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Thinking Levels Analysis of Flat Up Geometry Based on Van Hiele's Theory on Students in Fifth Grade

Ela Awik Tamara[1], Yuniawatika[2,*], Moh. Zainuddin[2]

[1] *MI MPI Cendono Kandat, Kediri, Indonesia*
[2] *Faculty of Education, Universitas Negeri Malang, Malang, Indonesia*
[*]*Corresponding author. Email: yuniawatika.fip@um.ac.id*

ABSTRACT
The purpose of this study was to analyze/describe the level of geometric thinking of fifth grade students based on Van Hiele's theory. The research method used in this research is descriptive qualitative. The subjects of this study were 20 students of class VA MI MPI Cendono who were grouped based on high, medium, and low ability groups. The data analysis technique used is based on Miles Huberman's theory through data reduction activities, data presentation, and conclusions or verification. The results showed that the students of class VA MI MPI Cendono had different levels of Van Hiele geometric thinking. The level of Van Hiele geometric thinking in the high ability group students is averaged at level 2 of informal deduction, while students in the medium and low ability groups averaged at level 1 of the analysis.

Keywords: *Geometric Thinking Level, Van Hiele' Theory, Class V Students.*

1. INTRODUCTION

Mathematics is one of the important subjects for education in Indonesia. According to Yuniawatika [1] mathematics is very important to learn because mathematics has a relationship with everyday life both now and in the future. Almost all levels of education study mathematics, starting from Elementary School (SD) and even Kindergarten (TK) to Higher Education (PT).

One of the important mathematics materials in the curriculum is geometry material. The purpose of learning geometry according to Bobangoo [2] is so that students gain confidence in their mathematical abilities, become good problem solvers, can communicate mathematically, and can also reason mathematically. From this, it shows that geometry is an important science that must be truly understood by students. which in learning must also pay attention to the level of development and characteristics of students.

The level of development of a child is closely related to the learning process. In teaching a material a teacher should pay attention to how students think. One of the theories that discusses the development of children's cognitive thinking is Van Hiele's theory, which discusses specifically the field of geometry. As explained by Ruseffendi [3], Van Hiele was a Dutch mathematics teacher who in 1954 wrote a dissertation on teaching geometry. From the results of his research, Van Hiele concluded that there are five stages of understanding geometry material. Musser and Burger [4] explain that the stages of students' mental development in understanding geometry according to Van Hiele's theory include: level 0 introduction (visualization), level 1 analysis, level 2 sorting, level 3 deduction, and level 4 accuracy (rigor).

According to Van Hiele's theory at level 0 of visualization, students have identified geometric shapes based on their visual characteristics and appearance. In level 1 analysis, students are used to analyzing the parts that exist in a shape and observing the properties possessed by these elements [5]. Level 2 is informal deduction/abstraction, besides students already know geometric shapes and understand their properties and can sort geometric shapes that are related to each other [6]. At level 3 deduction, students at level 3 have started to be able to formally compile evidence [5]. Level 4 rigor or accuracy, this level of thinking is categorized as a high, complicated, and complex level of thinking [7].

In reality, Indonesian students have not been able to understand geometry well and correctly. The results of a survey from PISA (Program for International Student Assessment) in 2018 showed that the mathematics achievement of Indonesian students was still weak. One of the mathematics topics that have low scores is the topic

of space and shape, which means that Indonesian students have more difficulty in geometry topics than other topics [8]. Basically, geometry has a very big opportunity to be understood by students, this is because geometric ideas are most involved in aspects of student life such as the introduction of lines, fields and spaces [9].

Many factors cause the above problems to occur, one of which is that students still experience errors in doing math problems. Errors that occur in these students are not entirely caused by the students themselves. The teacher's error in teaching the material is also one of the causes of students experiencing errors in working on the questions.

From the various problems that arise, it shows that mathematics is a subject that is still difficult for students to master. One of the problems that arise can be seen from the results of the PISA survey which shows that the average geometry value of Indonesian students is lower than the international average. So from these problems a research was conducted on the geometric thinking level of elementary school students based on Van Hiele's theory.

On November 18, 2017, researchers conducted observations and interviews with the class teacher of MI MPI (Islamic Development Madrasah) Cendono. Based on interviews with teachers, the researchers found that some of the students' scores when taking the UTS had reached the KKM and some were less. In addition, the teacher also explained that the geometry material in class V will be studied in semester 2 of 2018. However, the geometry of flat shapes has been studied at the previous grade level. This means that students already have knowledge about the material of flat shapes. Therefore, to find out the level of students' geometric thinking in working on the problem of flat shapes, it is held research on the level of geometric thinking of flat shapes in fifth grade students where the material has been taught at the previous grade level based on the 2013 curriculum.

Research on the identification of geometric thinking levels according to Van Hiele's theory has been carried out by several researchers. Alifah [10] conducted research on students' geometric thinking levels according to Van Hiele's theory based on gender with the material of rectangular shapes in class VII SMPN 2 Gedangan. In addition, research on the level of thinking of elementary school students according to Van Hiele's theory with students' flat shapes has been carried out by Hidayah [11], Zainal [12], and Romika [13]. However, research related to the analysis of geometric thinking levels based on Van Hiele's theory that pays attention to students' abilities is still rarely done. To complete the research, this research was conducted. This study aims to analyze/describe the level of geometric thinking of fifth graders based on Van Hiele's theory based on three groups, namely high, medium, and low groups based on the previous students' mathematical abilities. The results of this analysis are expected to be taken into consideration for teachers and education practitioners to design the next step in helping students to improve students' geometric thinking skills.

2. METHOD

The type of research used in this study is descriptive qualitative, because the data obtained is in the form of written data about the students' geometric thinking level which is then analyzed and described based on Van Hiele's theory. In this study, the authors describe the results of the study using words about students' geometric thinking levels according to the level of development of Van Hiele's theory.

The research procedure carried out consisted of the preparation stage, the trial stage, the implementation stage, the data analysis stage, and the conclusion drawing stage. At the preparation stage, the activities carried out were applying for permission to the MI MPI Cendono School Principal, agreement with class teachers, preparation of instruments, and instrument validation by lecturers and teachers. The trial phase, the trial is given to students in class IV and students who have a higher level, namely class VI. The purpose of the trial on fourth grade students is to determine the level of readability of the test instrument to be given to the research subject. Meanwhile, the test conducted in class VI aims to determine the level of validity and reliability of the test instrument. At the implementation stage, the activities carried out were giving tests to class VA students who were the research subjects and conducting interviews with some of these subjects. At the analysis stage, the data obtained in the study were analyzed according to data analysis techniques, namely based on the theory of Miles Huberman. Based on the data that has been analyzed, conclusions are then drawn about the level of students' geometric thinking in solving geometry test questions in accordance with the Van Hiele theory indicators. Sources of data and research subjects in this study were all students of class VA MI MPI Cendono as many as 20 students.

The type of data collected is in the form of student work when solving problems of flat shape material in the form of pictures, writing, and numbers given through tests. All students were then categorized into high, medium, and low ability categories to make it easier to analyze the data. The selection of students with different abilities can be seen from the previous math test scores, so it is expected that students' geometric thinking levels can be easily analyzed.

Data collection techniques used in this study were documentation, test methods, and interviews. The data in this study were obtained from several different students, but the treatment given to each student was the same, namely by means of documentation, written tests, and interviews. While the instruments or tools used in data

collection are using cameras, test sheets, and interview guidelines.

Analysis of the data used is a qualitative description analysis. Miles and Huberman [14] suggested that the activity in analyzing qualitative data was carried out interactively and continued continuously until it was completed, so that the data was saturated. Activities in analyzing the data consist of data reduction, data presentation, and conclusion or verification. The data that is reduced in this study is the instrument of test results and interviews with students. The data were analyzed based on the indicators of the Van Hiele theory. The data from the reduction are organized by category, then presented in the form of a description or narrative in written form obtained from the results of the reduction. The activity is carried out by classifying and identifying geometric thinking skills according to Van Hiele's theory, namely: level 0 (visualization), level 1 (analysis), and level 2 (abstraction) which comes from test results and interviews with students. So, it will be possible to draw conclusions. Conclusions in qualitative research are carried out by concluding the data that have been described in data presentation activities, namely in relation to the level of thinking of Van Hiele's theory.

3. RESULT AND DISCUSSION

Based on the data obtained during the study, the results of the analysis showed that the geometric thinking levels of students in class VA MI MPI Cendono were different (see Table 1). In group students the high level for level 0 indicators has been achieved with a percentage of 95%, level 1 indicators have been achieved with a percentage of 75%, and level 2 indicators have been achieved with a percentage of 50%.

Table 1. Van Hiele's Geometric Thinking Level Achievement Table

Groups	Geometric Thinking Level					
	Level 0		Level 1		Level 2	
High	√	95%	√	75%	√	50%
Medium	√	92,8%	√	65,8%	-	36,8%
Low	√	92%	√	72%	-	32%

In the medium group students, the level 0 indicator has been achieved with a percentage of 92.8%, the level 1 indicator has been achieved with a percentage of 65.8%, and the level 2 indicator has not been achieved with the percentage of achievement obtained is 36.8%. Meanwhile, in the low ability group students, the level 0 indicator has been achieved with a percentage of 92%, the level 1 indicator has been achieved with a percentage of 72%, and the level 2 indicator has not been achieved with an achievement percentage of 32%.

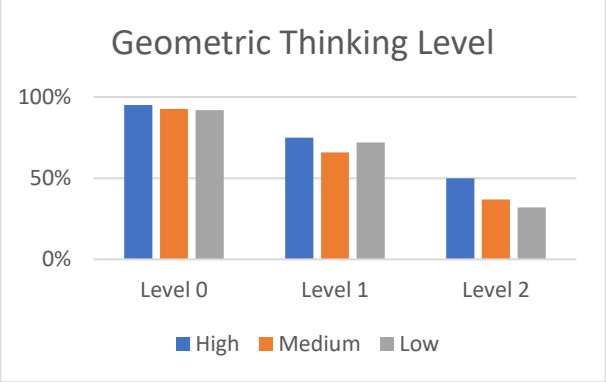

Figure 1. Graph of Geometric Thinking Level

The geometric thinking level of students in the high ability group reached level 0 of visualization, level 1 of analysis, and level 2 of informal deduction. The result of students' geometric thinking level can be seen in Figure 1. At level 0 visualization, all students in the high ability group have been able to achieve good indicators, students are able to identify flat shapes based on the shapes they see, students are able to group triangles and quadrilaterals, students are able to name visual examples of triangular and quadrilateral objects in the surrounding environment, students are able to determine the names of the shapes from the objects mentioned, besides that students are also able to draw rectangular shapes that are known to students. Based on Van Hiele's theory at level 1 of analysis students have started to recognize the properties of the observed geometric objects [5].

Overall, the students of class VA MI MPI Cendono high group have reached this level. Description at level 1 students, are able to distinguish shapes based on the properties they have, students are able to determine shapes based on the properties mentioned, students are able to determine the name of the shape of an object based on its properties. At level 2 informal deduction, not all students reach this level. There are 2 students who have reached this level, while the other 2 students have not. At this level students are able to sort or group shapes based on the properties they have, students are able to explain the related relationships between geometric shapes, students are able to understand the form of similarity from a definition. However, not all indicators were successfully achieved by students. Many errors occur in the first and second indicators, namely in questions 11 and 12. Students have not been able to define a shape completely. In defining a shape, students ignore the properties of other shapes, thus allowing the interpretation of other shapes to occur. In addition, students are also not able to make a definition of a shape based on the nature of the shapes.

Van Hiele's geometric thinking level of students in the medium ability group has reached level 0

visualization and level 1 analysis. At level 0 visualization, medium group students are able to identify the name of a flat shape, students are able to determine examples and not examples of grouping triangles and quadrilaterals, students are able to name visual examples of surrounding objects, students are able to determine the name of the shapes from objects that are as mentioned, students are also able to draw quadrilaterals that are known by students. At level 1 of analysis students are able to distinguish triangle shapes based on the properties they have, students are able to explain triangle and trapezoid shapes using their properties, students are able to determine the name of the shapes based on the properties mentioned, students are also able to recognize the properties geometric properties of physical objects.

Van Hiele's geometric thinking level of students in the low ability group has reached level 0 visualization and level 1 analysis. At level 0 visualization, low ability students are able to determine being able to identify the name of a flat shape, students are able to determine examples and not examples of grouping triangles and quadrilaterals, students are able to name visual examples of surrounding objects, students are able to determine the names of shapes from objects. the objects mentioned, students are also able to draw quadrilaterals that are known by students. At level 1 of analysis students are able to distinguish triangle shapes based on their properties, students are able to explain triangle and trapezoidal shapes using their properties, students are also able to recognize geometric properties of physical objects.

The research finding at level 0 visualization is that there are students who are less precise in naming trapezoidal and rhombus shapes. High group TNS students named the trapezoidal shape with the name geometry, while the SAK subject named the rhombus with a quadrilateral. This is because students forget the name of the wake. In classifying rectangular shapes, there are high, medium, and low ability group students who are less careful in choosing shapes, students assume that shapes that have a shape like a rectangle bounded by curved lines are quadrilaterals. Students ignore the basic concepts of quadrilaterals bounded by straight lines. In the 5th indicator, students only focus on 6 types of quadrilaterals that have been taught, namely square, rectangle, rhombus, kite, parallelogram, and trapezoid. Students cannot imagine that the number of quadrilaterals drawn is infinite.

The research findings at level 1 of the analysis of many students are less thorough in seeing the types of triangles so that students are wrong in mentioning the properties they have. In the fifth indicator, some students do not understand the meaning of the question, and some are confused about how to answer it. In mentioning the name of a square shape, there are students who mention the name of a right and a quadrilateral. In this case, students experience errors because students forget the name of the wake. In the fifth indicator students have not been able to do solving problems involving the properties of flat shapes. In this case, students do not understand the steps of mathematical proof.

The research findings at level 2 of informal deduction from 20 students of class VA there are 5 students who reach the level of informal deduction, while the other 15 students have not reached this level. This shows that most of the class VA MI MPI Cendono students have not reached this level. From the results of the analysis of all students, it was found that only 1 student from the low ability group was able to achieve the second indicator. This shows that high ability students do not necessarily have a high level of geometric thinking. Students in combining flat shapes do not use overall properties, but students see visual forms of rectangular shapes that have similarities. Based on these findings, it is in line with Unaenah [5] which states that at this stage, middle and high school students have generally reached this stage.

Based on the results of the discussion and research findings indicate that the level of thinking of students in class VA MI MPI Cendono is different. This shows that there is still a level that is not maximized. So, it is expected that teachers can provide effective learning in accordance with the level of thinking of children.

4. CONCLUSION

Based on the discussion of the results of the study, it shows that the students of class VA MI MPI Cendono have different levels of Van Hiele geometric thinking. The level of Van Hiele's geometric thinking in the high ability group students was averaged at level 2 of informal deduction, while the students in the medium and low ability groups averaged at level 1 analysis.

For students in the high ability group, the description of Van Hiele's level of geometric thinking for level 0 visualization is that students are able to name flat shapes and mention examples of objects in the form of rectangular and triangular shapes, for level 1 students are able to name the properties of shapes and distinguish shapes based on its nature, while for level 2 students are able to group interrelated flat shapes. In the medium ability group, the description of Van Hiele's geometric thinking level for level 0 visualization of students is able to name flat shapes and mention visual examples of flat shapes, for level 1 students are able to analyze the properties of flat shapes, distinguishing flat shapes based on their nature. Whereas in the low ability group students for level 0 visualization students are able to name flat shapes and mention visual examples of flat shapes around, for level 1 analysis students are able to distinguish flat shapes based on their nature and recognize the geometric properties of physical objects. Thus, the most student achievement is at stage 0

(visualization) both in the group high, medium, and low. This is in line with the results of research by Sholihah et al. [15], Sahara [16], and Risqiyanti [17] who found that level 0 was the level most achieved by students.

For teachers, from the results of this study the teacher knows that the level of Van Hiele geometric thinking in class VA students is different, so it is expected that in providing learning the teacher adapts to the level of student development, uses the right model, and learns effectively. In learning the teacher is expected to use media or props of flat shapes that are fun and easy to understand by children, linking them to the properties of shapes, and the teacher also teaches the grouping of interrelated flat shapes through the same properties.

For advanced researchers, the results of this study can be used as material for thinking for similar research activities. In addition, for those who are related to education policy holders, the results of this study can be used as a material for discussion about the geometric thinking level of students according to Van Hiele's theory so as to improve the quality of education.

REFERENCES

[1] Y. Yuniawatika, "Application of Mathematics Learning with REACT Strategy to Improve Connection Ability and Mathematical Representation of Elementary School Students: A Quasi-Experimental Study in Class V Elementary School in Cimahi City," 2011.

[2] A. Abdussakir, "Learning geometry according to Van Hiele theory," Madrasah: Journal of Basic Education and Learning, vol. 2, no. 1, 2009.

[3] E. T. Ruseffendi, "An introduction to helping teachers develop their competence in teaching mathematics to improve CBSA," Bandung: tarsito, 2006.

[4] G. L. Musser, B. E. Peterson, and W. F. Burger, Mathematics for elementary teachers: A contemporary approach. John Wiley & Sons, 2013.

[5] E. Unaenah et al., "Van Hiele's Theory in Learning to Build Flat," NUSANTARA, vol. 2, no. 2, pp. 365–374, 2020.

[6] E. T. Ruseffendi, "Assessment of Education and Student Learning Outcomes Especially in Teaching Mathematics for Teachers and Prospective Teachers," Bandung: Diktat, 1991.

[7] K. Safrina, M. Ikhsan, and A. Ahmad, "Improving geometric problem solving skills through van Hiele theory-based cooperative learning," Journal of Mathematics Didactics, vol. 1, no. 1, 2014.

[8] Z. Zulkardi, R. I. I. Putri, and C. Hiltrimartin, "Students' Difficulty in Solving Geometry Problems at Higher Order Thinking Skills Level," SJME (Supremum Journal of Mathematics Education), vol. 5, no. 2, 2021.

[9] N. Sari, "Analysis of Students' Reasoning Ability in Solving PISA Problems on Geometry for Class X Students of SMAN Titian Teras H. Abdurrahman Sayoeti Jambi," PhD Thesis, Jambi University, 2020.

[10] S. K. Alifah, "Identification of students' geometric thinking levels according to Van Hiele's theory in terms of gender differences in the subject matter of Quadrilaterals: Class VII case study of SMPN 2 Gedangan," PhD Thesis, IAIN Sunan Ampel Surabaya, 2012.

[11] N. Hidayah, "Analysis of Students' Geometric Thinking Levels in Solving Problems on Constructing Flat Side Spaces Based on Van Hiele Theory in Class V Students of SDN-SN Pasar Lama 3 Banjarmasin Academic Year 2019/2020," 2020.

[12] Z. Zainal, "Analysis of Geometric Thinking Processes Based on Van Hiele Theory for Class VI Students of SD Negeri 3 Parepare," in LP2M UNM National Seminar, 2017, vol. 2, no. 1.

[13] R. Romika and Y. Amalia, "Analysis of Students' Mathematical Problem Solving Ability in the Material of Constructing Flat Side Spaces with Van Hiele Theory," Bina Gogik: Scientific Journal of Elementary School Teacher Education, vol. 1, no. 2, 2018.

[14] H. Miles and A. M. Huberman, “Saldana.(2014)," Qualitative data analysis: A methods sourcebook, vol. 3, 2020.

[15] S. Z. Sholihah and E. A. Afriansyah, "Analysis of students' difficulties in the process of solving geometric problems based on Van Hiele's thinking stages," Mosharafa: Journal of Mathematics Education, vol. 6, no. 2, pp. 287–298, 2017.

[16] R. I. A. Sahara and P. Nurfauziah, "Student Difficulty Analysis of Building Flat Side Space Materials Based on Van Hiele's Thinking Stage," JPMI (Journal of Innovative Mathematics Learning), vol. 4, no. 4, pp. 911–920, 2021.

[17] E. Dwi Risqiyanti and N. Setyaningsih, "Students' Mistakes in Solving the Volume Cube and Block Story Problems Based on Van Hiele's Theory Viewed from Gender," PhD Thesis, University of Muhammadiyah Surakarta, 2018