

ANALYSIS OF STUDENTS' MATHEMATICAL REASONING ABILITIES ON TWO-VARIABLE LINEAR INEQUALITY SYSTEM MATERIAL

Nabila^{1*}, Nicky Dwi Puspaningtyas²

^{1,2} Universitas Teknokrat, Bandar Lampung, Indonesia

* Corresponding author. Jl. Z.A. Pagar Alam No. 9-11, Labuhan Ratu, Labuhan Ratu District, Bandar Lampung City, Lampung

E-mail: nbila2481@gmail.com^{1*}
nicky@teknokrat.ac.id²

Received 02 December 2025; Received in revised form 07 January 2026; Accepted 20 March 2026

ABSTRACT

This study aims to describe students' mathematical reasoning abilities in the subject of Two-Variable Linear Inequality Systems (SPtLDV). This study was conducted because many students still have difficulty understanding the concepts and steps for solving SPtLDV, especially in understanding the relationship between variables and drawing logical conclusions from a mathematical problem. These difficulties often arise when students have to interpret mathematical statements into inequalities and describe the solution area on a coordinate plane. This study used a qualitative descriptive method with 14 students from class XI of SMA Negeri 12 Bandar Lampung as subjects. Data were collected through mathematical reasoning ability tests and interviews to explore the students' thinking processes. The results show that students' mathematical reasoning abilities vary. High-ability students are able to meet all reasoning indicators, from making assumptions, performing mathematical manipulations, providing reasons for solutions, to drawing correct conclusions. Students with moderate abilities were still lacking in writing down the steps of manipulation systematically and tended to make small errors in calculations. Meanwhile, students with low abilities had difficulty understanding basic concepts and often made mistakes in manipulating the variables x and y , resulting in inaccurate solutions.

Keywords: descriptive qualitative; mathematical reasoning; system of two-variable linear inequalities;

ABSTRAK

Penelitian ini bertujuan untuk menggambarkan kemampuan penalaran matematis siswa dalam mata pelajaran Sistem Ketidaksetaraan Linear Dua Variabel (SPtLDV). Penelitian ini dilakukan karena banyak siswa masih mengalami kesulitan dalam memahami konsep dan langkah-langkah penyelesaian SPtLDV, terutama dalam memahami hubungan antara variabel dan menarik kesimpulan logis dari suatu masalah matematis. Kesulitan ini sering muncul ketika siswa harus menginterpretasikan pernyataan matematis menjadi ketidaksetaraan dan menggambarkan daerah penyelesaian pada bidang koordinat. Penelitian ini menggunakan metode deskriptif kualitatif dengan 14 siswa kelas XI SMA Negeri 12 Bandar Lampung sebagai subjek. Data dikumpulkan melalui tes kemampuan penalaran matematis dan wawancara untuk mengeksplorasi proses berpikir siswa. Hasil menunjukkan bahwa kemampuan penalaran matematis siswa bervariasi. Siswa dengan kemampuan tinggi mampu memenuhi semua indikator penalaran, mulai dari membuat asumsi, melakukan manipulasi matematis, memberikan alasan untuk solusi, hingga menarik kesimpulan yang benar. Siswa dengan kemampuan sedang masih kurang dalam mencatat langkah-langkah manipulasi secara sistematis dan cenderung membuat kesalahan kecil dalam perhitungan. Sementara itu, siswa dengan kemampuan rendah mengalami kesulitan memahami konsep dasar dan sering membuat kesalahan dalam memanipulasi variabel x dan y , yang mengakibatkan solusi yang tidak akurat.

Kata kunci: kualitatif deskriptif; penalaran matematika; sistem pertidaksamaan linear dua variabel



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Introduction

Education is a means to create quality human resources. Education is also able to direct humans to have a clearer and more directed view of life (Widyanawati & Firmansyah, 2022). The low quality of education can cause a nation or country to lag behind in various aspects. The education system in Indonesia is still facing problems that are one of the causes of low education in Indonesia (Kurniawati, 2022). Based on the results of a survey of the secondary education system in the world released by Programme for International Student Assessment (PISA) in 2019, Indonesia ranked 74th out of 79 countries surveyed in 2018. The data shows that the ability of students in Indonesia is in the sixth lowest position compared to other countries. This is very concerning for Indonesia, which has quite a lot of human resources (HR). The success of students' abilities can be influenced by many things, such as the role of a teacher, school facilities, learning environment, family environment, economic conditions, mental state, and various other factors (Kurniawan, 2016). To improve education in Indonesia, quality learning is needed, one of which is mathematics.

Mathematics is a subject that can develop logical, systematic, and creative thinking skills (Ramdan & Lessa Roesdiana, 2022). Mathematics learning has an important role and needs to be understood well, and mathematical knowledge must be mastered by students from an early age. However, some students still find math to be a difficult subject (Siregar & Restati, 2017). Students are required to understand concepts based on mathematics so that students can understand the problems at hand and develop creative ideas. As according to National Council of Teachers of Mathematics (NCTM, 2000), there are five basic mathematical abilities of students, including; mathematical problem-solving skills (problem solving), mathematical communication skills (communications), mathematical connection ability (connections), mathematical reasoning skills (reasoning), and mathematical representation capabilities (representations). Of the five basic mathematical skills, there is mathematical reasoning skills which are one of the important aspects that must be considered in mathematics learning.

Mathematical reasoning is a thinking activity that has characteristics in determining the truth (Nurhalin & Effendi, 2022). The results of the study are in line with the opinion Scarlet Witch (2016), which states that mathematical reasoning is the activity of the thought process in drawing conclusions or making new statements based on statements that are already known or considered true. In other words, mathematical reasoning skills are students' ability to think to solve various mathematical problems and determine the truth or reason for statements that are considered true. Mathematical reasoning focuses not only on the final result, but also on the systematic logical process of producing truth. Mathematical reasoning skills are important things that must be possessed by students, especially at the high school level. A high level of student reasoning can accelerate the achievement of learning indicators. In addition, students' reasoning skills also contribute to improving student learning outcomes (Inayah, 2017). Reasoning skills are not only remembering facts, rules, or problem solving, but students can use their reasoning skills in making guesses based on their experience. So that students gain an understanding of interrelated mathematical concepts and learn meaningfully or Full Meaning (Santosa et al., 2020).

Mathematical reasoning skills play a role in building a logical mindset in drawing conclusions that are general and specific to the learning activity process (Lesmana, 2022). However, in reality, the level of students' reasoning ability is still relatively low. This is because there are obstacles in the process of working on problems, students are not used to working on complicated problems and require mathematical reasoning skills (Asdarina & Ridha, 2020). Another study showed that 60% of students had a relatively low level of mathematical reasoning ability (Sihombing et al., 2021). One of the causes of low student reasoning is the use of conventional learning methods that are still predominantly used by teachers, where students are less actively involved in the learning process (Alawiyah, Fajriana, & Elisyah, 2025). As a result, students' reasoning skills and strategic competencies do not develop as they should. (Muslimin & Sunardi, 2019). Students still have difficulty solving problems that require mathematical reasoning skills and students' lack of mastery of the mathematical concepts that have been learned (Vebrian, Putra, Saraswati, & Wijaya, 2021). However, reasoning skills can be honed through practice questions or solving more complex contextual problems. Through problem-solving that is contextual or relevant to everyday life, students can identify and estimate appropriate resolution steps (Mubharokh et al., 2022).

One of the materials that can be poured into contextual problems is the Two-Variable Linear Inequality System (SPtLDV). SPtLDV is material that requires steps to solve various problems so that good reasoning is needed to be able to solve the problems that have been given. However, there are still many students who have difficulty solving the problems in the SPtLDV material.

Through this study, it is hoped that a clearer picture can be obtained of students' reasoning ability in solving story problems in SPtLDV material. This study also aims to analyze the factors that affect these abilities and provide recommendations to improve the quality of mathematics learning.

Research Methods

The method in this study uses a descriptive qualitative approach. Abdussamad & Sik (2021) Qualitative research is a type of research that analyzes facts, symptoms, or events that actually occur. The results of such analysis are used as a basis for determining next steps or actions. The focus of this study is to analyze students' reasoning ability in solving SPtLDV essay questions. The subject of this study is 14 students of grade XI KP 1.3 at SMA Negeri 12 Bandar Lampung.

The sampling technique in this study uses Simple Random Sampling to determine one class to be analyzed. Furthermore, Purposive Sampling is used to select three students from the class who are the subject of interviews based on the results of the essay test and certain criteria (high, medium, and low). The purpose of using Purposive Sampling is to select students who are considered to be able to provide more relevant and in-depth information according to the focus of the research.

The data collection techniques used during the data collection process are essay tests and interviews. Essay tests are used to find out students' mathematical reasoning. The questions given consist of two questions related to SPtLDV material in daily life. In addition, the essay questions are arranged based on mathematical

reasoning indicators. The indicators of mathematical reasoning ability used in the research are as follows in Table 1.

Table 1. Indicators of Mathematical Reasoning Capability

Indicators	Description
Filing a suspicion	Students are able to formulate various possibilities or estimate solutions based on their knowledge.
Mathematical manipulation	Turning ordinary sentences into mathematical models.
Providing a Solution	Students are able to provide reasons for the solutions provided in complete
Drawing conclusions	Students are able to draw conclusions from the statements submitted

Source: Asdarina & Ridha (2020)

The essay questions that have been prepared are then validated first by one mathematics teacher and one mathematics education lecturer. After validation, the essay questions are tested for reliability, differentiation, and difficulty. The reliability test aims to measure the consistency of a question, with a Cronbach's Alpha value of at least 0.70 to be considered reliable. The differentiating power test is carried out to see how well the questions distinguish between students with high, medium and low abilities, with a minimum score of 0.30 so that the questions can be accepted. Meanwhile, the difficulty level test measures how difficult the question is for students. Questions that do not meet these criteria will be corrected or discarded so that the instrument used is valid and can be used.

Students' mathematical reasoning abilities are grouped based on high, medium, and low categories. This grouping aims to facilitate the analysis of students' mathematical reasoning skills. The classification is carried out based on the scoring guidelines stated in Arikunto's book (Hardianti & Effendi, 2021) shows in Table 2.

Table 2. Mathematical Reasoning Ability Grouping

Group	Criterion
Tall	$x \geq \bar{x} + s$
Keep	$\bar{x} - s \leq x < \bar{x} + s$
Low	$x < \bar{x} - s$

Source: Hardianti & Effendi (2021)

Information

x : Value obtained

\bar{x} : Average value

s : Baku Junction

This study uses two data collection techniques, namely tests and interviews, so that the process of examining the validity of the data is carried out through data triangulation. According to (Rachman et al., 2021), data triangulation is a data collection technique that combines various data collection techniques and existing data sources. The goal is to check or compare the data obtained so that the research results become more valid, reliable, and accountable. The type of triangulation used in this study is the triangulation technique, which is comparing data obtained from two different data collection methods against the same source. The results of the two techniques were then analyzed and compared to see the suitability and difference of the findings. Thus, the application of triangulation techniques in this study not only strengthens the validity of the data, but also provides a more comprehensive picture of the phenomenon being studied.

The next data collection technique is an unstructured interview that aims to dig deeper information related to the students' thinking process in completing the essay test, find out how students think directly, and detect any misconceptions or mistakes in students' thinking. Interviews are conducted after students have taken the essay test and are conducted on one student from each category (high, medium, and low). The selection of students is carried out based on the results of the answers to essay questions that have been analyzed according to the indicators of mathematical reasoning ability.

The data analysis in this study uses qualitative descriptive data analysis techniques. The data obtained in this study were in the form of student answer sheets and interview results. The steps taken in analyzing the data are data reduction, data presentation, and drawing conclusions (Palazzolo, 2023). Rijali (2019) Stating data reduction is the process of simplifying, sorting, and focusing raw data into specific concept units, themes, or categories. The goal is to infer data systematically and relevant to the focus of the research. Data presentation is the process of compiling information that has been reduced to be more structured, making it easier for researchers to see patterns and draw conclusions. The data presented are in the form of students' mathematical reasoning ability scores, essay test answers written by students in answer sheets, and interview results presented in the form of questions and answers conducted with students. Drawing conclusions is the final stage to obtain a description of students' reasoning in working on the SPtLDV material essay questions.

Results and Discussion

Based on the results of the mathematical reasoning ability test, an average score of 77.3 with a standard deviation of 21.7 was obtained. The test scores are then classified into three categories, namely high, medium, and low, according to the category division table that has been set.

Table 3. Mathematical reasoning ability level

Group	Criterion	Many student
High	$x \geq 99.6$	1
Medium	$55,7 \leq x < 99,6$	10
Low	$x < 55.7$	3
Total		14

Source: Hardianti & Effendi (2021)

The results of the research data were analyzed to obtain conclusions about the level of students' mathematical reasoning ability. Based on the results of the written test, it is known that 7.1% of students are in the category of high mathematical reasoning ability, 71.4% are in the medium category, and 21.4% are classified as low. From the results of the grouping, the researcher selected one student from each category to be analyzed in more depth. The subjects of the high category are given the code S1, the medium category is given the code S2, while the low category is given the code S3. Furthermore, the three subjects were interviewed to obtain more detailed information regarding the achievement of each indicator of mathematical reasoning ability in solving contextual problems.

Subject S1 (High mathematical reasoning ability)

S1 subjects who have high mathematical reasoning skills are able to meet all indicators of reasoning ability. Based on the results of the test and interview, S1 shows the ability to understand the problem and identify important information from the problem. S1 stated that before solving the problem, S1 first read and understood the context of the problem to determine the right way to solve it. This shows that S1 is able to submit initial allegations that are relevant to the problems faced. The results of S1's work at this stage are shown in Figure 1, which shows his ability to write down the information known from the problem clearly shows in Figure 1.

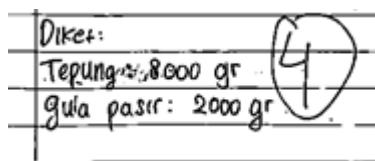


Figure 1. S1 Answer to the Indicator of Submitting Suspensions

At the mathematical manipulation stage, subject S1 was able to transform problems into appropriate mathematical models and carry out the steps to solve them systematically. Based on the interview results, subject S1 stated that each procedure was carried out carefully to minimize the possibility of calculation errors. These findings indicate that subject S1 has good mathematical manipulation skills and shows accuracy in the problem-solving process. The results of subject S1's work at this stage can be seen in Figure 2.

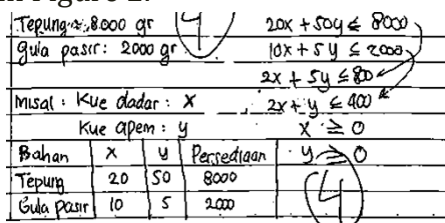


Figure 2. S1 Answer on Mathematical Manipulation Indicators

In the next stage, the S1 subject was able to provide logical reasons for the steps taken to solve the problem. Based on the interview results, subject S1 explained that each stage of the solution was based on mathematical concepts relevant to the problem. These findings indicate that subject S1 understood the relationship between the solution procedure and the mathematical principles used and was able to provide appropriate justification for the answers obtained. Examples of subject S1's work at this stage can be seen in Figures 3 and 4.

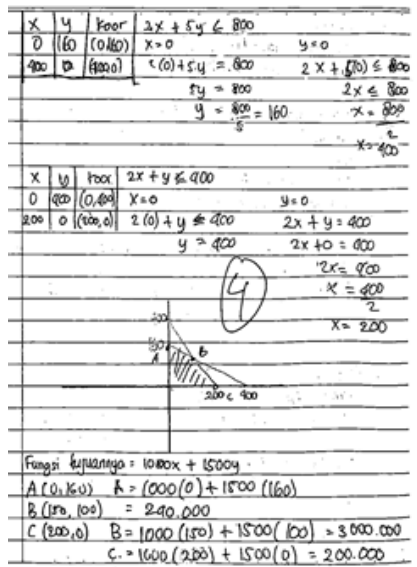


Figure 4. S1 Answer to the Indicator Giving Reasons for Solutions

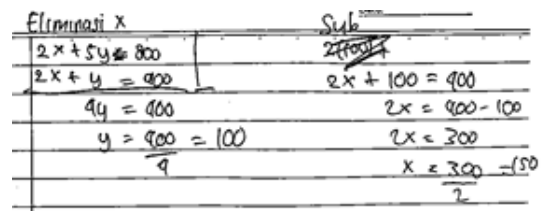


Figure 3. S1 Answer to the Indicator Giving Reasons for Solutions

At the conclusion stage, S1 is able to present the final result correctly and accompanied by an explanation that is appropriate to the context of the question. Based on the results of the interview, it is known that S1 re-checks the results of the calculation before writing the final conclusion to ensure the accuracy of the answers. This shows that S1 has good reflective ability in assessing the correctness of the completion results. The results of the S1 work at this stage are shown in Figure 5.

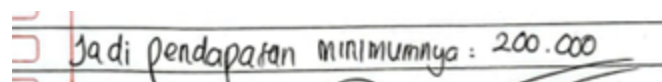


Figure 5. S1 Answer on Indicators Draw Conclusions

Subject S2 (Moderate Mathematical Reasoning Ability)

S2 subject has mathematical reasoning skills in the medium category. Based on the results of the written test and interviews, S2 is able to understand the information contained in the questions and submit initial conjectures on the solution method to be used. S2 explained that he read the question more than once so as not to make mistakes in determining what was known and what was asked. This shows that S2 already has the ability to make allegations, although it still takes longer to understand the context of the problem. The result of the S2 work that show this ability are shown in Figure 6.

Diket = Tepung : 8000 gr
Gula pasir : 2000 gr

Figure 6. S2 Answer to the Indicator of Submitting Suspicions

In the mathematical manipulation indicator, S2 is actually able to carry out the completion steps correctly, but there are shortcomings in terms of writing a complete calculation process. Based on the results of the interview, S2 stated that understood how to do the question, but forgot to write the process thoroughly on the answer sheet. This condition shows that S2 has a fairly good understanding of concepts, but is not fully able to communicate the mathematical process clearly and

misal = kue dacker = x			
kue apem = y			
Rahon	x	y	Persediaan
Tepung	20	50	8000
Gula pasir	10	5	2000

Figure 7. S2 Answer on Mathematical Manipulation Indicators thoroughly. The results of the S2 answers in this section can be seen in Figure 7.

In the ability to give reasons for solutions, S2 has shown good understanding. S2 can explain the reasons behind the completion steps taken and how they relate to the final results obtained. Based on the results of the interview, S2 understands the relationship between the method used and relevant mathematical concepts, so that the reasons presented are logical and in accordance with theory. Examples of the results of S2 work at this stage can be seen in Figure 8 and Figure 9.

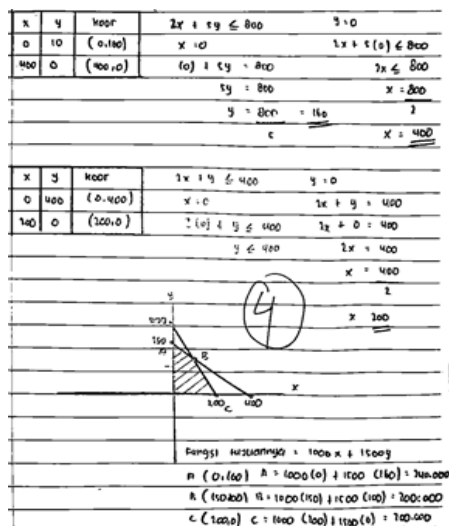


Figure 8. S2 Answer to the Indicator of Giving Reasons for Solutions

Eliminasi x	Substitusi
$2x + 5y = 800$	$2x + 100 = 400$
$2x + y = 400$	$2x = 400 - 100$
$4y = 400$	$2x = 300$
$y = 400 \div 4 = 100$	$x = 300 \div 2 = 150$
	$\frac{300}{2}$

Figure 9. S2 Answer to the Indicator of Giving Reasons for Solutions

At the stage of drawing conclusions, S2 is able to write the final result correctly and according to the context of the problem. S2 said that he always double-checks the answers to make sure that the results are logical and in accordance with the questions given. This shows that S2 has good reflective skills, although there are still shortcomings in the presentation of the previous completion steps. The results of the S2 work at this stage are presented in Figure 10.

Jadi Penalaran matematika = 100.000

Figure 10. S2 Answer on Indicators Draw Conclusions

Subject S3 (Low mathematical reasoning skills)

Subject S3 falls into the category of low mathematical reasoning ability. Based on the results of written tests and interviews, subject S3 has not been able to fully meet the four indicators of mathematical reasoning ability. At the stage of proposing a hypothesis, subject S3 was actually able to think of the first step of the solution, but did not write it down on the answer sheet because they focused directly on the calculation. Based on the interview results, subject S3 explained that they already had an idea of how to solve the problem, but did not have time to write it down. These findings indicate that subject S3's ability to make assumptions is beginning to develop, although this is not clearly reflected in the written results.

In the process of mathematical manipulation, S3 still made some mistakes. The main error occurs because S3 is wrong in placing the variables x and y , so the final result of the calculation becomes incorrect. Based on the results of the interview, S3 admitted that was still confused in determining the variables that should be used, which caused the next steps to be also wrong. The results of the S3 work in this section are shown in Figure 11.

Misal : Kue dadar : x mengijukan dengan (0)
 Kue apem : y

Bahan	x	y	Persediaan
Tepung	50	20	8000
Gula	5	10	2000

Maka model matematikanya:
 $50x + 20y = 8000 \rightarrow 5x + 2y = 800$
 $5x + 10y = 2000 \rightarrow x + 2y = 400$
 $x \geq 0$
 $y \geq 0$

Figure 11. S3 Answers to Mathematical Manipulation

In the indicator providing reasons for the solution, even though S3 made a mistake in the calculation, S3 still tried to explain the reasons behind the steps that had been taken. S3 stated that the method used was considered correct, even though it did not conform to the correct mathematical concept. This shows S3's attempt to provide justification, but it was not supported by a strong understanding of the concept. Examples of S3's work that show this condition can be seen in Figures 12 and 13.

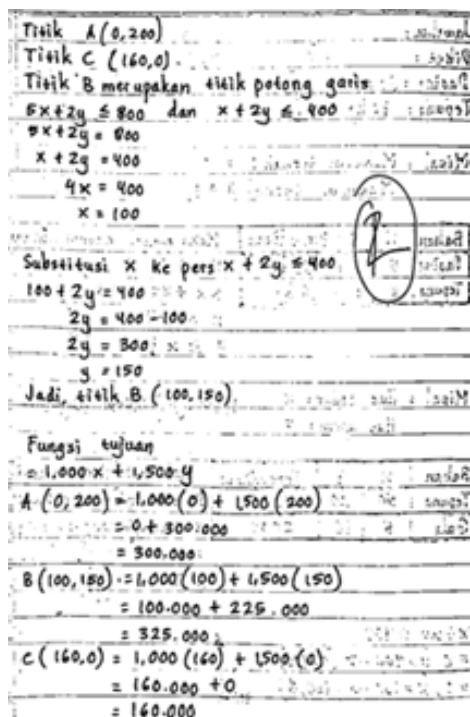


Figure 12. S3 Answer to the Indicator Giving Reasons for Solutions

At the stage of drawing conclusions, S3 has not been able to conclude the results correctly because the calculation process carried out is also still wrong. Based on the results of the interview, S3 admitted that S3 was not sure of the answer and only wrote down the final result based on the calculations that had been made. This condition shows that the ability of S3 to draw conclusions is still weak and needs to be further developed. The results of the S3 work that describe these conditions are presented in Figure 14.

Jadi, pendapatan minimumnya adalah 160.000

Figure 14. S3 Answer to Interesting Indicators Conclusion

Based on the results of the analysis, it can be concluded that students with high mathematical reasoning skills are able to meet all four indicators of mathematical reasoning ability very well. The subject shows the ability to think logically, systematically, and carefully in solving contextual problems. Based on the results of the written test and interviews, it can be concluded that S1 has a high level of mathematical reasoning ability. This is in line with research Muniroh & Buchori (2024)) which states that the S1 subject is able to meet four indicators of mathematical reasoning ability.

Students with mathematical reasoning skills are meeting most of the indicators of mathematical reasoning ability, although there are shortcomings in the writing aspect of mathematical manipulation steps. Based on the results of the written test and interviews, S2 has a fairly good understanding of concepts but is not able to write them completely. Therefore, S2 is categorized as having moderate

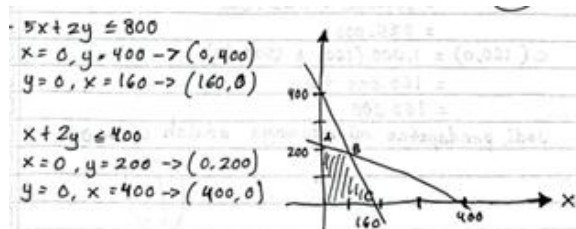


Figure 13. S3 Answer to the Indicator Giving Reasons for Solutions

mathematical reasoning skills. In line with research that reveals that one of the causes of student errors in solving contextual problems is due to a lack of precision when working on the completion steps (Debi et al., 2021).

Students with low mathematical reasoning skills have not met most of the indicators of mathematical reasoning ability. The subject showed that he understood the initial steps of the solution, but forgot to write it down, and made an error at the math manipulation stage. Nevertheless, S3 is still trying to give reasons for the steps taken. Based on the results of written tests and interviews, S3 is categorized as having low mathematical reasoning skills. This is in line with previous research which stated that subjects with low abilities can know what is asked, but are not able to design steps and complete the stages in the given question (Jais et al., 2023).

Conclusion and Suggestion

Based on the results and discussion of the research, it can be concluded that students with high mathematical reasoning skills are able to meet all indicators of mathematical reasoning ability well, namely making guesses, manipulating mathematics, giving reasons for solutions, and drawing conclusions. Students in this category show the ability to think logically, systematically, and carefully in solving contextual problems, so that they can find solutions correctly.

Students with moderate mathematical reasoning abilities are able to meet most of the indicators of mathematical reasoning. Subjects in this category understand concepts and are able to give reasons for the solutions obtained, but are less thorough in writing down the steps of mathematical manipulation. This shows that students have understood the SPtLDV material quite well, but still need to improve their accuracy and skills in writing the complete completion process.

Students with low mathematical reasoning skills have not been able to meet most of the indicators of mathematical reasoning ability. The subject understands the problem but forgets to write down the initial steps of the solution and experiences errors in performing mathematical manipulations, especially in the determination of variables x and y . However, students still try to give reasons for the steps taken, but their understanding of the concept of SPtLDV still needs to be improved in order to be able to solve the problem correctly.

As a reference for future research, it is recommended that researchers explore the influence of various factors such as learning methods, student motivation, and question difficulty on mathematical reasoning skills. In addition, further research could also examine specific learning strategies that have the potential to improve students' reasoning skills in solving contextual problems.

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