews with students were conducted to obtain a description of how students think in answering questions and how to learn students. Meanwhile, interviews with teachers were conducted to obtain an overview of the learning process that had been carried out. Based on interviews with teachers, the learning process due to Covid-19 changed the learning duration to only 20 minutes. This duration is not enough to teach whole number operations optimally. Due to inadequate face-to-face learning time at school, the learning objectives designed by the teacher previously were not fully achieved (Masyithoh & Arfinanti, 2021). Apart from that, the teacher uses a ruler as a medium for studying integer operations. According to researchers, rulers are not able to represent integer because there are no negative numbers on the ruler.

Document analysis is the analysis of lesson plans and textbooks. Lesson plan analysis was carried out to see the didactic situation in the learning that had been carried out. Textbook analysis was conducted to determine whether the learning resources used were able to help students achieve learning objectives. The learning resource used in the research school is the 2017 revised edition of the 2017 Middle School Class VII Mathematics Book published by the Ministry of Education and Culture of the Republic of Indonesia. This book presents material on integer operations using the number line. However, in this book there are solutions to problems using a number line which makes students confused.

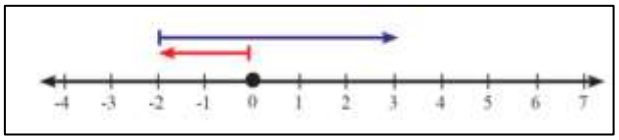


Figure 5. Example Question In Textbooks

Figure 5 is an excerpt from the student book for complete –2 – (–5). In the book there is ambiguity regarding the use of the number line. This book does not explain that subtracting a negative number is the same as adding a positive number. The book should explain that –2 – (–5) = -2 +5 = 3. Therefore, if the teacher only relies on what is in the book, this can become a didactical obstacle for students when working on integer operation questions.

Based on subject teacher interviews, it is known that the sample questions, practice questions and homework questions are based on questions in the student's book and questions written by the teacher. The questions given are of the same type so that students are only used to working on certain types of questions. This can be an obstacle for students to solve questions of different types. The habit of students solving routine questions so that it is difficult for students to develop knowledge can become a learning obstacle for students (Klau et al., 2022; Nurfauziah & Zanthy, 2019; Pirmanto et al., 2020).

The written test is done by giving ten short questions about integer operations to students. Based on the results of student answers, 93.75% still made errors in operating integers, there was only one person who managed to answer all the questions correctly. After conducting the written test, the researcher conducted interviews with students and teachers. The following is a description of the learning obstacle of learning integer operations obtained based on written test.

Addition and Subtraction of Integers

In the addition of two positive integers, there are still students who have not been able to add up correctly. The operation of adding positive integers has been studied and is widely used in elementary school. The cause of this occurrence was found by researchers through interviews with the students concerned. According to his statement, he was less precise in adding up the units of these integers. This also occurs in the results of research by Benge, Peni, & Meke which states that one of the causes of errors in junior high school students in solving integer arithmetic operations is that students are less thorough in solving problems, students are often in a hurry and careless in operating integers (Benge et al., 2021).

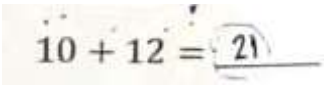


Figure 6. Student's Error In Adding Integers

Inaccuracy also occurs in the operation of subtracting two positive integers. Figure 7 shows that students are wrong in subtracting the units of the number. Based on the interview, the student admitted that he had been in a hurry in reducing the units of numbers. The student also added that he should have answered 0-2=2. According to him, the number zero cannot be operated with any number, so he argues that 0-2=2 as well as if 0+2=2. There are similar mistakes made by other students, as shown in Figure 8.

Figure 7. Student Answers About Subtraction

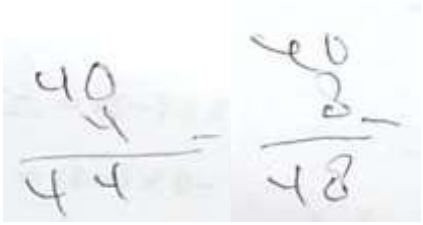


Figure 8. Student Error In Operating Zero

The researcher also found a rule error in solving integer operations. Students are wrong in adding positive integers and negative integers. The results of the interview stated that students added two integers first by ignoring the negative sign on one of the numbers. Then students compare the negative sign of being on a larger or smaller number. As in the problem in Figure 9, the negative sign is owned by the number (-12) where 12 is greater than 10. So, the result of the addition follows the sign of the larger number.

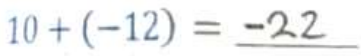


Figure 9. Student Errors In Adding Positive And Negative Numbers

Based on teacher interviews, ordinary integer operations are taught by teachers in schools using number lines. Based on the preliminary study, some students used the number line to help them calculate integers. However, in doing the addition of integers using a number line, students also experience errors.

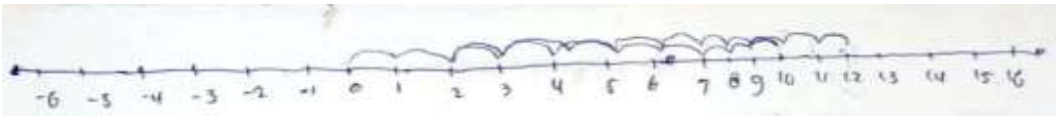


Figure 10. Addition Using A Number Line

In figure 10 students operate 10+(-12). First of all, students start making jumps on the number line starting from zero to the right as many as 10 jumps so that the position is at 10. An error occurred in adding to numbers (-12), should jump to the left of zero as many as 12 jumps starting from position 10, however, the student only jumped two units to the right so that he was

in position 12. Based on the interview, the student hesitated with the + sign which then met the -, whether to move to the left of zero or the right of zero.

Misunderstanding of rules causes students to fail in achieving learning objectives. In recent years, many schools only teach procedural skills to students with a rote learning model. As a result, students are only able to solve routine problems given by the teacher. Students have not been able to know when a mathematical concept or rule is used in solving a new problem. Moreover, if students understand the wrong mathematical rules, students can correctly answer a certain problem but fail in other problems.

Al-Mutawah mentions that understanding mathematical concepts helps students avoid mistakes in learning mathematics. Understanding the wrong rules causes students to make mistakes in working on questions (Al-Mutawah & Thomas, 2019). Incorrect rules may result in the correct answer to a particular problem. However, if the same rule is applied to different problems, the resulting answer may be wrong. The limited understanding of these students is included in the epistemological obstacles. According to Brousseau, epistemological obstacles are learning obstacles due to the limited understanding of students about a certain context (Brousseau, 2011).

In addition to the limited ability of students to certain contexts, the symbol "-" also confuses students. It is evident from the results of the respondents' ability test answers, only 13.3% of students were able to answer correctly on the addition and subtraction of integers involving positive and negative numbers. Based on the interviews, students were confused about the difference between the subtraction symbol and the negative symbol. Khalid and Zulmaryan in their research found that many students were confused by the subtraction symbol and negative values (“-“) causing students to make the wrong integer operations (Khalid & Embong, 2020). According to Fuadiah, Suryadi, and Turmudi, this error was caused by the teacher when starting learning negative integers did not give students an introduction to the "-" symbol in subtraction operations or as a marker for negative numbers (Fuadiah & Suryadi, 2019). In addition, students are confused about addition with negative numbers that can produce smaller numbers and subtraction with negative numbers that can produce larger numbers. This is in line with Bishop's research which found that the learning obstacles faced by students when learning integer operations were differences in knowledge which had been believed by students for too long, namely addition cannot produce smaller numbers and subtraction cannot produce larger numbers (Bishop et al., 2014). However, this knowledge does not apply to operations with negative integers.

The concept of negative number operations is one of the causes of errors in operating integers. Ulusoy stated that the process of understanding the concept of the number system is not an easy thing for teachers and students (Ulusoy, 2019). For example, since the first grade of elementary school students are very familiar with natural numbers. Then as learning increases, students begin to learn the existence of zero. Then students are introduced to negative numbers. It is not easy to transform students' understanding from natural numbers to integers. Students have difficulty understanding negative numbers that are abstract and not in accordance with the previous concept of number operations.

The existence of differences in the rules of knowledge that students previously obtained with the rules of knowledge that students are learning now shows that there are conceptual ontogenic obstacles. Brousseau stated that conceptual ontogenic obstacles are types of difficulties related to the conceptual level contained in learning designs that are currently not in accordance with students' previous learning experiences (Nurfauziah & Zanthy, 2019). Students' knowledge of natural numbers has been embedded since students began to learn to count. Students are introduced to counting numbers and doing number operations that are real and can be seen or touched by students. For example, counting the number of pens, performing the operation of adding two groups of apples and so on. In contrast to the abstract concept of negative numbers, students cannot see or touch anything that has a negative value. This is also one of the factors that cause student errors in answering integer operations questions.

Teaching that relies on practical formulas to students is also the cause of student errors. Providing this practical formula initially aims to help students concisely understand the material. But in the end, resulted in a misunderstanding of the operating rules by students. As in the addition of integers discussed earlier, the result of the addition follows the sign of the larger number. For example, 10+(-12)=-22, because there is a negative in the number 12, where 12 is greater than 10. So the result of the operation follows the sign of the larger number. Based on this practical formula, students are again wrong in using the rules for subtracting integers.

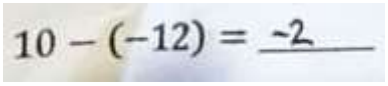


Figure 11. Student Errors In Subtracting Integers

Figure 11 is the majority of students' answers in operating 10-(-12)=-2. Students first operate 12-10=2, then because 12 is greater than 10, the result of the operation follows the sign of the larger number, namely the "-" (negative) sign. So we get the result of 10-(-12)=-2. Another example of the effect of giving practical formulas is the results of an interview by Fuadiah, Suryadi, and Turmudi (2017) with one of their research respondents (Klau et al., 2022). One respondent answered -31+(-8)=39, after further interviewing the respondent answered "negative meets negative, the result is positive, right?". Whereas the rule of negative meets negative produces positive only applies to multiplication and division operations. But by students this rule of thumb applies to all integer operations. This proves that students can wrongly use the rules of thumb that teachers teach. Giving practical formulas like this includes didactical obstacles. Brousseau stated that didactical obstacles can occur because of an inappropriate learning presentation (Nurfauziah & Zanthy, 2019). The presentation of this practical formula is considered inappropriate if it is directly conveyed to students, without students first understanding the basic rules of integer operations.

Multiplication and Division of Integers

The students also apply the same rules as before in the multiplication operation. Where the sign of the result of the operation follows the largest number in the operation. As in figure 11, the multiplication between 5 and -7 produces a negative number because 7 is greater than 5, and 7 has a negative sign. At first glance, this rule produces the correct answer, namely positive times negative will produce a negative number. However, this rule cannot be used if you meet a problem such as -8×(-4), with a rule that students understand that the result of the operation follows the sign of the larger number so that it produces a negative number. While the correct answer is -8×(-4) resulting in a positive number.

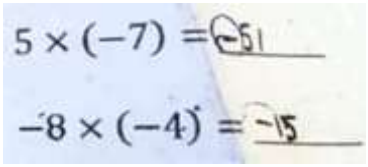


Figure 12. Student Error In Multiplication Of Integers

Not only that, but students are also less careful in calculating the product itself. Figure 12 shows that 5×(-7)=-51 and -8×(-4)=-15. This illustrates that students also have not memorized multiplication or have not understood the concept of multiplication itself or are not even careful in operating multiplication. One student said in the interview that when looking for the result of 8×4 students add up 8+8+8+8. It should be 8×4=4+4+4+4+4+4+4+4. Even though they produce the same number, the concept is still different.

Figure 13 also illustrates that students do not yet understand how to operate multiplication on integers. It can be seen that students perform multiplication operations starting from 6×7=39 for the unit place, but students add up for the tens place to 3+5=8. Based on this student's answer,

the researcher again found that there were learning obstacles faced by students so that they were wrong in performing integer operations.

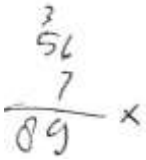


Figure 13. Multiplication Operations By Students

Integer division is also operated with wrong rules by students. In Figure 14, students operate 36÷4=9 first. Then because 36 is greater than 4 and 36 is positive, the result of the operation is also positive.

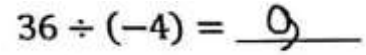


Figure 14. Student Errors In The Division Of Integers

In contrast to Figure 15, students understand different operating rules from previous students. Students operate first 56÷7=8, but because both numbers are negative, the result of the operation is confirmed to be negative. Although different rules are understood by students, they are still not the correct rules. This again indicates that there are learning obstacles that students face when studying integer operations.

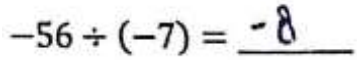


Figure 15. Student Errors In The Division Of Integers 2

CONCLUSION

Learning obstacles found in integer operations are ontogenic obstacles, didatical obstacles, and epistemological obstacles. The ontogenic obstacle that was found was the difference in knowledge between natural number operations and integer operations. The didactical obstacle is the use of inappropriate learning media and less learning time. The epistemology of the obstacle is inadequate student books. The student book does not discuss much about operations on negative numbers. The implication of this research is that the teacher presents learning about integer operations by paying attention to the learning obstacles that have been found. Teachers create learning trajectories that can reduce learning obstacles. Other researchers can also create didactic designs to eliminate learning obstacles that have been discovered and then try them out on students.

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