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Thinking Process of Student in Solving Mathematical Problems Based on Logis-Mathematical Intelligence

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Abstract

The root of the problem of this research is the lack of interest in student learning during the COVID-19 pandemic which resulted in low student learning outcomes. The purpose of this study was to see the improvement of student learning outcomes during online learning by using learning videos on a two-variable linear equation system material. The type of research used in this research is classroom action research which was carried out at MTS Negeri 1 Simalungun. This research was conducted in two cycles with each action including planning, implementing, observing and reflecting. To see the learning outcomes used tests in cycles I and II. The results of the study show that learning video media on the material of a two-variable linear equation system in the Covid-19 Pandemic Era can improve learning outcomes and minimum learning mastery of students in class VIII-5 MTS Negeri 1 Simalungun for the 2020/2021 academic year". The completeness of student learning outcomes on the SPLDV material after being taught using learning video media when the initial condition (23.52%) increased to 52.94%. Furthermore, there was an increase in student learning outcomes by 23.53% with a mastery level of learning obtained around 76.47%. This result is in line with what is expected, namely 75% of students complete.

Keywords
logical-mathematical; intelligence; problem solving; thinking process

I. Introduction

Mathematics is one of the most important lessons in an effort to improve the quality of education in Indonesia. The ability of Indonesian students, in general, is still very low, especially in the field of mathematics studies (Yani, 2016). Mathematics itself is a means to develop logical thinking, critical, careful and creative ways (Soedjadi, 2000). The mathematics education community values students' thinking to develop mathematics (Keith, 2015). According to Setiawan states that mathematics is one of the disciplines taught at every level of school education, hoping to contribute to developing the ability to think critically, systematically, logically, creatively, and work together effectively (Lestari, 2014). Therefore, mathematics is one of the lessons in a structured, organized, and tiered arrangement that is needed by students to form a logical, systematic, critical, and creative mindset in order to solve problems in everyday life. This is in accordance with Permendikbud number 20 of 2016 concerning the standard of graduate competence in junior high school / MTs mathematics students. It is expected that students have the skills to think and act creatively, productively, critically, independently, collaboratively, and communicatively through scientific approaches in accordance with those studied in educational units and other sources independently (Permendikbud Nomor 2o Tahun 2016).

Referring to the Minister of Education and Culture, junior / MTs students are expected to have a better thought process by showing students can understand and master the mathematical concepts learned. In mathematics learning itself, problem-solving is very important, it can even be said to be the heart of mathematics (Widyastuti, 2015).

The thinking process influences how students solve a daily problem given by teacher. Problems in daily life related to mathematics are usually expressed in problem solving. In connection, a teacher certainly seeks so that students achieve optimal results by knowing the thinking process. When students are faced with a problem, a thought process will emerge as an attempt to solve the problem at hand, so students can arrive at the answer or not. The cause of students not being able to solve problems can be used as a source of information to improve the learning process. But in reality some teachers do not pay attention to how students think in solving problems and only see the final results of student work. Marpaung states that the process of thinking is a process that consists of receiving information (from outside or within students), managing, storing, and recalling certain information from student memories (Retna, 2013). That is, someone who thinks must do a process to find a conclusion or solution about something that is thought.

The thought process shows the seriousness of students in learning which is an activity that occurs in the human brain so that it is difficult to observe by the senses. The thought process can be seen from the behavior of students who appear in solving problems through the ways or steps taken. Therefore, the learning process is very important for the teacher to know the process of thinking of students in solving problems in order to know the steps of each student who might be different in solving the problem given. The thinking process that exists in each student in solving the problem must be different because the understanding of each student is different (Yanti, 2016).

Problem solving is a process of solving mathematical problems through steps that have been learned. According to Karatas and Baki, problem solving is important a way of conducting learning and teaching mathematics to students (Karatas, 2013). NCTM (2014) also states that mathematics learning is very effective when students are involved in completing tasks related to mathematical reason and problem solving. Ormrod (2008) states problem solving that using existing knowledge and skills to answer a question that has not been answered or in a difficult situation. According to Polya (2004) problem solving is an attempt to find a way out of difficulty to achieve a goal that is not immediately achievable. Polya (2004) also stated that someone in solving a problem would take steps such as understanding the problem, making a plan of completion, implementing a plan of completion, and reevaluating the results (In'Am, 2014). This based on Lee and Chen's (2015) opinion that the stages of problem solving proposed by Polya are methods that are able to encourage students to explain how to use the problem correctly.

Based on experience of researchers while teaching mathematics at Muhammadiyah 2 Junior High School in Kartasura, not all of students can understand the problem solving problem easily. This can be known by the researcher when the PPL taught about the SPLDV chapter, only a few students who were in the class could understand the problem solving problem given by SPLDV. In solving the problem solving problem, of course, ability to understand is needed, planning a solution, and checking the results of the questions given. This ability is the intelligence that students already have, not only used in solving problems at school but also needed in solving problems that exist in surrounding environment.

Each student must have the seven intelligences expressed by Gardner (2013), but only a few intelligences stand out as the dominant intelligence of each student. As a teacher, the teacher should know what intelligence is more dominant than the seven intelligences that exist in each student so that learning runs as expected. With the information about the dominant intelligence of each student, the teacher can decide which learning method is suitable for the class. Teachers can make Student Worksheets (LKS) that are in accordance with the intelligence of their students in the class.

Of the seven intelligences that have one intelligence that can help in solving problem solving problems, namely logical-mathematical intelligence. Logical-mathematical intelligence greatly contributes to the problem solving process (Hoerr, 2010). This is certainly related to the logical-mathematical intelligence possessed by someone (Fadjar, 2016). According to Wulandari (2014) states mathematical logical intelligence is related to a person's thinking ability in calculating and understanding, analyzing, and solving a mathematical problem. Given the importance of mathematics in the realm of life outlined above, mathematics education must employ the appropriate strategy to ensure that the concepts ingrained in students' minds are not readily forgotten or even survive for life (Junaedi, 2021). Mathematics is one of the main subjects in the field of school education. In addition, mathematics is a science that is also needed is solving problems of everyday life (Sipayung, 2020). Mathematics as a basic science is one of the subjects that play an important role in every level of education as a means of logical, critical, analytical, rational and systematic thinking (Rambe, 2020).

Given the important role of mathematics in everyday life, mathematics learning should be given more attention (Irhamna, 2020). One effort that can be done so that students' problem solving becomes reliable is by increasing logical-mathematical intelligence. In the opinion of Oommen that there is a relationship between logical-mathematical intelligence and problem solving abilities of junior high school students (Oommen, 2016). In harmony with Yaumi which states that someone can solve problems easily then the person has logical-mathematical intelligence (Widyastuti, 2015). Likewise Fadjar states that mathematical logical intelligence is related to the ability to think inductively and deductively, think according to the rules of logic, understand and analyze patterns of numbers, and solve problems by using thinking skills (Fadjar, 2010). Armstrong also states that students who have logical-mathematical intelligence usually tend to be interested in analyzing causes and effects of things, counting, and solving mathematical problems (Amstrong, 2017). Thus, students with logical-mathematical intelligence will have the skills to understand problems, analyze, calculate, and have abstract abilities that students can use in solving mathematical problems so that the objectives of mathematics learning can be achieved optimally.

Based on the description above, the author is interested knowing how thinking a process of junior high students in solving mathematical problems based on logical-mathematical intelligence. Like other researchers who examined the use of thinking skills components to help improve language learning (Osman, 2014). In addition, the other researchers who examine the design of thinking and its application for solving specific problems in higher education (Pusca, 2018). Then research on thought process of problem solvers is naive based on Polya's heuristics (Mairing, 2017). There are those who examine the Effect of Logical-Mathematical Intelligence on Financial Accounting Achievements (Pehlivan, 2017). In addition there are also those who examine the existence of a significant positive influence and mathematical-logical intelligence on learning independence in the learning outcomes of mathematics. While in this study the questions used are two-variable linear equations. There are also those who compare the thinking process of students with mathematical linguistic and logical intelligence in solving

mathematical problems (Nugroho, 2013), while this study only focuses on thinking processes of students with mathematical logical intelligence in solving mathematical problems.

II. Research Methods

This research is a type of qualitative descriptive research that is providing an overview of an object that is observed today, based on facts that appear as they are. The method study is used to analyze students' thinking processes in solving problems with logical-mathematical intelligence. The data source of this research is the written results of problem solving tests and direct interviews with class VIII D students of SMP Budi Utomo who were the subjects of the study. The main data is in the form of student thinking processes which are obtained from the results of student work on SPLDV material interviews. While supporting data in the form of data from the results of students' logical-mathematical intelligence tests. Determination of research subjects using purposive sampling technique based on three criteria, namely in the category of logical-mathematical intelligence (high, medium, and low). Data collection methods used in this study are direct interview methods. The validity technique of the data used is methods triangulation the data analysis technique is done by reducing data, presenting data and conclusions.

III. Discussion

Indicators in analyzing students' thinking processes in problem solving using thinking processes at the Polya stage in Table 1. as follows:

Table 1. Indicators of Students' Thinking Processes with Polya Stages in Problem Solving

Polya Stages	Information Processing	Indicators
Understanding the problem	Receive information	▸ Read the problem solving problem given. ▸ Know what information is on the question.
	Processing information	Identify questions that have been read for example knowing what is known and what is asked on the question
Polya Stages	Information Processing	Indicators
	Save information	Write any information that has been known
	Call back	Re-examine what is written
Planning problem solving	Processing information	1. Know what methods can be used to solve problems in the problem. 2. Determine what plan will be used to solve the problem in the problem
	Save information	Students write ways to solve problem solving problems
	Call back	Re-examine what is written
Solve the problem	Processing information	1. Using a predetermined way to solve the problem 2. Complete the problem solving problem to find the results of the settlement using mathematical concepts in solving problems

	Save information	Write down the results of the settlement
	Call back	Re-examine what has been done
Check back	Processing information	Re-check settlement
	Save information	Match the results of the answers with the stages of understanding the problem, planning the problem solving and resolving whether it is appropriate
	Call back	Remember the process of how the results of the settlement can be obtained

Table 1. Indicators of students' thinking processes with Polya stages in problem solvingThe results showed that the problem-solving process of thinking was done by the research subjects of class VIII D of SMP Budi Utomo based on the steps of Polya (1) understanding the problem, (2) making a completion plan, (3) implementing the plan and (4) checking the explained in table 1. The subjects in this study were 3 students, namely students with high logical-mathematical intelligence (S1), students with medium logical-mathematical intelligence (S2), and students with low logical-mathematical intelligence (S3). Then the subject was given a question to do and interview. So that the description of problem solving for each research subject is obtained as follows:

3.1 The Thinking Process of Students with High Logical-Mathematical Intelligence in Solving Problems (S1)

The following is a snippet of S1 completion results in a two-variable linear problem solving system problem:

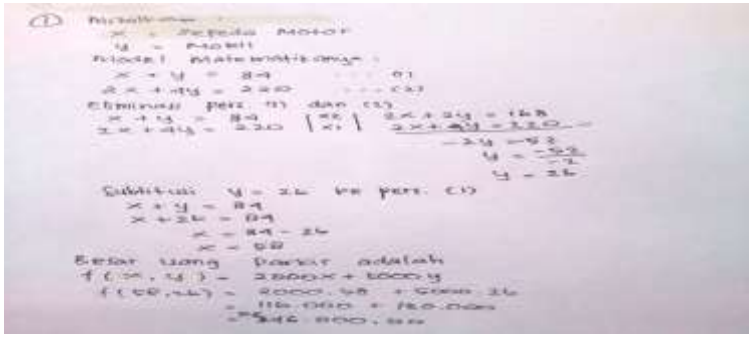

Figure 1. *Snippet of S1 Completion Results*

At the stage of understanding the problem described in Table 1, S1 receives information by reading the problem given and knowing what information is on the question by reading it only once. When processing information S1 can explain what is being asked and information that is known to be in trouble with its own language. So that S1 can build meaning about the problem to be solved, give reasons for the results of the formulation of the problem that has been built, know what is known and what is asked of the problem, and explain the terms used that can be seen in Figure 1. This is supported with the results of interviews with students who stated that "understand sir, it is a matter of SPLDV, then suppose that with two variables of what is known". Therefore S1 is said to be able to determine and write down what is known by identifying information that is known from the question then formed into two linear equations two variables by specifying objects with two variables namely x and y and checking the correctness of the information obtained by looking at the information that has been thought and expressed on the problem. This is in accordance with Polya's opinion that in understanding problems

students must be able to show what is known, what is asked, and whether conditions or data are known to be sufficient to answer questions (Polya, 2004).

S1 in planning problem solving can make a settlement plan by connecting problems according to the concepts that have been studied. S1 changes information that is known to be a two-variable linear equation so that S1 can write mathematical models of existing problems. Furthermore, S1 connects the resolution of problems that have been determined using known solutions, these can be seen in Figure 1. Supported by the results of student interviews, "the method for solving SPLDV is 4 such as the graph method, elimination, substitution, and substitutions, but which is easy using the pak elimination method." So S1 assumes the right and easy method by choosing the elimination-substitution method. This is in accordance with Novitasari's opinion that students with high logical-mathematical intelligence are able to associate concepts with knowledge and organize information (Novitasari, 2015).

From figure 1, S1 in implementing the problem solving plan with the method that has been made as planned. S1 implements the method by first writing a mathematical sentence namely $x + y = 84$, $2x + 4y = 220$ and the objective function is $f(x, y) = 2000x + 5000y$ correctly. The subject also wrote the steps of the substitution method according to what was previously planned to find the results of the settlement with the correct value of x and y. It can be concluded that S1 can implement a problem solving plan that is designed correctly. In accordance with Oommen that students with high logical-mathematical intelligence will be able to solve or solve a problem (Oommen, 2016).

Furthermore, S1 re-examines the results of problem solving obtained by returning the results of the problem resolution that has been obtained into the initial information. This is done by substituting the answers obtained to one of the equations he made. Strengthened by the results of interviews students stated that "sir, because after getting the values of x and y, I substitute again on one of the equations and the results match". So that what is solved is true and then substituted the results of the completion of the x and y values on the objective function made so that the right and correct results are obtained. It can be concluded that S1 is very thorough in solving problems by checking the results obtained by substituting the results obtained in one of the equations so that they can know whether or not the results obtained are correct. In accordance with the opinion of Fajriah and Suryawati that students who have good problem solving skills, these students can check the truth of the answers obtained (Fajriah, 2016).

3.2 The Thinking Process of Students with Logical-Mathematical Intelligence is in Solving Problems (S2)

The following are excerpts of S2 completion results in two-variable linear problem solving system problems:

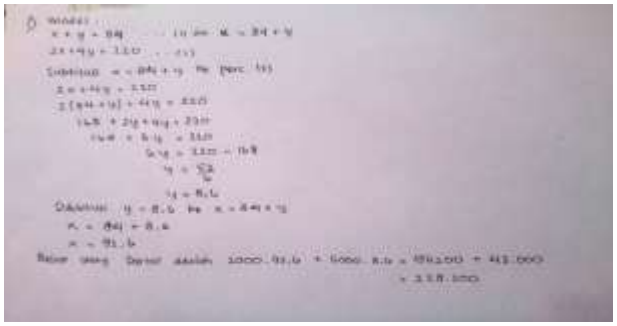

Figure 2. *Results of completion S2*

At the stage of understanding the problem described in table 1, S2 receives information by reading the problem given and knowing what information is in the problem by reading it repeatedly. When processing information S2 can explain what is being asked and information that is known to be in trouble with its own language. So S2 can build meaning about the problem to be solved, give reasons for the results of the formulation of the problem that has been formed, know what is known and what is asked of the problem, and explain the terms used. Marked by the results of interviews with students that read "I understand sir, the question is related to SPLDV, which later there are x and y variables to sample the object then form a mathematical model and function objective". But if seen in figure 2, S2 does not write the example of the variable used but directly makes a two-variable linear equation. S2 is still not careful in determining the value of x which must be $x = 84 - y$ but S2 gets the equation $x = 84 + y$. Therefore S2 is still said to be able to determine and write what is known by identifying the information that is known in the problem even though there is no example of the variable by forming two linear equations two variables with variables namely x and y directly. S2 does not check the correctness of the information obtained indicated by S2 without looking back at the information that has been written about the problem.

S2 in planning problem solving can make a plan, but it has not been able to plan well even though it has connected problems according to the concepts that have been studied. S2 changes the information known in the problem to a two-variable linear equation. S2 also connects problem solving with a system of linear two-variable equations using substitution methods. Though it should be easier with the elimination-substitution method. It was marked by the results of interviews with students stating "I remember the substitution method, sir, and it was easier for me". This S2 considers the substitution method to be easier than the elimination-substitution method, but there is a conceptual error made. So that they experience errors in solving the problem.

From Figure 2, S2 in implementing the problem solving plan by implementing the method that has been made as planned. S2 implements the method by first writing a mathematical sentence namely $x + y = 4$ then determining the value of x which must be x 1a= $84 - y$ but S2 obtaining the equation $x = 84 + y$, and $2x + 4y = 220$. S2 also does not write the objective function first of the related information. The subject has written the steps of the substitution method according to what was previously planned to find the results of the settlement with the acquisition of x and y values but the results are incorrect. S2 by suddenly substituting the x and y values for the equation of purpose. Characterized by the results of interviews with students stating "then I substitute the x and y values into the pack's destination formula". It can be concluded that S2 can implement the problem solving plan that was designed.

In terms of checking the results of solving problems obtained, S2 experiences different things than usual in checking the results of problem solving. The subject checks the correctness of the results of the resolution by returning the results of the problem resolution that has been obtained into the initial information. This is done by substituting the answers obtained to one of the equations but the results obtained do not match the equation used. Supported by the results of interviews with students stating "it seems like a mistaken sir, because I substitute back to one of the incompatible equations". This means that students are able to carry out all stages of the Polya when solving problems, namely understanding problems, making plans for completion, carrying out completion plans, and revisiting the results of completion, but there are several stages students are not able to do properly. According to Dara and Budiarto's opinion that students who have logical-mathematical intelligence are able to carry out all stages of Polya when solving problems, namely understanding problems, making plans for completion, carrying out completion

plans, and revisiting results of completion (Dara, 2018). But at some stage students have not been able to do it properly.

3.3 Students' Thinking Processes with Low Logical-Mathematical Intelligence in Problem Solving (S3)

The following are excerpts of S3 completion results in two-variable linear problem solving system problems:

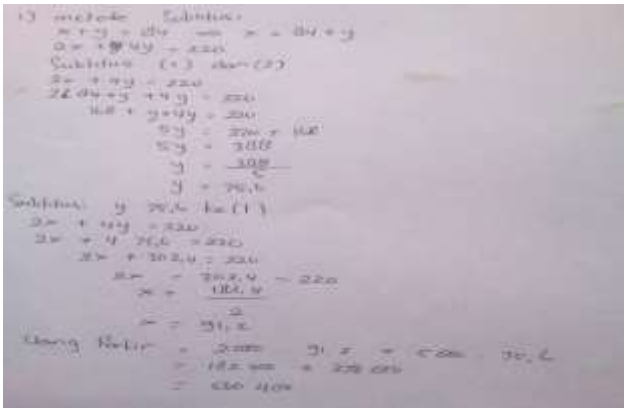

Figure 3. *Excerpts of S3 Completion Results*

At the stage of understanding the problem described in table 1, S3 receives information by reading the problem given and knowing what information is in the problem by reading it repeatedly. When processing information S3 can explain what is being asked and information that is known to be in trouble with its own language. So that S3 can build meaning about the problem to be solved, give reasons for the results of the formulation of the problem that has been formed, know what is known and what is asked of the problem, and explain the terms used. Marked by the results of interviews with students that read "I understand sir, the connection is with SPLDV, which later there are x and y variables to pair the two objects and then form a mathematical model and objective function". S3 does not first write the example variable used but directly makes a two-variable linear equation. S3 is still not careful in determining the value of x which must be $x = 84 - y$ but S3 gets the equation $x = 84 + y$. Therefore S3 is still said to be able to determine and write what is known by identifying the information that is known in the problem even though there is no example of the variable by forming two linear equations two variables directly namely $x + y = 84$ and $2x + 4y = 220$. S1 does not re-checking the truth of the information obtained is indicated by S3 without looking back at the information that has been written about the problem. This S3 is said to be able to determine and write what is known by identifying information that is known from the question then formed into two linear equations two variables by specifying objects with two variables, x and y even though there are no variable examples and immediately form two linear equations two variables.

S3 in terms of planning problem solving can make a plan, but have not been able to plan well even though it has connected problems according to the concepts that have been studied. Marked by the results of interviews with students stating "the problem is made a mathematical sentence then one of the equations is substituted to the second equation and substituted to the answer function x and y". S3 connects problem solving with a two-variable linear equation system. So that S3 is able to change the information that is known in the problem, then be made into a two-variable linear equation and solve it using the substitution method. Though it should be easier with the elimination-substitution method. It is possible for S3 to consider substitution methods to be easier than the elimination-

substitution method, but there are conceptual errors made. The subject also made a problem solving method by writing open sentences. So that they experience errors in solving the problem.

From figure 3, S3 in implementing the problem solving plan by implementing the method that has been made as planned. But S3 does not write variables in the system of linear equations that are made and can implement the problem solving plan, and implement the method that has been made as planned. S3 also does not write down the objective function first of the related information. The subject has written the steps of the substitution method according to what was previously planned. So S3 can still implement the problem solving plan to find the final answer even though the final answer obtained is the wrong answer. It can be concluded that S3 can implement the problem solving plan that was designed.

In terms of checking the results of solving problems obtained, S3 is experiencing confusion. S3 in checking the results of the resolution cannot or does not know how. Characterized by the results of interviews with students stating "do not know, confused if you want to check the answer". This case the students do not know the truth about the results of the resolution they have obtained.

In theory it is said that mathematical logical intelligence is intelligence that is related to the ability of an individual to think inductively and deductively, the ability to think logically, understand and analyze patterns (regularity) both in numbers and in the buildings, and the ability to solve problems with use thinking skills (Fadjar, 2010). Based on the results of Anton's research, it was found that the description of solving mathematical problems of subjects with mathematical logic intelligence was obtained: (1) when understanding the problem of the thought process first reading the problem, besides linking information read with the question with the aim of helping him determine important information and that is not in its cognitive structure, , (2) in planning problems, subjects making tables, problem solving plan ideas derived from prior knowledge of certain concepts or methods of solving problems that are similar to the problems at hand, (3) subjects run smooth problem solving plans, (4) in check again, the subject examines each step of the solution, and to ensure the results obtained (Anton, 2010). So that this intelligence is very helpful in finding ways of working, patterns, and relationships, developing problem solving skills, classifying, grouping, increasing understanding of a number, and more importantly improving memory. Based on this description, it can be interpreted that high logical-mathematical intelligence makes a big contribution for someone to solve mathematical problems. Logical-mathematical intelligence affects one's abilities and skills in solving mathematical problems. This is shown in students with high logical-mathematical intelligence who have a process of thinking in solving problems that are more systematic, logical and can be explained more fully than students with medium and low logical-mathematical intelligence. Students with high logical-mathematical intelligence can demonstrate their skills in understanding problems, planning to solve problems, implementing planning, and examining the results of completion.

IV. Conclusion

Based on the results of data analysis on three subjects in class VIII of SMP Budi Utomo Surakarta, the conclusions from this study are as follows:

The thinking process of students with high logical-mathematical intelligence in solving problems is: a) Students understand the problem by once reading the problem, explaining what is being asked and information that is known in the problem with their own language, and identifying information that is known to be formed into two linear

equations two variables and re-examine the information that is thought about the problem; b) planning problem solving by connecting problems with SPLDV, changing information that is known to be a two-variable linear equation, and designing a solution using the elimination-substitution method, and re-checking what is thought; c) implement a problem-solving plan by implementing a method by writing mathematical sentences as planned and writing the steps of the elimination-substitution method according to what was previously planned; d) check the results of problem solving by substituting the answers obtained to one of the equations.

The thinking process of students with medium logical-mathematical intelligence in solving problems is: a) understanding the problem by reading repeatedly, explaining what is being asked and information that is known in the problem with their own language and unable to explain the adequacy of information known in the problem to answer what is asked; b) plan problem solving by connecting problems with SPLDV but it is not appropriate to state the settlement method, change the information known in the problem to be a two-variable linear equation and design a solution using substitution methods, and check what is being considered c) implement a problem solving plan with implementing strategies for writing mathematical sentences as planned and writing problem solving steps as planned beforehand; d) The subject checks the results of problem solving by substituting the answers obtained to one of the equations and the results are not appropriate.

The thinking process of students with low logical-mathematical intelligence in solving problems is: a) understanding the problem by reading repeatedly and writing information that is considered important on scribbled papers, explaining what is being asked and information that is known in problems with their own language, and the subject can identify information that is known in the problem can be formed into two linear two-variable equations; b) plan problem solving by connecting problems with SPLDV but in the work the subject does not write variables in linear equations two variables that are made incorrect in stating the completion method, changing the information known in the problem into linear equations two variables will then be solved by substitution methods; c) implement a problem solving plan by implementing a method of writing mathematical sentences as planned and writing problem solving steps as previously planned; d) The subject does not check the results of problem solving, so the subject does not get the right or wrong results.

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