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EXPLORING OF STUDENTS' ABILITY TO SOLVE GEOMETRY PROBLEMS BASED ON VAN HIELE'S LEVEL OF THINKING

Ayu Andira[1], Muhammad Darwis M[2], Haerul Syam[3]
[1] Mathematics Education Program, University of Muhammadiyah Makassar, Indonesia
[2] Mathematics Education Program, State University of Makassar, Indonesia
[3] Mathematics Education Program, University of Muhammadiyah Makassar, Indonesia

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ABSTRACT

Based on Van Hiele's level of thinking, this study intends to investigate students' ability to solve geometric problems. Polya's heuristic of problem-solving steps is used to assess problem-solving ability. A qualitative, descriptive study is the form of research used in this case. The Van Hiele Geometry Test (VHGT), problem-solving aptitude assessments, and interviews were used. Based on Van Hiele's level of thinking, researchers chose three students from a group of 27 students in grade VIII high junior school Terpadu Sheikh Muhammad Ja'far as research subjects. Data collection methods include tests and interviews. Data condensation, data presentation, conclusion drafting, and verification are all research data analysis approaches. The validity of the data is verified using a triangulation of techniques and sources. The findings of the study are: subjects at the pre 0 level only have visual, verbal, and drawing skills. Subjects at level 0 (visualization) were not able to solve the four problem-solving heuristics by Polya. Subjects at level 1 (analysis) were able to reach the second stage of the problem-solving heuristic by Polya. Subjects at level 2 (informal deduction reached the third stage of the problem-solving heuristic by Polya.

Corresponding Author:

Haerul Syam,
Mathematics Education Program, University of Muhammadiyah Makassar, Indonesia
Email: haerulsyam.unismuh@gmail.com

1. INTRODUCTION

Mathematics is one of the subjects of study that plays a significant part in the educational system (Davis & Simmt, 2006; D'Ambrosio, 2007; Schukajlow et al., 2018). As a result, beginning in elementary school, all children are taught mathematics (SD). Geometry is a material that is considered important in mathematics. Geometry is a branch of mathematics that holds a unique place in the mathematics curriculum due to the numerous topics it contains (Abramovich & Grinshpan, 2008; Whitney, 2015; Serin, 2018; Morino, 2021).

Geometry exploration can aid in the development of problem-solving skills, which is one of the reasons why it is vital to study geometry. One of the talents that students must have after learning mathematics is the ability to answer mathematical problems. Problem-solving ability, connection ability, communication ability, reasoning ability, and representation ability are the five mathematical abilities that students must possess, according to NCTM (Graham & Fennell, 2001; Deal & Wismer, 2010; Huinker, 2018; Hasbi et al., 2019; Alabdulaziz & Higgins, 2021).

There are still a lot of students that are struggling with geometry. These issues arise from students' lack of ability or geometry skills, which are enabled by their lack of comprehension of geometric principles and skills in solving geometric problems (Tambychik & Meerah, 2010; Ramlan, 2016; Gal, 2019; Rellensmann et al., 2020). Good geometry instruction must be tailored to the skills of the students. The thought process and application of skills in solving geometry problems reveal children's abilities.

Geometry learning is effective if the learning activities are appropriate for the level of students' cognitive abilities (Hilbert et al., 2008; Clements & Sarama, 2011). As a result, an appraisal of the degree of students' thinking skills is necessary to use as a guide for providing learning that is appropriate for their capacities. The Van Hiele theory is one of several ideas that examine the progression of student learning (Halat, 2006; Yi et al., 2020). The level of student learning development is divided into different tiers according to this approach. Students' geometric abilities can be assessed using this theory.

Problem-Solving Abilities

Problem-solving is the process of defining a problem, understanding the root cause of the problem, identifying solutions and options for solving the problem, and putting the solution into action until the problem is fixed. It is critical for students to have problem-solving skills, to gain a better understanding of the problem-solving process (Tarim, 2009; Zhou et al., 2020; Rahayuningsih et al., 2021). While mathematical problem-solving refers to a person's capacity to apply previously learned mathematical principles in new situations that demand solutions (Elia et al., 2009; Haataja et al., 2019; Jäder et al., 2021). Problem-solving is more than just the ability to apply rules that have been mastered via prior learning activities; it is also a process of learning rules at a higher level. Therefore, mathematical problem solving can be defined as the application of rules through the use of mathematical concepts learned in prior learning activities..

Problem-Solving Stages

Table 1 shows the problem-solving indicators that were employed based on Polya's (Anwar & Rahmawati, 2017; Daulay & Ruhaimah, 2019; Taneo & Kusumah, 2021) settlement processes.

Table 1. The stages of problem-solving based on the Polya

Problem Solving Stage by Polya	Indicator
Understanding the problem	Students can mention the information provided from the questions asked.
Planning a solution	The student has a problem-solving plan that he uses and the reasons for using it.
Carrying out a settlement plan	Students are able to solve problems with the strategies they use with the correct results.
Checking again	Students check the correctness of the results or answers

Highlighting some of the previous descriptions, therefore, the goal of this study is to use Van Hiele's level of thinking to describe students' abilities to solve mathematical issues.

2. METHOD

This type of research is descriptive qualitative. This type of qualitative descriptive research has the aim of explaining phenomena that occur based on facts, thoroughly through the collection of data obtained (Creswell & Creswell, 2017).

In this study, researchers conducted research at the Integrated Middle School of Sheikh Muhammad Ja'far. The research subjects were taken from class VIII of Syekh Muhammad Ja'far Integrated Middle School for the 2020/2021 academic year. The data analysis technique of this research uses the model of Miles et al. (2014) which consists of data condensation, data presentation, as well as drawing conclusions and verification.

3. RESULTS AND DISCUSSION

a. The first subject's data exposure with Van Hiele thinking level 0 (visualization)

1. The first question
   a. Understanding the problem
   The subject was unable to understand the problem based on the results of tests and interviews, and the subject did not write down the elements that were known and asked in the questions.
   b. Develop a problem-solving plan
   The subject was unable to construct a problem-solving plan based on the results of tests and interviews, and the subject did not have a problem-solving plan.
   c. Implementing a problem solving plan
   According to the findings of the tests and interviews, the subject is unable to address the problem using the proper strategy and outcomes.
   d. Checking again
   The subject was unable to re-examine based on the results of tests and interviews.
2. Question number 2
   a. Understanding the problem
   The subject was unable to understand the problem, the subject did not write down the elements that were known and asked in the questions.
   b. Develop a problem-solving plan
   Based on the results of tests and interviews, the subject was unable to formulate a problem-solving plan, the subject did not have a problem-solving plan
   c. Implementing a problem solving plan
   It appears that the subject is not able to solve the problem with the correct strategy and results.
   d. Check again
   Based on the results of tests and interviews, the subject was unable to re-examine.

b. Exposure to second subject data with Van Hiele thinking level 1 (Analysis)

1. Question number 1
   a. Understanding the problem
   The subject is able to understand the problem in the problem by writing down the known elements and the elements being asked.
   b. Develop a problem-solving plan
   The subject is able to develop a settlement plan by determining the formula for the perimeter of a triangle.
   c. Implementing a problem solving plan

The subject is able to carry out the solution plan by adding up the three sides of the triangle.

d. Check again

Subjects cannot re-examine the results of their work.

2. Question number 2

a. Understanding the problem

The subject is able to understand the problem in the problem by writing down the elements that are known and the elements that are asked correctly.

b. Develop a problem-solving plan

The subject is able to develop a problem-solving plan, although the subject does not appear to have written it on the answer sheet, the subject can explain the plan for solving it.

c. Implementing a problem solving plan

Based on the results of tests and interviews, the subject was not able to solve the problem with the correct strategy and results.

d. Check again

The subject does not re-check the results of his work

c. Exposure to third subject data with Van Hiele level 2 (Informal Deduction)

1. Question number 1

a. Understanding the problem

Based on the results of tests and interviews, the subject is able to understand the problem, the subject is able to write and mention the elements that are known and asked in the question.

b. Develop a problem-solving plan

Based on the results of tests and interviews, the subject was able to develop a problem-solving plan by looking at the information (known and asked elements) in the questions.

c. Implementing a problem solving plan

Based on the results of tests and interviews, the subject was able to carry out a problem-solving plan with the correct strategy.

d. Check again

Subjects did not re-examine their answers.

2. Question number 2

a. Understanding the problem

Based on the results of tests and interviews, the subject is able to understand the problem, the subject is able to write and mention the elements that are known and asked in the question.

b. Develop a problem-solving plan

The subject is able to draw up an existing solution plan by looking at the information (known and asked elements) in the problem.

c. Implementing a problem solving plan

The subject carries out the problem-solving plan according to the correct strategy

d. Check again

The subject did not re-examine the results of his work.

Describe the first subject's problem-solving ability with Van Hiele thinking level 0 (visualization)

Based on the results of written tests and interviews, the first subject with Van Hiele's level of thinking level 0 (Visualization) was less able to understand the math problems given quite well. This can be seen in questions number one and two, where the subject cannot determine the elements that are known and asked in the question.

At the planning stage, the first subject with Van Hiele thinking level 0 (Visualization) developed a problem-solving plan. However, the plans prepared by the subject for questions number one and two are not relevant to the problems in each question. The subject is not able to understand well the relationship between the things that are known and asked in the question.

At the stage of implementing the plan, the first subject with Van Hiele thinking level 0 (Visualization) carried out a problem-solving plan. The final value obtained from the completion process is not a solution to the problem because the plan prepared by the subject is not relevant to the problem at hand. Thus, the subject of level 0 (Visualization) is less able to carry out the plan or solve the problem. In the re-examination stage, the first subject with Van Hiele thinking level 0 (Visualization) did not re-examine the answer.

Description of the second subject's problem-solving ability with van Hiele thinking level 1

Based on the results of written tests and interviews, the second subject of Van Hiele's level of thinking, level 1 (Analysis), is able to understand the math problems given quite well. This can be seen in the subject who is able to determine the things that are known and asked in the question correctly. In question number one, the subject is able to reveal things that are known and asked for. The subject is also able to write down all the information about these things on the answer sheet. Then in question number two, the subject is also able to write down things that are known correctly but are wrong about the thing being asked.

Even though the second subject at level 1 (Analysis) on questions 1 and 2 was unable to develop a problem-solving plan by making strategies and steps that were relevant to the questions given, the subject was able to provide an explanation at the time of the interview, despite the fact that the subject did not see any writing on the answer sheet in question number two..

The second subject at level 1 (Analysis) was unable to carry out the issue-solving strategy according to the plan he had created at the stage of implementing the plan or solving the problem. In the first question, the subject overlooks a crucial step in determining the length of the journey he has traveled. In the case of number two, the subject made a mistake in constructing a problem-solving strategy, resulting in inaccurate ultimate findings. As a result, while the subject at level 1 (analysis) can carry out the plan, it cannot provide the correct answer to the problem.

At the re-examination stage, the second subject at level 1 (Analysis) is able to provide an interpretation of the final results obtained well, even though the value obtained is not the right solution to the problem. However, the subject did not re-examine the answer either by re-examining the results obtained or by repeating arithmetic operations on the values obtained. Thus, the second subject at level 1 (Analysis) is less capable in the re-examination step.

Describe the third subject's problem-solving ability using Van Hiele thinking level 2

Based on the results of written tests and interviews, the third subject, who has Van Hiele's level of thinking level 2 (informal deduction), is able to understand the math problems given well. This can be seen in the subject's results when working on questions 1

and 2. The subject correctly wrote down the things that were known on the questions on the answer sheet.The subject writes down what is asked correctly.

At the planning stage, the third subject with van Hiele thinking level 2 (informal deduction) was able to develop a relevant problem-solving plan to determine the solution to the problem. Subjects are able to understand the relationship between things that are known and asked in the questions so that they are able to develop relevant plans. In question number one, the subject understands that in order to find out the length of the running track that is traversed by Budi, what must be calculated is the circumference of a right triangle. The subject also understands that to find the perimeter of the triangle, what must be sought is the length of the unknown side. While in question number 2, the subject understands that to find out how many m2 of paper is needed to make 100 kites of the same size, one must first calculate the area of one such kite by calculating the area of the two triangles that make it up, then add them up and multiply them. 100. In addition, the subject also understands that to find out the minimum amount of money that must be provided to make 100 kites at a price of Rp 800/meter is to multiply the price of paper/meter by multiplying the area of one kite by the number of kites, then multiply by the price of the kite/meter.

The third subject used Van Hiele's level of thinking capacity level 2 (informal deduction) to carry out a problem-solving strategy in accordance with the plan that had been prepared before at the stage of implementing the plan or addressing the problem. However, in the first question, there are still problems in determining the lengths of the two sides that are unknown, and in the second question, the subject made a mistake in the unit area conversion process. The third subject at level 2 (informal deduction) re-examined the response during the re-examination stage. The topic was able to overcome the problem in the plan's implementation step.

The research findings are relevant and support several previous studies such as (Watan, 2018; Yudianto et al., 2018; Maharani et al., 2019; Sulistiowati et al., 2019; Ersoy et al., 2019; Wijaya et al., 2019; Kusuma et al., 2021; Nusaibah et al., 2021; Yalley et al., 2021). Therefore, a new perspective generated in this study provides new knowledge about levels of geometric thinking based on Van Hiele's theory.

4. CONCLUSION

The following conclusions are drawn based on the findings of the analysis and discussion, as well as the research objectives.

1. Level 0 (Visualization) Van Hiele

   Subjects are less capable in the four stages of problem solving proposed by Polya.

2. Level 1 (analysis)

   The subject is able in the first stage, but unable in the second stage until the fourth stage.

3. Level 2 (Informal deduction)
4. Subjects are able in the first stage to the fourth stage.

Therefore, based on Van Hiele's hypothesis, the findings of this study look at the peculiarities of geometric thinking levels. The findings can be utilized as a guide for enhancing the quality of students' problem-solving abilities in school, particularly in mathematics.

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