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## **A STUDY ON THE JUNIOR HIGH SCHOOL STUDENTS' SPATIAL ABILITY AND MATHEMATICS PROBLEM SOLVING IN MOJOKERTO**

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### **Abstract**

*The aim of this study was to investigate the spatial ability the relation of spatial ability and geometrical problem solving ability of junior high school students in Mojokerto, Indonesia. Data in this descriptive study was collected using The Purdue Spatial Visualization Test (PSVT). PSVT was used to analyze students' rotation spatial skills element then categorized into three different spatial ability groups (High, Intermediate, and Low). The mathematics problem solving data was collected by giving mathematical ability written test to the students. Results showed that more than 70% participants possessed intermediate level both in spatial and problem solving ability. Furthermore, the statistics result indicated a positive correlation between spatial ability and geometrical problem solving ability. Qualitative analysis revealed that students had difficulty in solving problem about spatial rotation especially students in low level ability. Finally, significant evident recommend spatial ability need to be considered involved in learning activity.*

### **Keywords**

Spatial Skill, PSVT, Rotation, Problem Solving, Geometry

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## **1. Introduction**

Spatial ability is a cognitive skill that using imagination to move and arrange things and shapes mentally (National Research Council, & Geographical Sciences Committee, 2005). There were some studies that showed the positive relation between spatial ability and problem solving ability in mathematics (Turğut & Yılmaz, 2012; Rabab'h & Arsaythamby, 2015; Verdine, Brian, et al., 2013; Hannafin, Truxaw, Vermillion, Liu, 2010). Students in high spatial ability will be better in solving mathematical problems compared to students who have low level spatial ability. Tambunan (2006) found a relationship between achievements in mathematics and spatial ability of topology and Euclides spatial abilities. Whereas Mulligan, Mitchelmore and Prescott (in Van Nes & Doorman, 2011) are in their research found that students with a high level of awareness regarding patterns and structures tend to be clever in thinking and mathematical reasoning compared to their peers and vice versa. Likewise with research conducted by Battista, Winer, & Frazee (2017) found that students' spatial abilities provide useful input and organizing for numerical procedures in third, fourth and fifth grade students the basis for calculating the arrangement of squares.

As discussed earlier, spatial ability is one cognitive aspect that allows a child to connect abstract concepts an object in their mind with other aspects related to the object. The spatial ability of a child develops along with their growth. Spatial skills can be learned and should be taught at any level in education system (National Research Council, & Geographical Sciences Committee, 2005; Newcombe, 2013). The frequency of learning activities that involve spatial skill activities determine the students' ability in solving mathematics problem, especially geometry problems (Olkun, Sinan&Sinoplu, 2008; Kotsopoulos, Makosz, & Zambrzycka, 2016; Lowrie, Logan & Ramful, 2016). Other studies also found that gender issues had no effect in students' mathematics problem solving ability (Lowrie, Logan & Ramful, 2016; Adaboh, et al, 2017; Orton, 2004). However, spatial aspect usually is ignored by teacher so that students have not opportunity to train their spatial ability especially students in low level provided (Bakker, Smit, and Wegerif, 2015; Battista, 1990; Clements, 1998). Sorby (2009) stated that to make students think spatially, teachers should train students to be able to link the imagination and real world context.

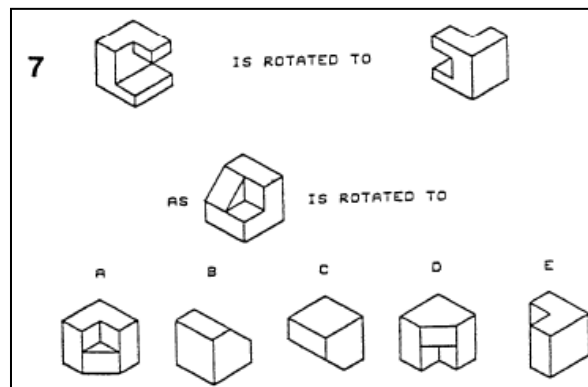
Based on preliminary observation and interviews with several mathematics teachers in junior high school in Mojokerto, Indonesia, students had difficulty to solve geometrical

mathematical. This problem can be caused by the rarely learning activities that include spatial skills so that students could not improve their spatial ability. Sorby (2009) stated that spatial ability is a mental process involving the ability to move things mentally and change the point of view when looking at an object. Sorby also stated that spatial skill is mandatory to help students in mathematics problem solving.

Given the importance of spatial ability to mathematics, this study aimed on describing the relation of junior high school students' spatial skill and the problem solving ability in geometry. The impact of spatial ability to students' ability in solving geometrical problems will be shown as the result of this study. The researchers also provide the example of mathematics problem in geometry that requires spatial ability to be solved.

## 2. Methodology

Descriptive quantitative research method was used to investigate junior high school students' spatial ability and problem solving ability in Geometry. The participants were 255 junior high schools students in Mojokerto. Two instruments were used, spatial ability test using The Purdue Spatial Visualization Test (PSVT) that focused on Visualization of Rotations (ROT) aspect. This test was adapted from spatial visualization test that was developed by Dr. Roland Guay in 1976 from Purdue University. There were 30 spatial ability problems that should be solved by participants, shown below as an example



**Figure 1:** Example of the spatial problem in PSVT

Participants should examine final position of the object in second row if it rotated in a same rotating direction as the object in the first row (Bodner & Guay, 1997). Mathematical test

was used to measure the participants' problem solving ability. This test consist of three geometrical problems. The participants will be divided into three group based on the both tests result as shown below

**Table 1:** *Spatial ability and problem solving ability categories*

No.	Score (x)	Category
1.	$80 \leq x \leq 100$	High
2.	$60 < x < 80$	Intermediate
3.	$0 \leq x \leq 60$	Low

The researcher also developed the example of mathematics problems for junior high students that require spatial ability to be solved. The developed mathematics problems already adapted from mathematics curriculum used in Indonesia.

### 3. Result and Discussion

Spatial ability test were conducted in nine junior high schools in Mojokerto, Indonesia. The participants were 255 students chosen randomly from second grade of those schools. The PSVT test should be finished by participants within sixty minutes. Result indicated that more than half of the participants possessed the intermediate level for both ability (Spatial and Problem Solving) as the table shows below.

**Table 2:** *Spatial Ability and Problem Solving Ability Test Results*

Spatial Ability (%)	Problem Solving Ability (%)	Category
14	15	High level
70	78	Intermediate level
16	7	Low level

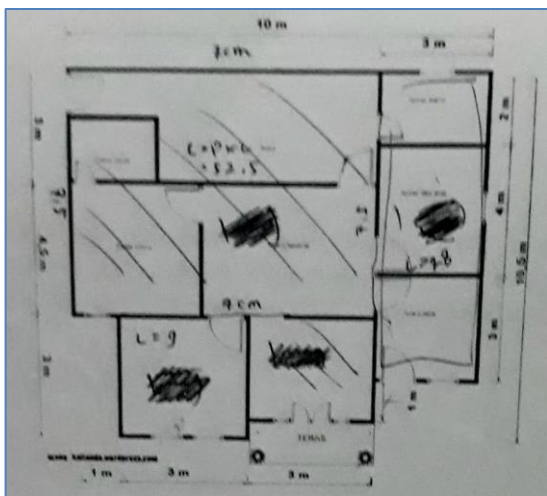
The table below shows that spatial ability had a statistically contribution to problem solving ability, accounting for 7.5 % of the variance.

**Table 3:** *Statistical Analysis between Spatial Ability and Problem Solving Ability*

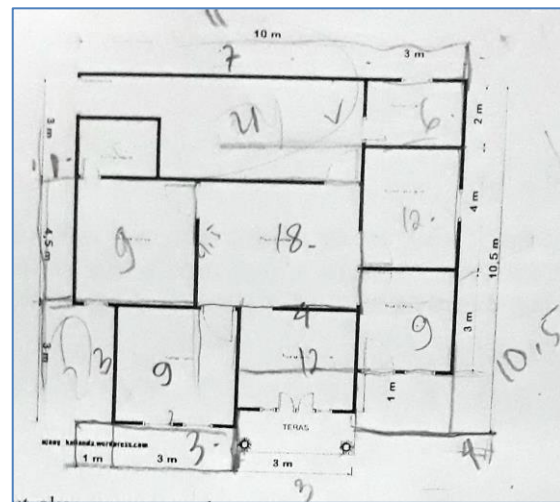
Model	R <sup>2</sup>	Adjusted R <sup>2</sup>	Std. Error of Estimate	R <sup>2</sup> Change	F (df 1,255)
Problem solving ability	0.075	0,072	19,366	0,075	20,598

Although the statistics result shows the number not too significant, some results evident showed that spatial ability and geometrical problem solving ability correlated positively which means participants in the high level of spatial ability tend to done better in solving mathematics problems than the lower level groups. The figure 3 shows students' answer of problem solving test. Picture on the right side (a) was the answer from the high spatial ability student and picture (b) was the answer from intermediate spatial ability student.

Figure 3 shows one of the three problems from the test, students must calculated the area of the shape. There were differences from the way they solved the problem. Student with high spatial ability could combine some small area of shapes so that became the area of whole shapes. On the other hand, students with intermediate spatial ability had difficulty finding the whole area; they tend to calculate the area of each small shape. Most of students with low spatial ability did not answer the problems, based on the interview; they had difficulty to answer the problem because they could not find the measurements of some small shapes.



(a)



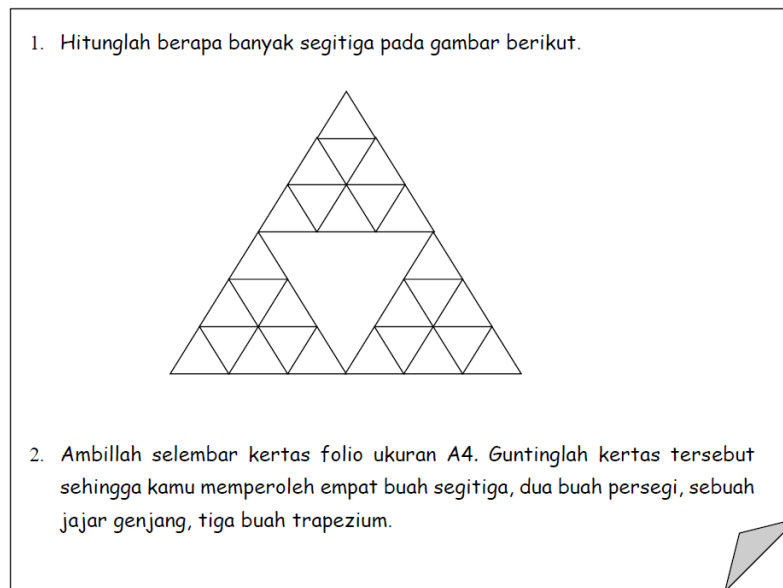
(b)

**Figure 3: Students' Problem Solving**

Based on the statistical analysis can be seen that most students still have intermediate level of spatial ability. In order to increase the students' ability in geometry, we develop an instructional module about geometry that can also support the spatial ability. The module is intended for junior high school students and focused on plane geometrical shape material that already adapted from the mathematics curriculum in Indonesia. Newcombe (2013) stated there are three strategies for specializing middle school curricula:

- Teach students how to read diagrams
- Encourage students to sketch
- Use maps and tools from geographic information systems
- Support students in understanding of spaces and times

Figure 4 shows problems (Indonesian) in the instructional module that require spatial visualization and spatial perception to be solved. Students need to use their understanding in spaces to count how many triangles in the picture for the first problem.



**Figure 4:** *The Example of Activity in the Module (Indonesian)*

Students asked to draw the same figure as the first problem then cut the figure into small triangles, construct new figures (4 triangles, 2 squares, a parallelogram, 3 trapezoids) using the small triangles. We expected teachers can increase the students' spatial ability and problem solving by using this module.

#### **4. Conclusion**

According to the result of the Purdue Spatial Visualization Test (PSVT) and Problem Solving in Geometry, most students had intermediate level for both abilities. The result also shows that there was a positive relation between spatial ability and mathematical ability, similar to the studies about spatial ability conducted by Lowrie, Logan, & Ramful (2016), Rabab'h and Arsaythamby (2015), Yenilmez & Kakmaci (2015), Verdine, et. al. (2013), and Turğut and

Yilmaz, (2012). The spatial ability can be improved by conducting some activities that related and supported by spatial skills (Kotsopoulos, Makosz, & Zambrzycka, 2016; Burte, et al, 2017), so that we have been developing an instructional module in Geometry which supported by spatial activities for junior high school students.

## **5. Acknowledgment**

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