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ANALYSIS OF MATHEMATICS PROBLEM-SOLVING ABILITY ON PLANE FIGURE SUBJECT BASED ON VAN HIELE'S THEORY AT JUNIOR HIGH SCHOOL

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Abstract: This study aims to describe the ability to solve mathematical problems in Plane Figure Subject based on van Hiele's theory in class VIII students of SMP Negeri 1 Mataram in the academic year 2021/2022. The type of research used is descriptive qualitative, which produces data in the form of written or spoken words from people and observed behavior. The subjects in this study were students in class VIII-E at SMP Negeri 1 Mataram, totaling 36 students. The method of taking the subject in this study used purposive sampling, which was selected based on the objectives to be achieved. The data collection methods used are the van Hiele test and the flat wake problem-solving ability test, interviews, and documentation. The thinking level of students in taking the van Hiele test was: 20 students at level 0 (visualization) with a percentage of 55.56%, 13 students at level 1 (analysis) with a percentage of 36.11%, and 3 students at level 2 (informal deduction) with a percentage of 8.33%. Furthermore, students at each level of van Hiele's thinking were taken as representatives of each of the 2 subjects to carry out a problem-solving ability test. Based on the results of the research on the problem-solving abilities of students based on the Polya problem-solving stage, students who are at level 0 can understand the problem but have not been able to carry out the other Polya-solving stages. Students at level 1 can understand the problem and develop a settlement plan but have not been able to carry out the other stages of Polya solving. Students at the level can understand the problem, develop a settlement plan, and carry out a settlement plan but have not been able to re-examine. It shows that the higher the van Hiele thinking level of the students, the better their problem-solving abilities will be.

Keywords: *Problem Solving, Plane Figure Subject, Van Hiele Theory.*

INTRODUCTION

Mathematics is a science that has an important role in shaping and developing thinking skills obtained by reasoning, namely thinking systematically, logically, and critically in problem-solving [1]. There are five standard processes of mathematical ability that must be possessed by students, namely: problem-solving ability, reasoning ability, connection ability, communication ability, and representation ability [2]. Of the five standard processes above, one standard is at the center of learning mathematics, namely solving mathematical problems. Problem-solving is an effort made by students to determine whether or not they can face the problems given to find an answer [3]. In the problem-solving process, there are four stages that must be passed: understanding the problem, devising a plan, carrying out the plan, and looking back [4].

The facts found in schools show that students' mathematical problem-solving abilities are still relatively low [5]. It means that students are less able to understand and solve the problems related to problem-solving given by the teacher. Another weakness found is the weakness of students in analyzing questions, monitoring the completion process, and evaluating the results, which are less visible to students [6]. In other words, students do not prioritize techniques in solving problems given by the teacher but prioritize the final results obtained. From the TIMSS (Trends in Mathematics and Science Study) survey conducted by the International Association for the Evaluation of Educational Achievement in 2015, Indonesia was ranked 44 out of 49 participating countries. The student's average score is 397, with the international average score of 500 [7].

The purpose of geometry learning is for students to gain confidence in their mathematical abilities (skills), become good problem solvers, communicate mathematically, and reason mathematically [8]. This field provides problem-solving approaches in drawings, diagrams, and coordinate systems [9]. There are five reasons why geometry is very important to study: (1) It can be found in the solar system, geological formations, crystals, plants, animals, architectural works of art, and machine work, which aids humans in having a complete perception of their world. (2) Geometric exploration can help them develop problem-solving skills daily. (3) Geometry also plays a major role in other areas of mathematics. (4) Geometry is used by many people in daily life. (5) Geometry provides a plethora of interesting challenges.[10]. Plane Figure subjects are the sub-subjects of geometry that involve problem-solving [11]. Plan figure subject is material that can be used when learning mathematics to develop a problem-solving ability.

However, despite some experts' views regarding the importance of learning geometry, the reality found in schools is that many students have difficulty solving geometry problems [12]. In addition, students still have difficulty using formulas in solving geometric problems. Not infrequently, students still do not understand the meaning of the

questions given [13]. Based on data from Puspendik (2019), the mastery of the national exam material for the geometry test material for SMP students in NTB is still at an average of 37.99, down from 42.27, the national average [14].

Based on teacher interviews, it is known that every year the most common problems encountered when learning mathematics are students' difficulties in solving problems in geometry and materials, especially plane figure subject. Students have difficulty solving problems because of a lack of conceptual understanding of the learning materials taught by teachers in the classroom, as students have not been able to relate one concept to another. In addition to the lack of understanding of concepts, another difficulty experienced by students is the lack of imagination, which causes students to be unable to have imagination in plane figure subject. It impacts students less skilled in solving problems and applying the concepts learned.

Table 1. Average Mathematics Odd Semester Exam Scores for Class VIII A-E SMP Negeri 1 Mataram

No.	Class	Average value
1	VIII-A	44.69
2	VIII-B	40.20
3	VIII-C	40.47
4	VIII-D	39.06
5	VIII-E	35.83

Table 1 shows the average value of the end-of-semester mathematics test for class VIII A-E at SMP Negeri 1 Mataram. These data indicate that the average score obtained by students is still relatively low and has not reached the minimum standard of completeness which is 75. It can be concluded that the ability of students to solve mathematical problems is not well developed.

In connection with this, the teacher plays an essential role in creating students with good problem-solving skills. In addition, it is also necessary for students to understand van Hiele's way of thinking. The application of van Hiele's theory is believed to identify students' problem-solving abilities in geometry materials, including Plane Figure subjects.

Van Hiele's theory of geometry thinking in the field of mathematics education, namely: Level 0: Visualization, students recognize geometric shapes only for their visual characteristics and appearance. (2) Level 1: Analysis: There is already a visible analysis of the concept and its properties at this level. Students can determine the properties of a shape by observing, measuring, experimenting, drawing, and modeling. (3) Level 2: Informal deduction, At this stage, students can see the relationship between the properties of a geometric shape and the properties of several geometric shapes. (4) Level 3: Deduction: Students can construct evidence, not just accept it at this level. Students can construct theorems in axiomatic systems. (5) Level 4: Rigor, At this level, students reason formally in mathematical systems and can analyze the consequences of manipulating axioms and definitions [15]. In this study, the level of thinking used by van Hiele is limited to level 2 (informal deduction), considering that this research was conducted in class VIII SMP, so it has not been able to understand up to level 4 (rigor). At each level of van Hiele thinking, students will pass each level of van Hiele thinking sequentially. Thus, students must pass the most basic level to go to the next level. Each student's ability at the van Hiele thinking level has certain criteria that cause students to differ from one another in understanding and solving geometric problems. So therefore, van Hiele's level of thinking is believed to affect the problem-solving ability of each student.

The researcher chose van Hiele's theory as the basis for classifying geometrical problems, including those involving plane shapes, for the following reasons: (1) van Hiele's theory focuses on geometry, (2) van Hiele's theory examines levels of understanding in learning geometry, (3) van Hiele's theory explains the general description of each level, which is described in a more operational description, (4) Van Hiele's theory has the accuracy in describing students' thinking levels in geometry.

Based on the description of van Hiele's theory, it can be concluded that a student who is at a low level of material understanding cannot be at a higher level. Therefore, we are interested in researching the analysis of mathematical problem solving ability of plane figure subject based on van hiele's theory of eighth grade of junior high school SMP Negeri 1 Mataram.

RESEARCH METHODS

This research type is descriptive qualitative, which aims to describe the ability to solve mathematical problems in Plane Figure Subject based on van Hiele's theory in class VIII SMP Negeri 1 Mataram. Qualitative research produces descriptive data in the form of written or spoken words from people or observable behavior [16]. The results of this study are expected to carefully reveal students' mathematical problem-solving abilities in solving geometrical problems based on van Hiele's theory. This research was conducted in November-December 2021 in the odd semester at SMP Negeri 1 Mataram for the academic year 2021/2022. The subjects in this study were from class VIII-E of SMP Negeri 1 Mataram. Then each student was selected based on the results of the geometry problem-solving ability test on the subject of quadrilaterals based on van Hiele's level of thinking. At each level of van Hiele's thinking, representatives of 2 subjects were taken who were able to reach level 0 (visualization), level 1 (analysis), and level 2 (informal deduction) so that the total subjects used in this study was 6 subjects. The method of taking the subject is purposive sampling, which is selected based on the objectives to be achieved. The data sources used in this study

are primary and secondary data. Primary data sources are written data from the results of students' work on the problem-solving ability test and interviews with teachers and students who are the research subjects. At the same time, the secondary data source in this research is documentation.

Data collection techniques in the study were divided into 3, namely tests, interviews, and documentation. First, a test is a technique or method used in measurement activities in which there are a series of questions, exercises, or other tools used to measure skills, knowledge, intelligence, abilities, or talents possessed by a person or group [17]. This test method is used to obtain data on student problem-solving based on van Hiele's level of thinking. There are 2 kinds of test questions used in this study: the Van Hiele Geometry Test (VHGT) and the problem-solving ability test. Second, the interview is a conversation with a specific purpose. The conversation is carried out by two parties, namely the interviewer who asks questions and the interviewee who provides answers to these questions to gather information from the interviewee [18]. Interviews in this study were used to confirm students' answers at the time of the mathematical problem-solving ability test on quadrilateral material, so researchers obtained data directly. Interviews were conducted using a cellphone as a recording device so that the results of the interviews showed validity and could be well organized for further analysis. Third, the documentation is divided into two, namely, initial documentation and final documentation. Initial documentation is data on student abilities in geometry and measurement materials based on Puspendik 2019. At the same time, the final documentation is data obtained after conducting a problem-solving ability test or during an interview. The instrument used is the validity of Aiken [19]. An instrument is valid if it can be used to measure what should be measured correctly [20]. The contents of the questions are reviewed using certain criteria by people who are competent in the field concerned, which in this case are lecturers of mathematics education and mathematics teachers at SMP Negeri 1 Mataram. There are 3 instruments used, namely the van Hiele test (VHGT), a problem-solving ability test, and a student interview guide. First, the van Hiele test (VHGT), which the Cognitive Development and Achievement have developed in Secondary School Geometry project, has been tested for validity to determine students' thinking levels. This test is in the form of a multiple choice test consisting of 15 questions arranged into 3 levels of van Hiele thinking, namely level 0 (visualization), level 1 (analysis), and level 2 (informal deduction). Second, a solving ability test that two professionals have validated. This test is a description test consisting of 2 questions on the subject matter of a quadrilateral, which is used to determine students' mathematical problem-solving abilities. Third, student interview guidelines have been validated by two experts. In this case, the interview guide was used to reinforce and deepen students' answers to the mathematical problem-solving ability test that had been tested on research subjects.

The results of the van Hiele test and the student's mathematical problem-solving ability tests were then analyzed and described. First, students carry out the van Hiele test. Then the results of student work are grouped into van Hiele's thinking levels, namely level 0 (visualization), level 1 (analysis), and level 2 (informal deduction). At each level of van Hiele's thinking, representatives from each of the two subjects who could reach that level were taken. As a result, six subjects have been identified to carry out the problem-solving ability test. After carrying out the problem-solving ability test, interviews were carried out, and the process was recorded and compiled into the form of student interview transcripts. The results of the problem-solving ability test and interview transcripts were analyzed to determine the description of the student's mathematical problem-solving abilities based on van Hiele's theory. The data analysis technique used went through the following stages: 1) data reduction, 2) data presentation, 3) conclusion drawing/verification, 4) data validity test.

RESULTS AND DISCUSSION

Data retrieval starts by taking documentation in the form of a list of names of class VIII-E students. Furthermore, to determine the research subject, the researcher gave the van Hiele test to the class VIII-E SMP Negeri 1 Mataram total of 36 students. From the data obtained, the researcher conducted an examination and then grouped each student's scores based on the van Hiele level. The percentage obtained from the number of students in class VIII-E SMP Negeri 1 Mataram at each van Hiele thinking level is presented in the following table.

Table 2. Results of Grouping Students' Thinking Levels Based on Van Hiele's Thinking Levels

No	Thinking Level of Learners	Many Students	Percentage
1	Level 0 (Visualization)	20	55.56%
2	Level 1 (Analysis)	13	36.11%
3	Level 2 (Informal Deduction)	3	8.33%

From Table 2, the results of grouping students' thinking levels based on van Hiele's thinking levels can be presented in the form of a pie chart (Figure 1).

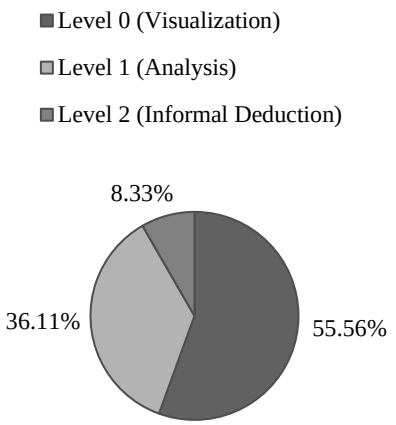

Figure 1. Diagram of Students' Thinking Level Grouping Results Based on Van Hiele's Thinking Level

Figure 1 shows that it can be seen the percentage of the number of students in each student's ability based on van Hiele's theory, where 55.56% of students are at level 0 (visualization), 36.11% of students are at level 1 (analysis), and 8.33% of students are at level 2 (informal deduction). From the diagram above, the dominant class VIII-E students are at level 0. In addition, students have reached levels 1 (analysis) and 2 (informal deduction), but the number of students who reach level 2 tends to be less than the number of students who reach level 1. Likewise, students who reach level 1 tend to be less than those who reach level 0.

The grouping of students into van Hiele thinking levels is not based on the value of each student but on the student's ability to answer questions from each van Hiele thinking level. It is in line with the van Hiele thinking level grouping criteria, namely that students are said to have reached a certain level if they can correctly answer at least 3 of the 5 questions at each van Hiele level. Vice versa, if students have failed at a certain level, they are considered to have failed at the next level.

After grouping students into van Hiele's thinking levels, six research subjects were selected. Every two students represented van Hiele's thinking levels and were then asked to work on the problem-solving ability test questions the researcher had prepared. Data collection was obtained through the results of student work and interviews. The data was obtained by recording all activities from the beginning to the end of data collection using cellphones and cameras.

Based on the results of student work in the problem-solving ability test, the level 0 group consisted of 2 subjects, namely $S0_{07}$ and $S0_{16}$. It can be concluded that $S0_{07}$ can understand the problem but has not been able to develop a settlement plan, implement a settlement plan, and re-examine it. It can be concluded that $S0_{16}$ has been able to understand the problem but has not been able to develop devising a plan, carry out the plan, and look back. So it can be concluded that students in the level 0 group are at the stage of understanding the problem.

Based on the results of student work in the problem-solving ability test, the level 1 group consisted of 2 subjects, namely $S1_{06}$ and $S1_{10}$. $S1_{06}$ can understand the problem and devise a plan but has not carried out the plan and looked back. Then, based on obtained exposure and data analysis of $S1_{10}$, it can be concluded that $S1_{10}$ has been able to understand the problem and devise a plan but has not been able to carry out the plan and look back. So it can be concluded that students in the level 1 group are at the stage of understanding the problem and devising a plan.

Based on the results of student work in the problem-solving ability test, the level 2 group consisted of 2 subjects, namely $S2_{08}$ and $S2_{09}$. $S2_{08}$ has been able to understand the problem, devise a plan, and carry out the plan but has not been able to look back. It can be concluded that they have been able to understand the problem, devise a plan, and carry out the plan but have not been able to look back. So it can be concluded that students in the level 2 group are at the stage of understanding the problem, devising a plan, and carrying out the plan.

Abilities Gained by Level 0 Group Students

Students at level 0 at the stage of understanding the problem have good abilities in understanding problems and knowing the information in the questions, such as being able to state what is known and what is being asked. Suppose students do not write down what is known in full on the answer sheet and are able to identify the data provided. At the stage of devising a plan, students have not been able to plan problem-solving by writing complete mathematical formulas on the answer sheet but have written one of the mathematical formulas that will be used. At the stage of carrying out the plan, students have not been able to solve problems, such as not writing down the steps to resolve the problem completely. Meanwhile, looking backstage, students have not been able to look back on such things as checking answers and making conclusions.

Students at level 0 are known to be in the stage of understanding the problem can be done correctly, but in the devising a plan, the stage of carrying out the plan, and the stage of looking back, it cannot be done correctly. It is in line with research that reveals that students at level 0 (visualization) understand the problem can be done correctly. Still, devising a plan, carrying it out, and looking back cannot be done correctly [15]. Students can already understand the problem but have not been able to devise a plan, carry out the plan, and look back at the process and result [21].

Abilities Gained by Level 1 Group Students

Students can understand the problem well because they can understand the sentence of the story well, knowing the information contained. In questions such as being able to state what is known and asked, even though students do not write down what is known in full on the answer sheet, they can identify the data provided. When devising a plan, students can explain the formulas that will be used in solving problems correctly. At the stage of carrying out the plan, students were unable to solve the problem correctly due to errors in reasoning and calculation, resulting in incorrect answers. Meanwhile, looking backstage, students have not been able to look back, such as by checking answers but only writing conclusions.

The group of students at level 1 is known to be in the stage of understanding the problem. Devising a plan can be done correctly, but the stage of carrying out the plan and the stage of looking back cannot be done correctly. It is contrary to research which reveals that students at level 1 (analysis) in understanding the problem, devising a plan, and carrying out the plan can be done correctly. Still, students have not been able to look back at the results of the answers even though the calculations have been done correctly [15]. It is also reinforced by the result of research which says that students at level 1 in problem-solving according to Polya's steps are in a good category. Students can understand the problem, devise a plan, and carry out the plan but have not been able to look back at the process and result [21].

Abilities Gained by Level 2 Group Students

Based on the results of test analysis and interview results in the research given by the researcher using 2 description questions on the problem-solving ability test, students can understand the problem well at the stage understanding the problem. They can understand the sentence of the story well, knowing the information in questions such as being able to state what is known and asked, even though on the answer sheet, students do not write what is known in full. They can identify the data provided so that it is sufficient to solve the problem. When devising a plan, students can explain the formulas used to solve problems correctly. At the stage of carrying out the plan, students can explain the steps used in solving problems by correcting errors on the answer sheet to produce the correct answer. Meanwhile, looking backstage, students have not been able to look back, such as by checking answers but only writing conclusions.

Based on the discussion above, it can be concluded that the group of students at level 2 is known to be in the stage of understanding the problem, devising a plan, and carrying out the plan that can be done correctly. Still, at the stage of looking back, it cannot be done correctly. This is contrary to research which reveals that students at level 2 (informal deduction) understand the problem, devising a plan, carrying out the plan, and looking back can be done correctly, and the calculation process carried out is also carried out correctly [15]. It is also reinforced by the results of research, which says that students at level 2 in problem-solving according to Polya's steps are in the very good category, which means that students are able to understand the problem, devise a plan, carry out the plan, looking back at the process and result [21].

Based on the above discussion regarding students' ability at levels 0, level 1, and level 2, it can be concluded as follows.

1. Students at level 0 (visualization) in solving problems based on the problem-solving stages Polya is at the stage of understanding the problem but has not been able to develop devising a plan, carrying out the plane, and looking back.
2. Students at level 1 (analysis) in solving problems based on the problem-solving stages Polya is at the stage of understanding the problem and devising a plan but has not been able to carry out the plan and look back.
3. Students at level 2 (informal deduction) in solving problems based on the problem-solving stages Polya is at the stage of being able to understand the problem, devising a plan, and carrying out the plan, but has not been able to look back.

Meanwhile, based on other research, the following conclusions can be drawn: It was found that students at level 0 could only understand the problem. Meanwhile, students at level 1 can understand the problem, devise a plan, and carry out the plan but have not checked and reviewed the results. Meanwhile, students at level 2 can understand the problem, devise a plan, carry out the plan, and look back at the results of the settlement [15].

CONCLUSION

The thinking level of students in the eighth grade of junior high school SMP Negeri 1 Mataram is generally dominant at level 0 with a percentage of 55.56%. In contrast, students at level 1 have a percentage of 36.11%, and students at level 2 are 8.33%. Based on van Hiele's theory, level 0 groups students in solving problems based on the stages of problem-solving. They have understood the problem well but have not been able to devise a plan, carry out the plan, and look back. It is because students cannot write down the formulas to be used, create concepts related to the questions, or arrange the steps for solving problems. They can be solved systematically, and not try to re-check answers and examine the steps taken from the answers that are obtained. While students at level 1 in solving problems based on the stages of problem-solving by Polya have been able to understand the problem well and devise a plan, but have not been able to carry out

the plan and look back. It is because students cannot arrange the steps for solving the problems so that they can be solved systematically and do not try to re-check the answers and examine the steps taken from the answers obtained. And students at level 2 in solving problems based on Polya's stages of problem-solving have been able to understand the problem well, devise a plan, carrying out the plan but have not been able to look back. It is because students do not try to re-check the answers and examine the steps taken to obtain the answers.

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