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STUDENTS' MATHEMATICAL REASONING ABILITY WITH VISUAL, AUDITORIAL, AND KINESTHETIC LEARNING STYLES IN SOLVING HOTS PROBLEMS

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Keywords

Penalaran Matematis, Gaya Belajar Visual, Gaya Belajar Auditorial, Gaya Belajar Kinestetik, HOTS

ABSTRACT

Penelitian ini bertujuan untuk mendeksripsikan kemampuan penalaran matematis siswa dengan gaya belajar visual, auditorial, dan kinestetik dalam menyelesaikan soal matematika tipe HOTS. Penelitian dilakukan di kelas VII C SMPN 3 Rambipuji. Instrumen terdiri dari angket, tes penalaran matematis, dan pedoman wawancara. Pada tahap awal peneliti memberikan angket kepada 37 siswa untuk mengetahui gaya belajarnya, kemudian memilih dua orang dari tiap gaya belajar untuk mengikuti tes penalaran matematis dan wawancara. Analisis data menunjukkan bahwa siswa dengan gaya belajar visual dan kinestetik memenuhi semua indikator, sedangkan subjek dengan gaya belajar auditorial hanya memenuhi tiga indikator. Hal ini karena siswa dengan gaya belajar visual dan kinestetik cenderung bekerja secara sistematis, berbeda dengan siswa dengan gaya belajar auditorial yang suka berpikir cepat.

Mathematical reasoning, Visual learning style, Auditorial learning style, Kinesthetic learning style, HOTS.

This study aims to describe students' mathematical reasoning with visual, auditory, and kinesthetic learning styles in solving HOTS-type math problems. The research was conducted in class VII C of SMPN 3 Rambipuji. The instrument consists of a questionnaire, a mathematical reasoning test, and an interview guide. In the early stages, the researcher gave a questionnaire to 37 students to find out their learning styles, then chose two people from each learning style to take a mathematical reasoning test and interviews. Data analysis showed that students with visual and kinesthetic learning styles fulfilled all indicators, while subjects with auditory learning styles only met three indicators. Students with visual and kinesthetic learning styles tend to work systematically, unlike those with auditory learning styles, who tend to think fast..

INTRODUCTION

As a branch of science, mathematics is formed from human empirical experience and processed rationally in a cognitive structure to create mathematical concepts. The foundation of mathematics is obtained through a thought process known as logic. One of the abilities students must have in learning and understanding mathematics is reasoning or logical thinking (Cahyani et al., 2022; Kholil, 2018). The mathematics material taught in schools is chosen to train reasoning, form personality, instill values, and prepare students to be skilled at solving problems (Aini et al., 2022; Wulan & Anggraini, 2019). This explanation shows that reasoning is an essential point in learning mathematics.

Reasoning is the ability to think logically based on a coherent thinking stage, drawing valid conclusions from existing evidence according to specific rules (Taufiq, 2020). Mathematical reasoning is reasoning about mathematical objects to draw conclusions or make new factual statements. This process is based on one or more arguments that have been proven true (Kusumawardani, Wardono, & Kartono, 2018). The reasoning process stimulates students to find relationships between mathematical objects, examine and evaluate mathematical assumptions, and develop mathematical arguments and evidence to prove the truth of the hypotheses that have been proposed (Nursoffina & Efendi, 2022). Reasoning is a thinking activity to formulate conclusions and make statements that have been proven true (Putri, Sulianto, & Azizah, 2019). Mathematical reasoning is the ability to connect problems into ideas so that they can solve mathematical problems (Salmina & Nisa, 2018). Mathematical reasoning is a student's ability to prove a statement and form new ideas to solve mathematical problems (Nababan, 2020). Mathematical reasoning is the most critical part of the thinking process because it involves generalization activities and draws valid conclusions about ideas and their interrelationships (Yusdiana & Hidayat, 2018).

Students with low reasoning abilities tend to experience difficulties when facing problems because they cannot relate various existing facts to obtain valid conclusions (Putri, Sulianto, & Azizah, 2019). Mathematical reasoning abilities are essential for students to master to solve everyday problems (Salmina & Nisa, 2018; Ariati & Juandi, 2022).

The National Council of Teachers of Mathematics states several indicators of mathematical reasoning ability, namely: (1) conclude logically, (2) provide an explanation of models, facts, properties, patterns, and relationships, (3) compile estimated solutions to a problem, (4) using relationship patterns to analyze situations, compile analogies, generalizations, and compile conjectures, (5) present opponents of examples, (6) follow the rules of inference, check the correctness of arguments, and compile valid arguments in the proof process, (7) compile direct proofs, indirectly, or using mathematical induction (Kusumawardani, Wardono, & Kartono, 2018).

The indicators of mathematical reasoning in this study are adjusted to the stage of solving the material problem-solving system of two-variable linear equations, namely:

Table 1.
Mathematical reasoning indicator

No	Indicator	Description
1.	Make a hypothesis	Student's ability to write down information about questions by mentioning what is known and asked from the questions
2.	Make mathematical manipulation	Student's ability to write down problem-solving steps according to procedures and perform math operations correctly
3.	Determine the pattern or nature of mathematical symptoms	The ability of students to choose a model or pattern of mathematics to analyze problems according to mathematical symptoms
4.	Arranging evidence against multiple solutions	The ability of students to compile evidence for problem solutions based on self-made models
5.	Draw a conclusion	The ability to conclude to show the truth of a statement

This study used an instrument in the form of questions of the Higher Order Thinking Skills (HOTS) type to determine students' reasoning abilities. It is because HOTS is related to reasoning abilities that are not limited to remembering but also the ability to analyze, solve problems, and draw conclusions (Sari, Cahyaningtyas, Maharani, Yustiana, & Kusumadewi, 2019). Students should use higher-order thinking skills in solving HOTS questions, including analyzing, evaluating, and creating (Aini, Mukhlis, Annizar, Jakaria, & Septiadi, 2020).

Mathematical reasoning ability can be an asset in students' success in solving HOTS questions. Many things, including learning style, can influence students' mathematical reasoning abilities. Learning styles show student preferences regarding understanding something controlled by a person's brain structure so that it is individualistic (Wardani & Aini, 2023). Experts categorize learning styles based on cognitive preferences, intelligence profiles, and sensory preferences. Based on sensory preferences, students with a visual learning style tend to like learning through what is seen, auditory through what is heard, and kinesthetic through movement, working, and touching. Every student certainly does all three, but only one is dominant (Rambe & Yarni, 2019). According to De Porter and Hernacki, students with a visual learning style tend to be neat and organized in doing things, speak at a fast tempo, focus on what they see, tend to read as quick readers, are weak in stringing words, memorize visual associations and pay attention to details. Auditory-type students prefer to talk, cannot focus when the environment is noisy, read and listen well, do not like to write but like to tell stories, learn by listening and remember more what is heard, and like discussions and detailed explanations. Students with a kinesthetic learning style often speak slowly, don't remember easily, easily understand when working on their own, use their fingers to guide reading, don't like to be silent without doing anything, their handwriting tends to be sloppy and remember information by doing their learning activities (Safitri & Farihah, 2019).

Research that describes reasoning abilities has been carried out a lot. Among them is the analysis of mathematical reasoning abilities based on gender (Salmina & Nisa, 2018), based on cognitive style (Rohmah, Septian, & Inayah, 2020), or problem-solving skills (Hidayatullah, Sulianto, & Azizah, 2019). Facts based on research results show that the mathematical reasoning abilities of junior high school students are still low (Aprilianti & Zanthy, 2019) or moderate (Octaviana & Aini, 2021). In connection with the influence of learning styles on mathematical reasoning abilities, this study will describe the reasoning abilities of students with visual, auditory, and kinesthetic learning styles in solving HOTS questions.

METHODS

This study uses a qualitative approach to describe students' mathematical reasoning abilities with visual, auditorial, and kinesthetic learning styles. The research was conducted on class VII-C students of SMP Negeri 3 Rambipuji. The research subjects are two students with visual, auditory, and kinesthetic learning styles. Two subjects were selected as source triangulation to compare reasoning abilities with the same learning style.

The research instruments are a learning style questionnaire, a mathematical reasoning test, and an interview guide. Before being used, the test instrument was tested for validity and reliability. Validity was carried out by experts in mathematics education (expert judgment), while reliability was carried out in a trial class. This test obtained a validity coefficient of 4.3 and a reliability coefficient of Cronbach's Alpha. r_h was 0.607, so the test instrument was declared valid and reliable.

In the early stages, 37 students were given a learning style questionnaire containing 30 statement items (Safitri & Farihah, 2019). Then two people were selected for each learning style. Furthermore, the six selected subjects took a mathematical reasoning ability test with two HOTS questions in the form of descriptions. Researchers also triangulated techniques through tests and semi-structured interviews with research subjects.

RESULT AND DISCUSSION

Table 2 below presents the test questions for mathematical reasoning abilities.

Table 2.
Mathematical reasoning questions

No.	Question Items
1	Mr. Fajar has rectangular land. With a length measuring two times the width of the land, it is known that the width of the land is $(2x + 3)$ meters. If the circumference of Pak Fajar's land is 84 meters, then make a mathematical model! then find the length and width of the land owned by Mr Fajar.
2	On Sunday, in the town square of Jember, Firda jogged at 11 km/h on the first route, then continued at $22\ \mathrm{km/h}$ on the second route. If during jogging the first route and the second route Firda covered a distance of $36\ km$ for 2 hours. So, where is Firda's shortest distance between the first and second routes? Explain it!

The following presents the results of research on six research subjects.

Visual Learning Styles Students

The results of the SV1 test can be seen in Figure 1 below. From the answer sheet, it is known that SV1 can write down the information about the questions and correctly what is asked so that it can be said to meet the indicators of making assumptions. SV1 was able to make a mathematical model of the problem and determine the equation for the length of the land, namely $2 \times l = 2(2x + 3) = 4x + 6$ and find the form of the equation for the perimeter of a rectangle with the substitution of the equations for length and width. In the end, we get the perimeter equation $84 = 12x + 18$. That is, SV1 can manipulate mathematics.

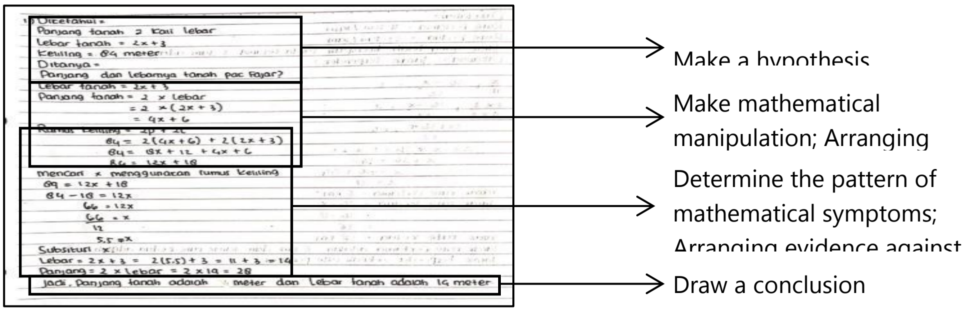

Figure 1. SV1 Answers to Questions Numbers 1

In the process of obtaining a value of $x = 5{,}5$ based on this equation, the length and width of the land can be calculated through substitution in the equation $p = 4x + 6$, and the width is $l = 2x + 3$. It turned out that SV1 only wrote down the length and width found without re-checking, so it didn't meet the indicators of drawing conclusions or making generalizations.

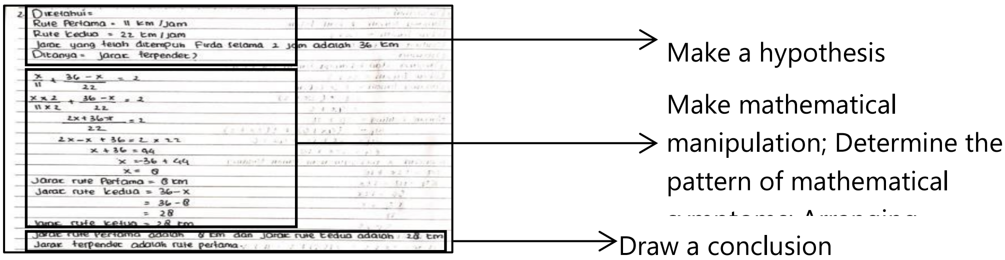

Figure 2. SV1 Answers to Questions Numbers 2

Analysis of the answers to question number 2 (Figure 2), SV1 also fulfills the indicator of making assumptions by writing down the information about the questions. Even though SV1 did not write down the mathematical model of the problem, it was found from interviews that SV1 was able to explain the pattern used to solve the problem. Then SV1 arranges the pattern using the equation $t = \frac{s}{v}$ and obtains $\frac{x}{11} + \frac{36-x}{22} = 2$. Solving this equation shows the result $x = 8$ and the distance traveled on the first route. Next, SV1 substitutes the x value in the second $36 - x$ route equation and obtains the distance traveled. In the final stage, SV1 made generalizations by determining the shortest distance traveled by Firda during jogging.

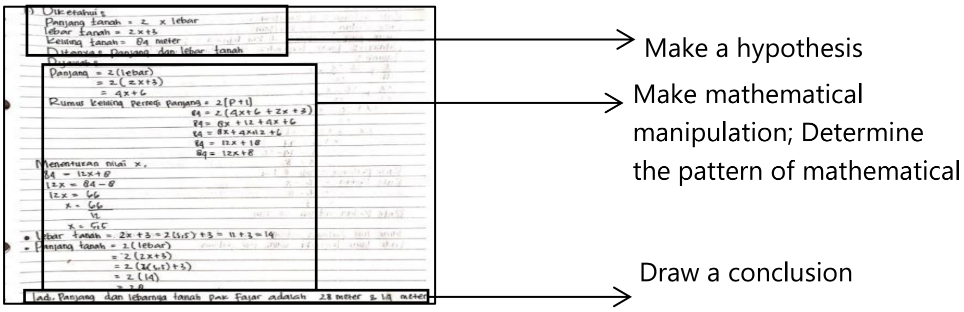

Figure 3. SV2 Answers to Questions Numbers 1

Figure 3 shows that SV2 could write down information about questions to make conjectures, which was the initial stage in solving problems. Then, SV2 writes a mathematical model by determining the equation $2 \times l = 2(2x + 3) = 4x + 6$. SV2 performs the process of substituting the perimeter of the rectangle, and equation $84 = 12x + 18$ is obtained, so it can be said that SV2 can fulfill the second indicator. SV2 analyzes the problem of using patterns by determining x to determine the length and width of Pak Fajar's land. SV2 utilizes the previous equation to obtain $x = 5{,}5$. Furthermore, SV2 constructs the proof by substituting the x values in the length and width equations and obtains $p = 14$ m and $l = 28$ m. In the final stage, he concludes with the answers obtained. SV2 writes that the length and width of the land is 14 meters and 28 meters.

SV2 wrote down the information as the first step in solving problem number 2 (Figure 4) but did not write down the mathematical model of the problem. Analysis of the results of the interviews shows that SV2 can explain the origin of the patterns it uses. Then he made a pattern using the formula $t = \frac{s}{v}$ and obtained $\frac{x}{11} + \frac{36-x}{22} = 2$. SV2 compiles evidence to get answers from the patterns that have been made. In the end, SV2 gets the value $x = 8$, and the distance traveled on the first route is obtained. In solving the problem to determine the distance traveled for the second route, SV2 uses the $36 - x$ equation so that the g-distance for the second route is 28 km. From the final answer, SV2 could conclude that the shortest distance was on the first route of $8\ k$

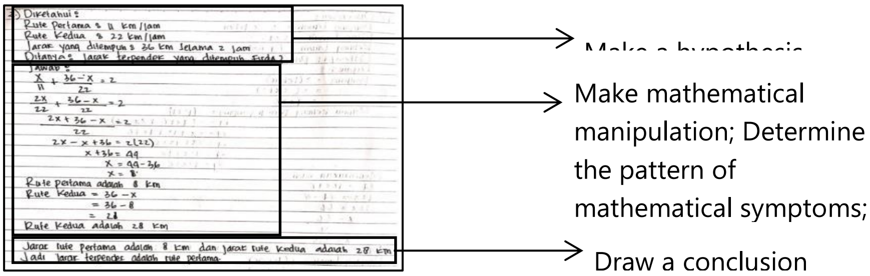

Figure 4. SV2 Answers to Questions Numbers 2

Auditorial Learning Styles Students

Figure 5 shows SA1 writing the complete information on the problem. He created a mathematical model for the long equation of the land, namely $p = 2 \times l = 2(2x + 3) = 4x + 6$, then substituted the p and l in the formula for the perimeter of the rectangle to get a new equation. In the next step, SA1 analyzes the problem using the substitution method to solve problem number 1. SA1 uses the substitution method to obtain the length and width and obtains $x = 5{,}5$. $p = 28$ and $l = 14$ are obtained by substituting the x value in the equations $p = 4x + 6$ and $l = 2x + 3$. The final stage is to conclude that the length and width of the land are 28 and 14 meters.

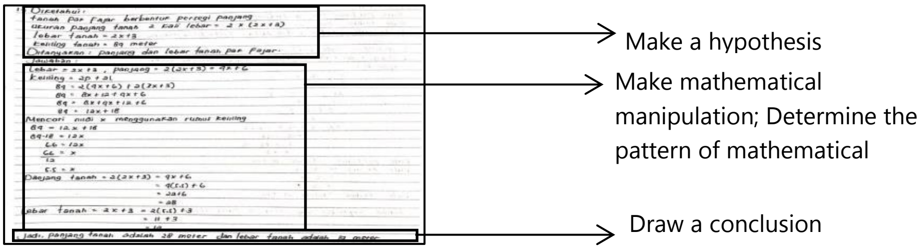

Figure 5. SA1 Answers to Questions Numbers 1

Based on Figure 6, SA1 writes down the complete information on the problem for question number 2. SA1 also creates a mathematical model with variable x as the first route and $36 - x$ for the second route, then determines the pattern through the substitution method. SA1 uses the formula $t = \frac{s}{v}$, and writes the equation $\frac{x}{11} + \frac{36-x}{22} = 2$. SA1 makes the denominators of the fractions equal $\frac{2x+36-x}{22} = 2$ to solve this equation.

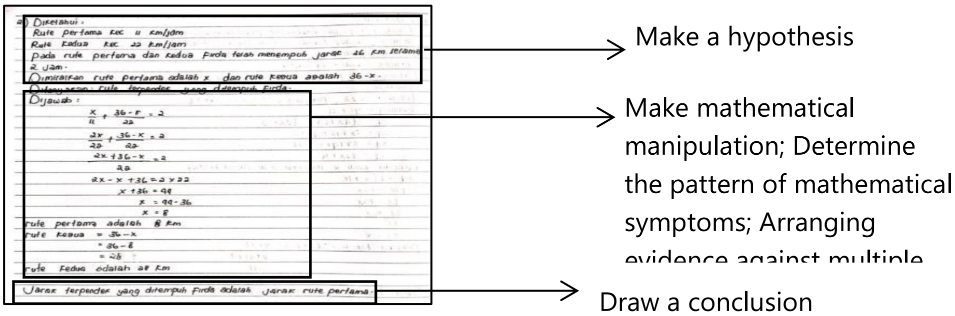

Figure 6. SA1 Answers to Questions Numbers 2

In the next process, SA1 multiplies both sides by 22 and collects similar variables, and the equation $2x - x = 44 - 36$ is obtained. This process obtains the result $x = 8$. In the final stage, SA1 concludes by stating that the shortest distance traveled by Firda is the first route. Furthermore, for SA2, the test results can be seen in Figure 7 below.

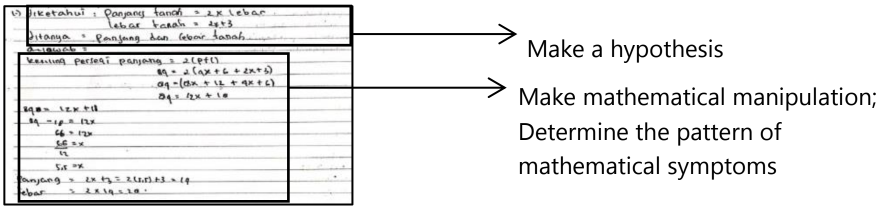

Figure 7. SA2 Answers to Questions Numbers 1

Based on Figure 7 and interviews, SA2 could not provide complete information about the questions. SA2 also doesn't mention the mathematical model of the problem but immediately writes $k = 12x + 18$ and $84 = 12x + 18$. From the interview, he was able to explain the x variable used. Then, he analyzes the problem using the substitution method to get the value of x and finds the length and width of the land. SA2 made an error in the calculation process, so the final result is wrong. On the answer sheet, he mistakenly wrote the equations p and l. After obtaining the final answer, he does not make conclusions so that it does not meet the last indicator.

As shown in Figure 8, SA2 was able to make predictions by writing down the complete information about the second question but did not write down the mathematical model of the problem.

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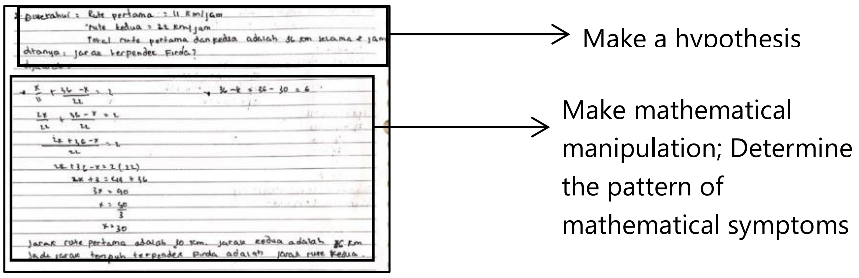

Figure 8. SA2 Answers to Questions Numbers 2

SA2 immediately writes the equation $\frac{x}{11}+\frac{36-x}{22}=2$ to get the value for x. Furthermore, SA2 analyzes the problem using substitution. After finding a pattern, he compiles the proof but makes a mistake in the calculation process, so the final result is wrong. SA2 concludes the final answer but is wrong. It means that SA2 fulfills 3 out of 5 reasoning indicators.

Kinesthetic Learning Styles Students

SK1 test results can be seen in Figure 9 below.

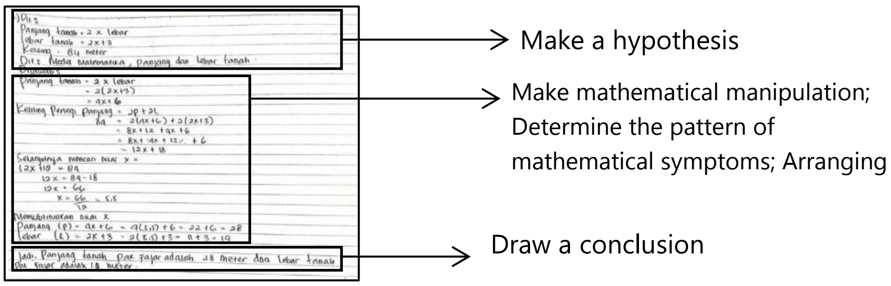

Figure 9. SK1 Answers to Questions Numbers 1

Based on Figure 9, SK1 wrote down the question information, namely $p = 2 \times width$, width $l = 2x + 3$, and circumference 84 meters, as well as questions to determine the length and width of Pak Fajar's land. In the next step, SK1 performs manipulation by creating a mathematical model. SK1 analyzes the problem using the substitution method and constructs evidence by first determining the length and substituting the value of x in the equation $p = 2(2x+3) = 4x + 6 = 4(5,5) + 6 = 28$. SK1 determines the width by substituting $l = 2x + 3 = 2(5,5) + 3 = 14$. In the final stage, SK1 completed the problem by writing the conclusion that the length and width of the land are 28 and 14 meters. SK1 fulfills all indicators of reasoning ability

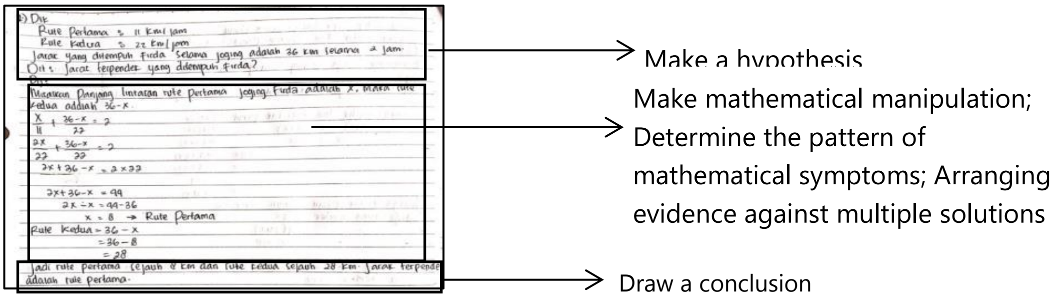

Figure 10. SK1 Answers to Questions Numbers 2

It can be seen in Figure 10 that SK1 wrote down the complete item information for the second question, then wrote down the mathematical model. SK1 performs mathematical manipulation by using the variable x for the length of the first route, while for the second route, it is $36 - x$. SK1 uses the substitution method to solve the equation. After finding a pattern, SK1 constructs the evidence by substituting the variable x to obtain the distance on the second route. This result means he can use patterns to analyze to draw the correct conclusions. SK1 concludes that the distance traveled by Firda on the first route is 8 km, and the distance on the second route is 28 km, so the shortest distance is on the first route. SK1 can fulfill all indicators of reasoning.

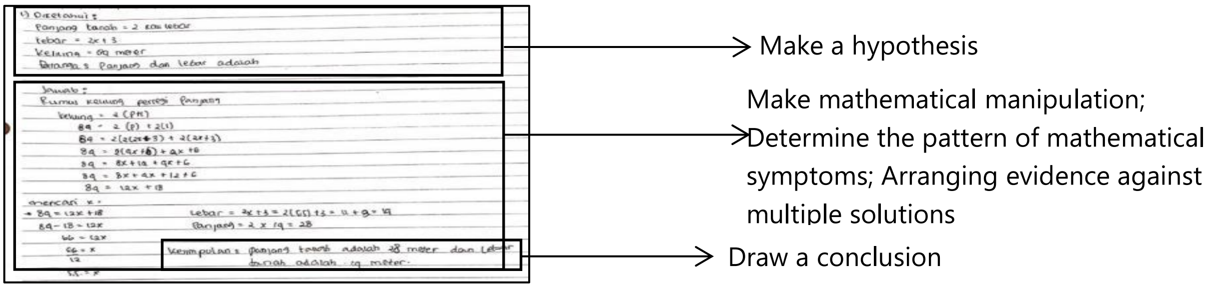

Figure 11. SK2 Answers to Questions Numbers 1

It can be seen from Figure 11 that SK2 was able to write down what was known and asked in the problem, namely the length of the land $p = width$, width $l = 2x + 3$, and the circumference was 84 meters, and questions to determine the height and width of Pak Fajar's land. SK2 can make a mathematical model and immediately write down the equation of the perimeter of a rectangle, then use the substitution method to obtain the value of x as well as the length and width of the land using the equation of the perimeter. SK2 determines the width by substituting the value x at $l = 2x + 3 = 2(5{,}5) + 3 = 14$and calculating the length at $p = 2 \times l = 2 \times 14 = 28$. This result means that SK2 can use patterns to analyze to draw the correct conclusions. In the final stage, SK2 concludes the final answers. SK2 meets all indicators of reasoning ability for question number 1.

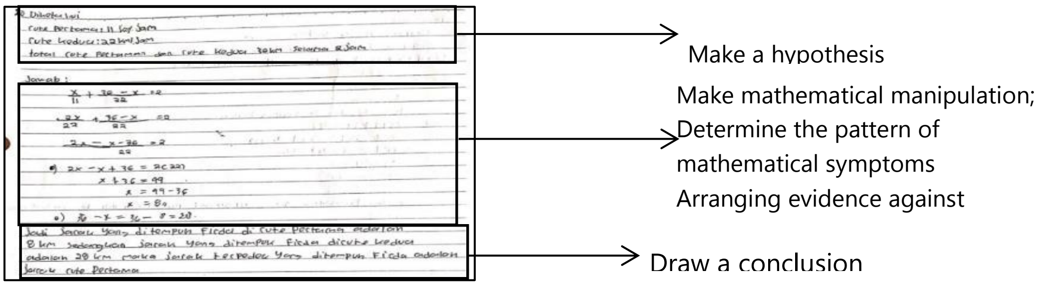

Figure 12. SK2 Answers to Questions Numbers 2

SK2 mentioned what was known and asked in the second problem, then made a mathematical model (Figure 12). Although not written on the answer sheet, SK2 was able to explain the meaning of variable x during the interview. SK2 analyzes the problem using the pattern, then substitutes the variable x to calculate the distance for the second route. This process shows that SK2 can use patterns to analyze item information to draw the correct conclusions. The conclusion written by SK2 is that the distance between the first and second routes is 8 and 28 km, so the shortest distance taken by Firda is the first route. SK2 has good reasoning ability, shown by all indicators being met.

The results of the data analysis show that subjects with visual and kinesthetic learning styles fulfill better reasoning indicators than subjects with auditory learning styles. They can make conjectures in dealing with mathematical problems, carry out mathematical manipulations, determine patterns and characteristics of mathematical phenomena, compile evidence, and draw conclusions. Subjects with a kinesthetic learning style can only make conjectures, perform mathematical manipulations, and determine patterns of mathematical phenomena. They cannot compile evidence from the solutions obtained and conclude the problem-solving process. The results of previous research stated that students with a visual learning style could write down information systematically and clearly when solving math problems (Apipah & Kartono, 2017). Analysis of the results of the interviews also shows that subjects with visual learning styles can explain the steps for solving the problems they face along with relevant reasons according to the solutions to the problems solved. These results align with previous research that the characteristics of subjects with a visual learning style can clearly and eloquently describe the conclusions about the answers they get (Setiana & Purwoko, 2020).

On the other hand, subjects with an auditory learning style tend to think fast but can write down information about questions even though they are incomplete (Apipah & Kartono, 2017). In this study, subjects with an auditory learning style did not write complete answers. They only write down the answers they think are important and don't write down the counting steps because they do the computations mentally. Based on the interviews, they could present the final, well-earned answers.

The two subjects with kinesthetic learning styles fulfill all reasoning indicators. Both subjects could explain their answers well during the interview but were slow. It is consistent with previous research that students with kinesthetic learning styles speak slowly (slowly), learn directly (practice), use real objects as learning aids, and are not good at spelling words, so they have difficulty expressing opinions and are difficult to keep silent (Daik, M. Abi, & I. Bien, 2020).

CONCLUSION

Based on data analysis, it is known that students with visual and kinesthetic learning styles fulfill all reasoning indicators. They tend to have better reasoning abilities than students with an auditory learning style. It is because students with visual and kinesthetic learning styles are used to working systematically, unlike students with auditory learning styles who like to think fast.

Given the differences in students' mathematical reasoning abilities for different learning styles, further research can be conducted to compare students' mathematical reasoning abilities quantitatively for visual, auditory, and kinesthetic learning styles.

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