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ANALYSIS OF STUDENT'S GEOMETRY THINKING ABILITY BASED ON VAN HIELE'S THEORY

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Abstract: Tujuan penelitian ini untuk menganalisis kemampuan berpikir geometri siswa dalam menyelesaikan soal geometri berdasarkan tahapan berpikir Van Hiele. Penelitian ini merupakan penelitian kualitatif. Subjek penelitian dua orang siswa kelas XII MIPA 2 SMA Negeri Tomo Sumedang. Metode pengumpulan data dengan soal tes dan wawancara. Analisis data penelitian adalah pengumpulan data, reduksi data, penyajian data, dan membuat kesimpulan. Hasil penelitian yaitu: tidak ada siswa yang mampu mencapai tahap rigor.

Keywords : *Geometri, Kemampuan Berfikir, Teori Van Hiele*

Abstract: The purpose of this study was to analyze students' geometric thinking skills in solving geometric problems based on Van Hiele's thinking stages. This research is a qualitative research. The subjects of this study were students of class XII MIPA 2 SMA Negeri Tomo, totaling 29 students. With purposive sampling obtained 6 research subjects representing the stages of thinking Van Hiele, data collection methods with test questions and interviews. Analysis of research data is data collection, data reduction, data presentation, and drawing conclusions. The results of the study are: no student can reach the rigor stage.

Keywords: *Geometry, Thinking skills, Van Hiele theory*

INTRODUCTION

The quality of the teacher in the future is determined by the quality of students as a prospective teacher today (Kania et al., 2020). Mathematics is a discipline science that has a strong and clear structure and linkage between one concept and another (Ratnawulan & Kania, 2020). Mathematics has five content standards, according to NCTM (Walle, 1994), namely numbers and their operations, algebra, geometry, measurement, data analysis, and probability. According to the expression of Afifah et al., (2019) that mathematics is one of the main subjects studied at every level of education.

Geometry consists of concepts that are interconnected in terms of representation and reasoning skills to create a concept. This is reinforced by the opinion (Alex & Mammen, 2012) , geometry consists of complex networks, interconnected concepts that demand a system of representation, and reasoning

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skills to conceptualize and be able to analyze not only the physical environment but also imaginable space. environment. .

Solving geometric problems also requires a thought process in applying the concepts and skills used to solve problems (Dewi, 2015) . The importance of understanding geometry for students to learn because it can solve problems of measurement and shape. According to the opinion (Walle, 1994) which revealed five reasons why geometry is important to study, (1) it can help to have complete aspirations about the world, (2) it helps develop problem solving skills in terms of geometric exploration, (3) becomes a major role in Theory. other mathematics, (4) used in daily life, (5) full of puzzles and interesting.

Students' geometric thinking ability greatly affects students' understanding of the material that has been taught and then continues to a higher understanding. The thinking ability of students is certainly very different from one another. According to (Fuys, 1988) states that to help students pass the thinking stage from one stage to the next in studying geometry, learning experiences are needed that are in accordance with the stages of thinking. Knowledge of students' thinking stage abilities and basic geometry skills can provide a reference for a teacher to make decisions in choosing the right learning model and media. Geometric thinking is very important for students because according to (Clement, DH, & Battista, 1992) it can: (1) build logical thinking skills, (2) build spatial intuition about the real world, (3) provide the knowledge needed to learn more mathematics , (4) teaching reading and interpreting mathematical arguments.

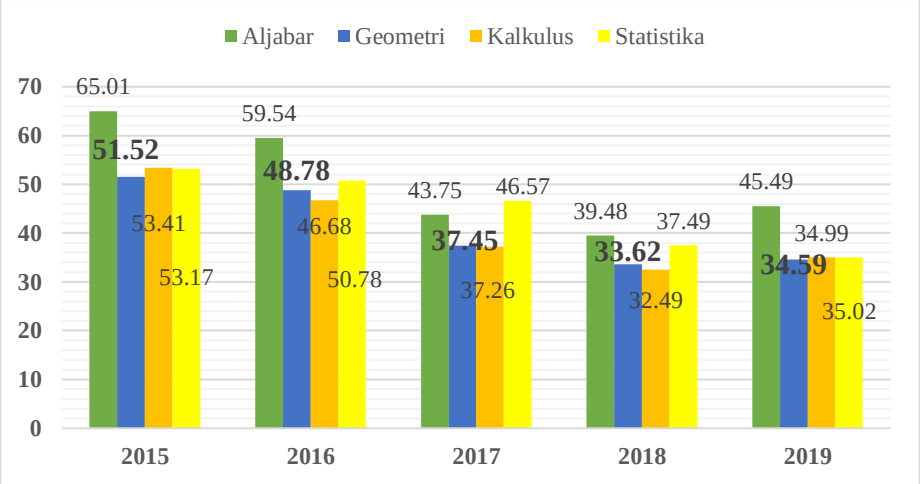

Figure 1. National Examination for Mathematics at National High School
(Source: http://puspendik.kemendikbud.go.id/hasil-un/2015-2019)

In accordance with the objectives of learning geometry, students must be good geometry problem solvers. According to the Ministry of National Education, geometry has the largest contribution to competence in the 2007-2010 national mathematics exam (Sunardi, 2006). However, mathematics is

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often considered difficult for students, especially geometry material. This can be seen from the results of the National Examination for Mathematics at the National High School majoring in Science 2015-2019 released by the Ministry of Education and Culture which shows that the average value for geometry material is the lowest value compared to other materials (Ministry of Education and Culture). Culture, 2019) . Figure 1 is the result.

The National Examination results in mathematics , geometry material occupies the lowest value among other materials. One of the causes of students' difficulties in understanding geometry material is the lack of student interest in learning and understanding geometric concepts.

To produce students who have good geometric thinking skills, it is necessary to test the geometric thinking stages based on Van Hiele's theory to determine the extent to which students understand geometric material so that later they can overcome difficulties in learning geometry. According to (Walle, 1994) Van Hiele's theory was developed for students who will go through five stages of thinking in understanding geometry, namely: stage 0 (visualization), stage 1 (analysis), stage 2 (informal deduction), stage 3 (reduction), and stage 4 (stiffness).

According to (Crowley, 1987) the geometric thinking stage of Van Hiele's theory has the following characteristics: (1) the student's thinking stage is passed continuously. When a student moves from one stage, it means that the student has experienced geometric thinking according to that stage and formed the thoughts that will be the focus of the next stage. (2) the stage of thinking according to Van Hiele's theory does not depend on age, but on content, methods, and learning methods rather than age and maturity. (3) The experience of geometry has the greatest impact on the speed at which a stage passes.

The advantages of Van Hiele's theory according to (Burger, 1986), among others, can help students better understand geometry by learning through experience, students' mathematical communication skills become better, intrinsic and extrinsic, namely objects that are still unclear will become objects that clear at a later date. Students are not required to know in advance the geometry material to be taught so that students will find their own knowledge through the learning process they do, besides the speed of understanding from the initial stage to the next stage is more dependent on the content and learning methods used by the teacher, not age and maturity of thinking. student.

Based on the description above, it can be seen that students' geometric thinking skills need to be considered in order to overcome students' difficulties in learning geometric material. Therefore, it is necessary to research analysis of students' geometry ability based on van hiele theory.

RESEARCH METHODS

Research Methods This section describes how the reported research was conducted. If this research is quantitative. The main material in this research method consists of students' mathematical geometric thinking skills based on Van Hiele's theory. Data collection was carried out carefully, including detailed contextual descriptions accompanied by notes from in-depth interviews, as well as analysis results and document notes (Sukmadinata, 2009).

The research subjects were 2 students of class XII MIPA 2 SMA Negeri Tomo. According to (Lexy J Moelong, 2016) said that "the purpose of the sample was chosen not to focus on differences which will later be developed into generalizations, but to detail the specificities that exist into unique context materials". The subjects selected were 6 students based on the ability of Van Hiele's theoretical thinking stage. For students who represent 2 each at the Van Hiele thinking stage 0-2, 0-3, and 0-4.

Data collection techniques in this study used tests and in-depth interviews. The test in this study was used by researchers to classify students into geometric thinking skills according to Van Hiele's theory and to determine students' geometric abilities in solving geometry problems. The geometry test was carried out before being used, the validation process was carried out to the expert validators, namely two lecturers and a class XII Mathematics Subject Teacher. Below is Aiken's V table before the geometry test was distributed to the subjects.

Table 1. V Aiken

Statement type	Evaluator			Process analysis						
	V1	V2	V3	S1	S2	S3	s	n(c-1)	V	Notes:
P1	3	3	4	2	2	3	7	9	0.78	at the moment
P2	3	3	4	2	2	3	7	9	0.78	at the moment
P3	4	3	3	3	2	2	7	9	0.78	at the moment
P4	3	4	4	2	3	3	8	9	0.89	tall
P5	4	4	4	3	3	3	9	9	1	tall
P6	4	3	4	3	2	3	8	9	0.89	tall

Table V Aiken above contains 6 statements (items) with 3 validators (raters), which in the description there are high and medium categories. The two categories are appropriate categories because according to (Azwar, 2019) in the opinion that V = 0.667 is interpreted as a fairly high coefficient, with the value of V ranging from 0-1. Therefore, the geometry test deserves to be used and distributed to students. The following is a grid of geometric ability tests.

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Table 2. Geometry Ability Test Box

question number	Van Hiele's Geometric Thinking Stage	Indicator
1	Stage 0-1	Determine the distance between the points
2	Stage 0-2	Determine the distance between the points
3	Stage 0-3	Determine the distance from the point to the line
4	Stage 0-4	Determine the distance from the point to the plane
5	Stage 0-4	Determine the distance from the point to the plane

Interview is a way of collecting data through conversations between researchers and research subjects or respondents. The instrument used in the interview is usually a list (called an interview guide) which contains an outline of questions that have been prepared in advance. The interview used in this research is a structured but open interview.

The data analysis used in this study is an interactive technique, namely a qualitative data analysis technique consisting of three activity lines, namely data reduction, data presentation, and conclusion drawing or verification that occurs simultaneously.

RESULTS AND DISCUSSION

Analysis of Geometric Thinking Ability Based on Van Hiele Theory. S4 written test data are as follows:

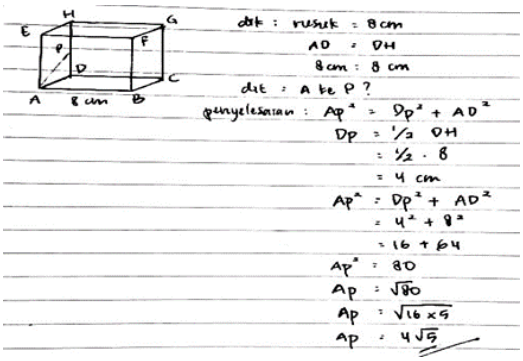

Figure 2. Results of Geometry Test Number 1 S4

Based on the results of the geometry test, S4 shows the answer steps starting from what is known, asked, then completed. Students can describe the cube ABCD. EFGH is obtained from identification through questions and describing the cube, then stage 0 (visualization) is reached then can show that there is another shape besides the cube, namely a triangle shape, then stage 1 (analysis) is achieved well.

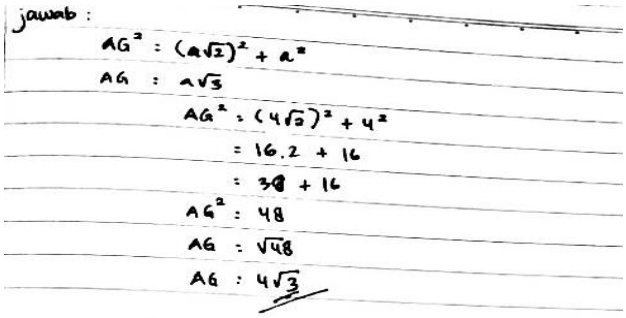

Figure 3. Results of Geometry Test Number 2 S4

Based on the results of the geometry test, S4 immediately completed the answer, namely determining the length of the AG line, so that without stage 0 (visualization), stage 1 (analysis) and stage 2 (informal deduction) were achieved quite well.

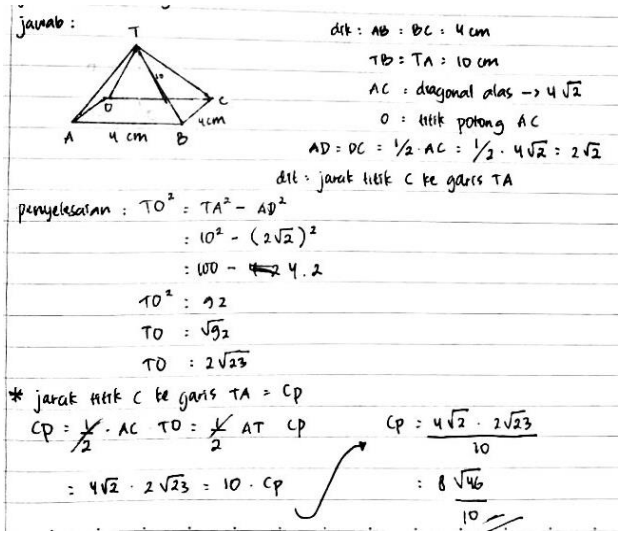

Figure 4. Results of Geometry Test Number 3 S4

Based on the results of the geometry test, S4 shows a systematic answer starting from what is known, asked, then solved. Starting with describing the cube, then showing other shapes contained in the cube, then stage 0 (visualization), stage 1 (analysis), stage 2 (informal deduction) and stage 3 (reduction) were achieved well.

Regarding the data analysis of the geometry test results, interviews were conducted. An interview snippet from S4 regarding question number 1 is as follows:

P : "What is the first step to solving this problem?"
S4 : "Before working on the problem, I first understand the problem"
P : "Why did you draw a cube?"
S4 : "From the problem, it is known that the cube ABCD. EFGH Ma'am"
P : "Is there any other shape besides the cube?"

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S4 : "There is ma'am, the triangle from the point ADP"
P : “Okay, what do you think this matter is about? Distance between points, distance between lines, or distance between planes?”
S4 : "This determines the distance between the points bu"
P : "Okay, what about the next step?"
S4 : “I found the formula that AP = . DH, DH = 8, then the result is 4, then just enter the existing value into the predetermined formula"

After the analysis of the S4 geometry test results and interview data analysis were obtained, a comparison was made to determine whether the data obtained were valid or not. Based on the results of the S4 geometry test analysis, it is known that S4 has reached the indicators of determining the distance of the point and geometric thinking skills at stage 0 (visualization) and stage 1 (analysis).

Based on the analysis of the S4 geometry test results and interview data analysis, it can be concluded that S4 has achieved the indicators of geometric thinking ability as shown in Table 3 below:

Table 3. Results of S4 Geometric Thinking Ability Analysis

Test results	Interview
S4 can work on questions number 1-3 with good steps according to the geometry test indicators and Van Hiele's geometric thinking stage from stage 0-3	S4 can explain the process of working on questions correctly and clearly, according to the results of tests that have been done previously
Conclusion	
If students can work on questions number 1-5 well and in accordance with the test questions indicators and Van Hiele's theory of thinking, then from stage 0-4 it is achieved well. This is in accordance with the opinion (Fuys , 1988) which states that, identifying things about a shape, constructing, drawing, or copying a shape, to proving the theorem relationship with a statement, the geometric thinking stage is achieved quite well.	

Analysis of Geometric Thinking Ability Based on Van Hiele Theory. S5 written test data are as follows:

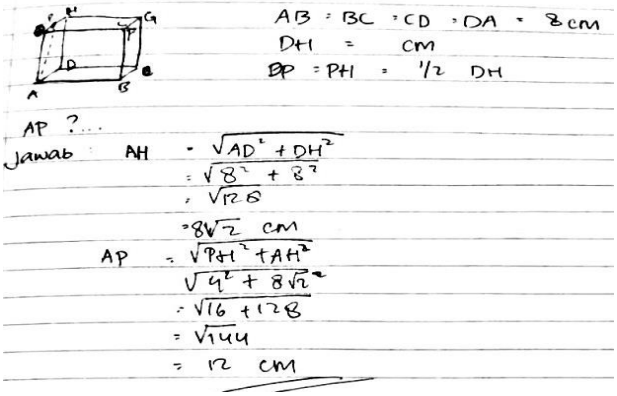

Figure 5. Geometry Test Results Number 1 S5

Based on the results of the geometry test, S5 shows the answer steps starting from what is known, asked, then completed. Students can identify and describe the cube, then stage 0 (visualization) is

achieved well, but for stage 1 (analysis) it is not appropriate because it does not mention another shape, namely a triangle and the location of point P is not between points D and H but is located between points E and H.

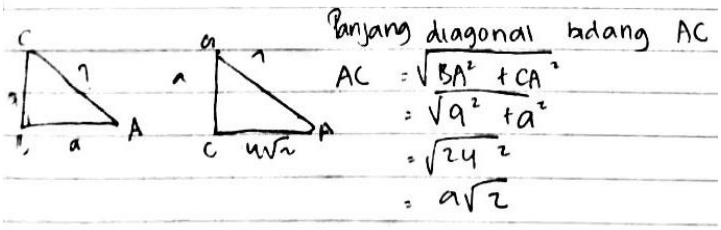

Figure 6. Results of Geometry Test Number 2 S5

Based on the results of the geometry test, S5 can identify and describe a triangle, without the cube ABCD.EFGH, then determine the AC line, then stage 0 (visualization), stage 1 (analysis) and stage 2 (informal deduction) are achieved adequately. Because the answer has not been completed, the answer has just arrived on the AC line and the AG route has not been determined.

Regarding the data analysis of the geometry test results, interviews were conducted. An interview snippet from the subject of S5 regarding question number 1 is as follows:

P : "What is the first step to solving this problem?"
S5 : "The first step, I determine what he knows ma'am"
P : "Why did you draw a cube?"
S5 : "From the problem ma'am, it is cube ABCD.EFGH"
P : "What do you think this matter is about? Distance between points, distance between lines, or distance between planes?"
S5 : "Determining the distance between the points bu"
P : "What are the next steps you take to address this problem?"
S5 : "I immediately determine the AP line, that is, $AP = \sqrt{PH^2 + AH^2}$before I determine the AH value, then just enter it into the AP formula"

After the analysis of the S5 geometry test results and interview data analysis were obtained, a comparison was made to determine whether the data obtained were valid or not. Based on the results of the analysis of the S5 geometry test, it is known that S5 has reached the indicators of determining the distance between points and the ability to think geometrically in stage 0 (visualization) and stage 1 (analysis).

Based on the analysis of the S5 geometry test results and interview data analysis, it can be concluded that S5 has achieved the indicators of geometric thinking ability as shown in Table 4.

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Table 4. Results of S5 analysis. Geometric Thinking Ability

Test results	Interview
S5 can work on questions number 1-2 with sufficient steps according to test indicators and thinking stage 0-2 based on Van Hiele theory	S5 can explain the process of working on the questions sufficiently, according to the results of tests that have been done previously
Conclusion	
If students can work on questions number 1-2 sufficiently and in accordance with the test indicators and Van Hiele's theory of thinking, then from stage 0-2 it is sufficient to achieve. This is in accordance with the opinion (Fuys, 1988) which states that, identifying things about a shape, constructing, drawing, or copying a shape, does not prove the relationship between theorems and statements, then the geometric thinking stage is sufficient. well.	

Based on the results of tests and interviews, S4 and S5 at stage 0 (visualization) were able to solve the problem with good steps and in accordance with Van Hiele's thinking stage indicators, namely being able to identify, draw, or copy a form as a whole based on the questions that have been given. S4 and S5 at stage 0 (visualization) are able to solve problems with good steps and in accordance with the indicators of the thinking stage, namely being able to identify, draw, or copy a form as a whole based on the questions that have been given. According to (Walle, 1994) that the higher the Van Hiele stage achieved, the higher the geometric ability. Students at stage 0 (visualization) are students with the lowest Van Hiele stage.

Stage 1 (analysis) S4 and S5 are able to solve problems with good steps and in accordance with the indicators of the thinking stage able to compare the two forms based on the relationship between their components. This is in line with the statement from (Fuys, 1988) when a student is able to meet the Van Hiele geometric thinking stage indicator, the student has achieved well. The difficulty of students at this stage is that they have difficulty in comparing a form with the questions given. The point of difficulty experienced due to a lack of understanding of the meaning of the questions given.

Stage 2 (informal deduction) only S4 is able to identify various sets of properties that characterize a shape. In line with research conducted by (Sujadi, 2014) that stage 2 (informal deduction) has been able to use the properties of a form to determine its classification and use mathematical concepts related to an object. S4 is able to reach this stage because it can solve problems systematically with good steps. Students are able to reach this stage because they can solve problems systematically with good steps. While the S5 is not at this stage. The difficulty experienced by S5 is the lack of understanding of the geometry concepts that have been studied previously.

Stage 3 (deduction) is a new S4 that is able to prove in the form and relationship of an axiomatic arrangement that is described informally. According to the explanation of the Van Hiele stage by (Hoffer, 1981) stage 3 students (deduction) should already understand about deductive proof. S4 can solve problems with good steps and is able to solve problems related to proof. While the S5 is not at this stage

less able to prove in terms of informally described axiomatic arrangement forms and relationships. S5 cannot solve problems with good steps and is less able to solve problems related to proof. The difficulty that is the reason for students in solving problems is that students pay less attention to the teacher when explaining the geometry concepts conveyed so that they think that three-dimensional questions are difficult to learn so that their interest in learning is low.

Stage 4 (rigor) S4 and S5 are less able to meet the indicators of the thinking stage, namely they cannot prove the relationship between theorems and statements. Based on tests and interviews, the difficulty of students at this stage is the lack of practice in the material of building space, besides that students do not understand the meaning of the questions given. Students are less able to meet the indicator of the stage of thinking that is unable to prove the relationship between theorems and statements. The difficulty that causes this stage is not achieved is the concept of geometry that has not been mastered or understood. The need for learning media that will help students reduce difficulties in understanding geometric concepts. Research conducted by which states that the benefits of using learning media, especially geometry material, will make it easier for students to improve understanding of geometric concepts.

Students to understand geometry material, one of which must be a lot of practice to work on the problem, start working on easier questions with the same type of questions to make it easier to work on the problem. This is in accordance with research conducted by (Listiani, 2018) which reports that practice questions can help improve mathematics learning outcomes. been taught.

The need for learning media that will help students reduce the difficulty of understanding something abstract. Research conducted by (Pranata, 2020) which states that the benefits of using learning media, especially geometry material, will make it easier for students to improve understanding of geometric concepts, and become a concrete visualization medium for students. By using effective and efficient learning media, learning objectives can be achieved, this is in accordance with research conducted by (Hidayani, 2021) which states that contextual learning media will help students understand mathematical concepts. Using learning media can improve student learning outcomes on geometry material, especially because this is one of the benefits of using learning media (Pranata, 2020) . This will improve students' ability to understand the material. Students will better understand the shape of space after it is associated with concrete objects and the media used must be effective and efficient in order to achieve the goal. One way to increase students' interest in learning is by applying effective learning media. In accordance with research conducted by (Ratu, 2019) which utilizes learning media by operating an android-based application, students are able to master the media by being trained and there is an increase in student interest in learning. In addition, to attract students' interest in learning according

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to research conducted by (Fini Rezy, 2021) is to use geogebra software media (Kania, 2018), the results obtained have a positive effect on students' interest in learning geometry material.

According to research conducted by (Sanusi, 2015) using interactive multimedia as one of the learning media for geometry material is good, judging from the results of the study, namely the percentage of each student's response to the questionnaire statement shows the percentage is above 70%, with "high" and "very high" qualifications. ". ", and the classical student response was 75.35% with high qualifications. That means the importance of applying learning media for students to understand geometry material.

The right solution for students in understanding the concept of geometry is to practice a lot with the various problems that have been given. This is in line with the opinion of research conducted by (Listiani, 2018) which reports that practice questions can help improve mathematics learning outcomes, this is also inseparable from the various benefits of practice questions for students, one of which is to find out the extent of understanding the material. that has been taught.

Based on the results of the analysis, it is shown that the students' geometric thinking abilities based on the Van Hiele stages vary according to the abilities of each student. This is in line with the research conducted by (Sujadi, I., 2014) which revealed that the geometric abilities of high school students according to Van Hiele stages were different in answering each item given. Students in class XII tend to be in stages 0-2. This means that the ability of students' geometric concepts is still lacking.

CONCLUSIONS AND SUGGESTIONS

Based on the results and discussion, it can be concluded that students who have been categorized according to the Van Hiele stage have different thinking abilities. Students at stage 0 (visualization) are able to identify, draw, or copy a shape in its entirety. Students at stage 1 (analysis) are able to compare two forms based on the relationship between their components. Stage 2 students (informal deduction) are able to identify various sets of properties that characterize a form. Stage 3 students (deduction) are able to prove in the form and relationship of an axiomatic arrangement that is described informally. Students at stage 4 (rigor) are able to meet the indicators of the thinking stage, namely being able to prove the relationship between theorems and statements.

The difficulties experienced by students in achieving each stage of Van Hiele's thinking are the lack of understanding of geometric concepts, lack of practice in solving geometry problems and the low interest of students in learning mathematics, especially spatial geometry.

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