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Junior High School Students' Geometry Ability Based on Van Hiele Level's Thinking

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Abstrak

Kemampuan memecahkan masalah dan berpikir logis siswa dapat ditumbuhkan dengan mempelajari Geometri. Namun, kenyataan di lapangan dan beberapa penelitian menunjukkan bahwa kemampuan berpikir geometris siswa SMP masih tergolong rendah. Penelitian ini bertujuan untuk mengkaji kemampuan berpikir geometris siswa SMP menurut Teori Van Hiele. Penelitian ini merupakan penelitian kualitatif dengan pendekatan deskriptif, yang dilaksanakan di salah satu SMP di Kabupaten Pringsewu dengan melibatkan 28 siswa kelas VIII. Subjek penelitian dipilih masing-masing satu siswa mewakili level 1, 2, 3, dan 4 Van Hiele. Pengumpulan data dilaksanakan dengan menggunakan tes pilihan ganda dan wawancara. Teknik analisis data dilaksanakan dengan tahap reduksi data, penyajian data, dan penarikan kesimpulan. Teknik originalitas data dilaksanakan dengan triangulasi di mana peneliti membandingkan data hasil tes dengan hasil wawancara siswa. Hasil penelitian menunjukkan bahwa siswa level 1 (28,57%) dapat mengenal dan menyebutkan nama bangun geometri secara visual; siswa level 2 (14,28%) dapat mempelajari bentuk-bentuk geometri dengan mengamati dan menyebutkan sifat-sifat bangun tersebut; siswa level 3 (7,14%) dapat membuat koneksi antara berbagai bentuk bangun geometri dan mendeteksi sifat umum dari bentuk geometri tertentu; siswa level 4 (3,57%) dapat membedakan dan membuat kesimpulan sederhana mengenai bentuk dan sifat bangun.

Kata kunci: Berpikir Geometri, Level Van Hiele, Siswa Sekolah Menengah Pertama.

Abstract

The ability to solve problems and logical thinking of students can be grown by studying Geometry. However, the reality in the field and some research in Indonesia shows that the geometric thinking ability of junior high school students is still relatively low. This study aims to examine the geometric thinking ability of junior high school students according to Van Hiele Theory. This research is a qualitative study with a descriptive approach, which was conducted in one of the junior high schools in Pringsewu Regency involving 28 students of class VIII. One student was selected to represent levels 1, 2, 3, and 4 Van Hiele as the research subject. Data collection was carried out using multiple choice tests and interviews. Data analysis techniques were conducted with data reduction, data presentation, and conclusion drawing stages. The data originality technique was carried out by triangulation, in which the researcher compared the test data with the results of student interviews. The results showed that level 1 students (28.57%) could recognize and name geometric shapes visually; level 2 students (14.28%) could study geometric shapes by observing and mentioning the properties of the shapes;

level 3 students (7.14%) could make connections between various geometric shapes and detect general properties of certain geometry; level 4 students (3.57%) could distinguish and make simple conclusions about the shapes and properties of shapes.
Keywords: Geometry Thinking, Junior High School Students, Van Hiele's Level

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INTRODUCTION

Geometry is one of the branches of mathematics that deals with or relates to a form of building and measurement. Students can identify the shapes and spaces around them after they learn geometry, because the basic objects of geometry usually resemble real objects that exist in everyday life (Rohendi et al., 2018). Learning geometry is used to support the development of logical thinking skills, spatial intuition skills, instill knowledge that can be useful and related to other materials (Kurnia et al., 2018). Therefore, knowledge of geometry is very important in improving the quality of geometric thinking skills. Based on this, it can be concluded that geometry is a mathematical science that studies lines, space, and volume, which are abstract and related to each other and important to learn. However, in reality geometry is still not sufficiently mastered in practice.

Some research shows that the geometric ability of students is still relatively low. Research conducted by Naufal et al (2020) found that 46.6% of junior high school students still have difficulty understanding geometry. This is in line with research conducted by Ali & Ni'mah (2023) which states that students' geometric abilities are low. The low mastery of geometry material is because it is difficult for students to understand, and many students do not master geometry concepts (Fauzi & Arisetyawan, 2020). However, when compared to other areas of mathematics, students are more likely to understand geometry because they are familiar with concepts such as line, plane, and space before entering school (Kurnia & Hidayati, 2022). This suggests that despite more opportunities to understand geometry, many students still face difficulties. Learning geometry requires a strong understanding of concepts so that students can apply their skills (Susanto & Mahmudi, 2021). In addition, learning geometry must be done gradually and adapted to the level of development of students' thinking (Afifah et al., 2019). Therefore, a theory related to the level or developmental level of students' thinking is needed. The theory that can be used to assess students' level of thinking is Van Hiele's theory (Anwar, 2020). Van Hiele's theory has been widely used by experts in their research, especially in geometry learning. According to Van Hiele, there are

five levels of geometric thinking, namely, visualization, analysis, informal deduction, deduction, and rigor.

Based on the problems obtained during the observation, it is supported by the results of interviews with mathematics teachers at SMP N 2 Ambarawa students, where researchers get an important problem to study, namely knowing how the level of geometric thinking of students in learning mathematics at school. The results of interviews with teachers convey that the geometric thinking ability of students is low. The value of mathematics students in grade VIII is lower than that of other subjects. The subject of mathematics material that is quite difficult for students to master is geometry. Based on some of the research that the author found, the novelty of this study is that it examines the entire tendency of students from different levels of ability, namely, level 1, level 2, level 3, and level 4 Van Hiele. Thus, this study aims to examine the geometric thinking ability of junior high school students according to Van Hiele Theory.

METHOD

This research used a descriptive qualitative approach. Qualitative research is performed by collecting the data needed to support the research itself (Cresswell, 2017). This research was conducted in one of the junior high schools in Pringsewu Regency, class VIII, totaling 28 students. The subjects of this study were 4 students selected from 28 prospective subjects in class VIIIA. The selection of subjects was done through purposive sampling based on considerations; the subject met the Van Hiele level, could communicate well, and was willing to participate in the research.

The data acquired were the outcomes of test sheets and student interviews that the researcher decided based on the students' ability to finish the provided exam. The data gathering technique was divided into two stages: written examinations consisting of 15 multiple-choice questions and interviews once the individual has completed the task. The unit utilized at the end of the calculation is percent (%).

This study adopted the Van Hiele Geometry Test (VHGT) instrument developed by (Usiskin, 1982) in the Cognitive Development and Achievement in Secondary School Geometry (CDASSG) Project. Each question was constructed to measure students' geometry level based on Van Hiele's theory. The 15 items were distributed in 5 stages of Van Hiele's geometry as shown in Table 1 below.

Table 1. Van Hiele Question Item Numbering

Questions	Thinking Levels
Number 1-3	1 (Visualization)
Number 4-6	2 (Analysis)
Number 7-9	3 (Abstraction)
Number 10-12	4 (Deduction)
Number 13-15	5 (Rigor)

The Van Hiele test scoring refers to Usiskin (1982), where in this study there were 15 questions with a score of 1 on each number, so that the maximum score was 15. Each question number represents a Van Hiele level; question numbers 1-3 are level 1, question numbers 4-6 are level 2, question numbers 7-9 are level 3, question numbers 10-12 are level 4, and question numbers 13-15 are level 5. If the student can do 3 problems correctly at each level, then the student is said to have reached that level. If the student reaches level 1 and level 3, but fails at level 2, then the student can be said to have reached level 1. This is because Van Hiele levels must be sequential, so students cannot reach a level without reaching the previous level. To calculate the score on each indicator as follows:

$$\frac{(students\ who\ are\ on\ each\ indicator)}{(students\ who\ took\ the\ test)} \times\ (100)$$

Data analysis in this study included: data reduction, data presentation, and conclusion drawing (Miles et al., 2018).

RESULTS

The results of this study showed that the 28 prospective subjects were mostly at the analysis level. The number of students who reached the Van Hiele level at each level is presented in Table 2 below.

Table 2. Presentage each Van Hiele level

Van Hiele Thinking Level	Students	%
Level 1	8	28,57
Level 2	4	14,28
Level 3	2	7,14
Level 4	1	3,57

Based on Table 2, there were 8 students who were at Van Hiele level 1, 4 students are at Van Hiele level 2, 2 students are at Van Hiele level 3, 1 student is at Van Hiele level 1. Meanwhile, 13 students could not reach level 1. The following question number 2 asked

students to identify shapes based on their appearance. The following question number 2 was presented to measure the achievement of level 1.

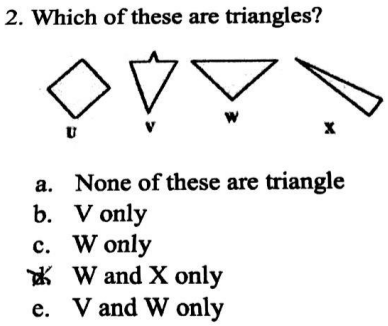


Figure 1. Results of Student Test Sheets on Visualization Questions

Figure 1 shows that students were able to pass the visualization stage (level 1) of Van Hiele because they were able to answer questions correctly. The following are the results of interviews with students related to the test sheet results.

P : *Why you choose "d"?*
S1 : *Because the question is triangle*
P : *Do know what the name of the shapes ?*
S1 : *Yes. "U" is rhombus, "V" is not triangle, "W" is triangle, "X" is triangle. Therefore, the triangle are "W" and "X"*

Based on the suitability between the student's answer sheet and the interview between the researcher and the student, the student met the indicators of Van Hiele's visualization level, namely being able to name geometric shapes based on visual forms. Furthermore, at the analysis (level 2) 14.28% of students were able to do the problem well. Problem number 5 was a question used to measure the subject's analysis ability. Figure 2 shows that students were able to mention the properties of geometric figures.

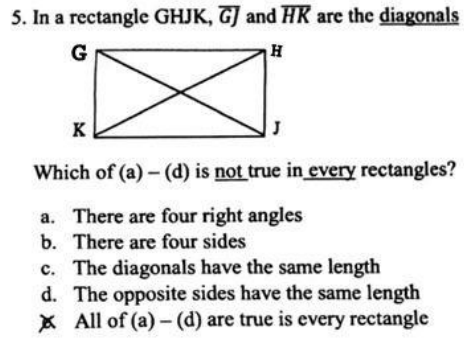
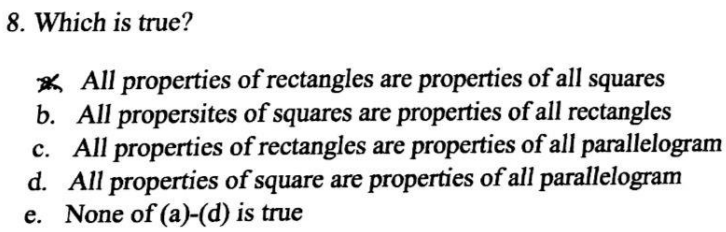


Figure 2. Results of Student Test Sheets on Analysis Questions

Figure 2 shows that students were able to pass Van Hiele's analysis (level 2) because they were able to answer questions correctly. The following are the results of the interview with the subject (S2) regarding the test sheet results.

P : *Explain me the reason why you choose that !*
S2 : *Because the question is "incorrect characteristics of each rectangle". The "a" until "d" is correct. So the answer is "e"*
P : *Explain me characteristics or properties of quadrilaterals that you know!*
S2 : *There are four right angles, it has four sides, the opposite sides has the same length, the diagonals has the same length, there are two diagonals..*
P : *Show me that there are four right angles and four sides in the figure!*
S2 : *The angles are H, J, K.and G. Then the sides are GH, KJ, HJ, GK*
P : *Which opposite sides has the same length?*
S2 : *sides GK and HJ, then JK and GH*

Based on the interview between the researcher and the subject (S2), it was found that S2 could mention and show the properties of the rectangle and the elements in question. S2 knew that the four right angles of the GHJK rectangle are angle G, angle H, angle J, and angle K. S2 also knew the four sides are side GH, side HJ, side KJ, and side KG. S2 understood that there are two diagonals of the rectangle that are has the same length, that is GJ and HK. In addition, S2 also understood that there are two pairs of opposite sides of equal length, that is GK and HJ, then JK and GH. Furthermore, at level 3 (abstraction) 7.14% were able to do the problem well. In Figure 3 shows that the subject (S3) could mention the properties of geometric shapes.


8. Which is true?

a. All properties of rectangles are properties of all squares
b. All propersites of squares are properties of all rectangles
c. All properties of rectangles are properties of all parallelogram
d. All properties of square are properties of all parallelogram
e. None of (a)-(d) is true

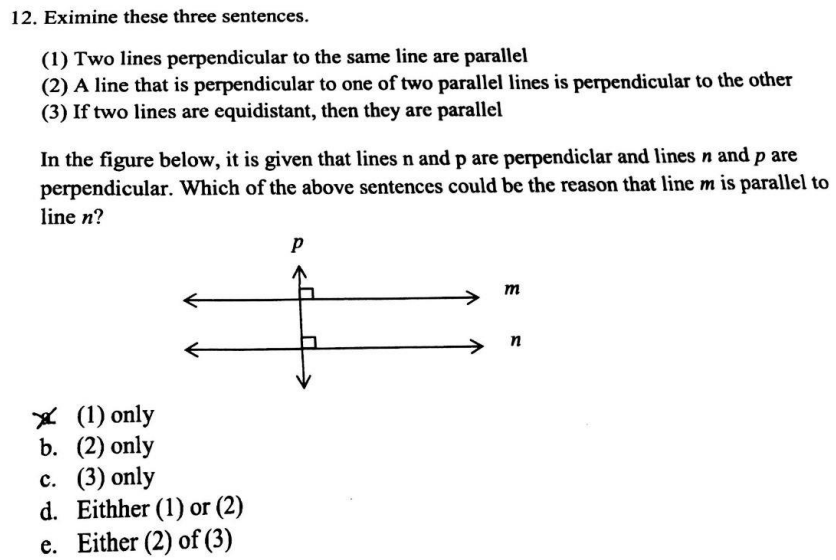
Figure 3. Results of Student Test Sheets on Abstraction Questions

In Figure 3, students were able to pass Van Hiele's level of abstraction (level 3) because they were able to answer questions correctly. The following are the results of interviews with subjects (S3) related to the test sheet results.

P : *Why you chose that answer?*
S3 : *Because the questions is correct statement. In my opinion is "a"*
P : *Why "a"? How about another options?*

S3 : *Because "a" the properties of all rectangles are the properties of all squares. That's correct. A rectangle has four sides, two diagonals has the same length, the opposite sides has the same length, and all these properties are present in a square. "b"is incorrect because a square has four equal sides, while a rectangle must have four equal sides. "c " also incorrect. The rectangle has right angles, while the parallelogram has angles that are not right angles. But The rectangle has all the same angles, which are 90 degrees right angles, While the parallelogram has angles that are not right angles. "d" also incorrect. A square has right angles and all four sides has the same length.*

Based on the correspondence between the answer sheet and the interview between the researcher and the subject (S3), it was found that S3 was able to understand the relationship between the characteristics of one another not just mentioning the characteristics, S3 was able to say that if a quadrilateral the opposite sides are parallel, then the opposite sides are equal in length. S3 understood that all the properties of a rectangle are properties of a square. S3 explained that the properties of a rectangle fulfill the properties of a square, which has four sides, and two diagonals are equal in length. Furthermore, at the deduction stage (level 4) 3.57% of students were able to do the problem well. Figure 4 shows that the subject (S4) was able to answer the question correctly.


12. Eximine these three sentences.

(1) Two lines perpendicular to the same line are parallel
(2) A line that is perpendicular to one of two parallel lines is perpendicular to the other
(3) If two lines are equidistant, then they are parallel

In the figure below, it is given that lines n and p are perpendiclar and lines *n* and *p* are perpendicular. Which of the above sentences could be the reason that line *m* is parallel to line *n*?

a. (1) only
b. (2) only
c. (3) only
d. Eithher (1) or (2)
e. Either (2) of (3)

Figure 4. Student Test Sheet Results on Deduction Questions

P : *Why your answer is "a" ?*

S4 : *Because the statement (1)said that two lines that are perpendicular to the same line are parallel. The lines"m" and "n" perpendicular to the same line, That's p. "m" is parallel to "n". Therefore, (1) is correct.*

P : *How about other statement?*

S4 : *(2) said that a line that is perpendicular to one of two parallel lines is*

perpendicular to the other line. It can be seen in the picture that it is perpendicular to two lines. In statement (2) said that it is perpendicular to one line. So it's incorrect.

P : *Okay. Statement (2) is wrong. How about statement (3)?*

S4 : *Statement (3)said that if two lines are equidistant, then they are parallel. I don't think it's definitely parallel. Therefore it's not true.*

Based on interview between the researcher and the subject (S4), it was found that S4 considered that statements (2) and (3) were wrong. Therefore, S4 answered that the logical reason for the question was statement (1). S4 argues that statement (2) “a line is perpendicular to one of the two parallel lines, where as it can be seen in the picture that a line is perpendicular to the two parallel lines", Therefore S4 considered statement (2) to be false because the sentence and the picture do not match and are not logical.

DISCUSSION

Based on the exposure of the results of the analysis of student test sheets and interviews based on Van Hiele's leveling indicators, it can be concluded that at the visualization stage as many as 28.57% of students were able to recognize geometric shapes based on their visuals. Students could mention the name of geometric shapes, anddistinguish between the shapes of geometric shapes in the problem. At this level, students make decisions based on perception, not reasoning. In addition, the results of research conducted by (Suwito et al., 2016) found that at the visualization level of junior high school students are familiar and familiar with the shapes of geometric figures. This is also in line with the results of research from (Yanuar et al., 2022), students who are able to reach the level of analysis are quite capable of explaining the properties of flat shapes contained in the problem, although the explanation is not comprehensive or not all students mention the properties of the two dimensional figure.

At the analysis level, 14.28%% of students were able to solve problems with the analysis level. At this level, students analyze images in terms of components and relationships between components and find their properties (Suwito et al., 2016). Students could recognize geometric shapes based on their visual form and begin to understand the properties of the geometric shapes they recognize. Students could recognize and determine the characteristics of shapes based on their properties. This is in accordance with the results of research found by (Kurnia & Hidayati, 2022), namely junior high school students can recognize the characteristics of each shape. Students are able to analyze that a square has four sides and four equal angles, while a rectangle has equal sides, and all four angles are equal. This is also in

line with the results of research from (Yuliana & Ratu, 2019) concluded that students with the analysis level are able to determine the type of quadrilateral flat building based on its appearance or visual, different positions and properties possessed, in explaining the properties of quadrilateral buildings based on images can explain specifically, but are less precise in the concept of diagonal, intersecting and perpendicular.

At the abstraction level 7.14%, students were able to solve the problem. At this level, students could recognize geometric shapes based on their visual form, begin to understand the properties of the geometric shapes they recognize and classify the general properties of geometric shapes. This is in line with the results of research conducted by (Yunianta & Lusiyati, 2021) which stated that junior high school students with Van Hiele level of thinking abstraction level achieve visual skills to recognize flat shapes based on their shape, mentioning the properties of a shape. At the abstraction level students can make connections between various geometric shapes, detect common properties of certain geometric shapes, and classify them in a hierarchical form (Zainal, 2020)

At the deduction level, 3.57% of students were able to solve the problem. At the deduction level, there was only 1 student. At this level, students could recognize geometric shapes based on their visual form, begin to understand the properties of familiar geometric shapes and classify the general properties of geometric shapes. At this level students do not just accept evidence, but have been able to compile evidence (Nurani et al., 2016). At the deduction level, students could distinguish and make simple conclusions about the shape and nature of the shape. Like students can conclude that a square is a rectangle. This is in accordance with the statement (Zainal, 2020); (Kurnia & Hidayati, 2022) which explained that at the deduction level, students can draw conclusions, understand definitions, theorems and proofs. Meanwhile, there ewere no students who met level 5 (rigor), and there were many students who had not met the Van Hiele level, namely as many as 46.42% of students could not answer correctly the Van Hiele geometry test on level 1 questions (visualization).

CONCLUSION

The research results showed that van Hiele's geometric thinking level owned by students of class VIII A as a whole was at level 1 (Visualization). According to Van Hiele's theory, the geometric thinking ability of students at SMP Negeri 2 Ambarawa was, at level 1 (28.57%), they could recognize and name geometric shapes visually; level 2 students (14.28%) could study geometric shapes by observing and mentioning the properties of these shapes; level 3 students (7.14%) could make connections between various geometric shapes

and detect general properties of certain geometric shapes; level 4 students (3.57%) could distinguish and make simple conclusions about the shape and nature of the shape. Based on the results and discussion, it can be concluded that the thinking ability of students was quite diverse and there were still many students who were at level 1 and 2. Therefore, students who were at level 1 and 2 needed to get special treatment (stimulus) during learning. This research provides an opportunity for further research into why most are at a low level.

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