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Analysis of the Difficulty of Mathematical Education Students in Completing the Geometric Running Problem Based on Van Hiele Theory in Geometry Transformation

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Abstract

The purpose of this study was to: (1) finding out the difficulties experienced by mathematics education students in solving geometric reasoning problems based on van Hiele's theory; (2) identifying the factors causing difficulties experienced by students in solving geometric problems based on van Hiele's theory; and (3) determining the steps that need to be taken to overcome the students' difficulties in solving geometric reasoning problems based on van Hiele's theory in the Transformation Geometry Course. The students' difficulties in solving geometric reasoning problems based on van Hiele's levels will give an idea of the indicators of geometrical reasoning abilities that are still low, so that the right alternative solutions are obtained. This type of research is descriptive research with a qualitative approach. The research subjects were 28 students who programed geometry transformation courses. The instrument in this study was a test instrument, namely geometric reasoning abilities of students as many as 5 questions consisting of 5 levels of ability, namely visualization, analysis, abstraction, formal deduction, and rigor. While the data analysis techniques in this study used descriptive analysis. Collecting data in this study used interview techniques and written tests. The results showed that from the five indicators of geometric reasoning ability, for the visualization level, there were 26 people who achieved the optimal score with a percentage of 92.9. Seen at the level of analysis still not reached optimally with a percentage of 21.4 or only 6 people who achieved the optimal score, while the level of abstraction, formal deduction, and rigor has not been achieved. Difficulties experienced by students at the level of analysis, abstraction, formal deduction, and rigor. The causal factors experienced by students based on the results of interviews obtained information that students have difficulty answering questions due to several things including; students have forgotten about the material being taught, when they learn they understand but are less interested in developing, feel unsatisfied so they expect concrete media, need to be trained in many questions, and follow up to students. From this information, an appropriate alternative is needed, for example using van Hiele's theory to familiarize students with reasoning skills.

Keywords: geometric reasoning, transformation geometry, van Hiele's theory

A. Introduction

Mathematics is an interesting thing to talk about. According to Warli (2010: 1), mathematics learning is always interesting to talk about, because it has abstract objects so it is not easy to present concepts that are easily understood by students.

Geometry as a branch of mathematics has a strategic position in developing students' reasoning abilities. Geometry can be seen as a vehicle for training students' reasoning or spatial insight. But the reality in the field shows that the mastery of geometry material by students is still weak especially in the transformation geometry. This is indicated by the results of the mid semester data of students who are below the standard, whose value is less than 65. In addition to information from students, many think that the geometry transformation subject is one of the subjects that is difficult to understand.

Based on teaching experience at the Universitas Sembilanbelas November Kolaka and direct interviews, information was obtained that there were still many students experiencing difficulties in the subject of transformation geometry. The main difficulty lies in solving problems related to geometric reasoning. In addition, in the learning process of transformation geometry, they experience difficulties in proving theorems, working on verification questions, using symbols, applying answers to images and understanding the concepts of geometry of transformation, and accuracy in solving systematic problems in the algebra. This results in the acquisition of student grades that are not in line with expectations.

Students' learning difficulties that also occur in the Universitas Sembilanbelas November Kolaka lead to an imperfect understanding of subsequent geometric concepts. In the end, this condition hampered the process of learning geometry later. As revealed by Muhassanah & Imswatama (2016: 2) that in the process of learning geometry transformation, students experience difficulties in proving theorems, working on proofs, using symbols, applying answers to images and understanding geometrical concepts of transformation and accuracy in solving questions systematically the algebra. Therefore, difficulties for students after being identified then alternative solutions can be found. For example, geometry material and learning are adapted to van Hiele's theory which begins with detecting the level of students' problematic geometric reasoning. The course of transformation geometry is not a significant problem. In connection with that expressed by Clement (2001) in Ramlan (2014: 20) that this theory would be useful if used, tested, and modified. Whereas According to Halat (2008: 8) some of the results of empirical research state that van Hiele's theory is useful in the development of student geometry concepts, ranging from elementary school to college. Therefore, it is better to anticipate early on for prospective high school teacher students who will become junior and senior high school teachers by identifying the extent to which the geometrical thinking stage achieved is mainly viewed from van Hiele's thinking stage. Based on this description, one of the reasons for choosing students' geometric reasoning abilities based on van Hiele's theory is in the transformation geometry course to be studied further.

B. Literature Review

Geometric reasoning

Reasoning is a thought or way of thinking according to reason (logic). Reasoning is also interpreted as part of mathematical (doing mathematics). Kariadinata (2012: 11-12) states that reasoning is one aspect of high-level mathematical thinking that is categorized as a basic competency that must be mastered by students. While geometry is a geometry or part of mathematics that studies the properties of lines, angles, planes, and spaces (Fajri & Senja, 2008: 58-324).

Geometric reasoning proposed by Wing (1985) in Ramlan (2016: 64) is a process of defining and deducing the properties of a unit of geometry by using the intrinsic nature of the unit, its relation to other unity of geometry, and rules to draw correct conclusions really intertwined between the properties that exist in geometric space (Euclid). Geometric reasoning is closely related to the stages of cognitive development in geometry learning proposed by van Hiele. Kepner (2006: 7) reveals that van Hiele's levels of geometric reasoning are visualization, analysis, informal deduction, formal deduction, and rigor (accuracy).

Van Hiele's Geometric Reasoning Levels

The level of thinking that students go through in understanding geometry material, according to van Hiele's theory is as follows:

Level 0 (Visualisation)

The result of thinking on level 0 is classes or groups of objects that look "similar". Emphasis on level 0 is in forms that can be observed, felt, formed, separated or used in various ways by students (Van de Walle, 2006: 151). For example, they say that the known geometry is a beam, because it's like a box. Children are not aware of the properties of geometry (Khotimah, 2013: 11).

Level 1 (Analysis)

The objects of thought at level 1 are groups of shapes not individual forms. Students can state all forms in groups other than the form of the unit. By focusing on the form group, students can think about how a rectangle is formed (four sides, parallel opposite sides, equal opposite sides, four right angles, congruent diagonals, etc.). Unrelated properties will disappear. At this level, students understand the nature of concepts or construct geometry based on informal analysis of parts and component attributes. (Van de Walle, 2006: 152).

Level 2 (Abstraction or Informal Deductiuon)

Van de Walle (2006: 153-154) explains the object of thought at level 2 is the properties of form. More understanding of dealing with "if-then" thinking, forms can be classified only by using some traits. For example, four sides are congruent and at least one right angle is sufficient to define a square. Students at level 2 will be able to follow and appreciate informal, deductive opinions about their forms and characteristics. The result of thinking on level 2 is the relationship between the properties of geometric objects. At this level, students begin to learn about the scholarship of a definition and the benefits of conflicting examples and form a collection of new relationships that exist between these traits.

Level 3 (Formal deduction)

Van de Walle (2016: 154) suggests that the thinking object at level 3 is a relationship between the properties of geometric objects. At level 3, students are able to research not only the characteristics of form. The thinking of students beforehand has yielded allegations about the relationship between traits. Is this estimate right? Is that all "right"? When informal opinion analysis takes place, the structure of a system complete with axioms, definitions, theorems, and postulates begins to develop and can be valued as a tool in geometry truth formation. At this level, students begin to appreciate the need for a system of logic based on a collection of assumptions and where other truths can be derived. Students at this level are able to work with abstract statements about the properties of geometry and make conclusions based more on logic than instinct. Students at this level can clearly observe that the diagonal lines of rectangles intersect, as students at level 2 can do it. But at level 3, there is an appreciation of the need to prove it based on deductive opinions. On the other hand, thinkers at level 2 follow opinions, but fail to appreciate their needs. The results of thinking at level 3 are deductive systems based on geometry. For example, make a list of axioms and definitions for making a theorem.

Level 4 (Accuracy or Rigor)

The thinking objects at level 4 are deductive systems based on geometry. At this top level in van Hiele's level, the objects of interest are their own basic system, not just the conclusion in the system. This geometry has its own set of axioms and theorems. The result of thinking at level 4 is a comparison and difference between various basic geometry systems. (Van de Walle, 2006: 154). Students rigorously prove theorems on different postulate systems and analyze or compare the two systems. Indicators according to David Fuys (1995) in Mariana (2016: 8) namely: 1) rigorously proving the theorems on different axiom systems (e.g. Hillbert's approach as the basis of geometry); 2) comparing axiom systems (e.g. Euclid and non-euclid geometry) spontaneously traces how changes in axioms affect the results of geometry; 3) proving the consistency of several axioms, independent of axioms, creating a system of axioms in geometry; 4) creating generalization methods to solve group problems; 5) looking for the broadest context in which the theorem or principle of mathematics can be applied; 6) carrying out in-depth studies on logical subjects to develop new insights and approaches to logical conclusions.

C. Methodology

This type of research is descriptive research with a qualitative approach. This research was conducted at the Universitas Sembilanbelas November Kolaka, at the Faculty of Teacher Training and Education (FKIP) mathematics education study program. There are 28 students of Semester VI of class B 2017/2018 Academic Year which programed geometry transformation courses. The data analysis technique in this study used descriptive analysis. The data collection in this study applied interview and written tests. The instrument in this study is a test, namely geometric reasoning abilities of students as many as 5 questions consisting of 5 levels of ability, namely visualization, analysis, abstraction, formal deduction, and rigor.

The category distribution for the value of the students' geometric reasoning abilities is categorized using benchmark reference with the criteria proposed by Kadir (2010: 251) in table 1 below:

Table 1. Categorizing Geometric Reasoning Capabilities

Score	Category
$80 \le x \le 100$	High
$60 \le x < 80$	Medium
$0 \le x < 60$	Low

D. Findings and Discussion

1. Findings

The results of the geometric reasoning test consist of 5 indicators including visualization, analysis, informal abstraction or deduction, formal deduction, accuracy or rigor. The data from the test results of students' geometric reasoning abilities are presented descriptively in table form. In general, the data from the students' geometric reasoning abilities are presented in the following table 2:

Table 2. Data on Geometric Reasoning Ability Test Results

CAPABILITIES OF GEOMETRICS	
Number of Respondents	28
Mean	51.50
Median	53.00
Mode	53.00
Standard Deviation	11.921
Variant	142.111
Minimum score	20
Maximum score	67
Total score	1442.00

The percentage of the total number of students and the mean of the students' geometric reasoning ability for each category of high, medium, and low groups is presented in the bar diagram in figure 1 below:

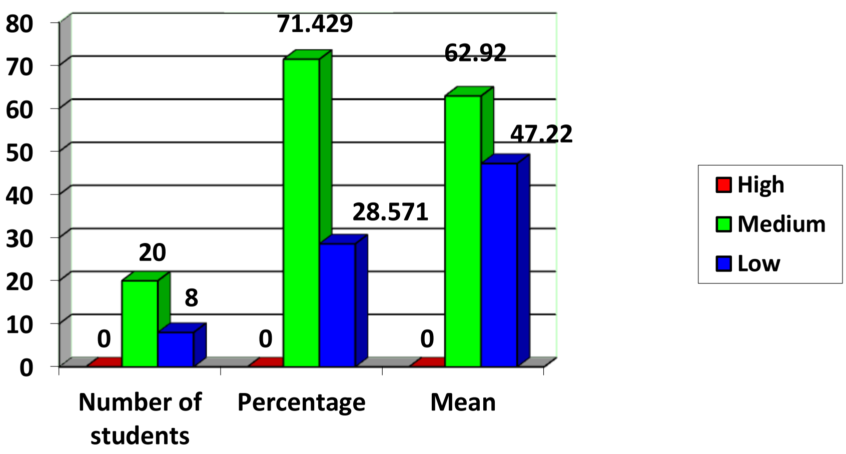

Figure 1. Percentage of total number of Students and Mean of Geometric Reasoning Ability

Based on the data obtained from the results of students' geometric reasoning tests for each level, as presented in table 3 below:

Table 3. Results of Geometric Reasoning Ability Analysis

Level of Thinking	N	Percentage (%)	Mean
Visualisation	26	92.9	4.64
Anaysis	6	21.4	3.88
Abstraction	0	0	2.50
Formal deduction	0	0	0.43
Rigor	0	0	0.04

Based on table 3, for the five levels of geometric reasoning abilities are visualization, analysis, abstraction, formal deduction, and rigor. For the level of visualization there were 26 students who achieved optimal scores with a percentage of 92.9 and an average of 4.64. Seen at the level of analysis there were 6 students who achieved optimal scores with a percentage of 21.4 and an average of 3.88, while there were no levels of abstraction, formal deduction, and rigor that reached the optimal percentage and score, while the average of each level of abstraction 2.50, formal deduction of 0.433 and rigor level of 0.04.

2. Discussion

Difficulties experienced by students at the level of analysis for non-proof questions were only 6 students whose solutions were almost completely complete and correct with their respective scores of 5, the level of abstraction, formal deduction, and rigor no students achieved the maximum score. In connection with what was stated by Mateya (2008: 2), it was revealed that problems regarding learning geometry were identified in 1950 by two Dutch mathematics educators, Pierre van Hiele and his wife, Dina van Hiele Geldof. Van Hiele's theory was further considered by many countries such as Britain, the United States and the Soviet Union as one of the best teaching designs to assess the geometrical reasoning of students stated at Atebe & Schafer (2008).

Based on the results of the interview, information obtained by students about the difficulty of answering questions based on van Hiele's theory is caused by several things including; students have forgotten about the material being taught, when they learn they understand, but are less interested in developing, feel unsatisfied so expect concrete media, need to be trained in many questions, and follow up to students. From this information, the right alternative is needed, for example using van Hiele's theory to familiarize students with practicing geometric reasoning skills and identifying problematic levels.

E. Conclusion

The conclusions in this study include: 1) the results of the study show that from the five indicators of geometric reasoning ability that is for the level of visualization there are 26 people who achieve optimal scores with a percentage of 92.9. Seen at the level of analysis still not reached optimally with a percentage of 21.4 or only 6 people who achieved the optimal score, while the level of abstraction, formal deduction, and rigor has not been reached; 2) the factors causing difficulties experienced by students in solving geometric problems based on van Hiele's theory. The results of the interview showed students had difficulty answering questions at the van Hiele's level because they had forgotten the material taught during lectures, sometimes they understood but were not interested in developing material, were not satisfied, expected concrete media, lecturers needed to train questions , and there is follow-up to students; 3) from this information, an appropriate alternative is needed, for example using van Hiele's theory to familiarize students with practicing geometric reasoning skills, especially in geometry transformation subjects and other geometry courses in general.

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