MATHEdunesa

Homepage: https://ejournal.unesa.ac.id/index.php/mathedunesa/index
Email: mathedunesa@unesa.ac.id

p-ISSN: 2301-9085; e-ISSN: 2685-7855
Vol. 13 No. 1 Tahun 2024
Halaman 104-118

MATHEMATICAL REASONING OF HIGH SCHOOL STUDENTS IN SOLVING *AKM* GEOMETRY AND MEASUREMENTS PROBLEM VIEWED FROM MULTIPLE INTELLIGENCES

Sabrina Wimala Putri[1], Rooselyna Ekawati[2]

[1,2]Mathematics Education, Universitas Negeri Surabaya, Surabaya, Indonesia

DOI: https://doi.org/10.26740/mathedunesa.v13n1.p104-118

Article History:
Received: 30 July 2023
Revised: 4 December 2023
Accepted: 26 February 2024
Published: 26 February 2023

Keywords:
Mathematical reasoning, geometry and measurement, logical-mathematical intelligence, linguistic intelligence, visual-spatial intelligence
***Corresponding author:**
sabrina.19046@mhs.unesa.ac.id

Mathematical reasoning is needed in solving *AKM* problems. Mathematical reasoning can be shown through geometry material. One of the factors that influence mathematical reasoning is multiple intelligences. Multiple intelligence is a theory presented by Gardner which states that each individual has eight intelligences. The three intelligences that affect the learning process of mathematics are logical-mathematical, linguistic, and visual-spatial intelligence. This study aims to describe students' mathematical reasoning in solving *AKM* problems about geometry and measurement content viewed from multiple intelligences. This research is qualitative research. The subjects of this study were three senior high school students consisting of one person each who has dominant logical-mathematical, linguistic, and visual-spatial intelligence. Data collection was carried out by providing multiple intelligence questionnaires, *AKM* geometry and measurements problems, and interviews. The data were analyzed based on the selected mathematical reasoning indicators. The results of the study show that: Student with dominant logical-mathematical intelligence analyze a problem by giving reasons based on important information using logic. Student with dominant linguistic intelligence and student with dominant visual-spatial intelligence analyze a problem by giving reasons using the help of an image that represents the shape described in the problems. Each student implements a strategy to solve the problem according to what was planned in the previous stage by giving reasons based on the results to be obtained. In reflecting on a solution to a problem, each student draws a conclusion by giving reasons based on the results obtained from implementing the strategy and providing evidence by giving reasons based on the calculation results.

INTRODUCTION

Education is one of the most important aspects of human life. Education is needed to prepare every human being to solve the problems faced in life today and in the future. In most education systems, mathematics is a compulsory subject from elementary school through college. According to the National Council of Teachers of Mathematics (2000: 7) regarding standard processes in learning mathematics in schools, it is stated that, "The next five Standards address the processes of problem solving, reasoning and proof, connections, communication, and representation". It can be concluded that one of the goals of learning mathematics is related to reasoning.

Susanah (2017) states, mathematical reasoning is logical thinking to draw conclusions based on statements that have been proven true or based on premises or information provided. This opinion is in line with the statement of Hidayati and Widodo (2015) which states that reasoning is a thinking process to draw conclusions or make a new correct statement based on several previously known statements using a logical method. It can be concluded that reasoning is a process of logical thinking to obtain conclusions based on statements that are proven to be true and have been known before.

OECD (2018:3) states, "Mathematical literacy in the 21st century includes mathematical reasoning and some aspects of computational thinking.". Brodie (2010: 7) states "Mathematical reasoning is reasoning about and with the objects of mathematics.". Mathematical reasoning is the process of logical thinking about mathematical objects to obtain conclusions based on statements that are proven to be true and have been known before. NCTM (2009) states that mathematical reasoning includes the following processes: analyzing a problem, implementing strategy, seeking and using connections across different mathematical domain, context, and representation, and reflecting on a solution to a problem. Mathematical reasoning is needed in solving math problems, especially numeracy. According to Vebrian, et al. (2021), this is because solving numeracy problems involves a logical thinking process to explore and connect parts of the problem to make conclusions, check answers, or provide justification for the reports/solutions obtained. In Indonesia, numeracy problems are a tool to measure students' numeracy competence in the *Asesmen Kompetensi Minimum* (*AKM*).

Asesmen Kompetensi Minimum (*AKM*) was designed with the aim of encouraging the implementation of innovative learning that is oriented towards developing reasoning abilities and not just focusing on memorization (Rohim, et al., 2021). In the numeration of *AKM*, there are four contents that are tested, namely numbers, geometry and measurement, algebra, and data and uncertainty. Wijaya and Dewayani (2021: 81) state that geometry and measurement are content that assesses students' competencies regarding the introduction of shapes to the use of the concepts of volume, surface area, and congruence in everyday life. In addition, it also assesses students' understanding of measuring length, weight, time, volume and discharge, as well as area units using non-standard units and standard units and assesses competence in using directions, plot coordinate systems, and Cartesian coordinate systems and area units using standard units. NCTM (2000:41) states that, "Geometry is a natural place for the development of students' reasoning and justification skills, culminating in work with proof in the secondary grades". Geometry is material in mathematics that can develop and demonstrate the reasoning abilities of high school students.

Mathematical reasoning is influenced by several things. Dawahdeh and Mai (2021) state that, "Multiple intelligence had a significant and positive indirect influence on thinking pattern.". Multiple intelligences have a positive influence on thinking processes. It can be concluded that multiple intelligences affect mathematical reasoning because mathematical reasoning is a thinking process, as previously defined.

Howard Gardner developed a theory which states that every individual has eight intelligences. This theory is called the theory of multiple intelligences. In his book, Howard

Gardner mentions that there are eight multiple intelligences, including (1) linguistic intelligence, (2) logical-mathematical intelligence, (3) visual-spatial intelligence, (4) bodily-kinesthetic intelligence, (5) musical-rhythmic intelligence, (6) intrapersonal intelligence, (7) interpersonal intelligence, and (8) naturalistic intelligence. Armstrong (2009:15) states, basically, every individual has all of these intelligences. However, all of these multiple intelligences work in a certain way that is different for each individual so that each individual has a tendency towards a certain intelligence.

In relation to learning mathematics, logical-mathematical intelligence involves the ability to analyze problems logically, find mathematical formulas or patterns and investigate things naturally (Suarca, et al., 2005). Logical-mathematical intelligence is also closely related to linguistic intelligence in relation to the elaboration of mathematical logical reasons (Irvaniyah & Akbar, 2014). Armstrong (2009: 6) mentions linguistic intelligence as "the capacity to use words effectively, whether orally (e.g., as a storyteller, orator, or politician) or in writing (e.g., as a poet, playwright, editor, or journalist).”. According to Suarca, et al. (2005), visual-spatial intelligence makes individuals able to imagine geometric or three-dimensional shapes more easily because they are able to accurately observe the spatial world and transform this perception including the capacity to visualize and present visuals with graphics or spatial ideas.

The linkages between mathematical reasoning assessed through *AKM* numerical content of geometry and measurement and the effect of multiple intelligences on reasoning raises the problem of how mathematical reasoning can be done between students who have dominant multiple intelligences differ in solving *AKM* problems with the same geometry and measurement content. Based on the background that has been described, this study aims to analyze the mathematical reasoning process of high school students who have dominant logical-mathematical multiple intelligences, dominant linguistic multiple intelligences, and dominant visual-spatial multiple intelligences in solving *AKM* problems on geometry and measurement content.

METHOD

This research is descriptive research with a qualitative approach. This study aims to describe the mathematical reasoning of high school students who have dominant logical-mathematical, linguistic, and visual-spatial multiple intelligences in solving *AKM* problems about geometry and measurement content. This research was conducted at SMAS Hang Tuah 2 Gedangan. The data presented is qualitative data regarding students' mathematical reasoning in solving *AKM* problems about geometry and measurement content viewed from multiple intelligences. The instruments used consisted of: Multiple Intelligences Questionnaire, *AKM* geometry and measurement content problems, and interview guidelines.

The Multiple Intelligences Questionnaire was distributed to 30 students. The results of the questionnaire were used to select three groups of students with dominant logical-mathematical, linguistic, and visual-spatial multiple intelligences. Furthermore, *AKM* problems were given to the three groups of students. After giving *AKM* problems, three research subjects were selected, consisting of one student with dominant linguistic intelligence, one student with dominant logical-mathematical intelligence, and one student with dominant visual-spatial intelligence. These students were students who could solve *AKM* problems with the most efficient steps in accordance with the indicators of mathematical reasoning in this study and have equivalent mathematical abilities that tend to be high (the difference in average scores is not more than 5). The average score is determined by calculating the average score of the trigonometry material assessment and the midterm assessment score. The indicators of mathematical reasoning are presented as follows.

Table 1. Mathematical Reasoning Indicators

Indicators	Activities	Code
Analyzing a problem	Identifying relevant mathematical concepts, procedures, or representations that reveal important information about the problem and contribute to its solution by giving reasons	A1
	Making preliminary deductions and conjectures by giving reasons	A2
Implementing a strategy	Making purposeful use of procedures by giving reasons	B1
	Monitoring progress toward a solution	B2
Seeking and using connections across different mathematical domain, context, and representation	Using connections across different mathematical domain, context, and representation by giving reasons	C1
Reflecting on a solution to a problem	Interpreting a solution and how it answers the problem by giving reasons	D1
	Justifying or validating a solution by giving reasons	D2

These indicators were adapted by selecting activities on the mathematical reasoning indicators by NCTM (2009) which appears in the *AKM* problems used to collect data.

RESULT AND DISCUSSION

The data collection process was conducted in X-3 grade consists of 30 students. Based on the results of the multiple intelligences questionnaire, the results of solving numerical *AKM* problems, and the average score of mathematics subject, 3 research subjects were selected consisting of 1 person who had dominant logical-mathematical intelligence, 1 person who had dominant linguistic intelligence, and 1 person who had dominant visual-spatial intelligence with average mathematics score of each subject classified as equal and tends to be high. The code of each research subject is presented in the table below.

Table 2. The code of research subjects

Subject	Average Score	Dominant Multiple Intelligence	Code
ARP	96	Logical-mathematical	LM
KHN	94	Linguistic	LI
AFZA	94	Visual-spatial	VS

The chosen subjects would do an interview to examine their mathematical reasoning based on the results of solving numerical *AKM* problems by each subject. The mathematical reasoning carried out by research subjects are described based on mathematical reasoning indicators presented in Table 1.

Result dan Data Analysis

The following are the mathematical reasoning for each subject based on the results of completing the *AKM* problems and the interview.

1. Subject with Dominant Logical-Mathematical Intelligence

The results of solving *AKM* geometry and measurement problems as well as the results of interviews by LM are presented below.

Table 3. Interview Transcript of LM

	Transcript	Indicator
R:	Here is your answer sheet. Here you did not write what is known and asked in the problem. Why don't you write it down?	
LM:	Because after I read the problem, it is clear what is known, so I did not rewrite it.	
R:	So, what information do you think is important from this problem to answer the problem?	
LM:	First, there is this first pot with a diameter of 36 cm on the top circle, 30 cm in diameter on the bottom circle, and 21 cm in height. Then the second here is a tubular pot with a diameter of 14 cm and a height of 18 cm.	A1
R:	Okay. What happened to the pots?	
LM:	The soil from the first pot will be transferred to some tubular pots.	A1
R:	After reading this problem, in your opinion, what concept is used to solve this problem?	
LM:	The concept that can be used is volume, right? cylinder volume. So, we have to find the volume of the first pot and the tubular pot.	A1
R:	So according to your guess, what is the order of solving this problem?	
LM:	First, find the volume of the truncated cone. Then find the volume of the tubular pot and multiply it by 6, because there are 6 tubular pots. Then calculate the difference between the two volumes by subtracting, because the soil is transferred. If there is remainder from the subtraction result, it means that 6 tubular pots are not enough.	A2
R:	Why do you think so?	
LM:	Because at the beginning, the soil was in the first pot. This pot is in the shape of a truncated cone. Then the soil will be transferred to tubular pots. So, I have to know the volume of each pot. The volumes are subtracted to find out whether this tubular pot is enough or not.	A2
R:	Why did you think the first pot was in the shape of a truncated cone?	
LM:	Because if I imagine it, the shape is like a cone that doesn't have a sharp part. So, this pot has the shape of a truncated cone.	A2
R:	Previously, did you already know about the volume concept you mentioned earlier?	
LM:	Yes. Yesterday I saw it on the internet.	
R:	On your problem-solving sheet, are your solving steps in line with your guess? Did you use the strategy you mentioned earlier?	
LM:	Yes, I use it	
R:	Can you explain, what are the steps?	
LM:	So, here is the volume of the truncated conical pot. The formula is $\frac{1}{3} \times \pi \times t({r_1}^2 + {r_2}^2 + r_1 r_2)$. Then the first pot sizes are substituted into the formula and the answer is 18.018 cm^3. Then for the volume of the tube pot, the formula is $\pi \times r^2 \times t$ then multiplied by 6 because there are 6 pots, the answer is 16,632 cm^3. Then, the two volumes are subtracted, and the result is 1,386 cm^3. So, this means that there is land left. This means that the volume of the truncated cone is larger so that if you move the soil there must be some left in the truncated cone pot.	B1
R:	What do these formulas and answers represent?	

LM:	The volume of this truncated cone represents the volume of the truncated cone pot. The volume of the tube represents the volume of the tube pot, here there are 6 pots so the formula is multiplied by 6.	C1
R:	So, while working on this, did you double check your answers?	
LM:	Yes, I did	B2
R:	So, what's your conclusion?	
LM:	In conclusion, I disagree with the opinion in the problem which states that 6 tubular pots are enough to be filled with soil from the truncated cone pot.	D1
R:	Now, try to prove that your conclusion is correct	
LM:	The volume of 7-tubular pots is 19,404 cm3. Bigger than the volume of the truncated cone pot so 7 is enough to be filled with the soil.	D2

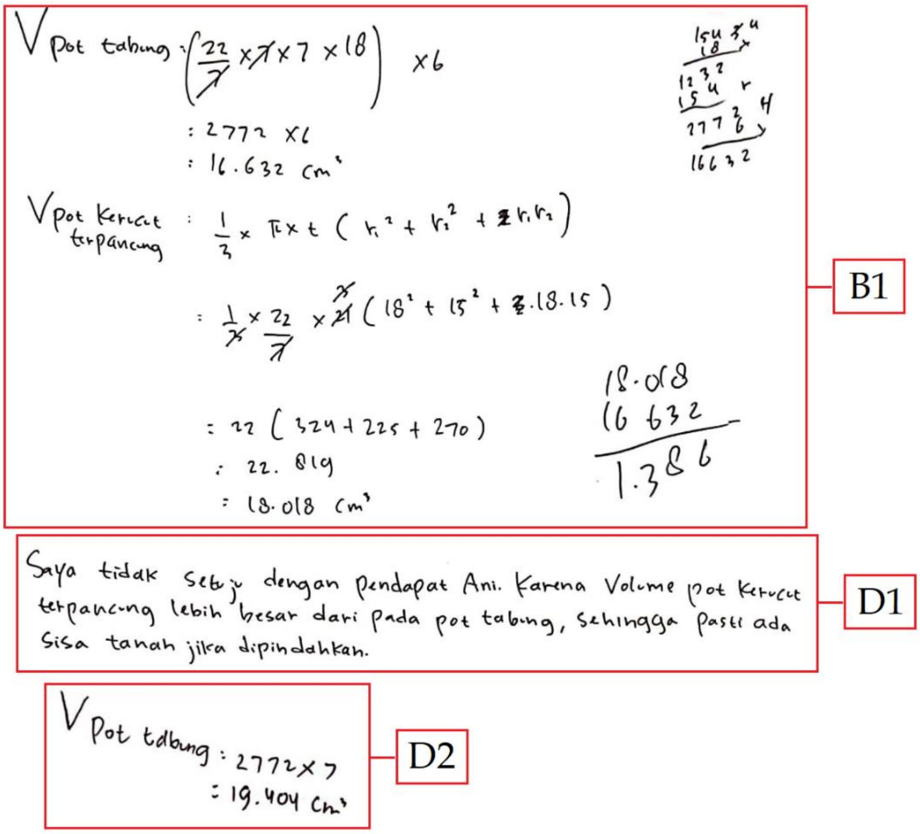

Figure 1. LM's problem solving to *AKM* geometry and measurements problem

In the process of analyzing a problem, LM identified the concept of a spatial volume relevant to the problem by imagining the shape of the pots described in the problem. This is in accordance with Gardner and Hatch (1989) who state that children with logical-mathematical intelligence have a sensitivity to logic. This is also in accordance with the results of research by Aziz, et al. (2020) which states that students with logical-mathematical multiple intelligences are able to use their logic to understand the geometric shapes described in the problem. In determining whether or not 6 tube pots were filled with soil from the first pot, subject LM thought of a strategy by calculating the difference between the volume of soil and the volume of 6 tubular pots with the reason to find out if there was any soil left in the first pot after being transferred. The strategy mentioned by subject LM will provide a conclusion whether or not 6 tube pots are sufficient to be filled with soil from the first pot.

In the process of implementing a strategy and seeking and using connections across different mathematical domains, context, and representation, LM implements strategies according to what is expected in the process of analyzing problems. Subject LM substituted the sizes of the tubular pots into the formula for the volume of the cylinder multiplied by 6 with the reason to calculate the volume of 6 tubular pots. Subject LM also substituted the sizes of the first pot into the formula for the volume of the truncated cone with the reason for calculating the volume of soil. After that, subject LM calculated the difference between the volume of the soil and the volume of 6 tube pots with the reason to determine the remaining volume of soil in the first pot after being transferred.

In the process of reflecting on a solution to a problem, LM concluded that she disagrees with the opinion in the problem which stated that only 6 tubular pots were needed to be filled with all the soil from the first pot. The reason is because the results of calculating the difference between the volume of the first pot and the volume of the 6 tube pots show that there is soil left in the first pot after being transferred to the 6 tube pots. To prove the correctness of the solution, LM showed that the number of tube pots needed to be filled with all the soil from the first pot was 7 because the volume of the 7 tube pots was bigger than the volume of the first pot.

From the processes described above, it can be seen that LM completed the steps in a coherent and logical manner. This is in accordance with the opinion of Gardner and Hatch (1989) which states that children with logical-mathematical intelligence have the ability to handle long chains of reasoning.

2. Subject with Dominant Linguistic Intelligence

Table 4. Interview Transcript of LI

	Transcript	Indicator
R:	In your opinion, what concept can be used to solve this problem?	
LI:	Volume	A1
R:	Okay, what's your reason for using the concept of volume to work on this problem?	
LI:	Because what is asked in the question is the number of tubular pots needed. So, I need to know the volume of the soil and the volume of the tubular pot.	A1
R:	Describe the strategy you came up with to solve this problem	
LI:	So, the first step is to determine the volume of the first pot. Then, find the volume of the tubular pot. After that, divide the volume of the first pot by the volume of the tubular pot. The result is the number of tubular pots needed	A2
R:	Have you ever studied about volume?	
LI:	Yes, I have	
R:	Okay. So, on your answer sheet, is it in accordance with the strategy you mentioned earlier?	
LI:	Yes, it is	
R:	If so, try to explain how you work on this problem from what you wrote here?	
LI:	First, I drew and wrote down the known information in the problem, which is the first pot and its dimensions. The first pot is in the shape of a truncated cone. Then, I also draw the tubular pot and write down the sizes. Then, what is asked is do I agree with the opinion on the question?	B1
R:	Okay, next	
LI:	The volume of the first pot is equal to the volume of the soil. I calculated the volume of this first pot using the formula for the volume of the truncated cone. The answer is 18.018 cm^3. So, the volume of the soil is also 18.018 cm^3.	B1

R:	Okay, so this is where you're calculating the volume of the soil, right?	
LI:	Yes	
R:	Why did you use the volume formula for the truncated cone to calculate the volume of the soil?	
LI:	Because the soil is in the first pot. The first pot is a truncated cone shape.	C1
R:	Okay, next.	
LI:	I calculated the volume of the tubular pot using the cylinder volume formula. The answer is 2.772 cm^3. So, the volume of the tubular pot is 2.772 cm^3.	B1
R:	Okay, next.	
LI:	I calculated the number of tubular pots needed. The volume of soil divided by the volume of the tubular pot. The answer is 6,5. So, the number of tubular pots is 6,5.	B1
R:	Why did you divide these volumes to find the number of tubular pots?	
LI:	Because the soil will be transferred from the first pot to the tubular pot. The volume of the soil is the same as the volume of the first pot. So, these volumes are divided to calculate the number of tube pots needed.	C1
R:	When calculating all this, did you double check the steps again?	
LI:	Yes	B2
R:	What's the conclusion?	
LI:	In conclusion, the results of the soil volume and the volume of the tubular pot were not in accordance with Ani's opinion, who only needed 6 tube pots to fill the soil from the first pot. From what I calculated earlier, 7 tube pots are needed.	D1
R:	Can you provide evidence that your conclusion is correct?	
LI:	If 6 tubular pots are used, the volume is smaller than the volume of the soil. The volume of the tube pot is 16.632 cm^3 while the volume of the soil is 18.018 cm^3. That way there will be leftover soil in the first pot.	D2

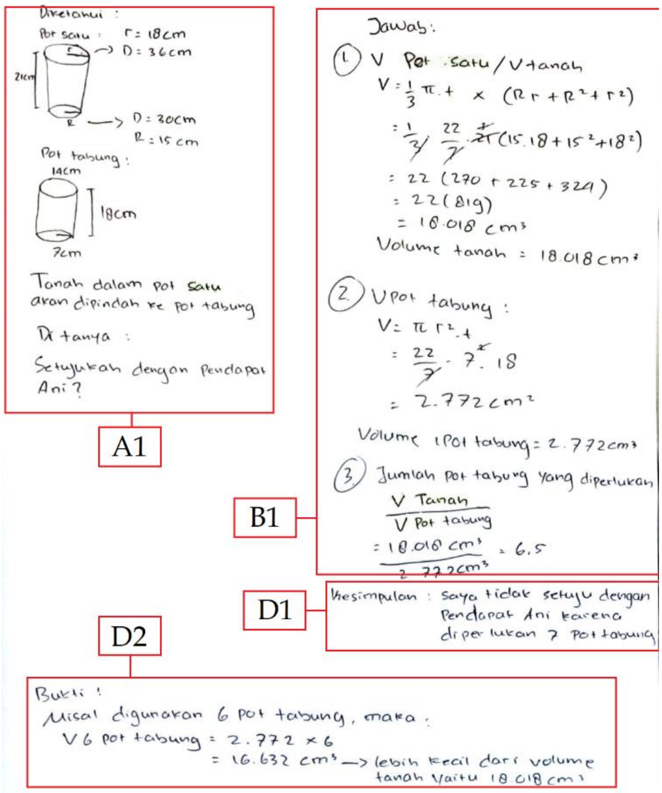

Figure 2. LI's problem solving to *AKM* geometry and measurements problem

In the process of analyzing a problem, LI writes down in detail the important information in the problem. This is in accordance with the opinion of Armstrong (2009: 6) which states that children with linguistic intelligence are able to use words effectively.

LI identifies the concept of geometric volume that is relevant to the problem by creating a geometric representation according to the description in the problem. LI explained that the reason the concept was relevant was because to determine the number of tubular pots needed, she had to know the volume of soil and the volume of the tubular pots. In this process, LI carries out activities using connections across different mathematical domains, contexts, and representations where the context is the pot described in the problem and represented in a geometric figure. In determining whether or not 6 tube pots were enough to be filled with soil from the first pot, LI thought of a strategy by dividing the volume of soil by the volume of the tubular pot. From this strategy, the number of tubular pots needed to be filled with all the soil from the first pot will be obtained.

In the process of implementing a strategy and seeking and using connections across different mathematical domains, contexts, and representations, LI implements strategies according to what is known in the process of analyzing problems. Subject LI substituted the sizes of the first pot into the formula for the volume of the truncated cone. The reason is to find the volume of soil that has the same value as the volume of the first pot. LI also substituted the tubular pot measurements into the cylinder volume formula. The reason is to know the volume of the tube pot. Then, subject LI divided the volume of the soil by the volume of the tubular pot with the reason to determine the number of tubular pots that could be filled with all the soil from the first pot. In the process of implementing this strategy, LI provides written information on the answer sheet regarding the process of calculating what is done at each step. This is in accordance with the opinion of Maskar, et al. (2022) in his research which states that someone who has high linguistic intelligence is able to understand complex problems and associate them with an idea in a systematic and logical manner.

In the process of reflecting on a solution to a problem, LI concluded that she did not agree with the opinion in the question that only 6 tubular pots were needed to be filled with all the soil from the first pot by giving reasons because the results of dividing the volume of soil by the volume of the tubular pot showed that 7 tubular pots were needed to be filled with all the soil from the first pot. To prove the correctness of this solution, LI showed that 6 tubular pots were not enough to contain the soil from the first pot by giving the reason that the volume of the 6 tubular pots was smaller than the volume of the soil.

3. Subject with Dominant Visual-Spatial Intelligence

Table 5. Interview Transcript of VS

	Transcript	Indicator
R:	What concept did you think of after reading this question?	
VS:	When I look at this problem, I think about the volume of the truncated cone. Then I thought about the concept of the volume of tubular for the second pot. Then, because the soil completely fills the first pot and will be divided into the tubular pots, the volume of the truncated cone will be divided by the volume of the tubular pot.	A1
R:	Okay, from that way what results will be obtained?	

VS:	Find the number of tubular pots needed to fill all the soil	A2
R:	Have you ever studied or know about the concepts you mentioned earlier?	
VS:	Yes. It was yesterday.	
R:	Okay. You mentioned the truncated cone earlier. Why do you use the concept of the volume of a truncated cone?	
VS:	Because the first pot had different top and bottom diameters and when it was drawn it had the shape of a truncated cone.	A1
R:	Then, why do you use the concept of volume?	
VS:	Since the first pot is filled with soil and will be moved, it is necessary to know the amount of soil in the pot.	A1
R:	Here is your answer sheet yesterday. Does it match the strategy you mentioned earlier?	
VS:	Yes. It matches.	
R:	Please explain, what are the steps?	
VS:	At the beginning, I drew the pots and then I wrote down the data in the problem. There are sizes of the first pot and tubular pot sizes. Then, the soil in the first pot will be transferred to a tubular pot. Then I started writing the formulas for the volume of a truncated cone and for the volume of a cylinder. The volume of the truncated cone is $\frac{1}{3}\pi a \times (Rr + R^2 + r^2)$ where a is the height of the truncated cone, R is the radius of the base, and r is the small radius of the lid. After that, the measurements from this data were entered and calculated. The answers for the volume of the truncated cone are 18,018 cm^3 and the volume of the cylinder is 2,772 cm^3.	B1
R:	What do the results you get indicate?	
VS:	Indicates the volume of soil in the first pot. For the volume of the tube shows the volume of the tubular pot	C1
R:	Okay, after that, continue here?	
VS:	Yes. After I found the two volumes of the geometric shape, I divided the volume of the truncated cone by the volume of the cylinder where I got the result of 6.5.	B1
R:	Why did you divide the volume of the truncated cone by the volume of this cylinder? What is the reason?	
VS:	Because the soil was transferred from the first pot to the tube pot, the soil seemed to be divided.	B1
R:	Okay. If so, what is your conclusion?	
VS:	My conclusion, I do not agree with this opinion where she said she only needed 6 pots. While the result I found was 6.5 so he needed at least 7 pots.	D1
R:	Please, try to prove that your opinion is correct.	
VS:	The volume of the tubular pot can be rounded up to 3,000. If there are 6 pots, the total volume is 18,000. So, it is still less than the volume of the truncated cone. Whereas if there are 7 tubular pots the total volume is 21,000 so there will be one pot that is not full.	D2
R:	OK, while working on this problem, did you double check the steps or the numbers?	
VS:	Yes, I did	B2

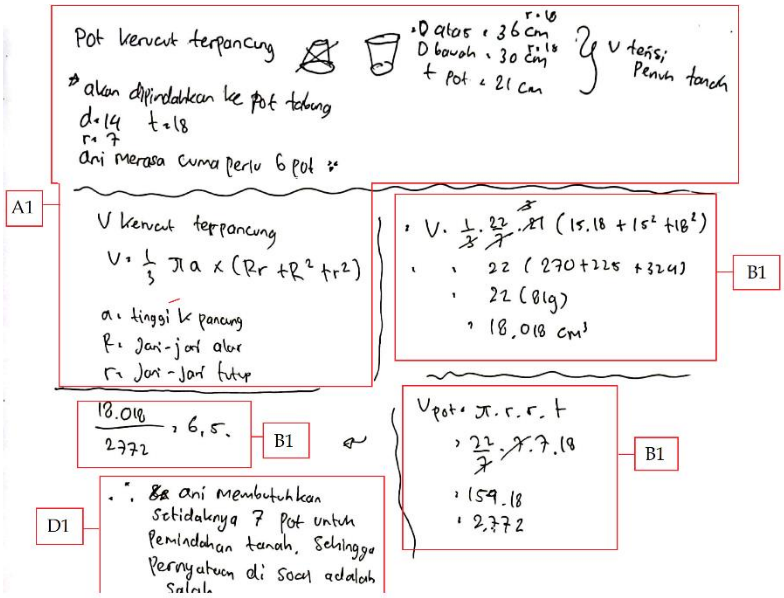

Figure 3. VS's problem solving to AKM geometry and measurements problem

In the process of analyzing a problem, VS identified that the concept of the volume of a geometric shape is relevant to the problem by drawing a geometric shape based on the description in the problem. VS explained that the reason the concept was relevant was because the first pot was filled with the soil to be moved, so it was necessary to calculate the volume of the soil. In this process, VS carries out using connections across different mathematical domains, contexts, and representations where the context is the tube pot described in the problem and represented in a geometric figure. This shows that VS requires the help of image visualization to determine the concepts relevant to the problem. This is in accordance with what is stated by the results of research by Aziz (2020) which states that students with visual-spatial multiple intelligences need image assistance to solve problems that involve recognizing the characteristics of a geometric object, but this is not in accordance with the theory presented by Suarca, et al. (2005) which states that individuals with visual-spatial intelligence can imagine geometric or three-dimensional shapes more easily. In determining whether or not 6 tubular pots were sufficient to be filled with all the soil from the first pot, subject VS thought of a strategy by dividing the volume of soil by the volume of the tubular pot by giving reasons because he needed to know the number of tubular pots needed to accommodate the soil.

In the process of implementing a strategy and seeking and using connections across different mathematical domains, contexts, and representations, VS implements strategies according to what is known in the process of analyzing problems. VS substitutes the sizes of the first pot into the formula for the volume of the truncated cone. The reason is to find out the volume of soil that is equal with the volume of the first pot. VS also substituted the sizes of the cylindrical pot in the formula for the volume of the cylinder. The reason is to calculate the volume of a tubular pot. After that, VS divided the volume of the soil by the volume of the tubular pot, with the reason of determining the number of tubular pots that could be filled with all the soil from the first pot.

In the process of reflecting on a solution to a problem, VS concluded that he disagreed with the opinion in the question which stated that only 6 tubular pots were needed to be filled with all the soil from the first pot by giving reasons because the results of dividing the volume of soil by the volume of the tubular pot showed that 7 tubular pots were needed to be filled with all the soil from the first pot. To prove the correctness of the solution, subject LI showed that there would be residual soil in the first pot after being transferred to 6 tubular pots by giving the reason that the volume of the 6 tube pots was smaller than the volume of the soil while the volume of the 7 tube pots was bigger than the volume of the soil so there will be 1 pot that is not completely filled with soil if 7 tube pots are filled with all the soil.

CONCLUSIONS AND SUGGESTIONS

Conclusions

Based on the results of data analysis and discussion, the researchers draw the following conclusions:

1. **Mathematical Reasoning of High School Students with Dominant Logical-Mathematical Intelligence in Solving AKM Geometry and Measurement Problem**
   In the indicator of analyzing a problem, students with dominant logical-mathematical intelligence identify concepts and strategies for solving questions using logic if the description of geometric shapes has been explained explicitly in the problem. In determining relevant concepts and strategies, students with multiple logical-mathematical intelligence give reasons based on important information obtained from the questions. In the indicator of implementing a strategy, students with dominant logical-mathematical intelligence apply the strategy according to what was previously mentioned by giving reasons based on the results to be obtained. In solving problems, students with dominant logical-mathematical intelligence also monitor progress toward solutions by re-examining the steps and calculation results. In the indicator of seeking and using connections across different mathematical domain, context, and representation, students with dominant logical-mathematical intelligence use symbolic representations to represent a variable that must be searched for to solve problems. In the indicator reflecting on a solution to a problem, students with dominant logical-mathematical intelligence provide conclusions that answer questions on the problem by giving reasons based on the solutions obtained from implementing the strategy and proving the correctness of these solutions by giving reasons based on the results of calculations.
2. **Mathematical Reasoning of High School Students with Dominant Linguistic Intelligence in Solving AKM Geometry and Measurement Problem**
   In the indicator of analyzing a problem, students with dominant linguistic intelligence represent important information from the problem in the form of an image according to

the description of the problem. Students also write down important information from the problem in the form of sentences. Students with dominant linguistic intelligence identify concepts and strategies that are relevant to the problem by paying attention to images that represent the context of the problem. In determining relevant concepts and strategies, students with dominant linguistic intelligence give reasons based on the images made and important information obtained from the questions. In the indicator of implementing a strategy, students with dominant linguistic intelligence apply the strategy according to what was previously mentioned by giving reasons based on the results to be obtained. Students with dominant linguistic intelligence write a lot of words or sentences that explain the steps in implementing the strategy. In solving problems, students with linguistic dominant multiple intelligences also monitor progress toward solutions by re-examining the steps and calculation results. In the indicators of seeking and using connections across different mathematical domain, context, and representation, students with dominant linguistic intelligence represent information in the problem in the form of pictures and words or sentences. Students also use symbolic representations to represent a variable that must be searched to solve the problem. In the indicator reflecting on a solution to a problem, students with dominant logical-mathematical intelligence provide conclusions that answer questions on the problem by giving reasons based on the solutions obtained from implementing the strategy and proving the correctness of these solutions by giving reasons based on the results of calculations.

3. **Mathematical Reasoning of High School Students with Dominant Visual-Spatial Intelligence in Solving AKM Geometry and Measurement Problem**

   In the indicator of analyzing a problem, students with dominant visual-spatial intelligence represent important information from the problem in the form of an image based on the description on the problem. Students also write down important information from the problem in the form of words or sentences. Students with dominant visual-spatial intelligence identify concepts and strategies that are relevant to the problem by paying attention to images that represent the context of the problem. In determining relevant concepts and strategies, students with dominant visual-spatial intelligence give reasons based on the images made and important information obtained from the problem. In the indicator of implementing a strategy, students with dominant visual-spatial intelligence apply the strategy according to what was previously mentioned by giving reasons based on the results to be obtained. In solving problems, students with visual-spatial dominant multiple intelligences also monitor progress toward solutions by re-checking the steps and calculation results. In the indicators of seeking and using connections across different mathematical domain, context, and representation, students with dominant visual-spatial intelligence represent information in the problem in the form of images. Students also use symbolic representations to exemplify a variable that must be searched to solve the problem. In the indicator reflecting on a solution to a problem, students with dominant visual- spatial intelligence provide conclusions that answer questions on the problem by giving reasons based on the solutions obtained from implementing the strategy and proving the correctness of these solutions by giving reasons based on the results of calculations.

Suggestions

Based on the results of this study, the researcher provides the following suggestions:

1. There are differences in the mathematical reasoning of students with dominant multiple intelligences logical-mathematical, linguistic, and visual spatial so that teachers are advised to provide learning methods based on multiple intelligences to maximize students' potential.
2. The research carried out still does not dig deeper into the reasons students apply certain procedures so that other researchers who will conduct research on reasoning, are advised to compile interview guidelines that can explore the reasons for students' reasoning more deeply.

REFERENCES

Armstrong, T. *Multiple Intelligences in the Classroom*. Virginia: ASCD

Aziz, A. J., Juniati, D., & Wijayanti, P. (2020). Students' Reasoning With Logical Mathematical and Visual Spatial Intelligence in Geometry Problem Solving. *Proceedings of the International Joint Conference on Science and Engineering (IJCSE 2020)*, pp.203-207.

Brodie, K. (2010). *Teaching Mathematical Reasoning in Secondary School Classrooms*. New York: Springer.

Dawahdeh, A. M. A, & Mai, M. Y. (2021). The Relationship between Multiple-Intelligence and Thinking Patterns through Critical Thinking among 10th-Grade Students in Private Schools in Abu Dhabi. *European Journal of Education*, 4(2), pp. 12-27.

Gardner, H., & Hatch, T. (1989). Multiple Intelligences Go to School: Educational Implications of the Theory of Multiple Intelligences. *Educational Researcher*, 18(8), pp. 4-10.

Gardner, H. (1993). *Frame of Mind: The Theory of Multiple Intelligences*. NY: BasicBooks

Hidayati, A., Widodo, S. (2015). Proses Penalaran Matematis Siswa dalam Memecahkan Masalah Matematika pada Materi Pokok Dimensi Tiga Berdasarkan Kemampuan Siswa di SMA Negeri 5 Kediri. *Jurnal Math Educator Nusantara*, 1(2), pp. 131-143.

Irvaniyah, I., & Akbar, R. O. (2014). Analisis Kecerdasan Logis Matematis Dan Kecerdasan Linguistik Siswa Berdasarkan Jenis Kelamin (Studi Kasus Pada Siswa Kelas Xi Ipa Ma Mafatihul Huda). *Eduma : Mathematics Education Learning and Teaching*, 3(1), pp. 138-159

Maskar, S., Puspaningtyas, N. D., & Puspita, D. (2022). Linguistik Matematika: Suatu Pendekatan untuk Meningkatkan Kemampuan Pemecahan Masalah Non-Rutin Secara Matematis. *Mathema Journal*, 4(2), pp.118-126.

NCTM. (2000). *Principles and Standards for School Mathematics*. USA: Key Curriculum Press.

OECD. (2018). PISA 2022 Mathematics Framework (Draft).

Rohim, D. C., Rahmawati, S., & Ganestri, I. D. (2021). Konsep Asesmen Kompetensi Minimum untuk Meningkatkan Kemampuan Literasi Numerasi Siswa Sekolah Dasar. *Jurnal Varidika*, 33(1), pp. 54-62.

Suarca, K., Soetjiningsih, S., & Ardjana, I. E. (2005). Kecerdasan Majemuk pada Anak. *Sari Pediatri*, 7(2), pp. 85-92.

Susanah. (2017). *Profil Penalaran Mahasiswa Calon Guru dalam Membuktikan Teorema Segitiga Ditinjau dari Perbedaan Kemampuan Matematika*. Disertasi Tidak Dipublikasikan. Universitas Negeri Surabaya, Surabaya.

Vebrian, R., Putra, Y. Y., Saraswati, S., & Wijaya, T. T. (2021). Kemampuan Penalaran Matematis Siswa dalam Menyelesaikan Soal Literasi Matematika Kontekstual. *Jurnal Program Studi Pendidikan Matematika*, 10(4), pp. 2602-2611

Wijaya, A., & Dewayani, S. (2021). *Framework Asesmen Kompetensi Minimum (AKM)*. Jakarta: Pusat Asesmen dan Pembelajaran Badan Penelitian dan Pengembangan dan Perbukuan Kementerian Pendidikan dan Kebudayaan.