THINKING PROCESS OF VISUAL-SPATIAL INTELLIGENCE OF 15-YEAR-OLD STUDENTS IN SOLVING PISA STANDARD PROBLEMS

Dian KURNIATI
Study Program of Mathematics Education, Faculty of Teacher Training and Education, University of Jember, Indonesia
dian.kurniati@unej.ac.id

SUNARDI
Study Program of Mathematics Education, Faculty of Teacher Training and Education, University of Jember, Indonesia
sunardifkipunej@yahoo.com

Dinawati TRAPSILASIWI
Study Program of Mathematics Education, Faculty of Teacher Training and Education, University of Jember, Indonesia
dinawati.fkip@unej.ac.id

Titik SUGIARTI
Study Program of Mathematics Education, Faculty of Teacher Training and Education, University of Jember, Indonesia
titiksugiarti@unej.ac.id

Muhammad Alfan ALFARISI
Study Program of Mathematics Education, Faculty of Teacher Training and Education, University of Jember, Indonesia
alfanalfarisimuhammad88@gmail.com

ABSTRACT
Visual-spatial intelligence is one of the basic intelligences needed in mathematics learning. Visual-spatial intelligence consisted of 4 characteristics, namely imagination, conceptualization, problem solving and pattern determining. This reserach aims to describe the visual-spatial intelligence of 15-year-old students in solving PISA standard problems. The type of this research was descriptive research with qualitative approach. The research participants consisted of 67 students aged 15 years. The used data collection methods were tests and interviews. The research indicators were based on 4 characteristics of visual-spatial intelligence, and each characteristic was stated in each question number. Data analysis was done by looking at the indicator achievement of each characteristic of visual-spatial intelligence from each research participant. Based on the data analysis of test and interview, it obtained the tendency on each characteristic as follows: a) imagination, students were included in the high level category with the tendency of being able to meet all indicators except the fourth indicator; b) conceptualization, students were included in the high level category with the tendency of being able to meet all the indicators provided; c) problem solving, students were included in the moderate level category with the tendency of being able only to meet the first and second indicators of the 4 indicators provided; d) pattern determining, students were included in the high level category with tendency of being able to meet 4 indicator provided.

Keywords: Thinking process, visual-spatial intelligence, PISA standard problems

INTRODUCTION

Progamme for International Students Assessment (PISA) is a study of the international level assessment of 15-year-old students related to the knowledge and the skills of students divided into 3 main assessments that are science, reading and math (OECD, 2014). The PISA study aims to provide an evaluation to the education system in a country around the world by testing students in abilities and skills of science, reading and math. Based on PISA results in 2015, it was known that Indonesian students were ranked 63 out of 70 countries in term of math skill and ability with the percentage of female students more dominant than male students (OECD, 2016). Furthermore, the ability of students in Indonesia in solving cognitive problems of PISA standard is low that is not able to reflect by providing another solution (Kurniati & Annizar, 2017). It shows that students' mathematical literacy ability and skill in Indonesia are still very low. Whereas the ability of mathematical literacy is very important for students in developing their thinking ability when solving a daily problem that is the ability to design, plan, diagnose, evaluate, summarize, generalize, and give suggestion (Goksu & Gulcu, 2016).

Intelligence is a natural talent that God gave to humans. Each individual has a unique and various levels of intelligence. The intelligence of each child is classified into 8 types of intelligence categories known as Multiple

Intelligence Theory (Smith, 2002, 2008). The 8 intelligences include 1) Verbal / Linguistic Intelligence, (2) Logical-Mathematical Intelligence, (3) Visual Spatial Intelligence, (4) Bodily-Kinesthetic Intellegence, (5) Musical Intelligence, (6) Interpersonal Intelligence, (7) Intrapersonal Intelligence, (8) Naturalist Intelligence. The concentration in this research was the visual-spatial intelligence of students in solving the problems of PISA content of shape and space that was translated into Indonesian and had been adapted to social and cultural conditions in Jember Regency.

Visual-spatial intelligence is a personal ability to create a mindset about the spatial world; using and manipulating this mindset in solving every problem related to the spatial world (Gardner, 2006). Visual-spatial intelligence is closely related to the learning of geometry (Kelly, 2017). The cause of low understanding and ability of students in solving geometry problems is generally caused by the object of geometry that is quite abstract and the students' visual-spatial ability is still low. Therefore, it is very important to improve students' visual-spatial ability in order to increase the percentage of students' understanding in geometry learning. The suitable implementation of learning strategies with the character of students can develop students' visual-spatial ability maximally. This research aimed to describe students' visual-spatial intelligence by looking at the tendency of each characteristic of student's visual-spatial intelligence. The research results were expected to help educators to know the characteristics of students' visual-spatial intelligence and become the first benchmark in formulating the appropriate strategy and method of learning geometry and can be applied especially in schools that became research place or all equal schools.

The instruments used in this research were PISA standardized problems and interview guideline. PISA standardized problems were PISA problems that had been translated into Bahasa Indonesia and had been adapted to local social and cultural conditions. Problem PISA is divided into some contents that are Change and Relationship, Space and Shape, Quantity, Uncertainty of Data. In this research, the content of PISA problem used was Space and Shape content where each question represented each characteristic of visual-spatial intelligence. PISA standardized problems were expected to really measure the students' visual-spatial intelligence because in solving the problem of PISA, it was not only needed the concept understanding but also required high order thinking skill and skills in applying mathematical concepts.

Visual-spatial intelligence has 4 main characteristics: imagination, conceptualization, problem solving and pattern-seeking. Characteristics of visual-spatial intelligence are divided into 4 which can be prepared the indicators used in research (Hass, 2003). The characteristic of imagination is the personal ability to understand the visual explanation rather than the audio explanation. From the definition, it can be formulated the indicators as follows: 1) Students are able to write down what is known and asked; 2) Students are able to pour a picture and information about PISA standardized problems of geometry material in their mind into image form; 3) Students are able to write down the steps correctly; 4) Students are able to write the final answer correctly. The characteristic of conceptualization is the personal ability to link information in the problems with mathematical concepts. From the definition, it can be formulated indicators as follows: 1) Students are able to write down what is known and asked; 2) Students are able to connect between known data and the concept they have; 3) Students are able to write down the steps correctly; 4) Students are able to write the final answer correctly. The characteristic of problem solving is the personal ability to solve problems properly and be able to formulate divergent problem solution strategies. From the definition, it can be formulated the indicators as follows: 1) Students are able to write down what is known and asked; 2) Students are able to have divergent strategies in solving problems related to problems of PISA standardized of geometry material; 3) Students are able to write down the steps of work correctly 4) Students are able to write the final answer correctly. The characteristic of pattern-seeking is the personal ability to find various patterns related to geometry problems. From the definition, it can be formulated the indicators as follows 1) Students are able to write down what is known and asked; 2) Students are able to have divergent strategies in solving problems related to PISA standardized problems of geometry material; 3) Students are able to write down the steps correctly; 4) Students are able to write the final answer correctly. Those indicators were used to analyze students' test answers and map the students' visual-spatial intelligence level. The 12 leveling categories of visual-spatial intelligence are described in Table 1.

Table 1. Leveling of Visual-Spatial Intelligence for Each Characteristic

Description	Level
Students are able to mention all steps correctly as well as the correct final answer.	1
Students are able to mention all steps correctly but the final answer is incorrect.	2
Students are able to mention all steps correctly but no final	3

Description	Level
answer.	
Students are unable to mention all steps correctly, but they are able to give the final answer correctly.	4
Students are unable to mention all steps correctly, and they are unable to give the final answer correctly.	5
Students are unable to mention all tsteps correctly, and no final answer.	6
Students mention all steps incorrectly, but they are able to give the final answer correctly.	7
All steps are incorrect, and the final answer is incorrect.	8
All steps are incorrect and no final answer.	9
Steps of work are not mentioned, but they are able to give the final answer correctly.	10
Steps of work are not mentioned, and the final answer is incorrect.	11
Steps of work are not mentioned, and no final answer	12

Leveling categories were then divided into 3 categories namely high, medium and low categories. The high category consisted of students at level 1 to 4; the medium category consisted of students at level 5 to 8; the low category consisted of students at level 9 to 12. The students' spatial intelligence analysis in solving the PISA problem was based on each category of high, medium, and low.

METHOD

This research was a descriptive research using qualitative approach. This research aimed to analyze and describe the visual-spatial intelligence of 15-year-old students in solving PISA standardized problems. The taking of research participants was done at schools in Jember regency. The research participants consisted of 67 students born in 2001 with detail of 27 male students and 40 female students.

The used data collection methods in this research were test and interview; so that, the used research instrument was PISA standardized problem test and interview guideline. The interview was aimed to dig deeper information and obtain data that was not obtained from the test result related to students' visual-spatial intelligence.

At first, the research participants were given PISA standardized problem test. Based on test results, students would be mapped into several categories of visual-spatial intelligence. The research participants who had taken the test would be selected randomly to attend the interview. The taking of interview participants was done by paying attention to student's gender and data saturation level. The data from test result and interview would be analyzed by using Snowball Throwing method by paying attention to data saturation. The overall data was said to be saturated if the level of students' visual-spatial intelligence after the test and the interview did not change. Furthermore, to increase data validity, the researcher conducted triangulation of test result data with interview result data. The used triangulation was method triangulation. The result data of triangulation were analyzed by looking at the achievement of indicator from each characteristic of visual-spatial intelligence.

RESULT AND DISCUSSION

Based on the result of test data analysis, it was obtained achievement data of research participant indicator from each characteristic of visual-spatial intelligence as follows.

Table 2. The Indicators of Achievement from Each Charateristic of Visual-Spatial Intelligence

The Indicators of Achievement	Indicators of Visual-Spatial Intelligence															
	Imagining				*Conceptualizing*				*Problem-Solving*				*Pattern-Seeking*			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Satisfied	49	61	8	20	56	51	44	45	58	5	29	27	59	65	54	66
Unsatisfied	18	6	59	47	11	16	23	22	9	62	38	40	8	2	13	1

Based on Table 2 above, the research participants can be categorized into high, medium and low categories as in Table 3 and Table 4 below.

Table 3. Leveling Category of Male Students' Visual-Spatial Intelligence after Test

Characteristic / Category	Imagining	Conceptualizing	Problem Solving	Patern Seeking
High	S03, S04, S12, S16, S18, S19, S21, S23, S30, S31	S01, S02, S03, S06, S14, S15, S17, S18, S19, S22, S26, S27, S28, S29, S30, S31, S32	S02, S05, S12, S15, S17, S18, S22, S25, S30, S32	S01, S03, S04, S05, S06, S13, S16, S17, S18, S19, S20, S21, S22, S24, S25, S26, S27, S29, S30, S32
Medium	S02, S05, S08, S13, S14, S15, S20, S22, S25, S26, S27, S28, S29, S32	S05, S12, S16, S20, S21, S23, S24, S25,	S01, S03, S04, S13, S14, S16, S19, S20, S21, S23, S24, S26, S27, S29, S31	
Low	S01, S17, S24	S04, S13	S06, S28	S02, S12, S14, S15, S23, S28, S31

Table 4. Leveling Category of Female Students' Visual-Spatial Intelligence after Test

Characteristic / Category	Imagining	Conceptualizing	Problem Solving	Patern Seeking
High	S07, S08, S38, S39, S52, S53, S55, S56, S57, S61, S62	S07, S08, S09, S34, S36, S38, S39, S40, S41, S42, S43, S45, S46, S47, S49, S50, S51, S52, S53, S54, S55, S56, S57, S58, S59, S61, S62, S63, S64, S66, S67	S08, S33, S38, S42, S43, S45, S49, S50, S51, S52, S53, S54, S56, S57, S58, S59, S61, S62, S63, S64 S66, S67	S07, S09, S10, S11, S33, S34, S35, S36, S37, S38, S39, S41, S42, S43, S44, S45, S46, S47, S48, S49, S50, S51, S52, S53, S54, S55, S56, S57, S58, S59, S60, S61, S62, S63, S64, S65, S66, S67
Medium	S09, S10, S11, S33, S35, S37, S41, S43, S45, S46, S47, S48, S49, S50, S51, S54, S58, S59, S60, S63, S64, S65, S66, S67	S10, S33, S35, S37, S60, S65,	S07, S09, S10, S11, S34, S35, S36, S37, S39, S40, S41, S44, S46, S47, S48, S55, S60, S65	
Low	S34, S36, S40, S42, S44	S11, S44, S48		S08, S40

After analyzing the results of the test data, then the researchers conducted interview to randomly selected students by paying attention on data saturation level. The total of students who followed the interview was 11 people with detail of 6 male students 5 female students. Based on the analysis of interview data, it was known that there was a level change on the research participants after interviewed. For example, the research participant of S05, after conducting test for characteristic of imagining, conceptualization, and problem solving, he was only on medium level, whereas for pattern seeking characteristic, he was on high level category, so the overall visual-spatial intelligence of research participant S05 was on medium level category. However, after the interview, there was a level change category on the characteristic of imagining and problem solving into high level category. It caused the category of visual-spatial level of research participant S05 became high level category. Generally, this level change was due to several reasons including students did not write down the steps or not all steps are mentioned correctly in doing test but students were able to mention all the steps correctly in interview. Students were less thorough in writing the final answer but students were able to mention step correctly in

interview. The students ran out of time; so that, the students did not write down the steps of work and final answer in doing the test, but students were able to mention the steps correctly in interview.

In imagining characteristic, the research participants tended to be in medium level category with the tendency of students at level 5. It happened because at this characteristic, students tended to be able to write what is known and asked, and able to pour information on problems into the form of image. Students did not write the steps of work during the test, but in the interview, students were able to mention the steps of work correctly. In addition, students tended to be less thorough in writing the final answer. Change levels before and after the interview was quite a lot happened. Of the 11 students interviewed, 6 students experienced a level change that was S01, S02, S03, S05, S08 and S09. Generally, the change was caused students did not write down the steps in doing test, but students were able to mention correctly in interview. Nevertheless, there were still some students who were difficult to understand the problem given; so that, students were not able to relate problems with mathematical concept. It caused the students unable to pour information on problems into the form of image. Based on table 3 and table 4, it was known that male students were more dominant than female students in term of imagining characteristic. It was in accordance with the research results which stated that there are significant differences in visual-spatial intelligence between men and women (Yenilmez & Kakmaci, 2015). Women's success rate was lower than that of men in solving problems.

In the conceptualizing characteristic, research participants tended to be on the high level category with the tendency of students at level 1. It happened because on this characteristic, students tended to be able to write what is known and asked, able to relate information in the problem with the mathematical concept, also able to write step of work and final answer correctly. Based on the data analysis results of test and interview, it could be seen that the conceptualizing ability of male and female students tended to be relatively the same. It was in line with the results of other researchers which suggested that there is no overly large difference between men and women associated with visual-spatial intelligence in solving a geometric problem (Seng & Chan, 2000). The level changes occurred on the conceptualizing characteristics was relatively less when compared with the imagining characteristic. It happened because the students' answers during tests and interviews remained consistent. The level change only occurred in 2 students out of 11 students who were interviewed e.g. S04 and S08 students. In the S04 student, the level change occurred because at the time of the test, the student ran out of time, so he did not do the given problem. However, at the time of the interview when the student was asked to mention the concept used and the step of accomplishing the problem, he was able to mention the steps of the work correctly. While the student S08, level change occurred because in the test, student was less thorough; so that, he did not write the final answer. However, in interview, the student was able to mention the final answer correctly. In this characteristic, it was also still found some students who were not able or wrong in relating problems with the mathematical concept.

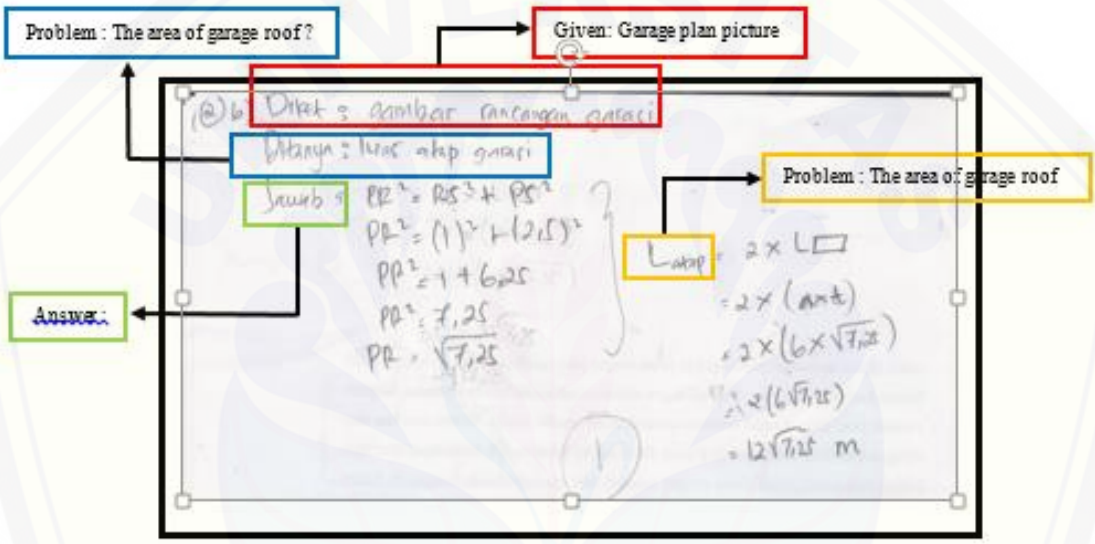
On the problem solving characteristic, research subjects tended to be on the medium level category with the tendency of students at level 5. It happened because on this characteristic, students tended only to be able to write what is known and asked, but students were unable to write the steps of work and the final answer correctly. In addition, students tended only to able to formulate one problem-solving strategy. Based on the data analysis results of test and interview, it could be seen that the problem solving ability of female students was more dominant than male students. This is suitable with the PISA results which stated that in term of problem solving, women were more dominant than men (OECD, 2016). Almost the same as the conceptualizing characteristics, the level change on problem solving characteristic was relatively few that only occurred in S05 students. The student's level change occurred due to in the test the student was less thorough in writing the final answer, so the final answer was incorrect, but in interview when the student was asked to mention the final answer, the student was able to mention the final answer correctly. On this characteristic, only a few students were able to meet all indicators given especially the second indicator. Based on the results of test and interview, it could be seen that students' mistake in accomplishing the problems caused by several reasons that was students were not able to relate the problem with the concept, so they were not able to formulate a problem-solving strategy correctly or the students were less thorough in writing the steps and final answer; so that, the step or final answer was incorrect.

On the pattern-seeking characteristic, research participants tended to be on the high level category with the tendency of students at level 1. It happened because on this characteristic, students tended to be able to write what is known and asked, and able to find the patterns contained in the problem. In addition, students were also able to write down the steps of work and the final answer correctly. Based on the data analysis results of test and interview, it could be seen that the ability of male students to solve relatively the same as female students. Level change in pattern-seeking characteristic was relatively less that only occurred in 2 students, e.g S02 and S08 students. Similarly with the level change in the two previous characteristics, on the pattern seeking characteristic,

change level occurred because the two students did not write the steps of work at the test, but able to mention the steps of work correctly during the interview. Based on the results of the test and interview, it could be seen that in accomplishing the problems related to the pattern seeking characteristic, students tended not to have trouble. It was seen from the number of students who were on high level category.

Based on the tendency description of each characteristic above, it could be concluded that gender did not give too much influence in term of students' visual-spatial intelligence. Other factors were more influential on students' visual-spatial intelligence such as students' high-order thinking skill and problem-solving skill. This conclusion was not suitable with the results of previous researches which suggested that male students are more dominant than women in terms of visual-spatial intelligence (Yenilmez & Kakmaci, 2015), but in line with other researches which suggested that gender does not have a significant effect on Students' visual-spatial intelligence (Seng & Chan, 2000). Both male and female students showed not too many different results when they were asked to solve the problems related to geometry problems.

High level category was a level category for students who tended to be at level 1 to 4 for each characteristic of visual-spatial intelligence. Here is an excerpt of an answer from one of the students who was in a high level category.

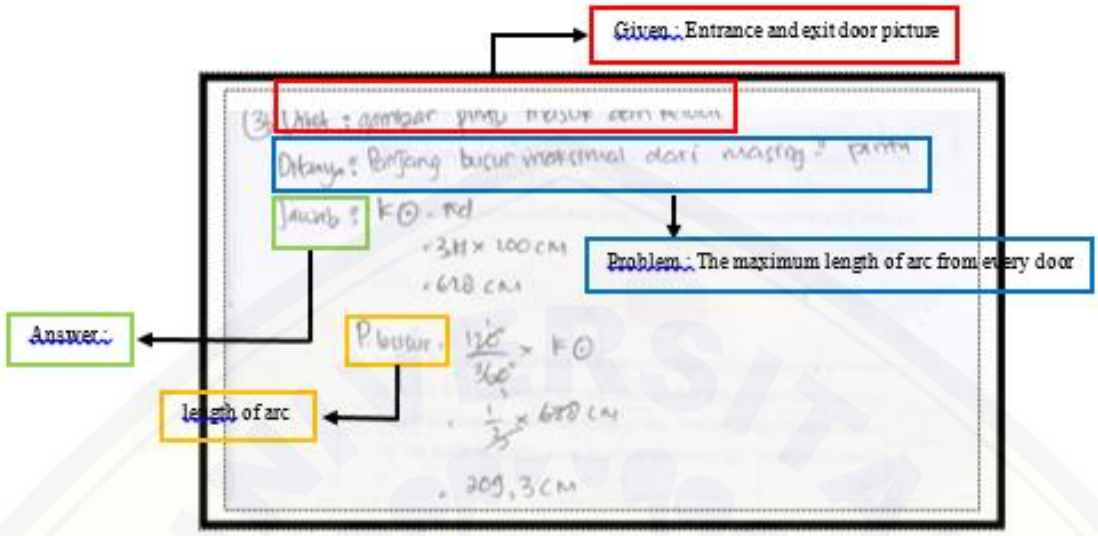


Picture 1. The example of student's answer on high category

Based on the data analysis results of test and interview, it could be seen that on the imagining characteristic, students on high-level category tended to be able to write down what is known and asked completely and correctly. Students were also able to pour information on the problem into the image form. In addition, students were also able to write down the steps of work and the final answer correctly. There were still some students on high-level who were less thorough in writing the final answer; so that, the final answers were written incorrectly. For the conceptualizing characteristic, students on high level category tended to write down what is known and asked completely and correctly. Students were also able to relate problems with mathematical concepts. In addition, students were able to write down the steps of work and the final answer correctly. In the conceptualizing characteristic, students tended to be at level 1, only some students who were not at level 1. It happened because students were wrong in relating problems with mathematical concept; so that, the steps of work were incorrectly written, but they were able to write the final answer correctly. In the problem-solving characteristic, students on high-level category tended to be able to write down what is known and asked completely and correctly. Students were also able to relate the problems with mathematical concepts, so able to write the steps of work and the final answer correctly. However, generally, students on high level category tended only to be able to formulate one strategy to solve the problem. From 32 high-level students, only 5 students were able to formulate a divergent solution strategy. In addition, there were also some students on high level category less thorough in writing the final answer; so that, the final answer was incorrect. In pattern search characteristics, high level category students tended to be able to write down what is known and asked. Students were also able to find the patterns in the problem, so they were able to write the steps of work and the final answer correctly. In pattern seeking characteristic, high level category students did not seem to have difficulties

in solving problems related to pattern seeking characteristic. It was seen from the number of high level category students who were at level 1.

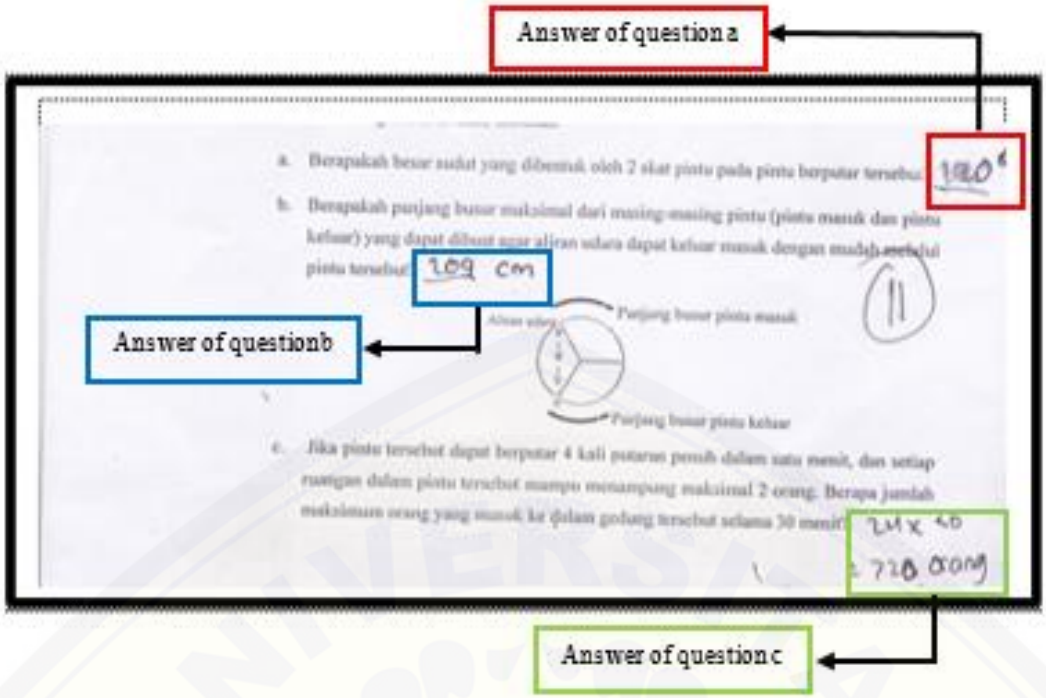
Medium level category was a level category for students who tended to be at levels 5 to 8 for each characteristic of visual-spatial intelligence. Picture 2 was an example of an answer belonged to one of the students who was in medium level category.



Picture 2. The example of student's answer on medium category

Based on the data analysis results of test and interview, it could be seen that on the imagining characteristic, medium level students tended to write down what is known and asked. In addition, students were also able to pour information on the problem into the image form. However, students tended not to write down the steps of work and less thorough in writing the final answer; so that, the final answer was incorrect. In imagining characteristic, students generally were at level 5. It happened due to students did not write the steps of work and the final answer correctly. Nevertheless, some students were at level 8 due to the inability of students in pouring the information contained in the problem into the image form; so that, all steps written along with the final answer were not true. For the conceptual characteristic, the students on medium level category tended to write down what is known and asked completely and correctly. The students were also able to relate the problem with the mathematical concept. However, students were not able to write down the steps of work and the final answer correctly. In the conceptualizing characteristic, students tended to be at level 5, and some students were at level 7 or level 8. Students who were at level 7 and 8 tended not able to relate problems with the correct mathematical concepts, so it caused that all steps of work were incorrect. Nevertheless, few students who were able to write the final answer even though the concept and steps of work were incorrect. In the problem-solving characteristic, the students on medium level category tended to be able to write down what is known and asked completely and correctly. Students also tended to be able to relate the problem with the mathematical concept, but not all the steps were written correctly, so the final answer was incorrect. Students on medium level tended to be able to formulate only one strategy to solve the problem. Generally, students' mistakes on this category were due to the students were less thorough and fooled, so there was as unmentioned step of work; so that, the final answer was incorrect. In addition, some medium level students were not able to relate problems with mathematical concept; so that, students had difficulties to formulate the strategies to be used. It caused all the steps of work and the final answers were incorrect. In pattern seeking characteristic, none of the research participants were in the medium level category. Nevertheless, the tendency of medium level students could be determined based on the achievement of indicators from level 5 to level 8. Students in medium level category tended to be able to write down what is known and asked. Students were also able to find the patterns in the problem but all the steps of work and the final answers were incorrect.

Low level category was a level category for students who tended to be at levels 9 to 12 for each characteristic of visual-spatial intelligence. Picture 3 was an example of an answer belonged to one of the students in a low level category.



Picture 3. The example of student's answer on low category

Based on the data analysis results of test and interview, it could be seen that on the imagining characteristic, the low level category students tended not write down what is known and asked. In addition, students were also not able to pour information on the problem into the image form, so students tended not to write down the steps and the final answer correctly. On this characteristic, students were generally at level 10 and 11. It happened because students had difficulty in pouring information on the problem into the image form; so that, students were not able to relate the problem with the concept and strategy that would be used. It caused that there were no students' steps of work, and the final answer was incorrect. For the conceptualizing characteristic, the low level category students tended not to write down what is known and asked. Students were also unable to relate problems with mathematical concepts. It caused that the students did not write the steps of work at all and the final answer was incorrect. In the conceptualizing characteristic, students tended to be at level 11 and some students were at level 12. Students at level 11 and 12 tended to be unable to relate the problem with the correct mathematical concepts; so that, there was no steps of work. Students argued that they had forgotten the material contained in the problem related to the conceptualizing characteristic. In the problem-solving characteristic, low level category students tended not to write down what is known and asked. Students also tended not able to relate the problems with mathematical concept; so that, the correct steps of work were not written. It caused the students on this level were unable to write the final answer correctly. Low level category students tended to be unable to formulate a strategy at all to solve the problem. Generally, students claimed that they had forgotten the material contained in the problems based on the problem solving characteristics. In pattern-seeking characteristic, there were only 9 students included in low level category. Low level category students tended not to write down what is known and asked. Students were also able to find the patterns in the problem. However, there were no the steps of work, but the students were able to write the final answer correctly. On this characteristic, students tended to be at level 10. Students admitted difficulty to write the steps of work because the students only imagine the steps of work. Nevertheless, one student was at level 11 because the student was not able to find the patterns of problems; so that, there were no steps of work, and the final answer was incorrect.

CONCLUSIONS

Based on the data analsysi result of test and interview, it can be concluded as follows

1. High category of visual-spatial intelligence tended to be able to write down what is known and asked, able to pour the information on the problem into images, able to relate the information with mathematical concepts, unable to formulate divergent solution strategies, able to find patterns, and able to write the steps of work and the final answer correctly.
2. Medium category of visual-spatial intelligence tended to be able to write down what is known and asked, able to pour the information on the problem into images, able to relate the information with mathematical

concepts, unable to formulate divergent solution strategies, able to find patterns, and unable to write the steps of work and the final answer correctly.

3. Low category of visual-spatial intelligence tended to be able to write down what is known and asked, unable to pour the information on the problem into images, unable to relate the information with mathematical concepts, unable to formulate divergent solution strategies, able to find patterns, there were no the steps of work, and unable to write the final answer correctly.

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