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Profile of MTs Students' Spatial Reasoning in Solving Contextual Problems Based on Mathematical Ability

Rizki Kurniawan Rangkuti[1)]*, Dwi Juniati [2)]
[1)] Mathematics Education, Faculty of Teacher Training and Education, Universitas Al Washliyah, Indonesia
[2)] Mathematics, Faculty of Mathematics and Natural Science, Universitas Negeri Surabaya, Indonesia

*Coresponding Author
Email : rizki.21038@mhs.unesa.ac.id

Abstract

Spatial reasoning as an important component in students' mathematical thinking and problem solving. How do students think spatially, how is the flow in solving contextual problems, this is spatial reasoning. Spatial reasoning consists of three characteristics, namely perceiving, visual-spatial and transforming. This research is included in descriptive qualitative which aims to describe the spatial reasoning of MTs students in imagining and explaining parts of objects, mentioning and describing parts of objects and changing the shape of objects from the problems given. The subjects in this study were three students from class VIII of MTs Negeri 3 Muara Ampolu Tapanuli Selatan who were taken from each level of mathematical ability, namely high, medium and low abilities after being given an initial math ability test. To find out the profile of students' spatial reasoning in contextual solving, the research subjects were given a spatial reasoning test. The results showed that students with high and moderate mathematical abilities in solving contextual problems that required spatial reasoning had good results. Meanwhile, low-ability students have difficulty in solving contextual problems so that their spatial reasoning has poor results.

Keywords: Spatial reasoning, Contextual problems, Mathematical ability.

INTRODUCTION

Contextual problems in learning are defined as objects of study obtained from everyday life. This is relevant to the statement of the Ministry of National Education (Yenti, 2009) that contextual problems help teachers relate the material they teach to real-world situations and encourage students to make connections between their knowledge and its application in their daily lives. According to Rangkuti, et al (2020) contextual learning is not just listening and taking notes, but learning is a direct experienced process. These objects can be taken from things that surround students' daily lives, one of which is culture. In addition, in everyday human interactions, they unwittingly carry out mathematical activities. By presenting the relationship between mathematics and culture in contextual problems in learning, it will enable students to understand mathematics material better. This is supported by the results of Fajriyah's research (2018) which states that mathematics associated with culture can facilitate students to construct mathematical concepts based on students' knowledge of their socio-cultural environment. The material that will be studied in contextual problems in this study is the material of flat shapes and spatial shapes which are included in geometric mathematical objects. Here, geometry is an object of knowledge that is learned by MTs students through the material of geometric shapes and flat shapes in class VIII. The material of spatial and flat shapes of geometric objects is presented in an abstract and concrete way. Geometry is called abstract because it relates to the object of the image that is learned from math books. This is in accordance with the opinion of Ayun, et al (Ismadji, 1993) which states that objects found in geometry are abstract objects. While geometric shapes are called concrete because they can be related to contextual problems. By presenting concrete objects through contextual problems

students will be guided in everyday life so as to allow students to get closer to mathematics. Based on the statement of NCTM (2000) that in general the geometric abilities that students must have to solve geometric problems, one of them is using spatial reasoning. In addition, Risalah (Kurniawan, 2019) states that thinking or spatial reasoning involves the location and movement of objects and oneself, both mentally and physically.

According to Rangkuti et al. (2020) learning so far is still dominated by teachers, students are less involved so that it seems monotonous and causes student boredom. Students in Indonesia have low achievement in spatial reasoning abilities as stated by Susilawati, et al (Latifah & Budiarto 2019), it is shown that low spatial reasoning competence is caused by the low ability of students to visualize objects contained in a problem that given. Based on information about students obtained from mathematics subject teachers, it shows that students' mastery of mathematics subjects about geometry still does not meet the minimum completeness criteria (MCC), there are only a few students whose scores meet the completeness criteria. Therefore, contextual problems are needed that contain geometry material, so that students are closer to mathematics so as to enable better learning achievements.

Spatial reasoning is the process by which information about objects in space and their relationships are collected by various means, such as measurements, observations, or inferences, and used to arrive at valid conclusions about the relationships of objects or in determining how to accomplish a particular task Sharma (1996). The indicator of student reasoning used in this study is based on the opinion of Armstrong (2013) which has the characteristics of perceiving, visual-spatial and transforming. Each of these characteristics has its own indicators. For more details, the spatial reasoning indicators of each characteristic can be written as follows:

Table 1. Spatial Reasoning Indicator

Characteristics	**Indicator**
Perceiving	Students are able to imagine the object part of the given problem. Students are able to explain the object part of the given problem.
Visual-Spatial	Students are able to name the object of the given problem. Students are able to describe the object of the given problem.
Transform	Students are able to change the shape of objects that are caught by the eye into other forms

The characteristic of perceiving has the meaning of revealing an understanding through empirical means, namely compiling, recognizing and interpreting sensory information in order to provide an understanding of an object from a given contextual problem. Meanwhile, visual-spatial characteristics mean that objects obtained based on space and time will be associated with visual abilities. When solving a contextual problem based on a given image object, the material concept will be connected to solve the contextual problem. After that, the characteristic of transforming has the meaning of changing the object obtained from the view into the form of another physical object. For example, we see a drum, then we store the memory in a mental object and then we pour the object back into the form of a tube or two inverse conical objects that are connected to each other.

The importance of spatial reasoning is stated by Wai, et al (Davis, 2015) that spatial reasoning and success in STEM (Science, Technology, Engineering and Mathematics) are strongly correlated. Spatial reasoning has an important role in geometry because to solve

contextual problems that contain geometry having an abstract object of study requires a spatial reasoning process in the component of spatial ability. This statement is supported by Astuti, et al (2016) who argue that if students have good spatial reasoning skills, these students can follow geometry lessons easily. Conversely, if students who have less spatial reasoning skills will have difficulty in learning geometry. The importance of spatial reasoning is stated by Pavlovicova & Svecoca (Tamizi, 2020) who argue that spatial reasoning plays a role in mathematics in the field of geometry. Spatial reasoning has an important role in geometry because to solve geometric problems that have abstract objects of study requires a spatial reasoning process in the component of spatial ability.

The relationship between spatial reasoning and ability in mathematics has been found in research conducted by Ayun, F.A.Q (2019). In his research, it was explained that the ability of spatial reasoning supports the development of students' abilities in solving certain problems. Students with good spatial reasoning will have better ability to solve contextual problems than students with low spatial reasoning.

Based on the description described above, this study aims to describe students' spatial reasoning in solving contextual problems in terms of the level of mathematical ability. In addition, the benefit of this research is to provide information or references for further research in the field of mathematics education related to spatial reasoning. Researchers hope that the results of this study can be used to improve mathematics education in Indonesia.

RESEARCH METHODS

This research is a descriptive study with a qualitative approach, because this study aims to describe students' spatial reasoning in solving contextual problems that are reviewed based on the level of mathematical ability. This research was conducted in class VIII of MTs Negeri 3 Muara Ampolu, Tapanuli Selatan. Research data obtained by using the test method. The instruments used in this study were the Early Mathematical Ability Test (EMAT) and the Spatial Reasoning Test (SRT). Data analysis was carried out by analyzing EMAT to determine the research subject. The criteria for the category of the subject's mathematical ability in this study are as follows:

Table 2. Criteria for Early Mathematics Ability

Test Score	Criteria
$86 \leq x \leq 100$	High
$75 \leq x < 86$	Midle
$0 \leq x < 75$	Low

SRT data analysis based on spatial reasoning indicators in this study are presented in Table 1. After analyzing the SRT data, the next analysis is analyzing the data with the stages of data reduction, data presentation, and drawing conclusions.

RESULTS AND DISCUSSION

EMAT is given to 12 students. From the results of the EMAT analysis and the consideration of the concerned mathematics teacher's suggestions, it was obtained 3 students who met the criteria and were used as research subjects. The details of the EMAT results of the three research subjects are presented in the following table:

Table 3. Research Subjects

Subject Code	Test Score	Criteria for Early Mathematics Ability
High Group (HG)	90	High
Midle Group (MG)	85	Midle
Low Group (LG)	74	Low

The selected research subjects were given SRT. The results and discussion of students' spatial reasoning in solving contextual problems in terms of the level of mathematical ability are as follows:

1. Spatial Reasoning of High Group Subjects

Subjects with high mathematical ability (HG) based on the results of spatial reasoning analysis on perceiving, visual-spatial and transforming characteristics in solving contextual problems have very good achievements. This is in accordance with Latifah & Budiarto's research (2019) that students with high mathematical abilities can solve spatial visualization problems carefully about the objects obtained and then imagine them from various points of view. In solving contextual problems ranging from perceiving, visual-spatial and transforming characteristics, subjects with high mathematical abilities (HG) have no difficulty in imagining, explaining, mentioning and describing the object of the given problem. HG subject in determining the difference between one gordang and another gordang classically can solve it well, then HG subject in explaining each side gordang can be formed from two truncated cone objects, classically can also solve it well. HG subjects are known to be able to determine the gordang that produces the kudong-kudong tone. Furthermore, the HG subject can adjust the height to the base textually, so that the HG subject can describe the tube base correctly. After that, the HG subject in solving the last problem was found to have no difficulty in drawing two opposite truncated cones to form one gordang image. Spatial reasoning in solving HG subject contextual problems can be described as follows.

On perceiving characteristics, on indicators imagine the object part of the given problem. Students write down the differences between one gordang and another. HG subjects pay close attention to pictures and textuals. Students see the suitability of the relationship between one gordang and the given text. This can be shown when the HG subject solves contextual problems in the perceiving characteristic domain by connecting the suitability of one gordang and another with textual explanations of each form of gordang. After obtaining an explanation of the difference between one gordang and another, the subject of HG was directed to explain why each of the side gordangs could be formed from two truncated cone objects, which included indicators explaining the object part of the given problem. The subject of HG explained that a sideline gordang can be formed from two truncated cone objects by first describing a gordang and then drawing two cone objects, where the first cone is depicted in contrast to the second cone and then connects the two cones so that they appear to form a tubular gordang. HG subject ensures that the answer given is correct by combining the two opposite cones in writing. After that, the HG subject looked back at the formed image whether it had formed a tubular gordang well.

On the visual-spatial characteristics, the indicator mentions the name of the object of the given problem, students determine which gordang produces the kudong-kudong tone, the HG subject pays attention and reads the text given well. This can be shown by the correct

answers given by students, namely gordang 3 and 4 which give a kudong-kudong tone. After getting answers about the object in question, the subject of HG is directed to describe the object of the given problem. In describing a given object, there are indicators describing the object of the given problem. HG's subject describes the tube base of the gordang which has a height of 120, 140 and 160 cm. This can be shown by the correct answers given by students. In this case, HG students adjust the textual given by looking at the relationship between the explanation of the height and the bottom of the tube. After obtaining a base that matches the height of the gordang, HG students can describe the base by looking at the radius of the gordang base.

On the characteristics of transforming, the indicator changes the shape of the object that is caught by the eye into another form. Students draw two truncated cones so that from the two truncated cones, when combined, they form one gordang. HG subjects describe it well, this is shown from the pictures that the students give correctly.

2. Spatial Reasoning of Midle Group Subjects

Subjects with midle mathematical ability (MG) based on the results of spatial reasoning analysis on perceiving, visual-spatial and transforming characteristics in solving contextual problems have quite good achievements. In solving contextual problems starting from the characteristics of perceiving, visual-spatial and transforming. Subjects with midle mathematical ability (MG) have little difficulty in imagining, explaining, mentioning and describing the object of the given problem. The MG subject in determining the difference between one gordang and another is divided into two parts, firstly, students can complete it with little difficulty but have quite good achievements, then the MG subject in explaining each side gordang can be formed from two truncated cone objects, classically they can solve it quite well. MG subjects are also known to be able to determine the gordang that produces the kudong-kudong tone. Furthermore, the subject of MG had a little difficulty in adjusting the height to the base textually, so that the subject of MG was slightly mistaken in describing the base of the tube correctly. After that, the MG subject in solving the last problem was found to have a little difficulty in drawing two opposite truncated cones so that they were not perfect in forming one gordang image. Spatial reasoning in solving MG subject contextual problems can be described as follows.

On the characteristics of perceiving, the indicators imagine the object part of the given problem. Students write down the differences between one gordang and another, the subject of MG pays less attention to pictures and textuals properly, so that when they see the suitability of the relationship between one gordang and the textual given, they are wrong. This can be shown when the MG subject solves contextual problems in the perceiving characteristic domain by not connecting the suitability of one gordang and another. The subject of MG explained that the side gordang cannot completely be formed from two truncated cone objects so that it does not describe a gordang. This is because the first cone which is depicted in the opposite direction to the second cone does not cover the entire side of the tube, so it does not appear to form a tubular gordang.

In visual-spatial characteristics, the indicator mentions the name of the object of the given problem, students can determine which gordang produces the kudong-kudong tone, the MG subject pays attention and reads the given text well. This can be shown by the correct answers given by students, namely gordang 3 and 4 which give a kudong-kudong tone. In describing a given object, there are indicators describing the object of the given problem. MG subject has a little difficulty in describing the base of the gordang which has a height of 120, 140 and 160 cm. This can be shown by the students' answers that are slightly wrong. In this case, the MG students were not observant in adjusting the textual given by looking at the relationship between the height and the base of the tube, so the MG subject was wrong in describing the base based on the radius of the gordang base.

On the characteristics of transforming, the indicator changes the shape of the object that is caught by the eye into another form. Students have a little difficulty in drawing two truncated cones so that the image obtained is not perfect from the two truncated cones when combined. MG subject misrepresents it.

3. Spatial Reasoning of Low Group Subjects

Subjects with low mathematical ability (LG) based on the results of spatial reasoning analysis on perceiving, visual-spatial and transforming characteristics in solving contextual problems have poor achievement. In solving contextual problems starting from perceiving characteristics, visual-spatial and transforming subjects with low mathematical ability (LG) have difficulty imagining, explaining, mentioning and describing the object of the given problem. The LG subject in determining the difference between one gordang and another also had difficulty, then the LG subject in explaining each side gordang could be formed from two truncated cone objects, classically unable to solve it. The subject of LG is also known to be wrong in determining the gordang that produces the kudong-kudong tone. Furthermore, the LG subject also had difficulty in adjusting the height to the base textually, so that the LG subject erred in describing the tube base correctly. After that, the subject of LG in solving the last question was found to be very difficult in drawing two opposite truncated cones so that they were unable to form a single gordang image. Spatial reasoning in solving contextual problems of LG subjects can be described as follows.

On the characteristics of perceiving, the indicators imagine the object part of the given problem. Students have difficulty in writing down the differences between one gordang and another, the subject of LG does not pay close attention to images and textuals, so that the relationship between one gordang and the textual is not visible. After that, the LG subject was directed to explain why each of these sideways can be formed from two truncated cone objects, where this is included in the indicator explaining the object part of the given problem. The subject of LG cannot explain that the side gordang can be formed from two truncated cone objects.

On the visual-spatial characteristics, the indicator mentions the name of the object of the given problem, students determine which gordang produces the kudong-kudong tone, the LG subject does not pay attention and does not read the textual given well. This can be shown by the wrong answers given by students. After that, the LG subject was directed to describe the object of the given problem. In describing a given object, there are indicators describing the object of the given problem. The subject of LG made a mistake in describing the tube base of the gordang which had a height of 120, 140 and 160 cm. This can be shown by the wrong answers given by students. In this case, the LG students did not adjust the textual given by looking at the relationship between the explanation of the height and the bottom of the tube.

On the characteristics of transforming, the indicator changes the shape of the object that is caught by the eye into another form. Students are very difficult in forming one gordang from the image of two truncated cones, so the subject of LG is wrong in describing it.

CONCLUSION

Based on the results of the analysis of research data obtained, conclusions can be drawn about the profile of students' spatial reasoning in solving geometric problems in terms of the level of mathematical ability as follows.

1. Subjects with high mathematical ability (HG) based on the results of spatial reasoning analysis on perceiving, visual-spatial and transforming characteristics in solving contextual problems have very good achievements. In solving contextual problems ranging from perceiving, visual-spatial and transforming characteristics, subjects with

high mathematical abilities (HG) have no difficulty in imagining, explaining, mentioning and describing the object of the given problem.

2. Subjects with moderate mathematical ability (MG) based on the results of spatial reasoning analysis on perceiving, visual-spatial and transforming characteristics in solving contextual problems have quite good achievements. In solving contextual problems starting from the characteristics of perceiving, visual-spatial and transforming. Subjects with moderate mathematical ability (MG) have little difficulty in imagining, explaining, mentioning and describing the object of the given problem.
3. Subjects with low mathematical ability (LG) based on the results of spatial reasoning analysis on perceiving, visual-spatial and transforming characteristics in solving contextual problems have poor achievement. In solving contextual problems starting from perceiving characteristics, visual-spatial and transforming subjects with low mathematical ability (LG) have difficulty imagining, explaining, mentioning and describing the object of the given problem.

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