Students' Errors in Solving Geometry Problems of Van Hiele Levels Based on Newman's Error Hierarchy Model

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ABSTRACT
The mathematical curriculum must include geometry because it helps pupils learn to think geometrically. This is so because geometry has many applications in both literacy and numeracy. One of the attempts undertaken is to identify the students' geometric thinking level because it is crucial to comprehend students' abilities in learning geometry. The levels of Van Hiele's theory, which include level 0 (visualization), level 1 (analysis), level 2 (informal deduction), level 3 (deduction), and level 4 (deduction), can be used to gauge pupils' proficiency in geometric reasoning (rigor). By examining students' errors in resolving geometrical problems using the Hierarchical Error Newman model, it is possible to gauge the level of their geometric thinking. Through reading, understanding, transformation, process skills, and writing errors in the final answer, this study examines Van Hiele's geometric thinking levels from errors made while working on geometry problems based on Newman's Hierarchical Error model. The study's target population is junior high school students. Students in class VIII at a school in Kendal Regency served as the test subjects for this study, which used a descriptive qualitative analysis as its research method. Techniques for gathering data included interviews, questionnaires, and extensive geometry student assessments. The study's findings revealed that pupils could only advance to level 2. According to the results, 14 students were at level 0 (visualization), 8 students were at level 1, just 3 students attained level 2 (informal deduction), and neither level 3 nor level 4 had any students who were able to complete them. The percentage of mistakes made by pupils in the areas of visualization (44%), analysis (30%), and informal deduction (26%), respectively. The predominant faults students make are those that are related to understanding and composing the final response.

Keywords: *Geometry thinking, van hiele, hierarchic model, informal deduction*

1. INTRODUCTION

Geometry is a mathematical material that must exist in all curricula in the world and is studied in every education unit [1], even geometry has been introduced at an early age [2]. Because geometry material is frequently employed in the study of mathematical content, geometry is one of the fields of mathematics that students must master [3];[4]. Teachers and students, meanwhile, continue to have trouble acquiring geometry[5] [6]. Particularly when students are in junior high school or between the ages of 13 and 15 years old. For the most part, first-year students only recall formulas to answer geometric problems [7], nevertheless, they struggle to solve issues in context [8].

Realizing the importance of understanding skills that students must possess in learning geometry, one of the efforts is to determine students' geometric thinking level [9]. One way that can be done to measure students' geometric thinking ability is the Van Hiele theory. Van Hiele's theory is one of the theories concerned with learning geometry [10], especially in rectangular and triangular shapes. The geometric thinking stage in the van Hiele model is divided into five stages, namely level 0 (visualization), level 1 (analysis), level 2 (informal deduction), level 3 (formal deduction), level 4 (rigour) [4]; [11]; [12].

Level 0 (visualization) students recognize geometric shapes only as visual characteristics of an [13]. Level 1 (analysis), at this level, students can determine the

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properties of a shape by observing, measuring, drawing and modelling [14]. In level 2 (informal deduction), students can relate the properties of a geometric figure using informal deduction to classify them in an orderly manner [15]. Level 3 (formal deduction), at this level, students not only accept evidence but are already able to compile evidence and prove the theorem using logical thinking [16]. Level 4 (rigour), at this level, students reason formally and understand the relationship between undefined forms, axioms, definitions, theorems and formal proofs can be understood [11]. Students have begun to realize how important the accuracy of the basic principles that underlie a proof is [17].

Each level has specific criteria, causing students to be different in understanding and solving geometric problems [18]. In learning mathematics, students often make mistakes in solving math problems [19], especially question descriptions [20]. Errors are deviations from the right things that are systematic and consistent. Students' errors in solving math problems vary widely. According to Newman, students make five types of errors when solving questions. These are divided into five types of errors: Reading errors, Comprehension errors, Transformation errors, Process skills errors, and Encoding errors [21][12].

The existence of these problems requires research to determine the description of the process of analyzing errors in working on geometry problems, the subject of triangular and rectangular flat shapes, and knowing the types of student errors in spelling geometry questions in terms of the achievement of van Hiele's geometric thinking level. The Newman Error Analysis model can be a solution to analyze any mistakes made by students in working on geometrical problems on the subject of triangular and rectangular flat shapes, as well as knowing the causes of student errors in solving geometric problems on the subject of triangular and rectangular flat shapes. This study emphasizes more on the characteristics of students in mastering geometric thinking based on the van Hiele level, which is obtained from the analysis of student errors using the Newman's error hierarchy model in doing geometric thinking tests. The existence of the Newman's error model will be able to find out in detail the stages of what mistakes are made by students. So that it is clearer to examine the characteristics of students' geometric thinking abilities.

2. RESEARCH METHOD

This research design is descriptive and qualitative, describing some of the information collected regarding error analysis according to Newman's theory in solving geometrical problems of triangles and quadrilaterals based on Van Hiele's level of geometric thinking in class VIII Junior High School students. The ability to think geometrically is seen in the ability to complete geometric material by looking at the mistakes made by students based on Newman's hierarchic error model. This study aims (1) to analyze students' ability to think geometrically in completing the test and (2) to characterize students' geometric thinking skills based on Newman's hierarchic error model.

This data was taken from eighth-grade students of Junior High School, which involved three participants as research subjects. This study uses a test consisting of two tests, namely the Van Hiele geometric thinking level test for junior high school and a geometry material test taken from the 2015-2020 national exam material for triangular and rectangular shapes, observations, documentation, and interviews for collect data more executive in digging information. The written test in this study uses the Van Hiele Geometry Test (VHGT), which consists of 25 multiple choice questions that have been tested for validity and reliability to determine students' geometric thinking levels [22]. The second test is a test that uses the National Examination questions consisting of 5 questions that are used; of course, their validation and reliability have been measured. The qualitative analysis applied in this study is collecting data sources and data triangulation from test, documentation, and interviews. The data obtained were based on the stages of the qualitative model: data collection, data selection, data separation, making analogies and making hypotheses. Research subjects were given a geometry test and then analyzed based on student errors in solving them based on Newman's hierarchic error model, namely reading errors, understanding errors, transformation errors, skill processing errors and writing answers errors.

Furthermore, the results of these errors were categorized into van Hiele's level of geometric thinking. In-depth interviews were conducted with students based on the level of geometric thinking that was mastered to obtain more in-depth information about van Hiele's level of geometric thinking so that the characteristics of students in mastering van Hiele's level of geometric thinking. Triangulation in this study was carried out to validate the data obtained, namely geometry material tests, observations, documentation and in-depth interviews.

3. RESULTS AND DISCUSSION

The results of the Van Hiele geometry level test showed that the students who were the research subjects were in the categories shown in the following table.

TABLE 1. Van Hiele Leveling Test Results

Level	Total of Students	Percentage %
0	14	56%

1	8	32%
2	3	12%
3	0	0%
4	0	0%

Table 1. shows that there are no students who are at level 3 and 4 of the 25 students who are given the Van Hiele geometry level test. The conclusion that can be obtained is that students are only at maximum level 3. The subject is then given a geometry test of triangles and quadrilaterals which aims to find out what errors are often made by students based on the Newman procedure. Based on the results of student work, the results of the analysis can be seen in the following table:

TABEL 2. Percentage Error of Students

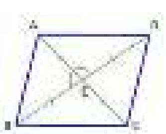
No	Level	Percentage %
1	Vizualitation(V)	44%
2	Analysis (A)	30%
3	Informal Deduction (ID)	26%

Based on table 3, then three (3) subjects were selected which represented the ability of each level of geometric thinking. The following is the distribution of errors made by the subject in completing the triangular and rectangular geometry tests based on van Hiele's geometric thinking on the test that was carried out once.

TABLE 3. Student errors in solving geometry problems

Level Van Hiele	Subjek	the distribution of errors made by the subject in each item			
		1	2	3	4
Vizualitation	V2	transform error, encoding error	weakness in process skill, encoding error	reading error, comprehension difficulty transform error, weakness in process skill, encoding error	reading error, comprehension difficulty, transform error, weakness in process skill, encoding error
Analysis	A23	encoding error	weakness in process skill, encoding error	transform error encoding error	
Informal Deduction	ID 14	encoding error	encoding error	encoding error	

Based on table 3. the results show that question 4 is a question with a high level of difficulty, so students who are at level 0-2 are unable to solve the problem. This is what makes mistakes made by students starting from reading errors, understanding errors, transformation errors, thinking process errors so that many make mistakes in writing answers. This means that there are many questions number 4 that are not answered or do not write down the answers. The following questions are presented in number 4.



Prove that the sum of the angles in a triangle is 360°!

FIGURE 1. Question number 4 geometry material

The results of interviews on subjects V2, A23 and ID14, obtained information about the reasons they did not work on question number 4 through interviews as follows.

Q : Why don't you answer question number 4?

V2 : Because it doesn't say how big the angle is, so I'm confused about how to do it. Actually angle B and angle D are the same, then angle A and angle C are also the same, only the angle is not given, so I can't answer.

A23 : The teacher never gives questions regarding "proof", so far the questions given are asked to calculate and then solve them using a formula

ID14: The problem is that the blade size is not given.

Q : Look at the parallelogram! Do you know the properties of angles in a parallelogram? If you know, please mention it!

V2 : You know, opposite angles are equal

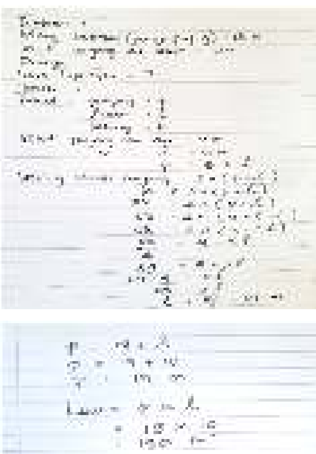
A23 : know, opposite angles are equal

ID14: opposite angles are equal

From the results of the interviews, it can be concluded that Visual students already have a little picture of the nature of the angles in a parallelogram so that students try to think about solving the problem based on the illustrations that the angles opposite are the same size. It's just that students don't realize that there are other properties of angles in parallelograms, that is, adjacent angles add up to 180 degrees. This shows that students visually identify problem solving based on pictures only they have a tendency to be unsure in answering the question [23]. Students of analysis and students of informal deduction could not answer the question because they were never given a question about proof by the teacher, even though they actually knew the nature of the angles in a parallelogram, i.e. the angles opposite them were equal in magnitude and had started to think that there were other angle properties, namely angles. adjacent ones are the same size. They were confused to write it down because the teacher never taught how to prove it. Proving in a case requires a deeper understanding and also the ability of students to link between concepts and the need for teacher habituation to provide problems regarding proof [5]. So that they will be able to solve questions number 1 to 3 which are more computational. In question number 3, the informal deduction students succeeded in doing it, except for an error in writing the final conclusion regarding the contextual question. The following are student answers ID14.

The perimeter of a square field is 58 m and the difference between the length and width is 9 m.
The are this field is…

FIGURE 2. Question Number 3 About Geometry



Translate:
Is known:
Perimeter of the field (rectangle) = 58 m
Difference between length and width = 9 m
Asked: The area of the field is…
Answer:
Let: length = p
Width = l
Perimeter = K
Difference between length and width = 9 m
P – l = 9 m
P = 9 + l

Perimeter of rectangle = 2 x (p + l)
K = 2 x (p + l)
58 = 2 x (p + l)
58 = 2 x (9 + l + l)
58 : 2 = 9 + 2 l
29 – 9 = 2 l
l = 20/2
l = 10 m
P = 9 + l
= 9 + 10
= 19 m
L = p x l
= 19 x 10
= 190 m^2

FIGURE 3. Student ID14's answer to question number 3

Based on Figure 3. shows that student ID14's error only lies in the final conclusion of the answer to question number 3. In the process of student skills in answering correctly and the numerical answer is correct, only students do not write down the complete conclusion of the answer, which should be "square area of the field". length is 190 m^2". The results of the interview, it was found that ID14 students felt that the final result of 190 m^2 was enough without writing down the final conclusion. The mistake made was an error in writing the final answer. For students, the informal deduction sequence from writing is asked to the processing process is enough to answer the question. Informal Deduction students have high confidence in solving problems [24], because they have good mastery of concepts and geometry problem solving skills [25]. This is different from the analysis students in answering question number 3.

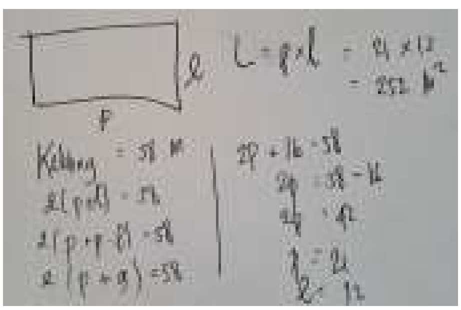
Translate:
Is known:
Perimeter = 58 m
Difference between length and width = 9 m
Asked: The area of the field is…
Answer:
P – l = 9 m
P – 9 = l
Perimeter = 2p + 2l
58 = 2p + 2 (p – 9)
58 = 2p + 2p - 18
58 + 18 = 4p
76 = 4p
p = 76/4
p = 19 m

ℓ = p – 9
= 19 – 9
= 10 m

L = p x ℓ
= 19 x 10
= 190 m^2

FIGURE 4. Student's answer A23 on question number 3

Based on Figure 4, it shows that the analytical students are able to continue the process of solving problem number 3. However, based on the New Man error indicator, there are errors in transform errors and encoding errors. The results of the interviews showed that the student's error analysis based on the New Man error indicator was skipping several stages in solving the contextual geometry problem, namely: (1) transformation errors, namely not writing down the example stage and students not changing the information in the questions into mathematical models and students not writing down information before writing the formula as a solution. Students make transformation errors because students do not transform the information they know in the problem into correct mathematical sentences [26]. (2) errors in writing answers, seen from students not making conclusions from the contextual questions presented. Errors in writing the final answer are often made by students who are not careful, in a hurry [19] and are



Translate:

Perimeter = 58 m2 (p + *l*) = 58 m
2 (p + p – *l*) = 58 m
2 (p + 9) = 58 m
2p + 16 = 58
2p = 58 – 16
2p = 42
p = 21
l = 12

L = p x ℓ
= 21 x 12
= 252 m^2

FIGURE 5. Student answer V2 on question number 3

Based on Figure 5, it shows that V2 students could not solve problem number 3 well. Errors that occur start from reading errors, comprehension difficulties, transform errors, weakness in process skills, encoding errors. The results of the interview with V2 can be concluded that in understanding the problem students tend to first draw or illustrate the geometry problem. As in remembering the circumference formula, it turns out that students are easier to remember by drawing it first. However, V2 students made more mistakes on this geometric contextual problem, this is because there is information on the problem that makes students unable to illustrate in the picture.

The results of data analysis showed that the cause of student work errors was because students made mistakes starting from reading errors, misunderstood the questions, not being able to provide the right solution, and not writing down answers. Reading errors made by research subjects resulted in them not being able to describe the visual form of geometric shapes. Difficulties in drawing visual shapes often result in mistakes being made due to poor visual-spatial skills[1] [27]. Another mistake that was made was an error in transforming the problem into a mathematical model so that it had an impact on solving the problem [9][28]. The next error is an error in encoding error, an error made by students when writing an incomplete solution or when giving a final conclusion [21]. This is of course related to the ability to think formal geometric deduction, where at this level in problem solving there needs to be formal proof from general to specific so that conclusions are obtained as a solution. The habit of doing practice questions and understanding the various types of symbols that exist can help make it easier for students to process information and help students reduce transformation errors in calculation operating procedures [3][29]. Increase mastery of formulas where students are more emphasized to understand not memorize[20]. If students understand basic formulas and concepts, they will be familiar with the steps of the problem solving process [26] and not be fixated on memorized formulas so as to reduce process skill errors and errors in writing the final answer [30].

4. CONCLUSION

According to the Van Hiele Geometry leveling test results, which indicate that up to 56% of students are at level 0, 32% are at level 1, 12% are at level 2, and 32% of students at level 1 are still at the visualization level, the analysis's findings indicate that students' levels are still at this level. level 3 is 0%, and students at level 4 are also 0%. The factors that cause students to be unable to reach a higher level are students who are wrong in determining the name of the shape, have difficulty determining formulas, make errors in calculations, cannot determine concepts, and are unable to make conclusions. In the results of the analysis of student errors working on geometry problems, it was found that the percentage of students' errors at the visualization level was 44%, analysis was 30% and informal deduction was 26%. Students making mistakes in reading, understanding questions and the information they contain, being unable to provide solutions to issues, making mistakes when processing information, and making mistakes in writing replies are all factors that contribute to students making mistakes in general. The reasons why students make mistakes when solving geometrical problems involving triangles and quadrilaterals in particular are due to improper process execution on their part. The original information in the questions is frequently ignored when students work on them. Information created by students will assist them in problem-solving and problem-analysis.

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