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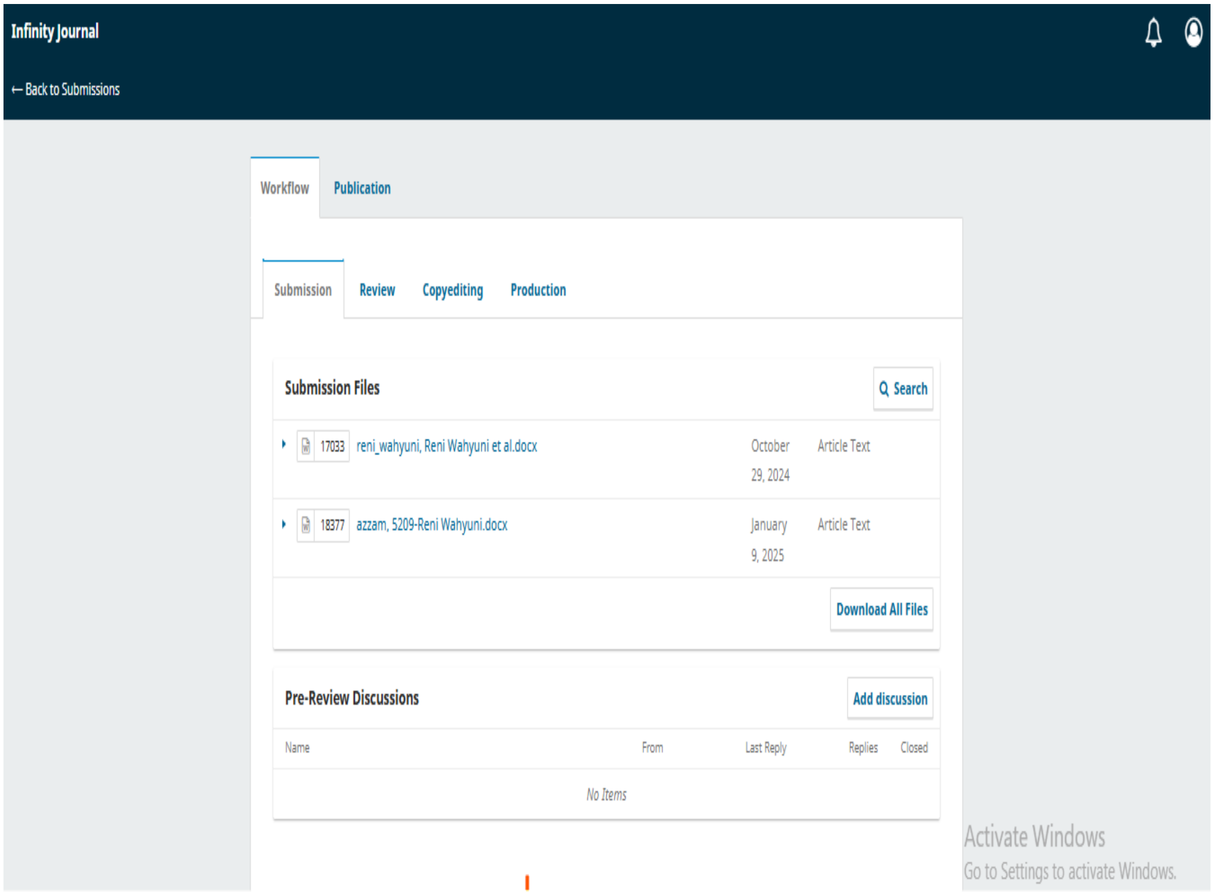
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Students' obstacles in solving algebra problems in viewed from mathematical problem-solving ability

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Abstract

This study aims to produce a description of the learning obstacles experienced by students based on their mathematical problem-solving abilities in algebra material. The method used in this study is didactical design research. This study was conducted at one of the State Junior High Schools in Siak Hulu in class VIII. Data analysis on students' mathematical problem-solving abilities and learning obstacles was carried out based on the results of the mathematical problem-solving ability test instrument, in-depth interviews, and document analysis. The results show that students experience learning obstacles that are ontogenic, epistemological, and didactic based on the identification of mathematical problem-solving abilities. Based on this, students' learning obstacles in solving algebra problems are identified.

Keywords:
Obsctale, Problem-solving ability, Algebra, Ontogenic, Epistemology

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1. INTRODUCTION

Mathematical problem-solving ability is fundamental to students' skills and activities in the 21st century (Lu & Xie, 2024; Rocha & Babo, 2024; Supriadi et al., 2024). For at least three decades, it has been recognized that mathematical problem-solving ability provides students with many opportunities to develop their creativity, enthusiasm, critical thinking, and interaction (Lester & Cai, 2016; Rocha & Babo, 2024; Säfström et al., 2024) This is because mathematical problem-solving ability includes several activities, such as solving word problems, creating patterns, interpreting figures, developing geometric constructions, and proving theorems (Supriadi et al., 2024; Zhu, 2007). Thus, mathematical problem-solving ability is essential in formal education and has consistently been an important subject of mathematics education research.

The terms of problem-solving can be referred to by Mayer as a summary of the cognitive processes aimed at transforming the initial state into the desired final state in

situations when the process of finding a solution is not immediately apparent (Dostál, 2015). Problem-solving is also a set of valuable abilities used to deal with and solve various problems (Friedel et al., 2008). In the topic of mathematics, George Polya, who is known as the founder of the mathematical problem-solving theory, defined problem-solving as follows: solving a problem means finding a way out of a difficulty, a way around an obstacle, and attaining an aim that was not immediately attainable (Jiang et al., 2022; Polya, 1985). It is undeniable that problem-solving is a challenging endeavor, and there are numerous factors to consider, including the appropriate approach (Rocha & Babo, 2024). So, mathematical problem-solving is related to thinking skills, which generally improve when one solves challenges requiring effort, enthusiasm, and investigation of the problems.

Furthermore, Polya's theory posited that mathematical problem-solving was an evolving process that involved the following activities: understanding the problem, devising a plan, performing the plan, and reflecting on the process (Polya, 1985). Most researchers in mathematics education use this theory (Amalina & Vidákovich, 2023). Besides that, Rocha & Babo (2024) stated that understanding the problem involves trying to understand the situation, defining the unknown, determining the conditions of the problem, and verifying whether it is possible to estimate the response. Then, devising a plan means finding resolution strategies, organizing the data, and trying to solve the problem. Next, performing the plan includes verifying each resolution step, executing all the calculations, and implementing all the strategies outlined. The last step is to confirm that the obtained solution is correct or that there is another way to solve the problem.

The process of mathematical problem-solving ability needs mathematical thinking commonly. For the students to develop mathematical problem-solving ability, they must be allowed to practice and cultivate problem-solving the problems in a non-stressful atmosphere (Lu & Xie, 2024). The students can be given a problem that relates to their daily life (Putri et al., 2022), and the problem does not have a given solution method, that is, a rule, template, or algorithm (Säfström et al., 2024). In other stated that they can figure out the solutions to a particular problem-based issue in learning mathematics and find appropriate solutions (Güner & Erbay, 2021). Therefore, a mathematical problem-solving ability that they have is their ability in inherent value during the students' problem-solving process.

Mathematical problem-solving ability can be improved in topic mathematics school by one of the crucial topics being algebra (Putri et al., 2022; Silvia et al., 2019). Algebra is commonly referred to as a fundamental step towards advanced mathematics, primarily because it serves as the medium through which mathematical concepts are taught (Jupri et al., 2014; Stacey & Chick, 2004; Wicaksono et al., 2024). Algebra is also vital to learning a conceptual understanding of features that are related to problem-solving (Booth & Koedinger, 2008; Wicaksono et al., 2024). Besides that, in the 2013 curriculum, algebra was first introduced in grade 7 of junior high school with material on algebraic forms and linear equations in one variable. These materials are initial concepts that students must understand well. This is because the material relates to the real world and current technological developments (NCTM, 2000; Rahmi & Yulianti, 2022). So, algebra concepts have become a crucial topic for educators and researchers in mathematics education to consider in the learning process.

Quality mathematics learning is determined by three critical elements that are interconnected with each other (Suryadi, 2019). These elements are teachers, students, and materials (Suryadi, 2019), so in stated that the learning process is the most essential part (Unaenah et al., 2023) and the learning process that is carried out naturally sometimes encounters difficulties in the learning process (Rahmi & Yulianti, 2022). These difficulties become obstacles for students to achieve learning outcomes well. In common, an obstacle is a situation that makes it difficult to do or achieve something. Then, these difficulties raise erroneous related to concepts and principles (Jupri et al., 2014; Wicaksono et al., 2024).

Suryadi stated that learning obstacles in the learning process of mathematics include three types (Suryadi, 2019). There are ontogenic obstacles, epistemic obstacles, and didactical obstacles (Brousseau, 2002). An ontogenetic obstacle is a difficulty associated with a student's readiness to learn. The second category of learning obstacles is epistemological obstacles. These learning obstacles primarily arise from the limited atmosphere in which a subject is initially examined. Consequently, children frequently encounter difficulties when confronted with varying environments. The third kind of learning obstacle, the didactical obstacle, arises due to the state of the employed didactic design or the teacher's intervention.

On the other hand, algebra still has several problems during the learning process, being algebraic content (Booth et al., 2017; Sari & Afriansyah, 2020; Warren et al., 2016). Furthermore, recent research also shows that several topics related to algebra have learning obstacles (Faradiba et al., 2024; Fauzah et al., 2023; Noto et al., 2020; Saputro et al., 2018; Wicaksono et al., 2024), then the other studies also stated that mathematical problem-solving ability in algebra still has problematics (Phonapichat et al., 2014; Putri et al., 2022; Samo, 2017). Nevertheless, in that case, those previous studies have yet to detail how obstacles to learning mathematical problem-solving ability in algebra are overcome. Using these facts, we will fill the gap in existing research by highlighting the importance of addressing students' learning obstacles related to students' mathematical problem-solving ability in terms of ontology, epistemic, and didactics. Therefore, this study aims to investigate students' learning obstacles related to mathematical problem-solving ability in algebraic material.

2. METHOD

Didactical Design Research (DDR) was chosen as the method in this research. DDR was the qualitative research on interpretive paradigms (Suryadi, 2019). Qualitative research in this research was used as an approach in which researchers as the main instrument that explored and understood the meaning of social or human problems by asking questions and using various procedures, collecting data from participants, analyzing inductively, and interpreting the data (Creswell, 2014; Merriam & Tisdell, 2016). Furthermore, the interpretive paradigm in this research also indicated that researchers were involved in a continually evolving and continuous experience with the participants (Creswell, 2014; Pramuditya et al., 2022). Therefore, DRR in this research was recognized as a technique for delineating, elucidating, and analyzing the data gathered.

DDR in this research was based on analyses of the students' learning obstacles from before the initial learning process until after the end. Then, DDR was also known as the

empirical didactic design (Suryadi, 2010) that contains three steps: prospective analysis, metapedadidactic analysis, and retrospective analysis (Suryadi, 2019). The first stage included the didactic situation analysis stage, which was carried out before learning took place as a form of didactic and pedagogical anticipation. The second stage was the metapedadidactic analysis stage, namely the analysis of a series of didactic situations that develop in the classroom, analysis of learning situations, and analysis of interactions that influence the emergence of changes in didactic and learning conditions. The third retrospective analysis stage was an analysis that links the results of the hypothetical didactic situation analysis with the results of the metapedadidactic analysis. In this article, we provided a study of the obstacles that students encounter in their learning process, specifically focusing on what obstacles they face in developing their problem-solving ability.

The subjects who participated in this research were eighth graders from 2023 to 2024 in SMP N Siak Hulu, Kampar Regency, Riau Province, Indonesia, and have been studying algebra subject. The number of students who took the problem-solving ability test was 54. After that, six of the 54 students were interviewed based on their answer sheets.

The collection data technique used instruments that tested problem-solving ability. The test was given after the eighth-grade mathematics semester. This was conducted to indicate the type of obstacles that students encountered in solving algebraic topics. Investigating the learning obstacles was expected to help the teacher prepare teaching material related to the student's problem-solving abilities. Two problems were given to the students. Here are the examples of issues that were given to students.

Type	Items test
Problem 1	The price of one dozen pencils is Rp. 39,000.00. a) How much does one pencil cost? Could you explain how to calculate it? b) How much do seven pencils cost? Could you explain how to calculate it?”
Problem 2	Pak Roni will set up flooring over a surface area of 144 square meters. Toko “Daya Bersama” sells ceramics in several dimensions, such as type 1 measuring 50cm × 50cm, priced at Rp. 8,000.00 per unit, type II measuring 40cm × 40cm priced at Rp. 6,000.00 per unit, and type III measuring 25cm × 25cm priced at Rp. 4,000.00 per unit. Assume you want to set up these three varieties of ceramic tiles on the floor of your house. Which ceramic selection process offers the lowest costs? Explain the reasons!

Furthermore, the other collection data technique was the non-instruments used in interviews and documentation studies. The researcher interviewed the students after checking the answer sheets. The researcher also discussed selecting students for the interview with the mathematics teacher. This was done to ensure that the students being interviewed had good communication skills so that the interview could run smoothly. In addition, the students selected also had ontological and epistemological obstacles in solving algebra problems. The documentation studies were used to complete the test and interview results as the triangulation material to check the suitability of the data gathered.

The data analysis technique used in this research was collecting data, organizing data, sorting the data from the students' obstacles, and then managing, synthesizing, and finding the pattern from the data to conclude.

3. RESULTS AND DISCUSSION

3.1. Results

This study was conducted to describe learning obstacles in students related to algebra material. This data was obtained from students who had taken a learning obstacle identification test on problem-solving abilities. This study's learning obstacle identification test included a diagnostic test given to students who had studied algebra material in grades VII and VIII. There were two questions tested. Before being offered to students, the mathematics subject teacher validated the diagnostic test questions at SMPN Siak Hulu, Riau. The result of the diagnostic test validation is about the alteration of sentence. After that, the diagnostic test could be given to students. Afterward, the diagnostic test was conducted, and the data was analyzed to determine the obstacles experienced by students by looking at student errors in solving the questions. This research appears to be a term error as it indicates the students made mistakes in concepts or principles that are viewed from the indicators of mathematical problem-solving ability.

Afterward, a grouping of data based on the test results by students while working on the questions was carried out. The number of students who experienced error (did not master based on the indicator of mathematical problem-solving ability) will be presented as a percentage (%) of the number of students who took the diagnostic test exam. The number of students who experienced error is given in Table 1.

Table 1. The results of students' errors from diagnostic tests

No	Indicator of mathematical problem-solving ability	% of errors	
		Problem 1	Problem 2
1.	Understanding the problem	7,4	33,3
2.	Make a plan	7,4	33,3
3.	Carry out a plan	9,2	38,9
4.	Looking back	66,7	64,8

Based on Table 1, students' errors in solving the problem are related to indicators of mathematical problem-solving ability derived from all 54 students who were given the test. The students' mistakes appear primarily in carrying a plan and looking back. Students do not make many errors in understanding problems and making plans, but in implementing the plans they have made, students experience many errors.

Furthermore, students' errors in that case are obstacles that students have. There are ontogenic, epistemological, and didactical obstacles related to students' mathematical problem-solving abilities.

Ontogenic obstacle

The ontogenic obstacle is the mismatch between the level of thinking of students and the type of learning provided, which impedes understanding the material. The students' ontogenic obstacles in understanding the problems can be shown by the students' answers in the following picture.

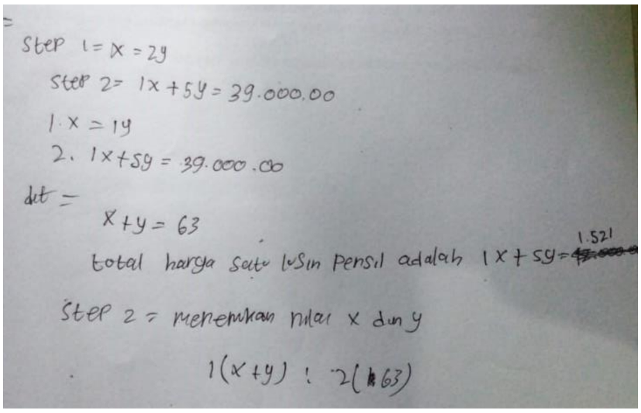

Figure 1. Student AZ answers regarding the first problem

Figure 1 shows student AZ trying to do the equations to understand the problem, but mistakes still occur when writing the algebraic modeling. He writes by forming two variables in the form of $x = 2y$. Then, he writes the next step by writing $1x + 5y = 39.000$. It implies that he tries to understand the question for one thing by replacing x. It seems that he does not understand what he did. At that point, in his final writing, he does the algebraic model without calculation. We assume he does not proceed to the strategy and computation process, so this student's answer was thought to be due to a lack of understanding of the problem.

Next, the student AW needed to correct the calculation of the first problem in part a. We assume that the student needs help understanding the measurement concept, which is one dozen being twelve. Then, he needs to realize there is a price for one pencil out of the total cost of twelve pencils. This can be seen from how he directly carries out the division operation process with divisors that are not written down. Therefore, he needs help to solve it. Here is the figure 2.

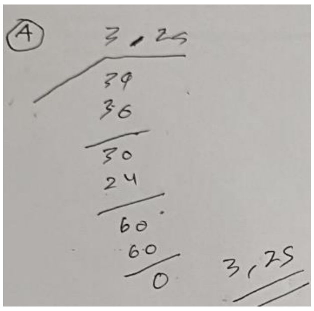

Figure 2. Student AW answers regarding the first problem number part a

Besides that, he carried out division operations with the number six as the divisor because there was a value of 36 from the subtraction process of 39. Furthermore, the mistakes showed that he needed to understand the concept of division and multiplication. This implied that he needed to prepare to study division and multiplication.

Next, he made the correct answer in problem part b on his answer sheet. it can be seen in Figure 3.

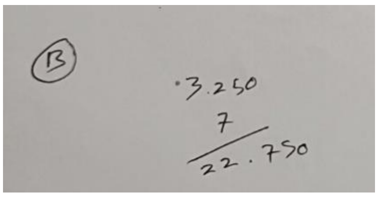

Figure 3. The student AW is correctly answering the first problem number part b

From Figure 3, we assume he made a correct answer by commonly doing multiplication. He multiplied the price of one thing to become seven things by about 3.250 and 7. This implies he is ready to calculate and multiply rather than read and translate a problem's meaning.

Moreover, students will encounter obstacles in understanding and devising a plan for the problem, which will continue throughout the student's computational process. In contrast, the students failed throughout the computation process and needed to comprehend the situation. This illustrates how student AY responses demonstrate this.

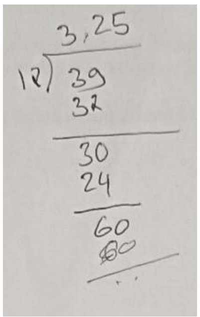

Figure 4. Mistakes in the student's computing process

Figure 4 shows that the student AY carries out the computing process by writing 39 divided by 18, but the result of the computing process is 3.25. This indicates that he makes mistakes in the computing process, removing the number 0 without realizing the meaning of the 0. Mistakes written by him indicate his unpreparedness to understand the meaning of the place value of a number, even though the place value of numbers is an essential concept of a number.

The final indicator is to verify the answers that have been obtained. The last indicates that the majority of students need to double-check their answers. They frequently write the result of the computation, such as a number, rather than rewriting the phrase. Here is evident from the response of the student who reviewed the answer.

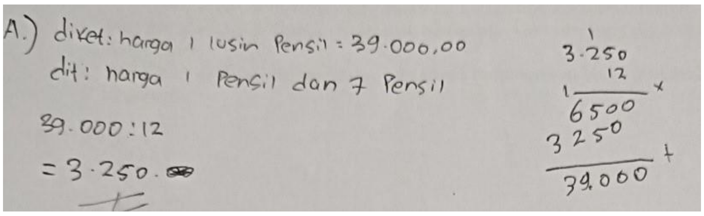

Figure 5. The student verifies his answer.

The student AB does recheck results using the inverse of division, namely multiplication. Figure 5 illustrates that he uses the division operation to write down his plans, followed by the multiplication process to rewrite him. What can be observed is that he checks their responses based on the computing approach he uses.

Ontogenic obstacles were found in students' answers to the second problem with the first indicator of mathematical problem-solving ability, namely understanding problems. From the second problem, it turned out that only 20 people could understand the situation. Students tend not to write down answers or only collect empty answer sheets. This shows that most students cannot understand the problem. Here is an example of the student's answer.

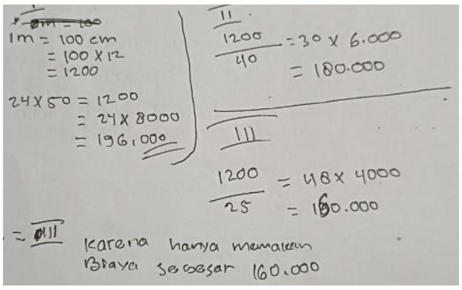

Figure 6. The student AD answer sheet

Based on figure 6 shows that the student AD does not understand the problem entirely. He can convert the unit from meter to centimeter but cannot apply the rectangle's area. He calculates the number in the problem for each type but cannot understand the meaning of the problem.

Similar to Figure 6, the student AC also writes down the answer by calculating the number in the problem. He put down the $12m$ to become $1200cm$, then wrote $12m \times 12m$ and $1200cm \times 1200cm$, but could not do the calculations based on the number. He tries to devise a plan but cannot continue the purpose of that problem. Here is the answer to the student AC.

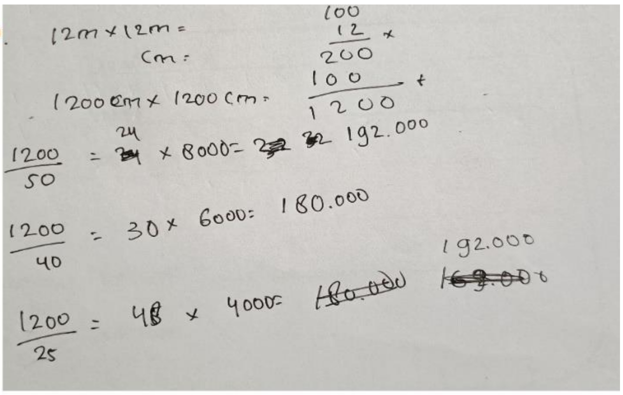

Figure 7. The student AC answer sheet

The first and the second indicators of problem-solving ability still relate to each other. While students cannot understand the problem and they cannot devise it, there are 20.

In the third indicator of problem-solving ability, 15 students can do calculations by using a multiply 1200×1200, but no one from the students used multiply $50 \times 50, 40 \times 40, 25 \times 25$. Most students are doing 1200 dividing 50, 1200 dividing 40, and 1200 dividing 25.

In the fourth indicator of problem-solving ability, eight students recheck the answer. Students do not rewrite the answers necessary to solve the problem; they merely write the responses to the results of their computations.

Epistemological Obstacle

Epistemological obstacles were found in students' responses to the two questions based on the four indicators of problem-solving ability: carrying out the plan, such as making mathematical modeling in the form of equations. In the first question, the student finds it too hard to change verbal contextual difficulties into algebraic models with x, such as the

number of pencils is $12x$, which is the number 12 times the number of one pencil. Then, the cost for 12 times the amount of one pencil is Rp 39,000.00, and the cost of one pencil is Rp 3,250.00. The results of the student's work showed that almost all students had not completed the algebraic modeling. Students still do not think in mathematical form. Therefore, the answer is correct, though the student did in arithmetic order, as shown on the student answer sheet below.

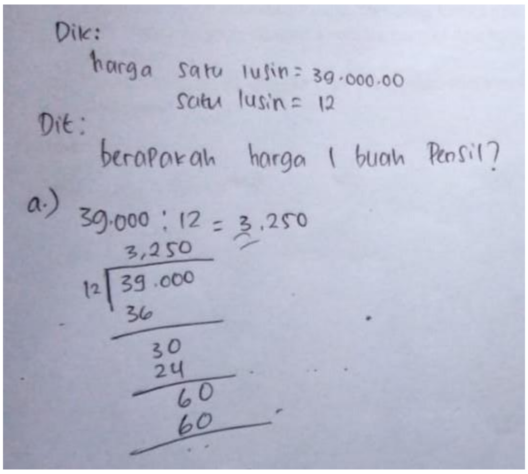

Figure 8. The student responds by applying arithmetic thinking

The example in Figure 8 illustrates that students solve problems correctly but remain required to demonstrate algebraic modeling. This could be due to students' weaknesses with algebraic modeling. The student is used to arithmetic-solving methods that provide a straightforward solution process.

In addition, an essential obstacle to students' problem-solving skills, as indicated by the four indicators of mathematical problem-solving, is their limited understanding of algebraic issues presented as algebraic models. The student's cognitive process of identifying the problem and formulating a strategy for addressing it still needs enhancement. This is apparent from the observation that the student has not yet recorded the information he needs to acquire and develop their problem-solving ability. This is a student answer sheet that shows the student's limitations.

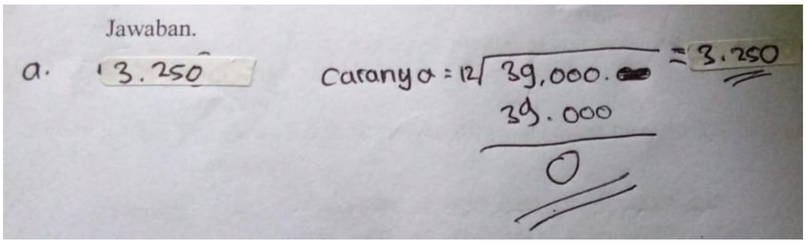

Figure 9. Students' limited comprehension of the problem

Figure 9 shows that the student performs the calculation process without specifying the known data from the problem, so he automatically selects the division calculation process as the solution method. However, the calculating process used by students still needed to be corrected incorrectly. This could occur due to students' weaknesses in the division calculation process.

Didactical obstacle

Interviews were conducted with students and mathematics teachers regarding the mathematics learning process to determine the didactical obstacles that occur to students.

Here is the following transcript of the interview conducted with the students.

Researcher : Have you studied algebra subject?
Student : I think so, but I forgot.
Researcher : Have you ever studied something like that, the problem you are working on?
Student : No drills like these questions, ma'am; we are only given questions in the school book. So yesterday I forgot, ma'am, how much is one dozen.
Researcher : What books do you use?
Student : This book ma'am. (student shows the mathematics book he uses, namely a book from publisher X)

Based on the interviews with students, information was obtained that students had studied algebra material but had forgotten the algebra material used in the problems. Students also stated that they had never worked on questions like the questions the researcher gave, so students had obstacles in solving these problems. Furthermore, students also stated that the books used in the learning process were books from publisher X, not books from the Ministry of Education and Culture.

Furthermore, interviews were conducted with mathematics teachers; a transcript is below.

Researcher : What curriculum are you currently using?
Teacher : Independent Curriculum
Researcher : Do your students have difficulty learning algebra subjects?
Teacher : Yes
Researcher : What kind of difficulties do you mean?
Teacher : Students find it challenging to operate on algebraic forms related to negative numbers
Researcher : What steps did you take to overcome the student's difficulties?
Teacher : I explained again to the students about integer counting operations
Researcher : What book do you use when teaching algebra?
Teacher : Ministry of Education and Culture book
Researcher : Do you use any other books?
Teacher : Yes, a book from publisher X

The results of interviews with mathematics teachers showed that she had difficulty teaching student’s algebraic forms related to algebraic properties and negative numbers.

Discussion

Algebra is the initial topic in middle school, where the average age of students is between 13-14 years. In line with Piaget's phases of cognitive growth, students within this age category attain the formal operations phase (Suryadi, 2018). This age range is still characterized by the student's cognitive transition from the concrete operations stage to the

formal operations stage. In constructivist theory, cognitive development involves building knowledge of students, as seen in the phases of comprehending mathematical concepts (Wicaksono et al., 2024). However, ontogenic obstacles remain problems. Findings from AZ and AW indicate that they do not understand the problems, whereas understanding the problem is the key to solving the problem (Putri et al., 2022). This was in line with the results of the research of Amalina & Vidákovich (2023) that students are unsuccessful in exploring and understanding the problem. This causes students to be less able to continue to the following completion stage. Students are unable to examine and understand the problem; it seems that from scratch on the paper, and they look like they are doing calculations, whereas they just did random calculations. This is a learning obstacle for the students while solving the problem.

On the other hand, epistemology obstacles also appear in this research. The students have a limited understanding of making model mathematics and have weaknesses in calculating. The findings of the student AW indicate that he has limited ability to carry out the plan. He preferred to write directly using arithmetic structures rather than having to form equations. This means that students have obstacles while understanding the problem and are limited in making a modeling algebra to carry out the plan. These findings are also in line with the research Widyawati et al. (2018).

4. CONCLUSION

After analyzing and discussing the learning obstacles students face in class VIII of Siak Hulu State Middle School, it can be inferred that students encounter distinct challenges in developing their understanding of mathematical problem-solving ability. Evidence of a lack of understanding of learning obstacles is when students demonstrate an inability to understand the concepts of measuring and the area. Consequently, they need help interpreting and solving problems presented in questions. Students demonstrate proficiency in using strategies for problem-solving, particularly in the areas of multiplication and division calculations. However, there is a distinction when reviewing answers, as students need to pay more attention to re-checking the accuracy of their acquired results

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Students’ obstacles in solving algebra problems in viewed from mathematical problem-solving ability

Hidden by Editor

Abstract

This study aims to produce a description of the learning obstacles experienced by students based on their mathematical problem-solving abilities in algebra material. The method used in this study is didactical design research. This study was conducted at one of the State Junior High Schools in Siak Hulu in class VIII. Data analysis on students' mathematical problem-solving abilities and learning obstacles was carried out based on the results of the mathematical problem-solving ability test instrument, in-depth interviews, and document analysis. The results show that students experience learning obstacles that are ontogenic, epistemological, and didactic based on the identification of mathematical problem-solving abilities. Based on this, students' learning obstacles in solving algebra problems are identified.

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Keywords:
Obsctale, Problem-solving ability, Algebra, Ontogenic, Epistemology

How to Cite:
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1. INTRODUCTION

Mathematical problem-solving ability is fundamental to students' skills and activities in the 21st century (Lu & Xie, 2024; Rocha & Babo, 2024; Supriadi et al., 2024). For at least three decades, it has been recognized that mathematical problem-solving ability provides students with many opportunities to develop their creativity, enthusiasm, critical thinking, and interaction (Lester & Cai, 2016; Rocha & Babo, 2024; Säfström et al., 2024) This is because mathematical problem-solving ability includes several activities, such as solving word problems, creating patterns, interpreting figures, developing geometric constructions, and proving theorems (Supriadi et al., 2024; Zhu, 2007). Thus, mathematical problem-solving ability is essential in formal education and has consistently been an important subject of mathematics education research.

The terms of problem-solving can be referred to by Mayer as a summary of the cognitive processes aimed at transforming the initial state into the desired final state in

situations when the process of finding a solution is not immediately apparent (Dostál, 2015). Problem-solving is also a set of valuable abilities used to deal with and solve various problems (Friedel et al., 2008). In the topic of mathematics, George Polya, who is known as the founder of the mathematical problem-solving theory, defined problem-solving as follows: solving a problem means finding a way out of a difficulty, a way around an obstacle, and attaining an aim that was not immediately attainable (Jiang et al., 2022; Polya, 1985). It is undeniable that problem-solving is a challenging endeavor, and there are numerous factors to consider, including the appropriate approach (Rocha & Babo, 2024). So, mathematical problem-solving is related to thinking skills, which generally improve when one solves challenges requiring effort, enthusiasm, and investigation of the problems.

Furthermore, Polya's theory posited that mathematical problem-solving was an evolving process that involved the following activities: understanding the problem, devising a plan, performing the plan, and reflecting on the process (Polya, 1985). Most researchers in mathematics education use this theory (Amalina & Vidákovich, 2023). Besides that, Rocha & Babo (2024) stated that understanding the problem involves trying to understand the situation, defining the unknown, determining the conditions of the problem, and verifying whether it is possible to estimate the response. Then, devising a plan means finding resolution strategies, organizing the data, and trying to solve the problem. Next, performing the plan includes verifying each resolution step, executing all the calculations, and implementing all the strategies outlined. The last step is to confirm that the obtained solution is correct or that there is another way to solve the problem.

The process of mathematical problem-solving ability needs mathematical thinking commonly. For the students to develop mathematical problem-solving ability, they must be allowed to practice and cultivate problem-solving the problems in a non-stressful atmosphere (Lu & Xie, 2024). The students can be given a problem that relates to their daily life (Putri et al., 2022), and the problem does not have a given solution method, that is, a rule, template, or algorithm (Säfström et al., 2024). In other stated that they can figure out the solutions to a particular problem-based issue in learning mathematics and find appropriate solutions (Güner & Erbay, 2021). Therefore, a mathematical problem-solving ability that they have is their ability in inherent value during the students' problem-solving process.

Mathematical problem-solving ability can be improved in topic mathematics school by one of the crucial topics being algebra (Putri et al., 2022; Silvia et al., 2019). Algebra is commonly referred to as a fundamental step towards advanced mathematics, primarily because it serves as the medium through which mathematical concepts are taught (Jupri et al., 2014; Stacey & Chick, 2004; Wicaksono et al., 2024). Algebra is also vital to learning a conceptual understanding of features that are related to problem-solving (Booth & Koedinger, 2008; Wicaksono et al., 2024). Besides that, in the 2013 curriculum, algebra was first introduced in grade 7 of junior high school with material on algebraic forms and linear equations in one variable. These materials are initial concepts that students must understand well. This is because the material relates to the real world and current technological developments (NCTM, 2000; Rahmi & Yulianti, 2022). So, algebra concepts have become a crucial topic for educators and researchers in mathematics education to consider in the learning process.

Quality mathematics learning is determined by three critical elements that are interconnected with each other (Suryadi, 2019). These elements are teachers, students, and materials (Suryadi, 2019), so in stated that the learning process is the most essential part (Unaenah et al., 2023) and the learning process that is carried out naturally sometimes encounters difficulties in the learning process (Rahmi & Yulianti, 2022). These difficulties become obstacles for students to achieve learning outcomes well. In common, an obstacle is a situation that makes it difficult to do or achieve something. Then, these difficulties raise erroneous related to concepts and principles (Jupri et al., 2014; Wicaksono et al., 2024).

Suryadi stated that learning obstacles in the learning process of mathematics include three types (Suryadi, 2019). There are ontogenic obstacles, epistemic obstacles, and didactical obstacles (Brousseau, 2002). An ontogenetic obstacle is a difficulty associated with a student's readiness to learn. The second category of learning obstacles is epistemological obstacles. These learning obstacles primarily arise from the limited atmosphere in which a subject is initially examined. Consequently, children frequently encounter difficulties when confronted with varying environments. The third kind of learning obstacle, the didactical obstacle, arises due to the state of the employed didactic design or the teacher's intervention.

On the other hand, algebra still has several problems during the learning process, being algebraic content (Booth et al., 2017; Sari & Afriansyah, 2020; Warren et al., 2016). Furthermore, recent research also shows that several topics related to algebra have learning obstacles (Faradiba et al., 2024; Fauzah et al., 2023; Noto et al., 2020; Saputro et al., 2018; Wicaksono et al., 2024), then the other studies also stated that mathematical problem-solving ability in algebra still has problematics (Phonapichat et al., 2014; Putri et al., 2022; Samo, 2017). Nevertheless, in that case, those previous studies have yet to detail how obstacles to learning mathematical problem-solving ability in algebra are overcome. Using these facts, we will fill the gap in existing research by highlighting the importance of addressing students' learning obstacles related to students' mathematical problem-solving ability in terms of ontology, epistemic, and didactics. Therefore, this study aims to investigate students' learning obstacles related to mathematical problem-solving ability in algebraic material.

2. METHOD

Didactical Design Research (DDR) was chosen as the method in this research. DDR was the qualitative research on interpretive paradigms (Suryadi, 2019). Qualitative research in this research was used as an approach in which researchers as the main instrument that explored and understood the meaning of social or human problems by asking questions and using various procedures, collecting data from participants, analyzing inductively, and interpreting the data (Creswell, 2014; Merriam & Tisdell, 2016). Furthermore, the interpretive paradigm in this research also indicated that researchers were involved in a continually evolving and continuous experience with the participants (Creswell, 2014; Pramuditya et al., 2022). Therefore, DRR in this research was recognized as a technique for delineating, elucidating, and analyzing the data gathered.

DDR in this research was based on analyses of the students' learning obstacles from before the initial learning process until after the end. Then, DDR was also known as the

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as a reader, I have not seen any interesting problems to study. This is because the presentation presented is not comprehensive. It would be better if the problems presented in this article were compared with relevant and current research results.

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empirical didactic design (Suryadi, 2010) that contains three steps: prospective analysis, metapedadidactic analysis, and retrospective analysis (Suryadi, 2019). The first stage included the didactic situation analysis stage, which was carried out before learning took place as a form of didactic and pedagogical anticipation. The second stage was the metapedadidactic analysis stage, namely the analysis of a series of didactic situations that develop in the classroom, analysis of learning situations, and analysis of interactions that influence the emergence of changes in didactic and learning conditions. The third retrospective analysis stage was an analysis that links the results of the hypothetical didactic situation analysis with the results of the metapedadidactic analysis. In this article, we provided a study of the obstacles that students encounter in their learning process, specifically focusing on what obstacles they face in developing their problem-solving ability.

The subjects who participated in this research were eighth graders from 2023 to 2024 in SMP N Siak Hulu, Kampar Regency, Riau Province, Indonesia, and have been studying algebra subject. The number of students who took the problem-solving ability test was 54. After that, six of the 54 students were interviewed based on their answer sheets.

The collection data technique used instruments that tested problem-solving ability. The test was given after the eighth-grade mathematics semester. This was conducted to indicate the type of obstacles that students encountered in solving algebraic topics. Investigating the learning obstacles was expected to help the teacher prepare teaching material related to the student's problem-solving abilities. Two problems were given to the students. Here are the examples of issues that were given to students.

Type	Items test
Problem 1	The price of one dozen pencils is Rp. 39,000.00. a) How much does one pencil cost? Could you explain how to calculate it? b) How much do seven pencils cost? Could you explain how to calculate it?”
Problem 2	Pak Roni will set up flooring over a surface area of 144 square meters. Toko “Daya Bersama” sells ceramics in several dimensions, such as type 1 measuring 50cm × 50cm, priced at Rp. 8,000.00 per unit, type II measuring 40cm × 40cm priced at Rp. 6,000.00 per unit, and type III measuring 25cm × 25cm priced at Rp. 4,000.00 per unit. Assume you want to set up these three varieties of ceramic tiles on the floor of your house. Which ceramic selection process offers the lowest costs? Explain the reasons!

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Furthermore, the other collection data technique was the non-instruments used in interviews and documentation studies. The researcher interviewed the students after checking the answer sheets. The researcher also discussed selecting students for the interview with the mathematics teacher. This was done to ensure that the students being interviewed had good communication skills so that the interview could run smoothly. In addition, the students selected also had ontological and epistemological obstacles in solving algebra problems. The documentation studies were used to complete the test and interview results as the triangulation material to check the suitability of the data gathered.

The data analysis technique used in this research was collecting data, organizing data, sorting the data from the students' obstacles, and then managing, synthesizing, and finding the pattern from the data to conclude.

3. RESULTS AND DISCUSSION

3.1. Results

This study was conducted to describe learning obstacles in students related to algebra material. This data was obtained from students who had taken a learning obstacle identification test on problem-solving abilities. This study's learning obstacle identification test included a diagnostic test given to students who had studied algebra material in grades VII and VIII. There were two questions tested. Before being offered to students, the mathematics subject teacher validated the diagnostic test questions at SMPN Siak Hulu, Riau. The result of the diagnostic test validation is about the alteration of sentence. After that, the diagnostic test could be given to students. Afterward, the diagnostic test was conducted, and the data was analyzed to determine the obstacles experienced by students by looking at student errors in solving the questions. This research appears to be a term error as it indicates the students made mistakes in concepts or principles that are viewed from the indicators of mathematical problem-solving ability.

Afterward, a grouping of data based on the test results by students while working on the questions was carried out. The number of students who experienced error (did not master based on the indicator of mathematical problem-solving ability) will be presented as a percentage (%) of the number of students who took the diagnostic test exam. The number of students who experienced error is given in Table 1.

Table 1. The results of students' errors from diagnostic tests

No	Indicator of mathematical problem-solving ability	% of errors	
		Problem 1	Problem 2
1.	Understanding the problem	7,4	33,3
2.	Make a plan	7,4	33,3
3.	Carry out a plan	9,2	38,9
4.	Looking back	66,7	64,8

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Based on Table 1, students' errors in solving the problem are related to indicators of mathematical problem-solving ability derived from all 54 students who were given the test. The students' mistakes appear primarily in carrying a plan and looking back. Students do not make many errors in understanding problems and making plans, but in implementing the plans they have made, students experience many errors.

Furthermore, students' errors in that case are obstacles that students have. There are ontogenic, epistemological, and didactical obstacles related to students' mathematical problem-solving abilities.

Ontogenic obstacle

The ontogenic obstacle is the mismatch between the level of thinking of students and the type of learning provided, which impedes understanding the material. The students' ontogenic obstacles in understanding the problems can be shown by the students' answers in the following picture.

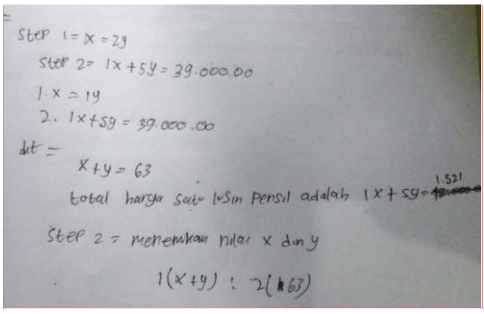

Figure 1. Student AZ answers regarding the first problem

Figure 1 shows student AZ trying to do the equations to understand the problem, but mistakes still occur when writing the algebraic modeling. He writes by forming two variables in the form of $x = 2y$. Then, he writes the next step by writing $1x + 5y = 39.000$. It implies that he tries to understand the question for one thing by replacing x. It seems that he does not understand what he did. At that point, in his final writing, he does the algebraic model without calculation. We assume he does not proceed to the strategy and computation process, so this student's answer was thought to be due to a lack of understanding of the problem.

Next, the student AW needed to correct the calculation of the first problem in part a. We assume that the student needs help understanding the measurement concept, which is one dozen being twelve. Then, he needs to realize there is a price for one pencil out of the total cost of twelve pencils. This can be seen from how he directly carries out the division operation process with divisors that are not written down. Therefore, he needs help to solve it. Here is the figure 2.

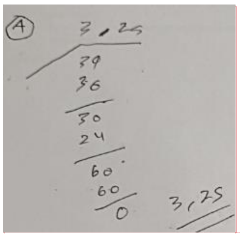

Figure 2. Student AW answers regarding the first problem number part a

Besides that, he carried out division operations with the number six as the divisor because there was a value of 36 from the subtraction process of 39. Furthermore, the mistakes showed that he needed to understand the concept of division and multiplication. This implied that he needed to prepare to study division and multiplication.

Next, he made the correct answer in problem part b on his answer sheet. it can be seen in Figure 3.

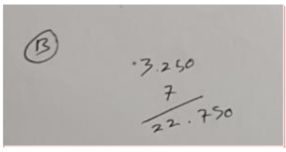

Figure 3. The student AW is correctly answering the first problem number part b

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From Figure 3, we assume he made a correct answer by commonly doing multiplication. He multiplied the price of one thing to become seven things by about 3.250 and 7. This implies he is ready to calculate and multiply rather than read and translate a problem's meaning.

Moreover, students will encounter obstacles in understanding and devising a plan for the problem, which will continue throughout the student's computational process. In contrast, the students failed throughout the computation process and needed to comprehend the situation. This illustrates how student AY responses demonstrate this.

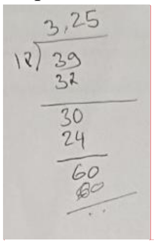

Figure 4. Mistakes in the student's computing process

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Figure 4 shows that the student AY carries out the computing process by writing 39 divided by 18, but the result of the computing process is 3.25. This indicates that he makes mistakes in the computing process, removing the number 0 without realizing the meaning of the 0. Mistakes written by him indicate his unpreparedness to understand the meaning of the place value of a number, even though the place value of numbers is an essential concept of a number.

The final indicator is to verify the answers that have been obtained. The last indicates that the majority of students need to double-check their answers. They frequently write the result of the computation, such as a number, rather than rewriting the phrase. Here is evident from the response of the student who reviewed the answer.

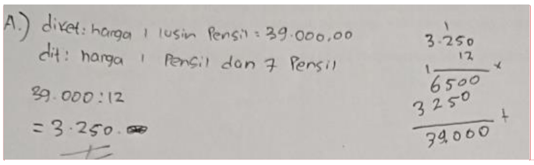

Figure 5. The student verifies his answer.

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The student AB does recheck results using the inverse of division, namely multiplication. Figure 5 illustrates that he uses the division operation to write down his plans, followed by the multiplication process to rewrite him. What can be observed is that he checks their responses based on the computing approach he uses.

Ontogenic obstacles were found in students' answers to the second problem with the first indicator of mathematical problem-solving ability, namely understanding problems. From the second problem, it turned out that only 20 people could understand the situation. Students tend not to write down answers or only collect empty answer sheets. This shows that most students cannot understand the problem. Here is an example of the student's answer.

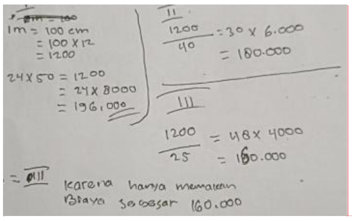

Figure 6. The student AD answer sheet

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Based on figure 6 shows that the student AD does not understand the problem entirely. He can convert the unit from meter to centimeter but cannot apply the rectangle's area. He calculates the number in the problem for each type but cannot understand the meaning of the problem.

Similar to Figure 6, the student AC also writes down the answer by calculating the number in the problem. He put down the $12m$ to become $1200cm$, then wrote $12m \times 12m$ and $1200cm \times 1200cm$, but could not do the calculations based on the number. He tries to devise a plan but cannot continue the purpose of that problem. Here is the answer to the student AC.

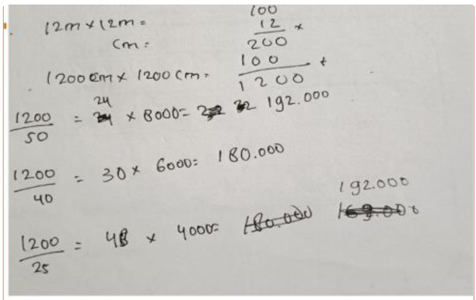

Figure 7. The student AC answer sheet

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The first and the second indicators of problem-solving ability still relate to each other. While students cannot understand the problem and they cannot devise it, there are 20.

In the third indicator of problem-solving ability, 15 students can do calculations by using a multiply 1200×1200, but no one from the students used multiply $50 \times 50, 40 \times 40, 25 \times 25$. Most students are doing 1200 dividing 50, 1200 dividing 40, and 1200 dividing 25.

In the fourth indicator of problem-solving ability, eight students recheck the answer. Students do not rewrite the answers necessary to solve the problem; they merely write the responses to the results of their computations.

Epistemological Obstacle

Epistemological obstacles were found in students' responses to the two questions based on the four indicators of problem-solving ability: carrying out the plan, such as making mathematical modeling in the form of equations. In the first question, the student finds it too hard to change verbal contextual difficulties into algebraic models with x, such as the

number of pencils is $12x$, which is the number 12 times the number of one pencil. Then, the cost for 12 times the amount of one pencil is Rp 39,000.00, and the cost of one pencil is Rp 3,250.00. The results of the student's work showed that almost all students had not completed the algebraic modeling. Students still do not think in mathematical form. Therefore, the answer is correct, though the student did in arithmetic order, as shown on the student answer sheet below.

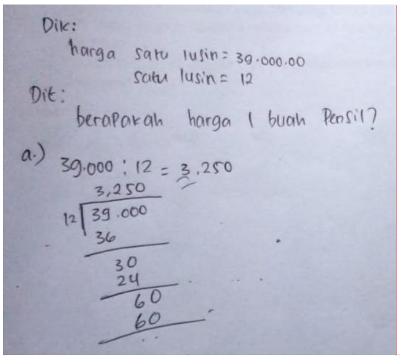

Figure 8. The student responds by applying arithmetic thinking

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The example in Figure 8 illustrates that students solve problems correctly but remain required to demonstrate algebraic modeling. This could be due to students' weaknesses with algebraic modeling. The student is used to arithmetic-solving methods that provide a straightforward solution process.

In addition, an essential obstacle to students' problem-solving skills, as indicated by the four indicators of mathematical problem-solving, is their limited understanding of algebraic issues presented as algebraic models. The student's cognitive process of identifying the problem and formulating a strategy for addressing it still needs enhancement. This is apparent from the observation that the student has not yet recorded the information he needs to acquire and develop their problem-solving ability. This is a student answer sheet that shows the student's limitations.

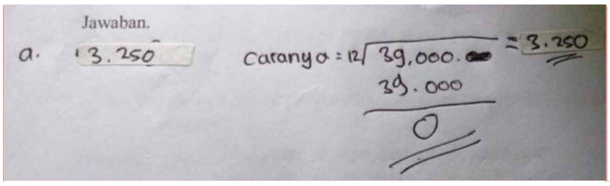

Figure 9. Students' limited comprehension of the problem

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Figure 9 shows that the student performs the calculation process without specifying the known data from the problem, so he automatically selects the division calculation process as the solution method. However, the calculating process used by students still needed to be corrected incorrectly. This could occur due to students' weaknesses in the division calculation process.

Didactical obstacle

Interviews were conducted with students and mathematics teachers regarding the mathematics learning process to determine the didactical obstacles that occur to students.

Here is the following transcript of the interview conducted with the students.

Researcher : Have you studied algebra subject?
Student : I think so, but I forgot.
Researcher : Have you ever studied something like that, the problem you are working on?
Student : No drills like these questions, ma'am; we are only given questions in the school book. So yesterday I forgot, ma'am, how much is one dozen.
Researcher : What books do you use?
Student : This book ma'am. (student shows the mathematics book he uses, namely a book from publisher X)

Based on the interviews with students, information was obtained that students had studied algebra material but had forgotten the algebra material used in the problems. Students also stated that they had never worked on questions like the questions the researcher gave, so students had obstacles in solving these problems. Furthermore, students also stated that the books used in the learning process were books from publisher X, not books from the Ministry of Education and Culture.

Furthermore, interviews were conducted with mathematics teachers; a transcript is below.

Researcher : What curriculum are you currently using?
Teacher : Independent Curriculum
Researcher : Do your students have difficulty learning algebra subjects?
Teacher : Yes
Researcher : What kind of difficulties do you mean?
Teacher : Students find it challenging to operate on algebraic forms related to negative numbers
Researcher : What steps did you take to overcome the student's difficulties?
Teacher : I explained again to the students about integer counting operations
Researcher : What book do you use when teaching algebra?
Teacher : Ministry of Education and Culture book
Researcher : Do you use any other books?
Teacher : Yes, a book from publisher X

The results of interviews with mathematics teachers showed that she had difficulty teaching student’s algebraic forms related to algebraic properties and negative numbers.

Discussion

Algebra is the initial topic in middle school, where the average age of students is between 13-14 years. In line with Piaget's phases of cognitive growth, students within this age category attain the formal operations phase (Suryadi, 2018). This age range is still characterized by the student's cognitive transition from the concrete operations stage to the

formal operations stage. In constructivist theory, cognitive development involves building knowledge of students, as seen in the phases of comprehending mathematical concepts (Wicaksono et al., 2024). However, ontogenic obstacles remain problems. Findings from AZ and AW indicate that they do not understand the problems, whereas understanding the problem is the key to solving the problem (Putri et al., 2022). This was in line with the results of the research of Amalina & Vidákovich (2023) that students are unsuccessful in exploring and understanding the problem. This causes students to be less able to continue to the following completion stage. Students are unable to examine and understand the problem; it seems that from scratch on the paper, and they look like they are doing calculations, whereas they just did random calculations. This is a learning obstacle for the students while solving the problem.

On the other hand, epistemology obstacles also appear in this research. The students have a limited understanding of making model mathematics and have weaknesses in calculating. The findings of the student AW indicate that he has limited ability to carry out the plan. He preferred to write directly using arithmetic structures rather than having to form equations. This means that students have obstacles while understanding the problem and are limited in making a modeling algebra to carry out the plan. These findings are also in line with the research Widyawati et al. (2018).

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4. CONCLUSION

After analyzing and discussing the learning obstacles students face in class VIII of Siak Hulu State Middle School, it can be inferred that students encounter distinct challenges in developing their understanding of mathematical problem-solving ability. Evidence of a lack of understanding of learning obstacles is when students demonstrate an inability to understand the concepts of measuring and the area. Consequently, they need help interpreting and solving problems presented in questions. Students demonstrate proficiency in using strategies for problem-solving, particularly in the areas of multiplication and division calculations. However, there is a distinction when reviewing answers, as students need to pay more attention to re-checking the accuracy of their acquired results

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Students' obstacles in solving algebra problems in viewed from mathematical problem-solving ability

Hidden by Editor

Abstract

This study aims to produce a description of the learning obstacles experienced by students based on their mathematical problem-solving abilities in algebra material. The method used in this study is didactical design research. This study was conducted at one of the State Junior High Schools in Siak Hulu in class VIII. Data analysis on students' mathematical problem-solving abilities and learning obstacles was carried out based on the results of the mathematical problem-solving ability test instrument, in-depth interviews, and document analysis. The results show that students experience learning obstacles that are ontogenic, epistemological, and didactic based on the identification of mathematical problem-solving abilities. Based on this, students' learning obstacles in solving algebra problems are identified.

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Keywords:
Obsctale, Problem-solving ability, Algebra, Ontogenic, Epistemology

How to Cite:
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1. INTRODUCTION

Commented [MOU4]: I did not find any gap analysis related to students' problem-solving abilities and learning barriers. Even though these two aspects are the focus of this study.

Mathematical problem-solving ability is fundamental to students' skills and activities in the 21st century (Lu & Xie, 2024; Rocha & Babo, 2024; Supriadi et al., 2024). For at least three decades, it has been recognized that mathematical problem-solving ability provides students with many opportunities to develop their creativity, enthusiasm, critical thinking, and interaction (Lester & Cai, 2016; Rocha & Babo, 2024; Säfström et al., 2024) This is because mathematical problem-solving ability includes several activities, such as solving word problems, creating patterns, interpreting figures, developing geometric constructions, and proving theorems (Supriadi et al., 2024; Zhu, 2007). Thus, mathematical problem-solving ability is essential in formal education and has consistently been an important subject of mathematics education research.

The terms of problem-solving can be referred to by Mayer as a summary of the cognitive processes aimed at transforming the initial state into the desired final state in

situations when the process of finding a solution is not immediately apparent (Dostál, 2015). Problem-solving is also a set of valuable abilities used to deal with and solve various problems (Friedel et al., 2008). In the topic of mathematics, George Polya, who is known as the founder of the mathematical problem-solving theory, defined problem-solving as follows: solving a problem means finding a way out of a difficulty, a way around an obstacle, and attaining an aim that was not immediately attainable (Jiang et al., 2022; Polya, 1985). It is undeniable that problem-solving is a challenging endeavor, and there are numerous factors to consider, including the appropriate approach (Rocha & Babo, 2024). So, mathematical problem-solving is related to thinking skills, which generally improve when one solves challenges requiring effort, enthusiasm, and investigation of the problems.

Furthermore, Polya's theory posited that mathematical problem-solving was an evolving process that involved the following activities: understanding the problem, devising a plan, performing the plan, and reflecting on the process (Polya, 1985). Most researchers in mathematics education use this theory (Amalina & Vidákovich, 2023). Besides that, Rocha & Babo (2024) stated that understanding the problem involves trying to understand the situation, defining the unknown, determining the conditions of the problem, and verifying whether it is possible to estimate the response. Then, devising a plan means finding resolution strategies, organizing the data, and trying to solve the problem. Next, performing the plan includes verifying each resolution step, executing all the calculations, and implementing all the strategies outlined. The last step is to confirm that the obtained solution is correct or that there is another way to solve the problem.

The process of mathematical problem-solving ability needs mathematical thinking commonly. For the students to develop mathematical problem-solving ability, they must be allowed to practice and cultivate problem-solving the problems in a non-stressful atmosphere (Lu & Xie, 2024). The students can be given a problem that relates to their daily life (Putri et al., 2022), and the problem does not have a given solution method, that is, a rule, template, or algorithm (Säfström et al., 2024). In other stated that they can figure out the solutions to a particular problem-based issue in learning mathematics and find appropriate solutions (Güner & Erbay, 2021). Therefore, a mathematical problem-solving ability that they have is their ability in inherent value during the students' problem-solving process.

Mathematical problem-solving ability can be improved in topic mathematics school by one of the crucial topics being algebra (Putri et al., 2022; Silvia et al., 2019). Algebra is commonly referred to as a fundamental step towards advanced mathematics, primarily because it serves as the medium through which mathematical concepts are taught (Jupri et al., 2014; Stacey & Chick, 2004; Wicaksono et al., 2024). Algebra is also vital to learning a conceptual understanding of features that are related to problem-solving (Booth & Koedinger, 2008; Wicaksono et al., 2024). Besides that, in the 2013 curriculum, algebra was first introduced in grade 7 of junior high school with material on algebraic forms and linear equations in one variable. These materials are initial concepts that students must understand well. This is because the material relates to the real world and current technological developments (NCTM, 2000; Rahmi & Yulianti, 2022). So, algebra concepts have become a crucial topic for educators and researchers in mathematics education to consider in the learning process.

Commented [MOU5]: In Indonesia, most students only use the stages, namely writing down what is known, asked and answered. How do you respond to this, and provide an explanation related to this culture?.

Commented [MOU6]: This step is very rarely done by students, how do you explain this? And ensure that students do this step

Commented [MOU7]: Need references to support this statement

Commented [MOU8]: How to? Whereas mathematics has an abstract context. This is what causes mathematics to be one of the subjects that students fear, causing students to become very stressed.

Commented [MOU9]: Are questions with everyday life contexts a problem for students?

Commented [MOU10]: Why should it be improved if the problem solving ability is already good?

Commented [MOU11]: Counterproductive, because algebra has been studied since elementary school for both the 2013 curriculum and the Merdeka curriculum. How do you respond to this?

Commented [MOU12]: The real world doesn't always have to come from algebra, calculus and geometry also have real world aspects. How do you deal with this?

Quality mathematics learning is determined by three critical elements that are interconnected with each other (Suryadi, 2019). These elements are teachers, students, and materials (Suryadi, 2019), so in stated that the learning process is the most essential part (Unaenah et al., 2023) and the learning process that is carried out naturally sometimes encounters difficulties in the learning process (Rahmi & Yulianti, 2022). These difficulties become obstacles for students to achieve learning outcomes well. In common, an obstacle is a situation that makes it difficult to do or achieve something. Then, these difficulties raise erroneous related to concepts and principles (Jupri et al., 2014; Wicaksono et al., 2024).

Commented [MOU13]: Use effective sentences

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Suryadi stated that learning obstacles in the learning process of mathematics include three types (Suryadi, 2019). There are ontogenic obstacles, epistemic obstacles, and didactical obstacles (Brousseau, 2002). An ontogenetic obstacle is a difficulty associated with a student's readiness to learn. The second category of learning obstacles is epistemological obstacles. These learning obstacles primarily arise from the limited atmosphere in which a subject is initially examined. Consequently, children frequently encounter difficulties when confronted with varying environments. The third kind of learning obstacle, the didactical obstacle, arises due to the state of the employed didactic design or the teacher's intervention.

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On the other hand, algebra still has several problems during the learning process, being algebraic content (Booth et al., 2017; Sari & Afriansyah, 2020; Warren et al., 2016). Furthermore, recent research also shows that several topics related to algebra have learning obstacles (Faradiba et al., 2024; Fauzah et al., 2023; Noto et al., 2020; Saputro et al., 2018; Wicaksono et al., 2024), then the other studies also stated that mathematical problem-solving ability in algebra still has problematics (Phonapichat et al., 2014; Putri et al., 2022; Samo, 2017). Nevertheless, in that case, those previous studies have yet to detail how obstacles to learning mathematical problem-solving ability in algebra are overcome. Using these facts, we will fill the gap in existing research by highlighting the importance of addressing students' learning obstacles related to students' mathematical problem-solving ability in terms of ontology, epistemic, and didactics. Therefore, this study aims to investigate students' learning obstacles related to mathematical problem-solving ability in algebraic material.

2. METHOD

Didactical Design Research (DDR) was chosen as the method in this research. DDR was the qualitative research on interpretive paradigms (Suryadi, 2019). Qualitative research in this research was used as an approach in which researchers as the main instrument that explored and understood the meaning of social or human problems by asking questions and using various procedures, collecting data from participants, analyzing inductively, and interpreting the data (Creswell, 2014; Merriam & Tisdell, 2016). Furthermore, the interpretive paradigm in this research also indicated that researchers were involved in a continually evolving and continuous experience with the participants (Creswell, 2014; Pramuditya et al., 2022). Therefore, DRR in this research was recognized as a technique for delineating, elucidating, and analyzing the data gathered.

Commented [MOU16]: Is DDR qualitative??

DDR in this research was based on analyses of the students' learning obstacles from before the initial learning process until after the end. Then, DDR was also known as the

empirical didactic design (Suryadi, 2010) that contains three steps: prospective analysis, metapedadidactic analysis, and retrospective analysis (Suryadi, 2019). The first stage included the didactic situation analysis stage, which was carried out before learning took place as a form of didactic and pedagogical anticipation. The second stage was the metapedadidactic analysis stage, namely the analysis of a series of didactic situations that develop in the classroom, analysis of learning situations, and analysis of interactions that influence the emergence of changes in didactic and learning conditions. The third retrospective analysis stage was an analysis that links the results of the hypothetical didactic situation analysis with the results of the metapedadidactic analysis. In this article, we provided a study of the obstacles that students encounter in their learning process, specifically focusing on what obstacles they face in developing their problem-solving ability.

The subjects who participated in this research were eighth graders from 2023 to 2024 in SMP N Siak Hulu, Kampar Regency, Riau Province, Indonesia, and have been studying algebra subject. The number of students who took the problem-solving ability test was 54. After that, six of the 54 students were interviewed based on their answer sheets.

The collection data technique used instruments that tested problem-solving ability. The test was given after the eighth-grade mathematics semester. This was conducted to indicate the type of obstacles that students encountered in solving algebraic topics. Investigating the learning obstacles was expected to help the teacher prepare teaching material related to the student's problem-solving abilities. Two problems were given to the students. Here are the examples of issues that were given to students.

Type	Items test
Problem 1	The price of one dozen pencils is Rp. 39,000.00. a) How much does one pencil cost? Could you explain how to calculate it? b) How much do seven pencils cost? Could you explain how to calculate it?”
Problem 2	Pak Roni will set up flooring over a surface area of 144 square meters. Toko “Daya Bersama” sells ceramics in several dimensions, such as type 1 measuring 50cm × 50cm, priced at Rp. 8,000.00 per unit, type II measuring 40cm × 40cm priced at Rp. 6,000.00 per unit, and type III measuring 25cm × 25cm priced at Rp. 4,000.00 per unit. Assume you want to set up these three varieties of ceramic tiles on the floor of your house. Which ceramic selection process offers the lowest costs? Explain the reasons!

Furthermore, the other collection data technique was the non-instruments used in interviews and documentation studies. The researcher interviewed the students after checking the answer sheets. The researcher also discussed selecting students for the interview with the mathematics teacher. This was done to ensure that the students being interviewed had good communication skills so that the interview could run smoothly. In addition, the students selected also had ontological and epistemological obstacles in solving algebra problems. The documentation studies were used to complete the test and interview results as the triangulation material to check the suitability of the data gathered.

Commented [MOU17]: Ability or skills? check for all phrases in this article

Commented [MOU18]: It would be better if a flowchart of the research conducted was also displayed.

Commented [MOU19]: Why use this subject? You mention the name of this subject very clearly, does the subject allow this and there will be no problems later on

Commented [MOU20]: The need for demographics of the research subjects used

Commented [MOU21]: Give reasons for taking these 6 students. What are the reasons? What are the considerations. The need to provide a description of the characteristics of the subjects for these six sub-subjects

Commented [MOU22]: Has the problem-solving test been validated and assessed by an expert? What would the results be if it had been consulted. If not, provide reasons why it is not necessary to consult

Commented [MOU23]: What is studies documentation used for? You haven't provided an explanation for this

The data analysis technique used in this research was collecting data, organizing data, sorting the data from the students' obstacles, and then managing, synthesizing, and finding the pattern from the data to conclude.

3. RESULTS AND DISCUSSION

3.1. Results

This study was conducted to describe learning obstacles in students related to algebra material. This data was obtained from students who had taken a learning obstacle identification test on problem-solving abilities. This study's learning obstacle identification test included a diagnostic test given to students who had studied algebra material in grades VII and VIII. There were two questions tested. Before being offered to students, the mathematics subject teacher validated the diagnostic test questions at SMPN Siak Hulu, Riau. The result of the diagnostic test validation is about the alteration of sentence. After that, the diagnostic test could be given to students. Afterward, the diagnostic test was conducted, and the data was analyzed to determine the obstacles experienced by students by looking at student errors in solving the questions. This research appears to be a term error as it indicates the students made mistakes in concepts or principles that are viewed from the indicators of mathematical problem-solving ability.

Afterward, a grouping of data based on the test results by students while working on the questions was carried out. The number of students who experienced error (did not master based on the indicator of mathematical problem-solving ability) will be presented as a percentage (%) of the number of students who took the diagnostic test exam. The number of students who experienced error is given in Table 1.

Table 1. The results of students' errors from diagnostic tests

No	Indicator of mathematical problem-solving ability	% of errors	
		Problem 1	Problem 2
1.	Understanding the problem	7,4	33,3
2.	Make a plan	7,4	33,3
3.	Carry out a plan	9,2	38,9
4.	Looking back	66,7	64,8

Based on Table 1, students' errors in solving the problem are related to indicators of mathematical problem-solving ability derived from all 54 students who were given the test. The students' mistakes appear primarily in carrying a plan and looking back. Students do not make many errors in understanding problems and making plans, but in implementing the plans they have made, students experience many errors.

Furthermore, students' errors in that case are obstacles that students have. There are ontogenic, epistemological, and didactical obstacles related to students' mathematical problem-solving abilities.

Ontogenic obstacle

The ontogenic obstacle is the mismatch between the level of thinking of students and the type of learning provided, which impedes understanding the material. The students' ontogenic obstacles in understanding the problems can be shown by the students' answers in the following picture.

Commented [MOU24]: This explanation is needed so that it is not too conceptual and abstract.

Commented [MOU25]: This explanation is needed so that it is not too conceptual and abstract.

Commented [MOU26]: This explanation is needed so that it is not too conceptual and abstract.

Commented [MOU27]: This explanation is needed so that it is not too conceptual and abstract.

Commented [MOU28]: This explanation is needed so that it is not too conceptual and abstract.

Commented [MOU29]: restructuring is needed for research results to be easy to read and understand

Commented [MOU30]: If he has this error? Does the student have a conceptual error? . Because the calculation results show doubt for me

Commented [MOU31]: I haven't found any error indicators for each of these stages in the previous section, so I haven't found any correlation with the previous section. You should provide an explanation of these indicators in the method section.

Commented [MOU32]: This is in contrast to table 1.

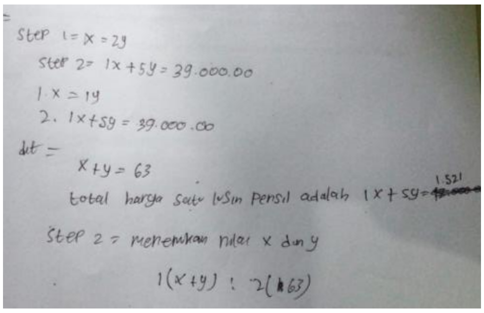

Figure 1. Student AZ answers regarding the first problem

Figure 1 shows student AZ trying to do the equations to understand the problem, but mistakes still occur when writing the algebraic modeling. He writes by forming two variables in the form of $x = 2y$. Then, he writes the next step by writing $1x + 5y = 39.000$. It implies that he tries to understand the question for one thing by replacing x. It seems that he does not understand what he did. At that point, in his final writing, he does the algebraic model without calculation. We assume he does not proceed to the strategy and computation process, so this student's answer was thought to be due to a lack of understanding of the problem.

Next, the student AW needed to correct the calculation of the first problem in part a. We assume that the student needs help understanding the measurement concept, which is one dozen being twelve. Then, he needs to realize there is a price for one pencil out of the total cost of twelve pencils. This can be seen from how he directly carries out the division operation process with divisors that are not written down. Therefore, he needs help to solve it. Here is the figure 2.

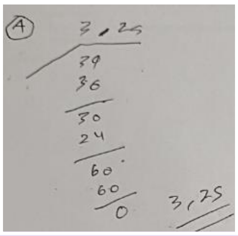

Figure 2. Student AW answers regarding the first problem number part a

Besides that, he carried out division operations with the number six as the divisor because there was a value of 36 from the subtraction process of 39. Furthermore, the mistakes showed that he needed to understand the concept of division and multiplication. This implied that he needed to prepare to study division and multiplication.

Next, he made the correct answer in problem part b on his answer sheet. it can be seen in Figure 3.

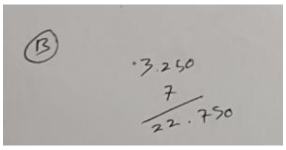

Figure 3. The student AW is correctly answering the first problem number part b

Commented [MOU33]: What are the characteristics of the subject

Commented [MOU34]: How can you conclude this?

Commented [MOU35]: In a study, it is highly avoided to use assumptions like this, it looks like a subjective statement from the researcher without any evidence. Check for all results

Commented [MOU36]: What about the other stages?

Commented [MOU37]: In a study, it is highly avoided to use assumptions like this, it looks like a subjective statement from the researcher without any evidence. Check for all results

Commented [MOU38]: What about the other stages?.

restructuring is needed for research results to be easy to read and understand

From Figure 3, we assume he made a correct answer by commonly doing multiplication. He multiplied the price of one thing to become seven things by about 3.250 and 7. This implies he is ready to calculate and multiply rather than read and translate a problem's meaning.

Moreover, students will encounter obstacles in understanding and devising a plan for the problem, which will continue throughout the student's computational process. In contrast, the students failed throughout the computation process and needed to comprehend the situation. This illustrates how student AY responses demonstrate this.

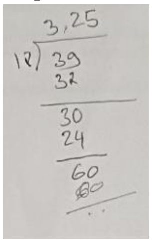

Figure 4. Mistakes in the student's computing process

Figure 4 shows that the student AY carries out the computing process by writing 39 divided by 18, but the result of the computing process is 3.25. This indicates that he makes mistakes in the computing process, removing the number 0 without realizing the meaning of the 0. Mistakes written by him indicate his unpreparedness to understand the meaning of the place value of a number, even though the place value of numbers is an essential concept of a number.

The final indicator is to verify the answers that have been obtained. The last indicates that the majority of students need to double-check their answers. They frequently write the result of the computation, such as a number, rather than rewriting the phrase. Here is evident from the response of the student who reviewed the answer.

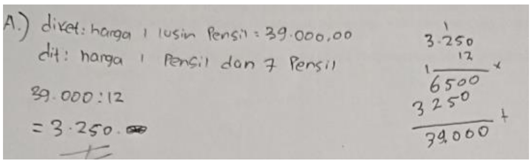

Figure 5. The student verifies his answer.

The student AB does recheck results using the inverse of division, namely multiplication. Figure 5 illustrates that he uses the division operation to write down his plans, followed by the multiplication process to rewrite him. What can be observed is that he checks their responses based on the computing approach he uses.

Ontogenic obstacles were found in students' answers to the second problem with the first indicator of mathematical problem-solving ability, namely understanding problems. From the second problem, it turned out that only 20 people could understand the situation. Students tend not to write down answers or only collect empty answer sheets. This shows that most students cannot understand the problem. Here is an example of the student's answer.

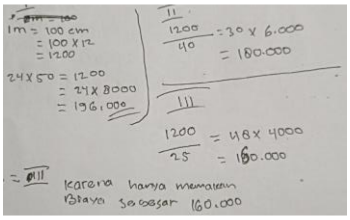

Figure 6. The student AD answer sheet

Based on figure 6 shows that the student AD does not understand the problem entirely. He can convert the unit from meter to centimeter but cannot apply the rectangle's area. He calculates the number in the problem for each type but cannot understand the meaning of the problem.

Similar to Figure 6, the student AC also writes down the answer by calculating the number in the problem. He put down the $12m$ to become $1200cm$, then wrote $12m \times 12m$ and $1200cm \times 1200cm$, but could not do the calculations based on the number. He tries to devise a plan but cannot continue the purpose of that problem. Here is the answer to the student AC.

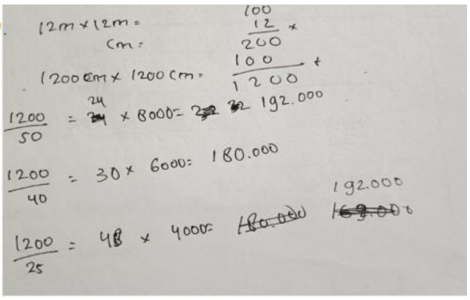

Figure 7. The student AC answer sheet

The first and the second indicators of problem-solving ability still relate to each other. While students cannot understand the problem and they cannot devise it, there are 20.

In the third indicator of problem-solving ability, 15 students can do calculations by using a multiply 1200×1200, but no one from the students used multiply $50 \times 50, 40 \times 40, 25 \times 25$. Most students are doing 1200 dividing 50, 1200 dividing 40, and 1200 dividing 25.

In the fourth indicator of problem-solving ability, eight students recheck the answer. Students do not rewrite the answers necessary to solve the problem; they merely write the responses to the results of their computations.

Epistemological Obstacle

Epistemological obstacles were found in students' responses to the two questions based on the four indicators of problem-solving ability: carrying out the plan, such as making mathematical modeling in the form of equations. In the first question, the student finds it too hard to change verbal contextual difficulties into algebraic models with x, such as the

number of pencils is $12x$, which is the number 12 times the number of one pencil. Then, the cost for 12 times the amount of one pencil is Rp 39,000.00, and the cost of one pencil is Rp 3,250.00. The results of the student's work showed that almost all students had not completed the algebraic modeling. Students still do not think in mathematical form. Therefore, the answer is correct, though the student did in arithmetic order, as shown on the student answer sheet below.

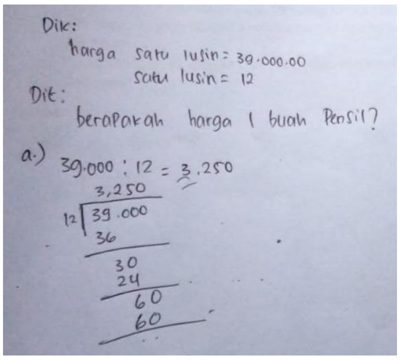

Figure 8. The student responds by applying arithmetic thinking

The example in Figure 8 illustrates that students solve problems correctly but remain required to demonstrate algebraic modeling. This could be due to students' weaknesses with algebraic modeling. The student is used to arithmetic-solving methods that provide a straightforward solution process.

In addition, an essential obstacle to students' problem-solving skills, as indicated by the four indicators of mathematical problem-solving, is their limited understanding of algebraic issues presented as algebraic models. The student's cognitive process of identifying the problem and formulating a strategy for addressing it still needs enhancement. This is apparent from the observation that the student has not yet recorded the information he needs to acquire and develop their problem-solving ability. This is a student answer sheet that shows the student's limitations.

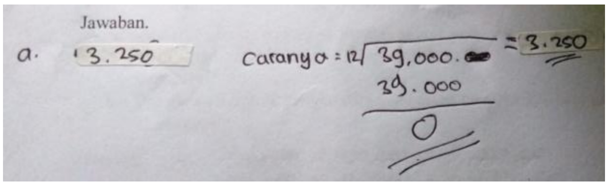

Figure 9. Students' limited comprehension of the problem

Figure 9 shows that the student performs the calculation process without specifying the known data from the problem, so he automatically selects the division calculation process as the solution method. However, the calculating process used by students still needed to be corrected incorrectly. This could occur due to students' weaknesses in the division calculation process.

Didactical obstacle

Interviews were conducted with students and mathematics teachers regarding the mathematics learning process to determine the didactical obstacles that occur to students.

Here is the following transcript of the interview conducted with the students.

Researcher : Have you studied algebra subject?
Student : I think so, but I forgot.
Researcher : Have you ever studied something like that, the problem you are working on?
Student : No drills like these questions, ma'am; we are only given questions in the school book. So yesterday I forgot, ma'am, how much is one dozen.
Researcher : What books do you use?
Student : This book ma'am. (student shows the mathematics book he uses, namely a book from publisher X)

Based on the interviews with students, information was obtained that students had studied algebra material but had forgotten the algebra material used in the problems. Students also stated that they had never worked on questions like the questions the researcher gave, so students had obstacles in solving these problems. Furthermore, students also stated that the books used in the learning process were books from publisher X, not books from the Ministry of Education and Culture.

Furthermore, interviews were conducted with mathematics teachers; a transcript is below.

Researcher : What curriculum are you currently using?
Teacher : Independent Curriculum
Researcher : Do your students have difficulty learning algebra subjects?
Teacher : Yes
Researcher : What kind of difficulties do you mean?
Teacher : Students find it challenging to operate on algebraic forms related to negative numbers
Researcher : What steps did you take to overcome the student's difficulties?
Teacher : I explained again to the students about integer counting operations
Researcher : What book do you use when teaching algebra?
Teacher : Ministry of Education and Culture book
Researcher : Do you use any other books?
Teacher : Yes, a book from publisher X

The results of interviews with mathematics teachers showed that she had difficulty teaching student’s algebraic forms related to algebraic properties and negative numbers.

Discussion

Commented [MOU39]: I did not find the discussion comprehensive enough. The researcher seemed to only summarize the research results obtained [in the previous section, and has not been linked to previous studies.

Algebra is the initial topic in middle school, where the average age of students is between 13-14 years. In line with Piaget's phases of cognitive growth, students within this age category attain the formal operations phase (Suryadi, 2018). This age range is still characterized by the student's cognitive transition from the concrete operations stage to the

formal operations stage. In constructivist theory, cognitive development involves building knowledge of students, as seen in the phases of comprehending mathematical concepts (Wicaksono et al., 2024). However, ontogenic obstacles remain problems. Findings from AZ and AW indicate that they do not understand the problems, whereas understanding the problem is the key to solving the problem (Putri et al., 2022). This was in line with the results of the research of Amalina & Vidákovich (2023) that students are unsuccessful in exploring and understanding the problem. This causes students to be less able to continue to the following completion stage. Students are unable to examine and understand the problem; it seems that from scratch on the paper, and they look like they are doing calculations, whereas they just did random calculations. This is a learning obstacle for the students while solving the problem.

On the other hand, epistemology obstacles also appear in this research. The students have a limited understanding of making model mathematics and have weaknesses in calculating. The findings of the student AW indicate that he has limited ability to carry out the plan. He preferred to write directly using arithmetic structures rather than having to form equations. This means that students have obstacles while understanding the problem and are limited in making a modeling algebra to carry out the plan. These findings are also in line with the research Widyawati et al. (2018).

4. CONCLUSION

After analyzing and discussing the learning obstacles students face in class VIII of Siak Hulu State Middle School, it can be inferred that students encounter distinct challenges in developing their understanding of mathematical problem-solving ability. Evidence of a lack of understanding of learning obstacles is when students demonstrate an inability to understand the concepts of measuring and the area. Consequently, they need help interpreting and solving problems presented in questions. Students demonstrate proficiency in using strategies for problem-solving, particularly in the areas of multiplication and division calculations. However, there is a distinction when reviewing answers, as students need to pay more attention to re-checking the accuracy of their acquired results

Commented [MOU40]: how can you justify this?

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Students' obstacles in solving algebra form problems viewed from mathematical problem-solving ability

Hidden by Editor

Abstract

Mathematical problem-solving ability is the most effective cognitive instrument in learning mathematics, and enhancing students' mathematical problem-solving ability is the primary objective of education. However, to reach the most effective level of mathematical problem-solving ability, we need to comprehend the reasons behind the challenges that students face while learning. This research investigates the learning obstacles of the students based on their mathematical problem-solving ability, particularly in algebraic form material. The method used in this research employed qualitative study with a series of Didactical Design Research (DDR) projects to learn the obstacles to the student's mathematical problem-solving ability. Seventy-six eighth-grade students from a public junior high school in Kampar region were given a test to assess their ability to solve mathematical problems. Various research instruments are used, including tests of mathematical problem-solving ability, interview guidelines, and interviews by audio recordings. The data were analyzed using a qualitative approach to determine students' obstacles while learning. The findings highlight ontogenic, epistemological, and didactical obstacles students face while understanding the problem, particularly the concept of algebraic form, interpreting the word to the mathematical concept of algebraic form, and designing the algebraic forms.

Keywords:
Obstacle, Problem-solving ability, Algebra, Ontogenic, Epistemology

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1. INTRODUCTION

Mathematical problem-solving ability is fundamental to students' ability and activities in the 21st century (Lu & Xie, 2024; Pramuditya et al., 2022; Rocha & Babo, 2024; Supriadi et al., 2024). For at least three decades, it has been recognized that mathematical problem-solving ability provides students with many opportunities to develop their creativity, enthusiasm, critical thinking, and interaction (Lester & Cai, 2016; Rocha & Babo, 2024; Säfström et al., 2024). Mathematical problem-solving ability includes several activities, such as solving word problems, creating patterns, interpreting figures, developing geometric constructions, and proving theorems (Doorman et al., 2007; Supriadi et al., 2024).

Thus, mathematical problem-solving ability is essential in formal education and has consistently been an important subject of mathematics education research.

Mayer can refer to the terms of problem-solving as a summary of the cognitive processes aimed at transforming the initial state into the desired final state in situations when the process of finding a solution is not immediately apparent (Dostál, 2015). Problem-solving encompasses an assortment of essential abilities employed to deal with and solve several different problems (Friedel et al., 2008). It also can be defined as the application of concepts and ability, often requiring the integration of these elements in unusual contexts (van Merriënboer, 2013; Widodo et al., 2025). Accordingly, problem-solving is an essential ability that students must acquire for exemplary achievement.

In mathematics, George Polya, known as the founder of the mathematical problem-solving theory, defined problem-solving as follows: solving a problem means finding a way out of a difficulty, a way around an obstacle, and attaining an aim that was not immediately attainable. (Jiang et al., 2022; Polya, 1985). It is undeniable that problem-solving is a challenging endeavor, and there are numerous factors to consider, including the appropriate approach (Rocha & Babo, 2024). Thus, mathematical problem-solving is related to thinking, which generally improves when one solves challenges requiring effort, enthusiasm, and investigation of the problems.

Moreover, Polya's theory posited that mathematical problem-solving was an evolving process that involved the following activities: understanding the problem, devising a plan, carrying out the plan, and looking back (Polya, 1985). Most researchers in mathematics education use this theory (Firda et al., 2023; Novriani & Surya, 2017; Putri & Hidayati, 2023), but the problem with using this theory is that most students fail along the problem-solving process (Putri et al., 2022; Stacey, 2005). One of the contributing factors is that the problem-solving process is ordered, students who struggle to understand or lack confidence in a problem will fail to accomplish the steps or stop that step (Aisyah et al., 2023; Amalina & Vidákovich, 2023). Besides that, Rocha & Babo (2024) and Polya (1985) stated that understanding the problem involves trying to understand the situation, defining the unknown, determining the conditions of the problem, and verifying whether it is possible to estimate the response. Then, devising a plan means conceiving the plan gradually until finding resolution strategies, organizing the data, and lastly, trying to solve the problem (Rocha & Babo, 2024). Next, carrying out the plan includes verifying each resolution step, executing all the calculations, and implementing all the strategies outlined with the correct answer (Firda et al., 2023; Rocha & Babo, 2024). The last step, looking back, is to confirm that the obtained solution is correct or that there is another way to solve the problem, to carry out this final stage, a discussion and confirmation with the students are required to know and verify the solution that the students have constructed (Firda et al., 2023; Polya, 1985).

To develop mathematical problem-solving abilities, the students should be allowed to practice and cultivate problem-solving problems in a non-stressful atmosphere (Lu & Xie, 2024). To provide an enjoyable atmosphere for students, a didactic approach is required that encourages students to associate mathematical concepts with context (Putri et al., 2022) to create meaningful learning, allowing them to understand mathematical topics based on their acquisition of fundamental understanding from their daily lives. The problem does not have a given solution method, a rule, a template, or an algorithm (Säfström et al., 2024). Others stated that they can figure out the solutions to a particular problem-based issue in learning mathematics and find appropriate solutions (Güner & Erbay, 2021). Thus, the development of students' mathematical problem-solving ability commences with their ability to address everyday challenges through engaging learning approaches, understanding the problem, and designing and solving the mathematical model rather than initiating with formal mathematical concepts.

The mathematical problem-solving ability still has problems in Indonesia (Putri et al., 2022; Septian et al., 2022; Widodo et al., 2025). The study was conducted by (Amalina & Vidákovich, 2023; Novriani & Surya, 2017; Widodo et al., 2025) exhibited that students face difficulties while solving problems. Fewer students can explore and understand the problem, present and formulate the plan, and monitor and reflecting (Amalina & Vidákovich, 2023; Novriani & Surya, 2017). In addition, students also have an inability to translate problems into mathematical concepts and use correct mathematics (Jupri & Drijvers, 2016; Ying et al., 2020).

Mathematical problem-solving ability can be improved in topic mathematics school by one of the crucial topics being algebra (Putri et al., 2022; Silvia et al., 2019). Algebra is commonly referred to as a fundamental step towards advanced mathematics, primarily because it serves as the medium through which mathematical concepts are taught (Jupri, Drijvers, & Heuvel-Panhuizen, 2014; Stacey & Chick, 2004; Wicaksono et al., 2024). Algebra is also vital to learning a conceptual understanding of features that are related to problem-solving (Booth et al., 2014; Wicaksono et al., 2024).

Among the algebra subjects, algebraic forms stand at the intersection of arithmetic and symbolic mathematics. Algebraic forms are composed of constants, variables, coefficients, and terms that interact through various operations (As'ari et al., 2017; Tim Gakko Tosho, 2021). Understanding algebraic form is essential for capturing the concept itself and progressing in various algebraic topics, including operations on algebraic forms, simplification of algebraic forms, and the identification of equivalent algebraic forms, among others.

Nevertheless, algebraic form presents challenges for students beginning their exploration of algebraic concepts in junior high school (Riskon et al., 2021). Research on algebraic forms is well-documented (Asmara et al., 2024; Utami & Puspitasari, 2022); however, a notable gap remains in understanding the specific difficulties and obstacles to learning encountered by middle school students, particularly concerning their mathematical problem-solving abilities. The means term of difficulties for students arise as a result of errors (Jupri, Drijvers, & Van den Heuvel-Panhuizen, 2014), then difficulties resulting from external factors or didactic design create obstacles (Suryadi, 2019; Wicaksono et al., 2024). Obstacles also occasionally occur during the learning process (Brousseau, 2002; Rahmi & Yulianti, 2022), which makes it difficult for students to achieve optimal outcomes in the learning process (Suryadi, 2019). Additionally, learning obstacles impede students' ability to acquire new knowledge, potentially leading to challenges in their educational experience (Suryadi, 2019). Learning obstacles are evident in the interactions among teachers, students,

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and educational materials (Suryadi et al., 2023). Therefore, obstacles for the students can occur due to student difficulty while doing a didactic design or learning process.

Furthermore, Suryadi enlightened that there are three types of learning obstacles, namely ontogenic obstacles, didactical obstacles, and epistemological obstacles (Brousseau, 2002; Suryadi, 2019). Suryadi also described ontogenetic obstacles as the difficulty level in a didactic situation that may interfere with the learning process. Then, didactic obstacles are related to the sequence and/or stages of the curriculum content and the process in which it is presented, which influences the continued development of students' thought processes. Meanwhile, epistemological obstacles refer to the limitations of a person's understanding of something that is only appropriate for a particular setting based on their learning experiences (Suryadi, 2019).

Investigations that identify and explore mathematical problem-solving ability and learning obstacles have been associated with various other contexts. To guarantee the originality of this study, the VOSviewer tool was employed, utilizing data sourced from Scopus. The terms used were 'problem-solving,' ‘mathematical,’ and 'obstacle.' The criteria for inclusion specified that the study must have been published between 1990 and 2024 in the fields of mathematics or social sciences and must be written in English. A total of 189 articles were identified as meeting these criteria. Figure 1 presents the results of the VOSviewer visualization.

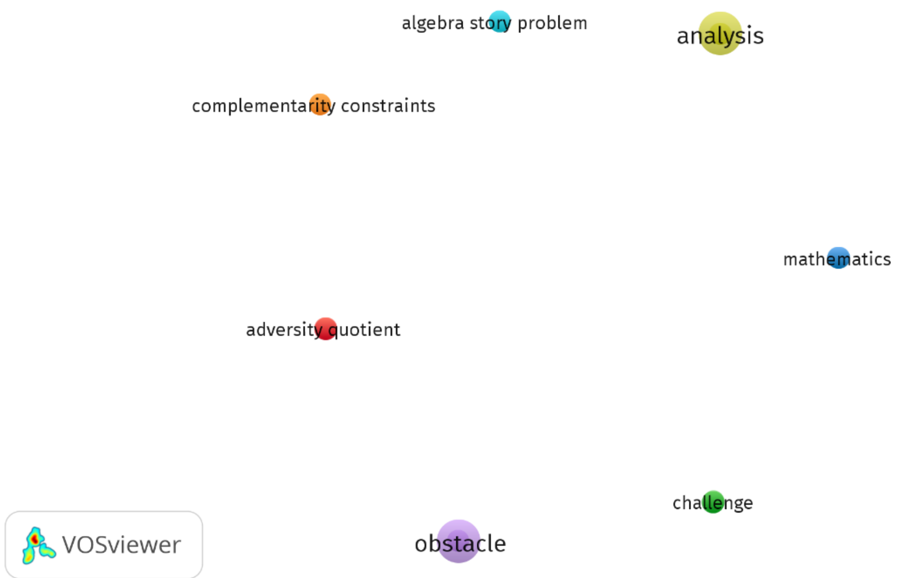


Figure 1. Linkages between the keywords 'problem-solving,' ‘mathematical’ and 'obstacle.”

There are seven clusters that appear, as illustrated by the VOSviewer tool (see Figure 1). There is no line connecting the elements or keywords analyzed. Keywords that are frequently discussed in the research are "obstacle," "challenge," "mathematics," "analysis," "algebra story problem," "complementary constraints," and "adversity quotient." No research work links “students' mathematical problem-solving ability” with “obstacle” or “learning obstacles”.

Based on the results of the above exploration, this study aimed to explore students’ mathematical problem-solving ability in the learning obstacles for algebraic form. This study poses a research question: "How did the learning obstacles affect the students' mathematical problem-solving ability in algebraic form?"

2. METHOD

This research is part of the Didactical Design Research (DDR) framework that was developed by Suryadi (2019), integrating an interpretive paradigm. The study of the interpretive paradigm in DDR is concerned with the impact of didactic design on students, particularly regarding the reality of meaning resulting from didactic factors and learning proceeds (Jatisunda et al., 2024; Suryadi, 2019; Unaenah et al., 2024). This study also employed a qualitative research design based on hermeneutic phenomenology. The use of hermeneutic phenomenology as a research method is required to investigate the learning obstacles faced by junior high school students because students align with their learning obstacles, leading to investigations based on the student's life experiences and subjective perspectives. Furthermore, hermeneutic phenomenology specializes in investigating the complex nature of human experiences, helping researchers to figure out the underlying meanings and interpretations behind phenomena like obstacles to learning.

There are three steps conducted in DDR, namely prospective analysis, metapedadidactic analysis, and retrospective analysis (Suryadi, 2019). The prospective analysis is the findings of students' learning obstacles in previous learning. Next, the metapedadidactic analysis is preparing and analyzing a hypothetical learning trajectory and didactic design. The final step is the retrospective analysis stage, where an analysis is conducted based on the results of reflection and evaluation, examining the relationship between prospective analysis and metapedadidactic analysis (Jamilah et al., 2024)

Before beginning to investigate the educational obstacles that students face, the researcher conducted an early step by consulting with the topic teachers about the learning process used by teachers. The discussion included the curriculum, the mathematics topic taught in grades VII and VIII, textbooks, material sequence, and learning approaches. This step is essential as an initial effort to determine the initial conditions of students when learning mathematics. Furthermore, the discussions with teachers also revealed that the subject of algebra and its learning need to be identified, especially regarding students' learning obstacles. Then, the result of that discussion also determined which students would participate in the research.

The students selected in this study were eighth graders from 2023 to 2024 in SMP N Riau Province and have been studying algebra subject. The number of students who took the problem-solving test was 76, 23 males and 53 females.

Data were collected by testing mathematical problem-solving ability instruments and follow-up interviews by recording audio. First, students were tested to solve two algebraic form problems individually with a time of 70 to 80 minutes. Students were given the freedom to write their answers on the paper provided. During the completion of the test, students were not allowed to use a calculator. This is because the test was conducted to determine students' obstacles in problem-solving abilities. Two problems were given to the students. Here are the examples of questions that were given to students.

Table 1. Type of the question

Type	Items test
Problem 1	Mr. Roni purchased three cartons of notebooks and two individual notebooks, while Mr. Ijal bought four cartons of notebooks and four individual notebooks. Each carton contains the same number of notebooks. a. What can you understand from the story? b. How do you find the algebraic expression from the story? Explain! c. Determine the constants, coefficients, variables, and terms in the story! d. Recheck the results from question d! Are they correct? Explain!
Problem 2	Bambang has two empty cans, namely can A and can B. These cans will be filled with 32 marbles. a. What can you understand from the story? b. How do you determine the number of marbles that can be filled into cans A and B? Explain! c. Calculate the number of marbles in can A if the number of marbles in can B is m marbles! d. Recheck the results from question d! Are they correct? Explain!

After the test, it was continued by coding the students' answer sheets according to the problem-solving ability indicators and their obstacles. The coding results of the students' answer sheets were then discussed with the subject teacher so that interview students could be selected. The purpose of considering conducting discussions with subject teachers was to determine students' ability to speak and work together well in time and openly to complete the completion process.

Six participants were selected for follow-up interviews. Interviews were conducted the following day after the written test, each lasting about 20-30 minutes. Because the interview could only be done after the entire learning process, the interview stage was conducted for three consecutive days. The interviews were conducted semi-structured manner that aimed to give students the freedom to explain the solutions they had written. Furthermore, the interviewer did not intervene to get the right or wrong solution. As a guideline for conducting the interview, initial and follow-up questions were prepared to focus on investigating students' mathematical problem-solving abilities, and the interviewer was allowed to be flexible in asking questions during the interview.

A guideline interview with initial questions includes: What can you understand about this story? How did you find/solve this story? Can you explain your solution? Furthermore, how do you check whether your solution is correct or not? Then, follow-up questions include, for example: Why did you take this writing? What is your obstacle/misunderstanding? What does it mean? This question progresses and depends on the student’s response.

The data analysis was carried out in two steps. In the first step, individual written work was analyzed, and mathematical problem-solving ability was measured. Measure mathematical problem solving using Polya’s four steps: understanding the problem, making a plan, carrying out the plan, and looking back. Based on those steps, a mathematical problem-solving ability scoring rubric is developed. After that, coding was created to address situations such as when students did not have an answer or were unable to understand the problem. The coding was not strict, but it can be developed based on the student's responses.

In the second step, an analysis of the interview is the confirmation of students' written work. The results of the interview are transcription data. Thus, the interview data were coded to explain that the students had no answer or misunderstanding. After completing the coding data from written work and interviews, the next step is to code it into ontogenic, epistemological, and didactic obstacles.

3. RESULTS AND DISCUSSION

3.1. Results

A test of students' mathematical problem-solving ability was initially administered to identify their learning obstacles. A mathematical problem-solving ability test was given to 76 students involved with the algebraic form subject. This test comprises inquiries related to the indicators of mathematical problem-solving based on Polya's theory and encompasses the concept of algebraic material. Following the mathematical problem-solving ability testing process, the overall average % for each question was determined based on the indicators of mathematical problem-solving ability relative to the students' responses. Figure 2 presents the average percentage of students' mathematical problem-solving ability for each indicator associated with the assessed questions.

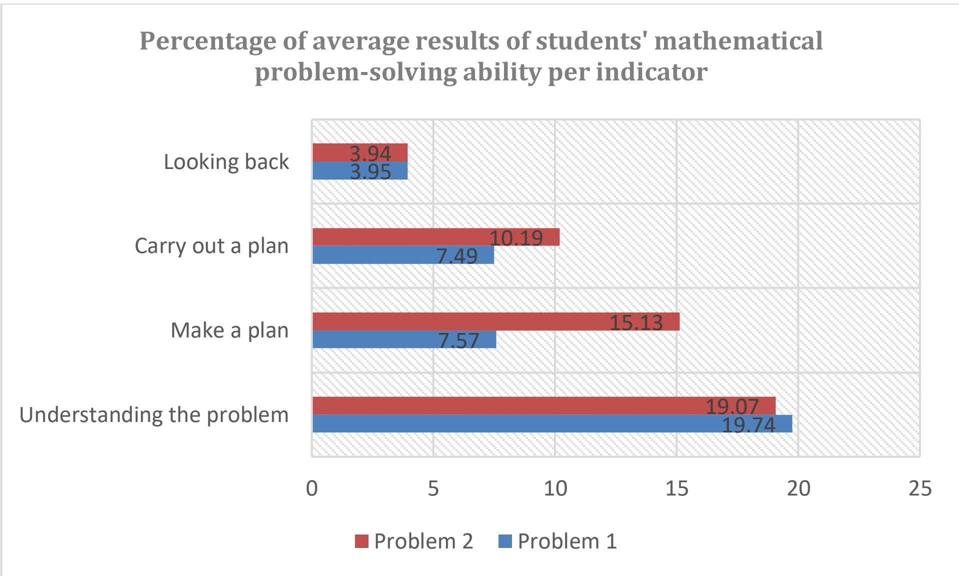


Figure 2. Percentage of average results of students' mathematical problem-solving ability per indicator

The results presented in Figure 2 indicate a decline in students' average mathematical problem-solving ability from indicator one to indicator four. The average percentage of problem-solving ability for question number one, which had the problem understanding indicator, was 19,74%. The average percentage of problem-solving ability for question number two, which also had the problem understanding indicator, was 19,07%. The findings reveal that students' ability to solve mathematical problems according to the problem understanding indicator of the two questions has a difference of 0,67. This indicates that students' ability to understand problems from the two questions is not different, so the average percentage of mathematical problem-solving ability in understanding problems is 19,41%.

Additionally, for the make-a-plan indicator, question one exhibits an average percentage of mathematical problem-solving ability at 7,57%. In contrast, under the same indicator, question two shows an average percentage of 15,13%. This indicates a difference of 7,56 in students' mathematical problem-solving abilities regarding the make-a-plan indicator, highlighting variability in their ability in this second indicator. Thus, the average percentage of students' mathematical problem-solving ability in the make-a-plan indicator is 11,35%.

Next, the average percentage of mathematical problem-solving ability is 7,89% for question number one, based on the indication of carrying out the plan. The average percentage of mathematical problem-solving ability is 10,19% for question number two, which is based on the same indicator. This indicates a 2,3% difference in students' mathematical problem-solving ability in the indication of carrying out the plan, which is a slight difference between the two questions. As a result, the average percentage of students' mathematical problem-solving ability on the indicator of implementing the plan is 9,04%.

Finally, the average mathematical problem-solving ability is 3,95% when considering question number one. In contrast, the average percentage of mathematical problem-solving ability is 3,94% when looking back at question number two. This indicates a difference of 0.01 in the student's ability to solve mathematical problems on the looking back indication. The average percentage of s' mathematical problem-solving ability on the looking back indication is 3,945%.

The results of the test not only indicate the average percentage of students who were able to solve mathematical problems but also the number of students who were unable to answer the two questions that were presented. The number of students who could not respond to each indicator of mathematical problem-solving ability is illustrated below in Table 2.

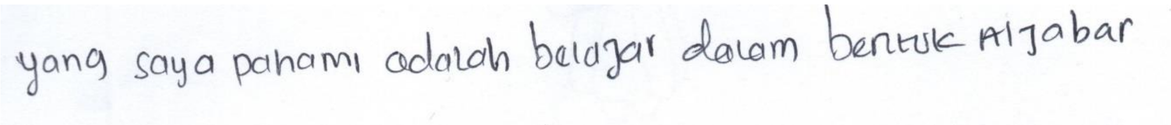
Table 2. Many students are unable to answer indicator

No	Indicator of mathematical problem-solving ability	Many students are unable to give an answer	
		Problem 1	Problem 2
1.	Understanding the problem	37	41
2.	Make a plan	56	50
3.	Carry out a plan	56	60
4.	Looking back	65	65

Table 2 indicates that many students cannot understand and comprehend the issue presented in the second problem. Forty-one students struggle with understanding the problem rather than problem 1, with 37 students indicating obstacles to their ability to make plans, carry out them, and indicate their outcomes. Nevertheless, the reality of the obstacles students encounter in the second indicator, in particular, is increasing. In addition to those 41 individuals, there are also 50, 60, and 65. This has also been addressed in problem 1, where the consecutive students unable to respond are 37, 56, 56, and 65. Therefore, this indicates that when students struggle to understand a problem, their progression to the subsequent step is also impeded.

Ontogenic obstacle

The ontogenic obstacle in this study referred to the discrepancy in students' cognitive levels. Students in eighth grade are expected to understand an algebraic form of a commonplace issue. In actuality, students have struggled to understand the algebraic form of a written problem. Consequently, a disparity exists between the knowledge students are supposed to have and the actual situation. This presents an obstacle for students in problem-solving tests.



Translate: What I understand is learning in the notation of algebra form

Figure 3. Student’s answer, S1, in solving a mathematical problem based on the first indicator

The student’s answer in Figure 3 shows that she could only understand algebraic form problems in the formal form of the algebraic form. In other words, she was not yet able to understand algebraic forms involving stories, such as the provided questions. Here is the transcription of the interview with the student in supporting Figure 3.

Researcher: What do you mean by this writing?

The student: I have not studied anything like this, ma'am. I just recognized about this. (see Figure 4)

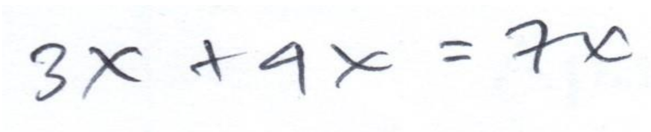
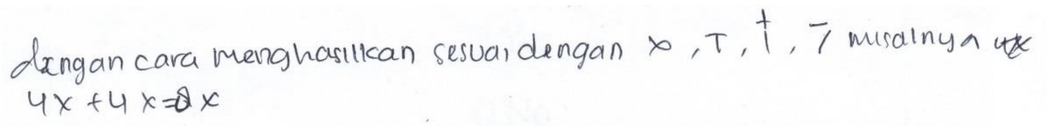


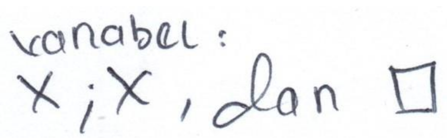
Figure 4. Student’s answer in algebraic form

Furthermore, from Figure 4, S1 wrote down the equation as the formal form of algebra as her transformation of the meaning of the stories from 3 cartons of notebooks and two individual notebooks to $3x + 4x$ After that, she summed $3x + 4x$ to became $7x$. Thus, $3x + 4x = 7x$. It was the formal form of algebra for the S1. The reason why she found that the formal form of algebra was to produce variables like x, t, l, y then she gave examples such as $4x + 4x = 8x$.



Translate: to produce a suitable result x, t, l, y then example $4x + 4x = 8x$

Figure 5. Student's description of finding algebraic form

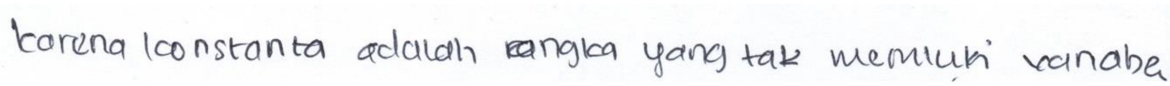


Translate: variable $x, x,$ *and* □

Figure 6. Student's answer about the variables

Continuing the question about the constants, coefficients, variables, and terms in the story, S1 carried out her plan by just writing down the variables (see Figure 6). It implied that she struggled to understand constants, coefficients, and terms of algebra. Here is the transcription of the interview with the student in supporting Figure 6.

Researcher: What do you mean by this writing?
The student: This is variable.
Researcher: All of these variables?
The student: Yes, I have not found where is constant.

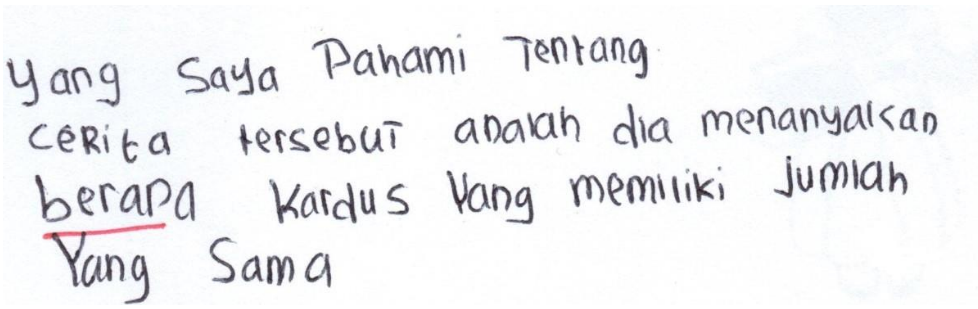


Translate: Because the constant is a number that has no variable

Figure 7. Student's answer in phase looking back

Nevertheless, in phase looking back from Figure 7, S1 stated that the constant was a number that has no variable. It implied that while she looked back on the question and her answer about the constants, coefficients, variables, and terms, she did not find what the question wanted from her algebraic form. She just wrote $3x + 4x = 7x$. So, there was no constant in that algebraic form. Consequently, she did for a phase looking back, but she was confused with what she wrote.

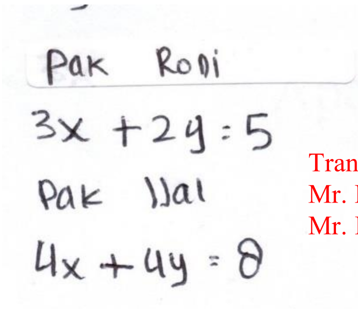
In another situation, the answer obtained from the other student, namely S2, indicated that the abilities she possesses in the first indicator, specifically in capturing the problem, are limited when it comes to interpreting its meaning. The student wrote a statement that she understood the first problem about asking how many cartons have the same number. Figure 8 illustrates this point.



Translate: What I understand about the story is that it asks how many cartons have the same number of cartons.

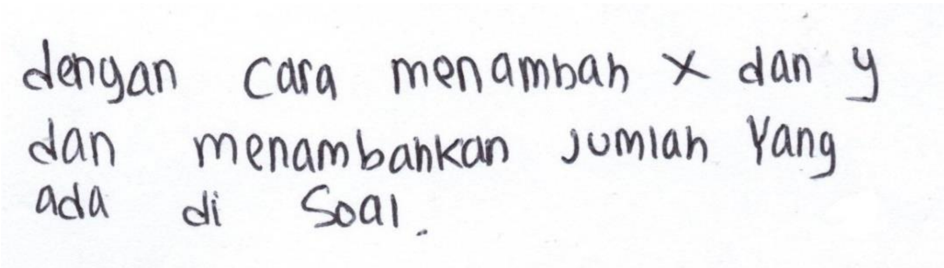
Figure 8. Student's answer while understanding the problem

S2 stretched a different meaning from what should be understood from the question so that the student's mistake in understanding the problem causes an incorrect solution process. Next, the process of determining mistaken interpretations of S2 can be seen in Figure 9.



Translate:
Mr. Roni $3x + 2y = 5$
Mr. Ijal $4x + 4y = 8$

Figure 9. Student's answer to finding the algebraic form



Translate: by adding x and y and adding the sums to the question

Figure 10. Student's description of her answer while working on the plan

Figure 10 illustrates that S2 carried out her making plan by adding x and y. Moreover, she added each algebraic term that she had formed into a number. S2 also posited that various algebraic terms can be summed together to become a number such that. $3x + 2y = 5$ or $4x + 4y = 8$, like in Figure 4. Additionally, when asked to identify constants, variables, coefficients, and algebraic terms, S2 was unable to respond.

Epistemological Obstacle

The epistemological obstacle in this study indicates that students gain a limited understanding of the concept, which results in obstacles to its application across varying contexts. Students face challenges in developing an understanding of algebraic forms when presented with written questions. The study indicated several epistemological obstacles regarding the concept of algebraic forms and their applications. This takes place during the completion process within the make-a-plan indicator.

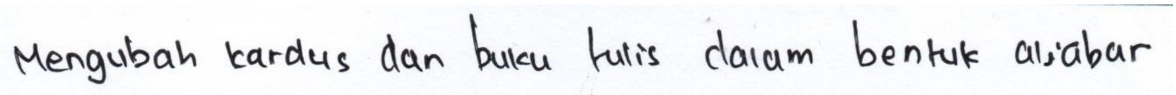


Figure 11. Student's answer while make-a- plan

Figure 11 shows that while students tried to make a plan to become an algebraic form, they thought of changing a cartoon and notebook into a show. The algebraic form that students thought was like in Figure 12.

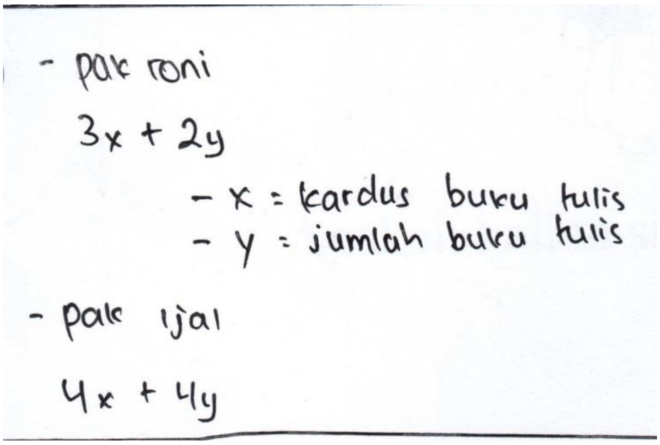
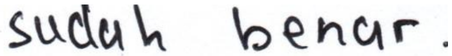


Figure 12. The student interprets the problem to become an algebraic form.

The answer form presented in Figure 12 suggests that the student possessed knowledge that was primarily limited to algebraic forms featuring variables while lacking involvement with constants. Consequently, when the student was questioned regarding constants, coefficients, and algebraic terms, she often experienced confusion concerning the algebraic forms that she had formulated. Ultimately, the student responded that she was uncertain due to a lapse in memory. The insufficient understanding that students have in converting story problems into algebraic forms presents obstacles to her ability to grasp constants, coefficients, and algebraic terms effectively. At the finish of the question, the student indicated that she had accurately transformed the story problem into algebraic form, which indicated that there was no need for her to revise her answers (see Figure 13).



Translate: Already correct

Figure 13. The student's answer in the last step

Didactical obstacle

Didactic obstacles in this study are present in various fundamental concepts provided by the teachers, significantly influencing the development of students' understanding of algebraic forms. Here, the interviews were conducted with the students regarding the algebraic form test to determine the didactical obstacles that occur to students.

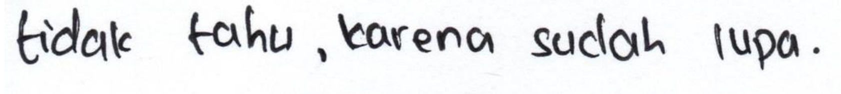
Researcher: Have you studied algebraic form subject?

The student: I think so, but I forgot.

Researcher: Have you ever studied something like that, the problem you are working on?

The student: No drills like these questions, ma'am; we are only given questions in the worksheet book. So yesterday I forgot.

Based on the interviews with students, information was obtained that students had studied algebraic form but had forgotten the algebraic form material used in the problems. Students also stated that they had never worked on questions like the questions the researcher gave, so students had obstacles in solving these problems. Her answers in the interview are also supported in her answer sheet in Figure 14.



Translate: Do not know, because I have forgotten

Figure 14. Student's answer while solving the problems

Moreover, the other findings from interviews conducted with other students indicate that most of the instructional methods teachers employ in teaching algebraic forms are predominantly procedural in nature class. The teachers also present the content using a structured algebraic form from a textbook from school, demonstrate through example problems, and assign students tasks that closely resemble the examples provided. This enables students to comprehend the material through the procedures presented by the teacher. However, the teacher engages students in the learning process, and they do not include them in developing the conceptual understanding of the material through problems involving stories. As a result, the concept of algebraic material is presented solely in the textbook's formal notation, leading to a lack of comprehension regarding story-based questions among students. Here is the student interview about the textbook.

Researcher: What books do you use?

The student: This book, ma'am. (student shows the mathematics book he uses, namely a book from publisher X)

Researcher: Do you only use books from this publisher?

The student : No. we also use a student worksheet book.

From that interview, the student also stated that the books that she used in the learning process were books from publisher X, not books from the Ministry of Education and Culture. She also uses a student worksheet book to drill the material. Besides that, we also interviewed the teacher to learn about the learning processes that the teacher had. Here are the transcripts of the interviews.

Researcher: What curriculum are ma'am currently using?

The teacher: Indonesian Curriculum is "Merdeka"

Researcher: Do you know your students have difficulty learning algebra subjects?

The teacher: Yes

Researcher: What kind of difficulties do they mean?

The teacher: Students find it challenging to operate on algebraic forms

Researcher: What steps did you take to overcome the student's difficulties?

The teacher: I explained again to the students about integer counting operations

Researcher: How do you do the learning process?

The teacher: I do suitable in curriculum and ordered subject by textbook then supporting by student's worksheet

Researcher: What book do you use when teaching algebra?

The teacher: Ministry of Education and Culture book

Researcher: Do you use any other books?

The teacher: Yes, a book from publisher X and a student worksheet book.

In that interview, the teacher said she uses an Indonesian for the independent curriculum. For the topic of algebraic form, she had difficulties learning with the students because they were stuck while learning operating algebraic form. She also explained that she should reteach about integer numbers in operation numbers. In additional information, she also said that she used the book in the learning process. That information is the same as the student's.

Discussion

The ability to solve problems can be characterized as the student's ability to address a specific issue through systematic stages and appropriate strategies to attain a solution. Indicators of mathematical problem-solving ability represent a sequence of steps involved in addressing a specific problem (Widodo et al., 2025). The strands of mathematical problem-solving ability are referred to as (Polya, 1985), understanding the problem, devising a plan, carrying out the plan, and looking back. Therefore, the current study focuses exclusively on four strands: understanding the problem, devising a plan, carrying out the plan, and looking back.

From there, the results of the study showed that students' overall mathematical problem-solving ability, as assessed by each indicator in Figure 1, was still below 50%. Moreover, the achievement of students' mathematical problem-solving ability that has not passed 50% means that there are still many students who experience obstacles when facing algebraic problem-solving tasks. Consequently, it may be asserted that students' mathematical problem-solving ability remain inadequate, and the majority encounter obstacles when addressing problems. This result is supported statement by Putri & Hidayati (2023).

In addition, based on the findings, some students have shown an understanding of the problem; however, it seems that this understanding does not always result in the ability to make a plan. The continuation of the resolution process is hampered, so obstacles occur in completing the next indicator. Consequently, the student is recognized as possessing mathematical problem-solving ability in the first and second indicators, whereas in the third and fourth indicators, the student has not yet demonstrated that capability. The study revealed that the sequences of problem-solving processes for the students are precise and systematic, also indicating that their problem-solving abilities are strong. On the other hand, if students do not demonstrate the first indicator, it suggests that they are not yet able to continue solving the process of the problem. This result is strengthened by the findings of (Aisyah et al., 2023).

Students encounter three different types of obstacles during the problem-solving process: ontogenic, didactic, and epistemological. The process of addressing about understanding the problems highlights these three sources as a reflection of the ability to solve mathematical problems. In the problem-understanding indicator, the first source, the student challenges emerge concerning students' comprehension of concepts presented in algebraic form. Students' comprehension of algebraic form begins with the formal structure rather than progressing from everyday situations to informal representations. When students encounter a daily problem that is subsequently expressed in mathematical terms, their understanding becomes constrained, and the depth of their knowledge diverges from their practical experiences. Consequently, as students move from everyday situations to mathematical representations, they often do not possess the requisite understanding to grasp these concepts. This highlights challenges' developmental and knowledge-based dimensions, revealing that students' understanding can be limited and primarily limited to formal knowledge. This was also found by (Ying et al., 2020), who observed that students have difficulties when facing unfamiliar contexts. This student's inability to understand mathematical terms within practical contexts indicates the existence of an epistemological obstacle (Jatisunda et al., 2024; Suryadi, 2019).

When students feel they are able to understand the problem but are wrong in writing the algebraic form. This is a form of student inconsistency in understanding algebraic forms. In fact, students tend to write in the form of equations rather than algebraic forms. This is because students' daily lives are more faced with procedural forms than with the process of solving problems. (Widodo et al., 2020) stated that students who are faced with a mechanistic process make students always imitate what the teacher writes without thinking or processing to solve it. As a result, when students are faced with problems in the form of problem-solving, they feel unsure and do not understand the problem, and they state that they do not learn algebraic forms.

Students might understand the problem yet incorrectly formulate the algebraic forms. This represents a type of inconsistency among students in comprehending algebraic forms. Students often prefer to express their work using equations instead of algebraic forms. Students' everyday experiences are more often engaged with procedural forms than with problem-solving processes. According to (Widodo et al., 2020), students confronted with a mechanistic process tend to replicate the teacher's written work without engaging in thought processes, critical thinking, or problem-solving. Consequently, when students encounter problem-solving tasks, they often experience uncertainty and a lack of comprehension regarding the problems, leading them to assert that they lack an understanding of algebraic forms. The stage that causes students to be inconsistent in interpreting a problem, thus causing obstacles to their knowledge, is called an ontogenetic obstacle (Suryadi, 2019).

Furthermore, observations are made based on the teacher's instructional methods to assess the acquisition of student knowledge, particularly the influence of the employed didactic design. The data acquired from this study provided insights into the concept of algebraic forms and the learning obstacles encountered by students. Teachers are unintentionally engaged in didactic obstacles. This was evident when she demonstrated that learning was centered on school textbooks and student worksheets, which were predominantly characterized by mechanical processes. In line with (Pauji et al., 2023), instructional learning of the didactic system can create obstacles, which can be caused by elements such as the order and stages of the curriculum, as well as the way that the material is presented in the classroom learning environment.

4. CONCLUSION

Having the ability to solve mathematical problems plays an important role in mathematics education and serves as the foundation for students' ability to confront unconventional problems. Nonetheless, challenges in addressing these issues frequently relate to students' capacity for understanding problems, particularly those presented in a written format. Occasionally, students fail to approach problems systematically and instead generate results in formal formats. Frequently, the formal expressions produced by students do not align with the concepts of algebraic forms. Consequently, mathematical problem-solving abilities are sometimes limited in comprehending issues related to fundamental algebraic ideas. Moreover, becoming accustomed students to challenges through problem-solving should be seen as an appropriate approach for enhancing their capacities for problem-solving. Consequently, it is imperative to create a learning trajectory that incorporates indicators of mathematical problem-solving abilities to enhance students' mathematical problem-solving abilities and regarding the osteogenic, epistemological, and didactical obstacles that students encounter such as the concept of algebraic form, interpreting the word to the mathematical concept of algebraic form, and designing the algebraic forms.

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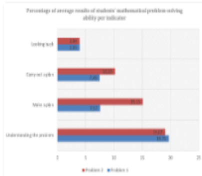

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Abstract

Mathematical problem-solving ability is the most effective cognitive instrument in learning mathematics, and enhancing students' mathematical problem-solving ability is the primary objective of education. However, to reach the most effective level of mathematical problem-solving ability, we need to comprehend the reasons behind students' challenges while learning. This research investigates the learning obstacles of the students based on their mathematical problem-solving ability, particularly in algebraic form material. The method used in this research employed qualitative study with a series of Didactical Design Research (DDR) projects to learn

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Students' obstacles in solving algebra form problems viewed from mathematical problem-solving ability

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Abstract

Mathematical problem-solving ability is the most effective cognitive instrument in learning mathematics, and enhancing students' mathematical problem-solving ability is the primary objective of education. However, to reach the most effective level of mathematical problem-solving ability, we need to comprehend the reasons behind students' challenges while learning. This research investigates the learning obstacles of the students based on their mathematical problem-solving ability, particularly in algebraic form material. The method used in this research employed qualitative study with a series of Didactical Design Research (DDR) projects to learn the obstacles to the student's mathematical problem-solving ability. Seventy-six eighth-grade students from a public junior high school in Kampar region were given a test to assess their ability to solve mathematical problems. Various research instruments are used, including tests of mathematical problem-solving ability, interview guidelines, and interviews by audio recordings. The data were analyzed using a qualitative approach to determine students' learning obstacles. The findings highlight ontogenic, epistemological, and didactical obstacles students face while understanding the problem, particularly the concept of algebraic form, interpreting the word to the mathematical concept of algebraic form, and designing the algebraic forms.

Keywords:
Algebra, Epistemology, Obstacle, Ontogenic, Problem-solving ability

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1. INTRODUCTION

Mathematical problem-solving ability is fundamental to students' ability and activities in the 21st century (Lu & Xie, 2024; Pramuditya et al., 2022; Rocha & Babo, 2024; Supriadi et al., 2024). For at least three decades, it has been recognized that mathematical problem-solving ability provides students with many opportunities to develop their creativity, enthusiasm, critical thinking, and interaction (Rocha & Babo, 2024; Safstrom et al., 2024). Mathematical problem-solving ability includes several activities, such as solving word problems, creating patterns, interpreting figures, developing geometric constructions, and proving theorems (Doorman et al., 2007; Supriadi et al., 2024). Thus, mathematical problem-solving ability is essential in formal education and has consistently been an important subject of mathematics education research.

Mayer can refer to the terms of problem-solving as a summary of the cognitive processes aimed at transforming the initial state into the desired final state in situations when the process of finding a solution is not immediately apparent (Dostál, 2015). Problem-solving encompasses an assortment of essential abilities employed to deal with and solve several different problems (Friede et al., 2008). It also can be defined as the application of concepts and ability, often requiring the integration of these elements in unusual contexts (van Merriënboer, 2013; Widodo et al., 2025). Accordingly, problem-solving is an essential ability that students must acquire for exemplary achievement.

In mathematics, George Polya, known as the founder of the mathematical problem-solving theory, defined problem-solving as follows: solving a problem means finding a way out of a difficulty, a way around an obstacle, and attaining an aim that was not immediately attainable (Jiang et al., 2022; Polya, 2014). It is undeniable that problem-solving is a challenging endeavor, and there are numerous factors to consider, including the appropriate approach (Rocha & Babo, 2024). Thus, mathematical problem-solving is related to thinking, which generally improves when one solves challenges requiring effort, enthusiasm, and investigation of the problems.

Moreover, Polya's theory posited that mathematical problem-solving was an evolving process that involved the following activities: understanding the problem, devising a plan, carrying out the plan, and looking back (Polya, 2014). Most researchers in mathematics education use this theory (Firda et al., 2023; Novriani & Surya, 2017; Putri & Hidayati, 2022), but the problem with using this theory is that most students fail along the problem-solving process (Putri & Riskanita, 2022; Stacey, 2005). One of the contributing factors is that the problem-solving process is ordered, students who struggle to understand or lack confidence in a problem will fail to accomplish the steps or stop that step (Aisyah et al., 2023; Amalina & Vidákovich, 2023). Besides that, Rocha and Babo (2024), and Polya (2014) stated that understanding the problem involves trying to understand the situation, defining the unknown, determining the conditions of the problem, and verifying whether it is possible to estimate the response. Then, devising a plan means conceiving the plan gradually until finding resolution strategies, organizing the data, and lastly, trying to solve the problem (Rocha & Babo, 2024). Next, carrying out the plan includes verifying each resolution step, executing all the calculations, and implementing all the strategies outlined with the correct answer (Firda et al., 2023; Rocha & Babo, 2024). The last step, looking back, is to confirm that the obtained solution is correct or that there is another way to solve the problem, to carry out this final stage, a discussion and confirmation with the students are required to know and verify the solution that the students have constructed (Firda et al., 2023; Polya, 2014).

To develop mathematical problem-solving abilities, the students should be allowed to practice and cultivate problem-solving problems in a non-stressful atmosphere (Lu & Xie, 2024). To provide an enjoyable atmosphere for students, a didactic approach is required that encourages students to associate mathematical concepts with context (Putri & Riskanita, 2022) to create meaningful learning, allowing them to understand mathematical topics based on their acquisition of fundamental understanding from their daily lives. The problem does not have a given solution method, a rule, a template, or an algorithm (Safstrom et al., 2024). Others stated that they can figure out the solutions to a particular problem-based issue in learning mathematics and find appropriate solutions (Güner & Erbay, 2021). Thus, the development of students' mathematical problem-solving ability commences with their ability to address everyday challenges through engaging learning approaches, understanding the problem, and designing and solving the mathematical model rather than initiating with formal mathematical concepts.

The mathematical problem-solving ability still has problems in Indonesia (Desti et al., 2020; Pertiwi et al., 2020; Putri & Riskanita, 2022; Septian et al., 2022; Widodo et al., 2025). Previous research shows that students face difficulties when solving problems. Fewer students can explore and understand the problem, present and formulate the plan, and monitor and reflecting (Amalina & Vidákovich, 2023; Harisman et al., 2020, 2021; Hutajulu et al., 2019; Novriani & Surya, 2017; Sari & Hidayat, 2019; Widodo et al., 2020; Widodo et al., 2025). In addition, students also have an inability to translate problems into mathematical concepts and use correct mathematics (Jupri & Drijvers, 2016; Ying et al., 2020).

Mathematical problem-solving ability can be improved in topic mathematics school by one of the crucial topics being algebra (Putri & Riskanita, 2022; Silvia et al., 2019). Algebra is commonly referred to as a fundamental step towards advanced mathematics, primarily because it serves as the medium through which mathematical concepts are taught (Jupri et al., 2014; Stacey & Chick, 2004; Wicaksono et al., 2024). Algebra is also vital to learning a conceptual understanding of features that are related to problem-solving (Booth et al., 2014; Wicaksono et al., 2024).

Among the algebra subjects, algebraic forms stand at the intersection of arithmetic and symbolic mathematics. Algebraic forms are composed of constants, variables, coefficients, and terms that interact through various operations (As'ari et al., 2017; Tosho, 2021). Understanding algebraic form is essential for capturing the concept itself and progressing in various algebraic topics, including operations on algebraic forms, simplification of algebraic forms, and the identification of equivalent algebraic forms, among others.

Nevertheless, algebraic form presents challenges for students beginning their exploration of algebraic concepts in junior high school (Riskon, 2021). Research on algebraic forms is well-documented (Asmara et al., 2024; Utami & Puspitasari, 2022); however, a notable gap remains in understanding the specific difficulties and obstacles to learning encountered by middle school students, particularly concerning their mathematical problem-solving abilities. The means term of difficulties for students arise as a result of errors (Jupri et al., 2014), then difficulties resulting from external factors or didactic design create obstacles (Suryadi, 2019; Wicaksono et al., 2024). Obstacles also occasionally occur during the learning process (Brousseau, 2011; Rahmi & Yulianti, 2022), which makes it difficult for students to achieve optimal outcomes in the learning process (Suryadi, 2019). Additionally, learning obstacles impede students' ability to acquire new knowledge, potentially leading to challenges in their educational experience (Suryadi, 2019). Learning obstacles are evident in the interactions among teachers, students, and educational materials (Suryadi et al., 2023). Therefore, obstacles for the students can occur due to student difficulty while doing a didactic design or learning process.

Furthermore, Suryadi enlightened that there are three types of learning obstacles, namely ontogenic obstacles, didactical obstacles, and epistemological obstacles (Brousseau, 2011; Suryadi, 2019). Suryadi (2019) also described ontogenetic obstacles as the difficulty level in a didactic situation that may interfere with the learning process. Then, didactic obstacles are related to the sequence and/or stages of the curriculum content and the process in which it is presented, which influences the continued development of students' thought processes. Meanwhile, epistemological obstacles refer to the limitations of a person's understanding of something that is only appropriate for a particular setting based on their learning experiences.

Investigations that identify and explore mathematical problem-solving ability and learning obstacles have been associated with various other contexts. To guarantee the originality of this study, the VOSviewer tool was employed, utilizing data sourced from Scopus. The terms used were 'problem-solving,' 'mathematical,' and 'obstacle.' The criteria for inclusion specified that the study must have been published between 1990 and 2024 in the fields of mathematics or social sciences and must be written in English. A total of 189 articles were identified as meeting these criteria. Figure 1 presents the results of the VOSviewer visualization.

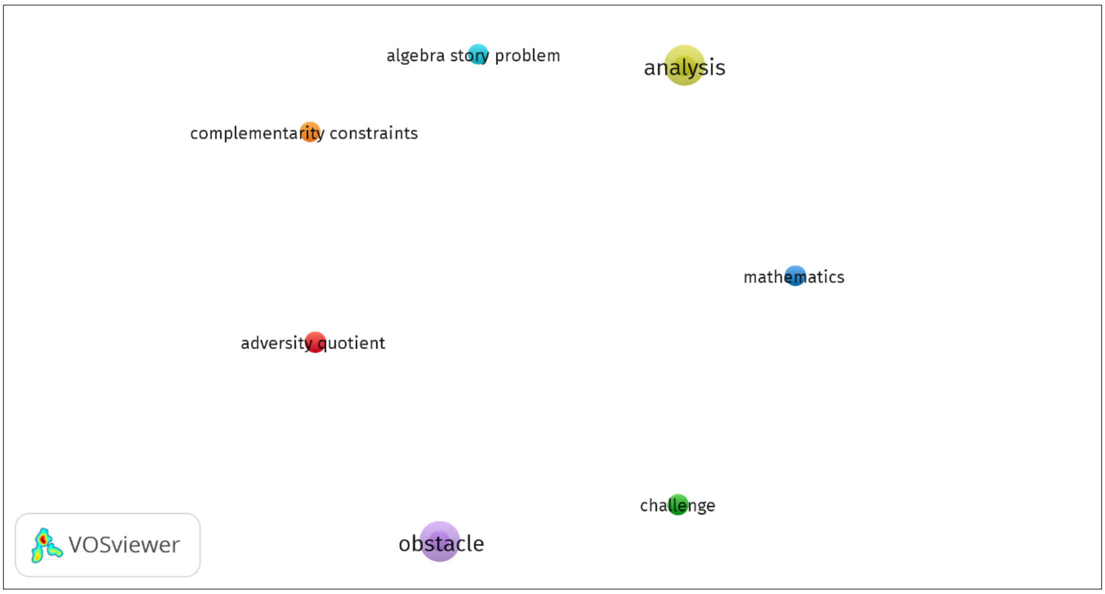


Figure 1. Linkages between the keywords 'problem-solving,' 'mathematical' and 'obstacle."

There are seven clusters that appear, as illustrated by the VOSviewer tool (see Figure 1). There is no line connecting the elements or keywords analyzed. Keywords that are frequently discussed in the research are "obstacle," "challenge," "mathematics," "analysis," "algebra story problem," "complementary constraints," and "adversity quotient." No research work links "students' mathematical problem-solving ability" with "obstacle" or "learning obstacles".

Based on the results of the above exploration, this study aimed to explore students' mathematical problem-solving ability in the learning obstacles for algebraic form. This study poses a research question: "How did the learning obstacles affect the students' mathematical problem-solving ability in algebraic form?"

2. METHOD

This research is part of the Didactical Design Research (DDR) framework that was developed by Suryadi (2019), integrating an interpretive paradigm. The study of the interpretive paradigm in DDR is concerned with the impact of didactic design on students, particularly regarding the reality of meaning resulting from didactic factors and learning proceeds (Jatisunda et al., 2025; Suryadi, 2019; Unaenah et al., 2024). This study also employed a qualitative research design based on hermeneutic phenomenology. The use of hermeneutic phenomenology as a research method is required to investigate the learning obstacles faced by junior high school students because students align with their learning obstacles, leading to investigations based on the student's life experiences and subjective perspectives. Furthermore, hermeneutic phenomenology specializes in investigating the complex nature of human experiences, helping researchers to figure out the underlying meanings and interpretations behind phenomena like obstacles to learning.

There are three steps conducted in DDR, namely prospective analysis, metapedadidactic analysis, and retrospective analysis (Suryadi, 2019). The prospective analysis is the findings of students' learning obstacles in previous learning. Next, the metapedadidactic analysis is preparing and analyzing a hypothetical learning trajectory and didactic design. The final step is the retrospective analysis stage, where an analysis is conducted based on the results of reflection and evaluation, examining the relationship between prospective analysis and metapedadidactic analysis (Jamilah et al., 2024).

Before beginning to investigate the educational obstacles that students face, the researcher conducted an early step by consulting with the topic teachers about the learning process used by teachers. The discussion included the curriculum, the mathematics topic taught in grades VII and VIII, textbooks, material sequence, and learning approaches. This step is essential as an initial effort to determine the initial conditions of students when learning mathematics. Furthermore, the discussions with teachers also revealed that the subject of algebra and its learning need to be identified, especially regarding students' learning obstacles. Then, the result of that discussion also determined which students would participate in the research.

The students selected in this study were eighth graders from 2023 to 2024 in SMP N Riau Province and have been studying algebra subject. The number of students who took the problem-solving test was 76, 23 males and 53 females. Data were collected by testing mathematical problem-solving ability instruments (see Table 1) and follow-up interviews by recording audio. First, students were tested to solve two algebraic form problems individually with a time of 70 to 80 minutes. Students were given the freedom to write their answers on the paper provided. During the completion of the test, students were not allowed to use a calculator. This is because the test was conducted to determine students' obstacles in problem-solving abilities. Two problems were given to the students. Here are the examples of questions that were given to students.

Table 1. Type of the question

Type	Items test
Problem 1	Mr. Roni purchased three cartons of notebooks and two individual notebooks, while Mr. Ijal bought four cartons of notebooks and four individual notebooks. Each carton contains the same number of notebooks. a. What can you understand from the story? b. How do you find the algebraic expression from the story? Explain! c. Determine the constants, coefficients, variables, and terms in the story! d. Recheck the results from question d! Are they correct? Explain!
Problem 2	Bambang has two empty cans, namely can A and can B. These cans will be filled with 32 marbles. a. What can you understand from the story? b. How do you determine the number of marbles that can be filled into cans A and B? Explain! c. Calculate the number of marbles in can A if the number of marbles in can B is m marbles! d. Recheck the results from question d! Are they correct? Explain!

After the test, it was continued by coding the students' answer sheets according to the problem-solving ability indicators and their obstacles. The coding results of the students' answer sheets were then discussed with the subject teacher so that interview students could be selected. The purpose of considering conducting discussions with subject teachers was to determine students' ability to speak and work together well in time and openly to complete the completion process.

Six participants were selected for follow-up interviews. Interviews were conducted the following day after the written test, each lasting about 20-30 minutes. Because the interview could only be done after the entire learning process, the interview stage was conducted for three consecutive days. The interviews were conducted semi-structured manner that aimed to give students the freedom to explain the solutions they had written. Furthermore, the interviewer did not intervene to get the right or wrong solution. As a guideline for conducting the interview, initial and follow-up questions were prepared to focus on investigating students' mathematical problem-solving abilities, and the interviewer was allowed to be flexible in asking questions during the interview.

A guideline interview with initial questions includes: What can you understand about this story? How did you find/solve this story? Can you explain your solution? Furthermore, how do you check whether your solution is correct or not? Then, follow-up questions include, for example: Why did you take this writing? What is your obstacle/misunderstanding? What does it mean? This question progresses and depends on the student's response.

The data analysis was carried out in two steps. In the first step, individual written work was analyzed, and mathematical problem-solving ability was measured. Measure mathematical problem solving using Polya's four steps: understanding the problem, making a plan, carrying out the plan, and looking back. Based on those steps, a mathematical problem-solving ability scoring rubric is developed. After that, coding was created to address situations such as when students did not have an answer or were unable to understand the problem. The coding was not strict, but it can be developed based on the student's responses.

In the second step, an analysis of the interview is the confirmation of students' written work. The results of the interview are transcription data. Thus, the interview data were coded to explain that the students had no answer or misunderstanding. After completing the coding data from written work and interviews, the next step is to code it into ontogenic, epistemological, and didactic obstacles.

3. RESULTS AND DISCUSSION

3.1. Results

A test of students' mathematical problem-solving ability was initially administered to identify their learning obstacles. A mathematical problem-solving ability test was given to 76 students involved with the algebraic form subject. This test comprises inquiries related to the indicators of mathematical problem-solving based on Polya's theory and encompasses the concept of algebraic material. Following the mathematical problem-solving ability testing process, the overall average % for each question was determined based on the indicators of mathematical problem-solving ability relative to the students' responses. Figure 2 presents the average percentage of students' mathematical problem-solving ability for each indicator associated with the assessed questions.

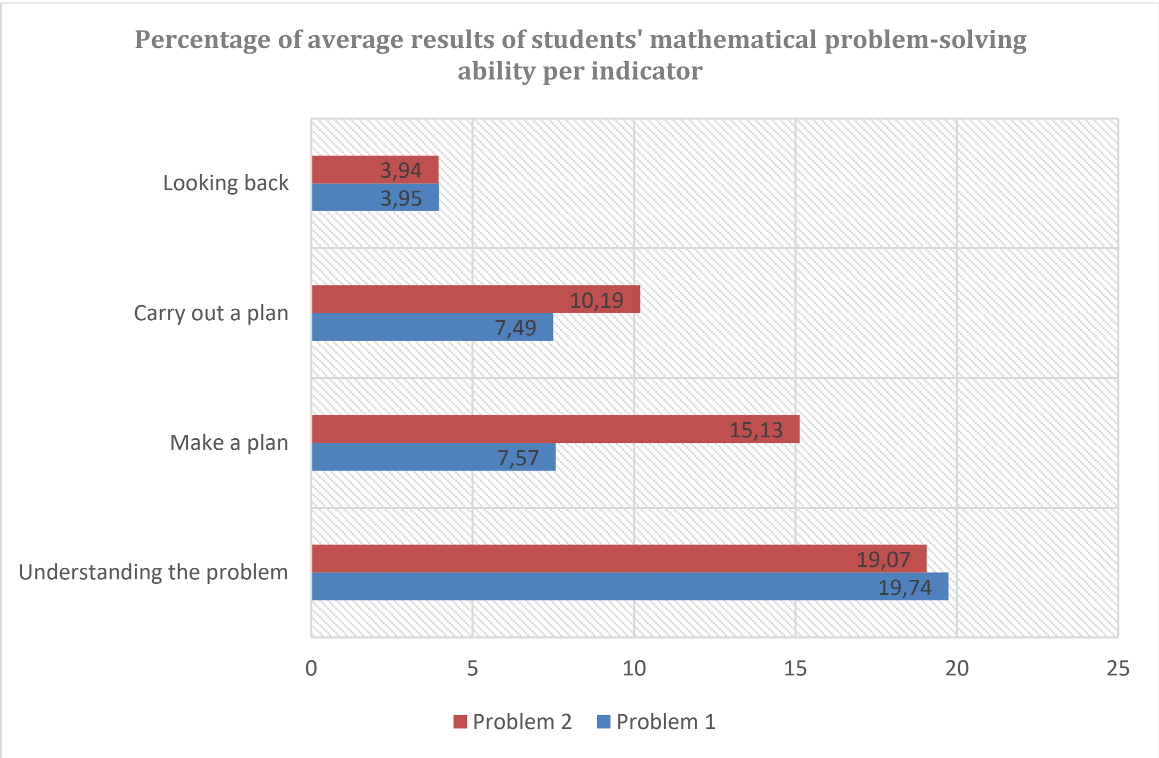


Figure 2. Percentage of average results of students' mathematical problem-solving ability per indicator

The results presented in Figure 2 indicate a decline in students' average mathematical problem-solving ability from indicator one to indicator four. The average percentage of problem-solving ability for question number one, which had the problem understanding indicator, was 19.74%. The average percentage of problem-solving ability for question number two, which also had the problem understanding indicator, was 19.07%. The findings reveal that students' ability to solve mathematical problems according to the problem understanding indicator of the two questions has a difference of 0.67. This indicates that students' ability to understand problems from the two questions is not different, so the average percentage of mathematical problem-solving ability in understanding problems is 19.41%.

Additionally, for the make-a-plan indicator, question one exhibits an average percentage of mathematical problem-solving ability at 7.57%. In contrast, under the same indicator, question two shows an average percentage of 15.13%. This indicates a difference of 7.56 in students' mathematical problem-solving abilities regarding the make-a-plan indicator, highlighting variability in their ability in this second indicator. Thus, the average percentage of students' mathematical problem-solving ability in the make-a-plan indicator is 11.35%.

Next, the average percentage of mathematical problem-solving ability is 7.89% for question number one, based on the indication of carrying out the plan. The average percentage of mathematical problem-solving ability is 10.19% for question number two, which is based on the same indicator. This indicates a 2.3% difference in students' mathematical problem-solving ability in the indication of carrying out the plan, which is a slight difference between the two questions. As a result, the average percentage of students' mathematical problem-solving ability on the indicator of implementing the plan is 9.04%.

Finally, the average mathematical problem-solving ability is 3.95% when considering question number one. In contrast, the average percentage of mathematical problem-solving ability is 3.94% when looking back at question number two. This indicates a difference of 0.01 in the student's ability to solve mathematical problems on the looking back indication. The average percentage of s' mathematical problem-solving ability on the looking back indication is 3.945%.

The results of the test not only indicate the average percentage of students who were able to solve mathematical problems but also the number of students who were unable to answer the two questions that were presented. The number of students who could not respond to each indicator of mathematical problem-solving ability is illustrated in Table 2.

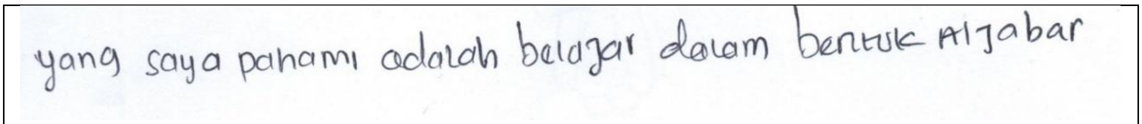
Table 2. Many students are unable to answer indicator

No	Indicator of mathematical problem-solving ability	Many students are unable to give an answer	
		Problem 1	Problem 2
1.	Understanding the problem	37	41
2.	Make a plan	56	50
3.	Carry out a plan	56	60
4.	Looking back	65	65

Table 2 indicates that many students cannot understand and comprehend the issue presented in the second problem. Forty-one students struggle with understanding the problem rather than problem 1, with 37 students indicating obstacles to their ability to make plans, carry out them, and indicate their outcomes. Nevertheless, the reality of the obstacles students encounter in the second indicator, in particular, is increasing. In addition to those 41 individuals, there are also 50, 60, and 65. This has also been addressed in problem 1, where the consecutive students unable to respond are 37, 56, 56, and 65. Therefore, this indicates that when students struggle to understand a problem, their progression to the subsequent step is also impeded.

Ontogenic obstacle

The ontogenic obstacle in this study referred to the discrepancy in students' cognitive levels. Students in eighth grade are expected to understand an algebraic form of a commonplace issue. In actuality, students have struggled to understand the algebraic form of a written problem. Consequently, a disparity exists between the knowledge students are supposed to have and the actual situation. This presents an obstacle for students in problem-solving tests.



***Translate**: What I understand is learning in the notation of algebra form*

Figure 3. Student’s answer, S1, in solving a mathematical problem based on the first indicator

The student’s answer in Figure 3 shows that she could only understand algebraic form problems in the formal form of the algebraic form. In other words, she was not yet able to understand algebraic forms involving stories, such as the provided questions. Here is the transcription of the interview with the student in supporting Figure 3.

Researcher : *What do you mean by this writing?*

The student : *I have not studied anything like this, ma'am. I just recognized about this. (see Figure 4)*

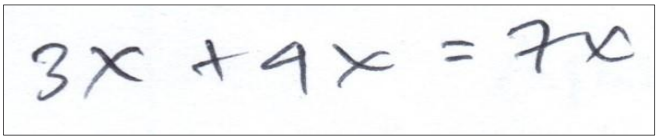
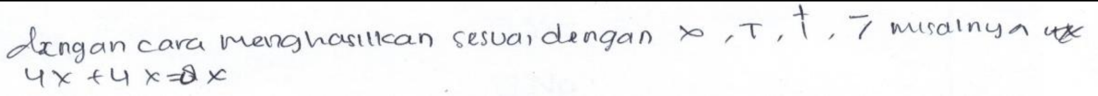


Figure 4. Student’s answer in algebraic form

Furthermore, from Figure 4, S1 wrote down the equation as the formal form of algebra as her transformation of the meaning of the stories from 3 cartons of notebooks and two individual notebooks to $3x+4x$ After that, she summed $3x+4x$ to became $7x$. Thus, $3x+4x=7x$. It was the formal form of algebra for the S1. The reason why she found that the formal form of algebra was to produce variables like x,t,l,y then she gave examples such as $4x+4x=8x$ (see Figure 5).

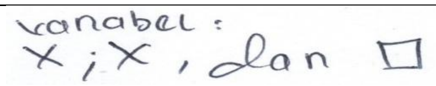


***Translate**: to produce a suitable result x,t,l,y then example 4x+4x=8x*

Figure 5. Student's description of finding algebraic form

Continuing the question about the constants, coefficients, variables, and terms in the story, S1 carried out her plan by just writing down the variables (see Figure 6). It implied that she struggled to understand constants, coefficients, and terms of algebra. Here is the transcription of the interview with the student in supporting Figure 6.

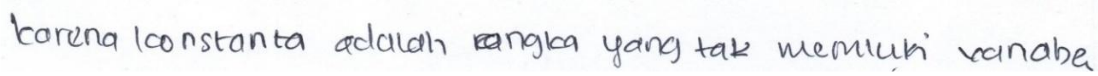
Researcher : *What do you mean by this writing?*
The student : *This is variable.*
Researcher : *All of these variables?*
The student : *Yes, I have not found where is constant.*



***Translate**: variable x,x,and □*

Figure 6. Student's answer about the variables

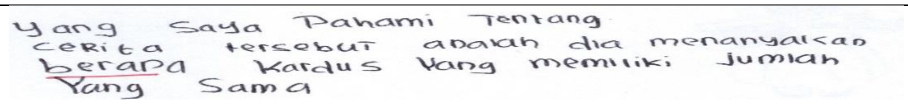
Nevertheless, in phase looking back from Figure 7, S1 stated that the constant was a number that has no variable. It implied that while she looked back on the question and her answer about the constants, coefficients, variables, and terms, she did not find what the question wanted from her algebraic form. She just wrote *3x+4x=7x*. So, there was no constant in that algebraic form. Consequently, she did for a phase looking back, but she was confused with what she wrote.



***Translate**: Because the constant is a number that has no variable*

Figure 7. Student's answer in phase looking back

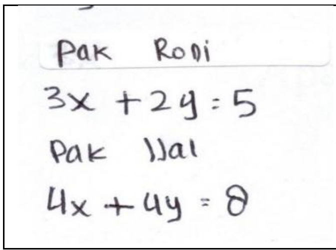
In another situation, the answer obtained from the other student, namely S2, indicated that the abilities she possesses in the first indicator, specifically in capturing the problem, are limited when it comes to interpreting its meaning. The student wrote a statement that she understood the first problem about asking how many cartons have the same number. Figure 8 illustrates this point.



***Translate**:*
What I understand about the story is that it asks <u>how</u> many cartons have the same number of cartons

Figure 8. Student's answer while understanding the problem

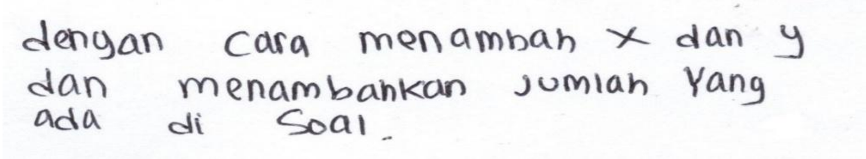
S2 stretched a different meaning from what should be understood from the question so that the student's mistake in understanding the problem causes an incorrect solution process. Next, the process of determining mistaken interpretations of S2 can be seen in Figure 9.



Translate:
Mr. Roni
3x+2y=5
Mr. Ijal
4x+4y=8

Figure 9. Student's answer to finding the algebraic form

Figure 10 illustrates that S2 carried out her making plan by adding x and y. Moreover, she added each algebraic term that she had formed into a number. S2 also posited that various algebraic terms can be summed together to become a number such that. *3x+2y=5* or *4x+4y=8*, like in Figure 4. Additionally, when asked to identify constants, variables, coefficients, and algebraic terms, S2 was unable to respond.

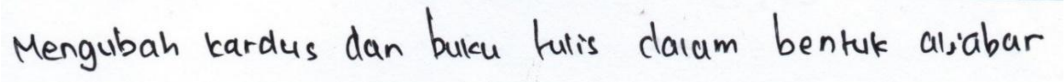


Translate*: by adding x and y and adding the sums to the question*

Figure 10. Student's description of her answer while working on the plan

Epistemological Obstacle

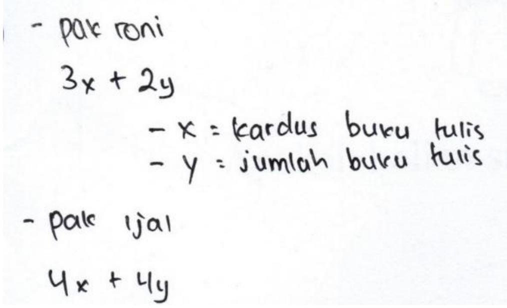
The epistemological obstacle in this study indicates that students gain a limited understanding of the concept, which results in obstacles to its application across varying contexts. Students face challenges in developing an understanding of algebraic forms when presented with written questions. The study indicated several epistemological obstacles regarding the concept of algebraic forms and their applications. This takes place during the completion process within the make-a-plan indicator.



Translate*: Convert cardboard and books into algebraic form*

Figure 11. Student's answer while make-a-plan

Figure 11 shows that while students tried to make a plan to become an algebraic form, they thought of changing a cartoon and notebook into a show. The algebraic form that students thought was like in Figure 12.

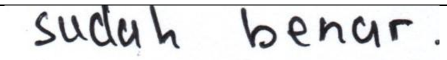


Translate:
Mr. Roni 3x+2y
- *x : cardboard of book*
- *y : number of book*

Mr. Ijal
4x+4y

Figure 12. The student interprets the problem to become an algebraic form

The answer form presented in Figure 12 suggests that the student possessed knowledge that was primarily limited to algebraic forms featuring variables while lacking involvement with constants. Consequently, when the student was questioned regarding constants, coefficients, and algebraic terms, she often experienced confusion concerning the algebraic forms that she had formulated. Ultimately, the student responded that she was uncertain due to a lapse in memory. The insufficient understanding that students have in converting story problems into algebraic forms presents obstacles to her ability to grasp constants, coefficients, and algebraic terms effectively. At the finish of the question, the student indicated that she had accurately transformed the story problem into algebraic form, which indicated that there was no need for her to revise her answers (see Figure 13).



***Translate**: Already correct*

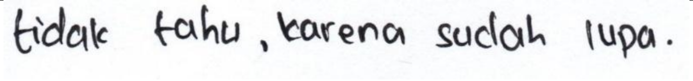
Figure 13. The student's answer in the last step

Didactical obstacle

Didactic obstacles in this study are present in various fundamental concepts provided by the teachers, significantly influencing the development of students' understanding of algebraic forms. Here, the interviews were conducted with the students regarding the algebraic form test to determine the didactical obstacles that occur to students.

Researcher : *Have you studied algebraic form subject?*
The student : *I think so, but I forgot.*
Researcher : *Have you ever studied something like that, the problem you are working on?*
The student : *No drills like these questions, ma'am; we are only given questions in the worksheet book. So yesterday I forgot.*

Based on the interviews with students, information was obtained that students had studied algebraic form but had forgotten the algebraic form material used in the problems. Students also stated that they had never worked on questions like the questions the researcher gave, so students had obstacles in solving these problems. Her answers in the interview are also supported in her answer sheet in Figure 14.



***Translate**: Do not know, because I have forgotten*

Figure 14. Student's answer while solving the problems

Moreover, the other findings from interviews conducted with other students indicate that most of the instructional methods teachers employ in teaching algebraic forms are predominantly procedural in nature class. The teachers also present the content using a structured algebraic form from a textbook from school, demonstrate through example problems, and assign students tasks that closely resemble the examples provided. This enables students to comprehend the material through the procedures presented by the teacher. However, the teacher engages students in the learning process, and they do not include them in developing the conceptual understanding of the material through problems involving stories. As a result, the concept of algebraic material is presented solely in the textbook's formal notation, leading to a lack of comprehension regarding story-based questions among students. Here is the student interview about the textbook.

Researcher : *What books do you use?*
The student : *This book, ma'am. (student shows the mathematics book he uses, namely a book from publisher X)*
Researcher : *Do you only use books from this publisher?*
The student : *No. we also use a student worksheet book.*

From that interview, the student also stated that the books that she used in the learning process were books from publisher X, not books from the Ministry of Education and Culture. She also uses a student worksheet book to drill the material. Besides that, we also interviewed the teacher to learn about the learning processes that the teacher had. Here are the transcripts of the interviews.

Researcher : *What curriculum are ma'am currently using?*
The teacher : *Indonesian Curriculum is "Merdeka"*
Researcher : *Do you know your students have difficulty learning algebra subjects?*
The teacher : *Yes*
Researcher : *What kind of difficulties do they mean?*
The teacher : *Students find it challenging to operate on algebraic forms*
Researcher : *What steps did you take to overcome the student's difficulties?*
The teacher : *I explained again to the students about integer counting operations*
Researcher : *How do you do the learning process?*
The teacher : *I do suitable in curriculum and ordered subject by textbook then supporting by student's worksheet*
Researcher : *What book do you use when teaching algebra?*
The teacher : *Ministry of Education and Culture book*
Researcher : *Do you use any other books?*
The teacher : *Yes, a book from publisher X and a student worksheet book.*

In that interview, the teacher said she uses an Indonesian for the independent curriculum. For the topic of algebraic form, she had difficulties learning with the students because they were stuck while learning operating algebraic form. She also explained that she should reteach about integer numbers in operation numbers. In additional information, she also said that she used the book in the learning process. That information is the same as the students.

3.2. Discussion

The ability to solve problems can be characterized as the student's ability to address a specific issue through systematic stages and appropriate strategies to attain a solution. Indicators of mathematical problem-solving ability represent a sequence of steps involved in addressing a specific problem (Widodo et al., 2025). The strands of mathematical problem-solving ability are referred to as Polya (2014), understanding the problem, devising a plan, carrying out the plan, and looking back. Therefore, the current study focuses exclusively on four strands: understanding the problem, devising a plan, carrying out the plan, and looking back. The results of the study showed that students' overall mathematical problem-solving ability, as assessed by each indicator was still below 50%. Moreover, the achievement of students' mathematical problem-solving ability that has not passed 50% means that there are still many students who experience obstacles when facing algebraic problem-solving tasks. Consequently, it may be asserted that students' mathematical problem-solving ability remain inadequate, and the majority encounter obstacles when addressing problems. This result is supported statement by Putri and Hidayati (2022), which is caused by students not being able to explain and interpret a solution from the initial problem given to choosing and implementing a problem-solving strategy.

In addition, based on the findings, some students have shown an understanding of the problem; however, it seems that this understanding does not always result in the ability to make a plan. The continuation of the resolution process is hampered, so obstacles occur in completing the next indicator. Consequently, the student is recognized as possessing mathematical problem-solving ability in the first and second indicators, whereas in the third and fourth indicators, the student has not yet demonstrated that capability. The study revealed that the sequences of problem-solving processes for the students are precise and systematic, also indicating that their problem-solving abilities are strong. On the other hand, if students do not demonstrate the first indicator, it suggests that they are not yet able to continue solving the process of the problem (Aisyah et al., 2023).

Students encounter three different types of obstacles during the problem-solving process: ontogenic, didactic, and epistemological. The process of addressing about understanding the problems highlights these three sources as a reflection of the ability to solve mathematical problems. In the problem-understanding indicator, the first source, the student challenges emerge concerning students' comprehension of concepts presented in algebraic form. Students' comprehension of algebraic form begins with the formal structure rather than progressing from everyday situations to informal representations. When students encounter a daily problem that is subsequently expressed in mathematical terms, their understanding becomes constrained, and the depth of their knowledge diverges from their practical experiences. Consequently, as students move from everyday situations to mathematical representations, they often do not possess the requisite understanding to grasp these concepts. This highlights challenges' developmental and knowledge-based dimensions, revealing that students' understanding can be limited and primarily limited to formal knowledge. This was also found by Ying et al. (2020), who observed that students have difficulties when facing unfamiliar contexts. This student's inability to understand mathematical terms within practical contexts indicates the existence of an epistemological obstacle (Jatisunda et al., 2025; Suryadi, 2019).

When students feel they are able to understand the problem but are wrong in writing the algebraic form. This is a form of student inconsistency in understanding algebraic forms. In fact, students tend to write in the form of equations rather than algebraic forms. This is because students' daily lives are more faced with procedural forms than with the process of solving problems. Widodo et al. (2020) stated that students who are faced with a mechanistic process make students always imitate what the teacher writes without thinking or processing to solve it. As a result, when students are faced with problems in the form of problem-solving, they feel unsure and do not understand the problem, and they state that they do not learn algebraic forms.

Students might understand the problem yet incorrectly formulate the algebraic forms. This represents a type of inconsistency among students in comprehending algebraic forms. Students often prefer to express their work using equations instead of algebraic forms. Students' everyday experiences are more often engaged with procedural forms than with problem-solving processes. According to Widodo et al. (2020), students confronted with a mechanistic process tend to replicate the teacher's written work without engaging in thought processes, critical thinking, or problem-solving. Consequently, when students encounter problem-solving tasks, they often experience uncertainty and a lack of comprehension regarding the problems, leading them to assert that they lack an understanding of algebraic forms. The stage that causes students to be inconsistent in interpreting a problem, thus causing obstacles to their knowledge, is called an ontogenetic obstacle (Suryadi, 2019).

Furthermore, observations are made based on the teacher's instructional methods to assess the acquisition of student knowledge, particularly the influence of the employed didactic design. The data acquired from this study provided insights into the concept of algebraic forms and the learning obstacles encountered by students. Teachers are unintentionally engaged in didactic obstacles. This was evident when she demonstrated that learning was centered on school textbooks and student worksheets, which were predominantly characterized by mechanical processes. In line with Pauji et al. (2023), instructional learning of the didactic system can create obstacles, which can be caused by elements such as the order and stages of the curriculum, as well as the way that the material is presented in the classroom learning environment.

4. CONCLUSION

Having the ability to solve mathematical problems plays an important role in mathematics education and serves as the foundation for students' ability to confront unconventional problems. Nonetheless, challenges in addressing these issues frequently relate to students' capacity for understanding problems, particularly those presented in a written format. Occasionally, students fail to approach problems systematically and instead generate results in formal formats. Frequently, the formal expressions produced by students do not align with the concepts of algebraic forms. Consequently, mathematical problem-solving abilities are sometimes limited in comprehending issues related to fundamental algebraic ideas. Moreover, becoming accustomed students to challenges through problem-solving should be seen as an appropriate approach for enhancing their capacities for problem-solving. Consequently, it is imperative to create a learning trajectory that incorporates indicators of mathematical problem-solving abilities to enhance students' mathematical problem-solving abilities and regarding the osteogenic, epistemological, and didactical obstacles that students encounter such as the concept of algebraic form, interpreting the word to the mathematical concept of algebraic form, and designing the algebraic forms.

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