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The Mindset of Students in Solving Geometry Problems in Terms of Spatial Ability

Adhitya Pratama Putra[1]*, Arie Purwa Kusuma[1], Abdul Hakim Ma'ruf[1]
[1]Mathematics Education, STKIP Kusuma Negara, Jakarta, Indonesia
*pratamaadhitya002@gmail.com

Abstract

This research aims to examine the mindset of students in solving geometry problems from the perspective of spatial ability. This type of research is descriptive qualitative research. The study is conducted to explore and elaborate on the thought processes of students when solving geometry problems in relation to their spatial abilities. The subjects of this research are twelfth-grade students at Perguruan Nasional Senior High School for the 2024/2025 academic year. The research instrument consists of four validated essay questions. Data collection techniques used include tests, interviews, and documentation. The results of the study indicate that subjects with high ability in solving three-dimensional problems have good visualization skills, can formulate problems, and can independently solve complex geometry problems. Students with moderate ability can use diagrams to solve problems, understand basic concepts, and solve questions well, except in the area of pattern recognition. Meanwhile, students with low ability face difficulties in nearly all aspects of testing, particularly in conceptualization, problem-solving, and pattern recognition.

Key words: Geometry problems, mindset, spatial ability

1 INTRODUCTION

Mathematics is a science that involves logical reasoning to assist humans in formulating ideas and solutions to problems. Furthermore, James states that mathematics is a science of logic that encompasses shapes, arrangements, magnitudes, and interrelated concepts, divided into three fields: algebra, analysis, and geometry (Novi, Anita, & Puput, 2022). These three fields form a unity that builds mathematics. One of the fields that plays a significant role in the basic competencies that students must possess is geometry. Geometry is one branch of mathematics that plays a special role in mathematics learning. According to Budiarto, the purpose of geometry is to develop logical reasoning skills, enhance spatial intuition, instill supporting knowledge for other subjects, and enable students to read and interpret mathematical arguments. Based on this perspective, one important aspect of successful mathematics learning is developing spatial ability. Spatial ability is a combination of cognitive skills that include spatial concepts, representational skills, and reasoning processes (NCTM, 2006; Evi et.al., 2024). This spatial ability explains that since it is a combination of cognitive skills, it is closely related to an individual's mindset. Mindset refers to an individual's way of thinking that influences their behavior and attitudes, ultimately determining their level of success in life. It can be said that mindset is what drives a person to take action. Based on this statement, it can be concluded that mindset can encourage the improvement of an individual's abilities. If someone wants to enhance their skills, they must be able to change their mindset, which may not have developed yet.

To develop students' mindsets, it is necessary to first analyze their thought processes when confronted with a problem. By understanding a person's mindset, it becomes easier for teachers to assist students in utilizing their brain capacity during the thinking process (Noviani, Hartono, Rusilowati, 2017; Utami et.al., 2024). One method used to analyze these mindsets, as seen in this research, is by presenting problems related to three-dimensional material, which can subsequently measure the students' abilities closely related to geometry itself. Research conducted by Dina Rahmatika and An Nur Ami Widodo titled "Analysis of Mathematical Representation Ability Viewed from Spatial Ability in Flat-Sided Space Material of Class VII Students at 01 Tonjong Junior High School" shows that students with high spatial ability also have high mathematical representation skills. Conversely, if a student's spatial ability is moderate, their mathematical representation skills are also moderate, and if their spatial ability is low, their mathematical representation skills will likewise be low.

This research indicates that spatial ability levels reflect the levels of students' mathematical representation abilities and their mindsets (Rahmatika, Dina, Widodo, 2018). Additionally, a study by Sefrina Dyah Purborini and Ratri Candra Hastari titled "Analysis of Spatial Ability in Flat-Sided Space Viewed from Gender Differences" found that male students met various spatial aspects and achieved spatial indicators such as solving problems using diagrams, visualizing solutions, connecting known data with concepts, viewing problems from different perspectives, and recognizing patterns in problem-solving. In contrast, female students only met some aspects and indicators of spatial ability, such as solving problems with the help of diagrams and stating known concepts (Purborini, 2018). Other research results also state that students with high spatial abilities have better mathematical reasoning abilities than students with medium and low spatial abilities (Kusuma, dkk 2021). students' mindsets are also influenced by spatial abilities. Visual spatial intelligence is a skill that includes the ability to think in images, as well as the ability to absorb, transform, and recreate various aspects of the visual spatial world (Nuraini et al., 2022). Visual-spatial intelligence helps students understand abstract concepts, including spatial perception involving spatial relationships including orientation to complex abilities involving mental manipulation and rotation (Achdiyat & Utomo, 2018). Related to spatial ability, each student has different spatial abilities. The most frequently studied differences are differences in initial mathematical abilities. According to Dahar (Nurmayan, 2015:10). The importance of spatial reasoning is stated by (Pavlovicova & Svecoca, 2015) that spatial reasoning plays a role in mathematics, especially geometry. Spatial reasoning has an important role in geometry because solving geometric problems that have abstract objects of study requires a spatial reasoning process in the spatial ability component. This statement is supported by (Yassir, 2013) who argues that spatial reasoning is an important component in the spatial ability possessed by students in solving geometric problems. Spatial reasoning is influenced by the basic concept of space and the representation of tasks in solving geometric problems.

After conducting observations, it was found that at Perguruan Nasional 1 Jakarta Senior High School, during mathematics lessons, some students appeared passive in the learning process. Students seemed unenthusiastic about participating in class. When faced with a problem, many students expressed difficulty, particularly in geometry, indicating they struggled to answer questions posed by the teacher regarding three-dimensional shapes. From this description, it can be concluded that some students have low spatial abilities. Their mindsets in problem-solving are also in question. However, to confirm this, an analysis of students' mindsets in solving geometry problems from the perspective of their spatial abilities will be conducted. Based on these issues, the researcher intends to conduct a study on this topic titled "Students' Mindset in Solving Geometry Problems from the Perspective of Spatial Ability." It should be noted that thinking is basically determined by various factors. The factors that influence changes in thinking include how someone sees or understands the problem, the situation that someone is experiencing and the external situation faced, the person's experiences, and how intelligent the person is (Setyawan,

2017). This is in accordance with research conducted by (Rozalinah, 2016) which states that there is an influence of visual spatial intelligence on the geometry problem solving abilities of grade IX SMP/MTS students in Panceng District.

2 RESEARCH METHODS

This research uses a qualitative research method. The nature of qualitative research is descriptive. This study is conducted to explore and elaborate on the thought patterns of students in solving geometry problems from the perspective of spatial ability. The subjects of this research are twelfth-grade students at Perguruan Nasional 1 Senior High School, and the test results, represented as scores, are grouped based on categories of high, medium, and low ability. The sampling technique used in this study is purposive sampling, which involves selecting data sources based on specific considerations. In this research, data collection techniques are carried out through tests, interviews, and documentation. The techniques used for verifying the validity of the data consist of credibility testing, transferability testing, dependability testing, and confirmability testing. The data analysis used includes data reduction, data presentation, and conclusion drawing.

3 RESULT AND DISCUSSION

Based on the research results conducted at Perguruan Nasional 1 Senior High School on three-dimensional material, the researcher grouped students into categories of high ability, medium ability, and low ability. Subsequently, subjects were selected from each category for analysis and interviews. The sampling technique used in this study is purposive sampling, where samples are taken from data sources based on specific considerations.

Table 1. The Sample Research

Subject	Score	Categories Of Students Ability
S7	93,8	High
S5	75	Medium
S13	25	Low

3.1 Data Presentation and Data Analysis

Table 2. Comparison Table Of Subjects In Solving Imaging-Type Problems

Stages Of Completion	Subject		
	S7	S5	S13
Understanding Problem	Answering all information completely and accurately	Answering all information completely and accurately	Can accurately answer the provided information but cannot formulate the question
Planning the Solution	Writing the solution steps accurately	Writing the solution steps accurately	Does not write the solution steps well
Implementing the Solution	Answering according to the	Answering according to the	Writing the answer is correct

Stages Of Completion	Subject		
	S7	S5	S13
	solution steps effectively	solution steps effectively	
Reviewing the Solution	Can restate the obtained answer as proof	Can restate the obtained answer as proof	Does not verify or check the answer again

Based on the Table 2, the tendency of subjects in solving imaginative-type problems effectively and thoroughly is observed only in high and medium ability subjects. This can be seen from the answers of subjects S7 and S5, who demonstrated a complete thought process at each stage when responding to the given questions. Meanwhile, low-ability students, although they can execute solutions well, still fall short as they have not progressed through the thought process stages of planning and checking their answers.

Table 3. Table of Comparison of Subjects in Solving Conceptual-Type Problems.

Stages Of Completion	Subject		
	S7	S5	S13
Understanding Problem	Answering all information completely and accurately	Answering all information completely and accurately	Can accurately answer the provided information but cannot formulate the question
Planning the Solution	Writing the solution steps completely	Can write the solution steps	Does not write the solution steps well
Implementing the Solution	Responding according to the previously determined solution steps accurately and effectively	Answering according to the solution steps effectively	Only able to draw according to the question's instructions but cannot answer the questions effectively
Reviewing the Solution	Can restate the obtained answer as proof	Can restate the obtained answer as proof	Does not verify or check the answer again

Based on the Table 3, the tendency of subjects in solving conceptual-type problems effectively and thoroughly is observed only in high and medium ability subjects. This can be seen from the responses of subjects S7 and S5, who successfully navigate the thought process stages of understanding the problem, planning the solution, executing the solution, and verifying their answers when addressing the given questions. In contrast, low-ability students, while they can carry out the solution well, still fall short as they are only able to effectively understand the problem, but struggle to progress through the other stages.

Table 4. Table of Comparison of Subjects in Solving Problem-Solving Type Problems.

Stages Of Completion	Subject		
	S7	S5	S13
Understanding Problem	Answering all information completely and accurately	Answering all information completely and accurately	Can accurately answer the provided information but cannot formulate the question
Planning the Solution	Writing the solution steps completely	Can write the solution steps, although they are not sufficiently clear and complete	Does not write the solution steps well
Implementing the Solution	Answering according to the previously established solution steps accurately and effectively	Answering according to the solution steps effectively	Only able to draw according to the question's instructions but cannot answer the questions effectively
Reviewing the Solution	Does not restate the obtained answer for verification	Does not restate the obtained answer as proof	Does not write anything because the calculation process was not carried out

Based on the table, the tendency of subjects in solving problem-solving type questions indicates that all three have yet to adequately fulfill the thought process stage of verification, resulting in answers that tend to be incorrect. This is particularly evident in low-ability subjects, who can only write information and answer questions by merely depicting the 3D shapes according to the question's instructions but do not understand how to solve the problems posed. This highlights that the spatial ability of students in problem-solving type questions needs greater attention.

Table 5. Table of Comparison of Subjects in Solving Pattern Recognition Type Problems.

Stages Of Completion	Subject		
	S7	S5	S13
Understanding Problem	Answering all information completely and accurately	Answering all information completely and accurately	Can accurately answer the provided information but cannot formulate the question
Planning the Solution	Writing the solution steps completely	Can write the solution steps, although they are not sufficiently clear and complete	Does not write the solution steps

Implementing the Solution	Answering according to the previously established solution steps accurately and effectively	Answering according to the solution steps, but the answer is incorrect	Only able to draw according to the question's instructions but cannot answer the questions effectively
Reviewing the Solution	Can restate the obtained answer for verification	Can restate the obtained answer as proof, even though the answer is incorrect	Does not write anything because the calculation process was not carried out

Based on the Table 5, the tendency of subjects in solving pattern recognition type problems shows that only high-ability subjects are able to solve the questions effectively. Medium-ability subjects can navigate through all stages of the thought process, but their answers are incorrect. In contrast, low-ability students follow a similar pattern to other question types, managing only to understand the problem while failing to complete the other stages when answering the questions.

3.2 Discussion of Findings

Subjects with high ability in solving three-dimensional problems show strong visualization skills, using drawings to resolve issues and translating information from geometry problems into visual representations. In terms of conceptual understanding, they can articulate concepts related to geometric problems and connect known data with their understanding. For problem-solving, they can clearly state what is known and what is being asked, employing various strategies to tackle spatial geometry problems. In pattern recognition, they can understand and identify concepts or patterns from the given problems, determine the appropriate pattern for answering questions, and outline new patterns for solving issues, writing their answers step-by-step and providing accurate conclusions.

Medium-ability subjects can also use drawings to assist in solving problems and convert geometric information into visual forms. They are able to mention relevant concepts related to geometric issues and link known data with these concepts. For problem-solving, they can write down what is known and what is asked, and they manage to solve problems satisfactorily. However, in pattern recognition, they struggle to understand and identify concepts or patterns, which affects their ability to write accurate conclusions.

Low-ability subjects can use drawings to help with problem-solving and express geometric information visually. However, they cannot articulate the concepts related to geometric problems or connect known data with their concepts. In terms of problem-solving, they can identify what is known and what is asked, but they lack strategies for addressing spatial geometry problems. In pattern recognition, they have difficulty understanding and identifying concepts or patterns, leading to incorrect conclusions in their answers.

These findings align with research conducted by Arie Purwa Kusuma titled "The Application of the Accelerated Learning Cycle Model on Mathematical Reasoning in Terms of Spatial Ability," which concluded that students with high spatial ability demonstrate better mathematical reasoning compared to those with medium and low spatial abilities. Additionally, students with medium spatial ability have mathematical reasoning skills comparable to those with low spatial ability (Kusuma. et al., 2021).

4 CONCLUSION

High-ability subjects demonstrate strong visualization skills, can formulate problems, and solve complex geometry problems independently. They effectively use drawings to assist in problem-solving, grasp concepts well, and accurately write solution steps, although there may be minor errors in presenting the final answer. Medium-ability subjects can use drawings to solve problems, understand basic concepts, and perform well in solving questions, except in pattern recognition. They tend to struggle with understanding more complex relationships and often require additional visual support to overcome these challenges. Low-ability subjects face difficulties in almost all aspects of the assessment, particularly in conceptualization, problem-solving, and pattern recognition. They can only follow basic instructions without grasping more complex concepts and are heavily reliant on visual aids to understand geometric problems.

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