Thinking process of 7th class students in understanding quadrilateral concepts based on Van Hiele theory

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Abstract. This study describes the thinking process of 7th class students in understanding quadrilateral concepts based on the van hiele theory. This research is a descriptive research with qualitative approach. The research instrument used was the researcher, the latest question sheets and interviews. Data analysis techniques include data reduction, data presentation, and drawing conclusions. The results showed that S1 underwent an assimilation process when determining a rectangle is a parallelogram because S1 can correctly state the reason why a rectangle is a parallelogram. This shows that S1 has met level 2 (Informal Deduction) even though S1 has not been able to prove. S2 undergoes assimilation when answering questions. S2 begins to experience disequilibrium when S2 is asked about the number of vertices as evidenced by long silences. But after being given an understanding of the concept, S2 began to understand and there was an equilibrium. Then S2 experiences, accommodation when restating the nature of the rectangular shape. This shows that S2 has met level 2 (analysis). S3 undergoes an assimilation process because S3 chooses a shape which is a rectangular shape based on S3's knowledge. This indicates that S3 meets level 0 (Visualization).

1. Introduction

Education is the maturation of students to develop their talents, potentials, and skills in running life [1]. The education system in Indonesia is always undergoing changes which aim to realize the education system to be of higher quality, with a better curriculum to produce better graduates [2]. Along with the times, the world of education also needs innovation. To achieve all that, a new teacher paradigm is needed in the learning process, from initially teacher-centered learning to innovative and learner-centered learning [3].

Mathematics is a branch of science that is studied in school education. Mathematics has five standard contents, namely numbers, and their operations, algebra, geometry, measurement, data analysis and probability [4]. All topics studied in mathematics are closely related to reasoning abilities. Understanding of concepts, and counting. To achieve competence in participating in mathematics learning, students must be able to understand the concept of the material provided by the teacher. Students' thinking skills are needed to build new knowledge from previous experiences and knowledge.

States that geometry is a branch of mathematics that is taught with the aim that students can understand the properties and relationships between geometric elements and can become good problem solvers [5]. Geometry studies abstract patterns of points, lines, angles, planes, and spaces that are presented with concrete/real objects in the environment. Based on this, geometry is considered to be able to develop students' logical thinking skills, so that these logical thinking skills can be applied in everyday life. In studying geometry students have difficulty solving proofs in geometry, recognizing the properties and characteristics of the objects being studied and students also having difficulty determining
the geometric relationships between geometric objects. So, it has implications for student errors in solving geometry evaluation problems, especially those related to quadrilateral, including errors in drawing rectangles with certain rules and errors in making mathematical models/sentences of the problems/images presented. These errors are also thought to be due to the lack of thoroughness of the students and the lack of understanding of the students' concepts that are not optimal.

States that to help students pass the thinking stage from one stage to the next in learning geometry, a learning experience is needed that is by the students' thinking stages [6]. The thought process is a series of forming a student's mindset to solve a given problem involving disequilibrium, assimilation, accommodation and equilibrium. When someone interacts with the environment (including math problems), there will be an adaptation process.

Assimilation is the process of responding to a new event with an existing scheme according to [7]. Accommodation is the process of responding to a new event by modifying an existing scheme or forming a new scheme [7]. In solving problems, cognitive processes (assimilation and accommodation) continue until equilibrium occurs. In the assimilation process, the thinking structure (schema) owned by students is in accordance with the information structure (including math problems); so that the stimulus can be linked to the schema in the student's mind or can be interpreted directly by the child. In this case, the stimulus is integrated into the existing scheme. Meanwhile, the accommodation process occurs when the scheme is not in accordance with the problem structure; so that there will be a process of modification of the old scheme or the formation of a new scheme so that the thought structure that is owned is in accordance with the structure of the problem. In the problem solving process, the two processes (assimilation and accommodation) can occur together.

A person will go through five hierarchical levels of understanding in learning geometry [8]. States that each level shows the thought processes a person uses in learning geometric concepts [8]. The levels show how one thinks and what types of geometric ideas are thought, so it does not show how much knowledge the student has. The levels meant are level 0 visualization (introduction), level 1 analysis, level 2 informal deduction (sorting), level 3 deduction, level 4 rigor. Van Hiele's levels are hierarchical and sequential, for students to reach higher levels they must master most of the previous levels [8]. Level 0 (visualization) as the basic level in van Hiele's hierarchy is a prerequisite for better mastering the higher levels. Most of these levels of visualization must be mastered by students to play a good role at the next level. The thinking process scheme related to the level of geometric thinking according to van Hiele is presented in Figure 1. below.

![Thinking Process of Students with Van Hiele Theory](image)

**Figure 1.** Thinking Process of Students with Van Hiele Theory

Relevant research was conducted by Lestari [9]. The results showed that the two subjects experienced disequilibrium when the subject was silent and unable to answer questions and did not use props.
Furthermore, relevant research was also conducted by Nurani et al. [10], the results showed that grade VII students of Hasanudin Islamic Junior High School were at level 0 (visualization) and level 1 (analysis). This research is viewed from gender. High and moderate female students are at level 1 (analysis) while low-ability female students are at level 0 (visualization). High-skilled male students are at level 1 (analysis), while moderate and low-ability male students are at level 0 (visualization).

The difference that occurs in this study with previous research is that the researcher analyzes how "The thinking process of 7th class students in understanding quadrilateral concepts based on the van Hiele theory". In this study, the thinking process of students in terms of indicators of thought processes according to Piaget was related to the thinking level of students according to Van Hiele.

In this study, the problem is limited to the material of rectangles, namely parallelograms, rectangles, squares, rhombuses, and kites. Based on the description above, the researcher is interested in conducting research entitled "The thinking process of 7th class students in understanding quadrilateral concepts based on the van Hiele theory".

2. Research Method

This type of research was a descriptive study with a qualitative approach. There were 3 students selected as research subjects, 1 student per Van Hiele level in seventh grade SMP Darul Ulum. The instruments used in this study were researchers, question sheets, and interview guides. The research was conducted by giving the first test of the Van Hiele Geometry Test to all students in one class who were familiar with the Van Hiele level. Furthermore, every 1 student from each level was determined as a research subject. After giving the first test, the next step was to give the second test, which was a test of students' thinking processes with understanding the concept to 3 specific students.

The validity of the instrument in this study was conducted to test students' thought processes by understanding the concept and interview guidelines. Usiskin's VHGT test instrument is valid and does not need to be re-validated. Testing the validity of the instrument was carried out by providing validation sheets to 2 lecturers from the Mathematics Education Study Program, Faculty of Teacher Training and Education, University of Jember, and 1 mathematics teacher at Darul Ulum Middle School. The final step is an interview that aims to confirm students' writing and reinforce the findings obtained, as well as to get more in-depth analysis. The problems given to the research subjects are as follows:

In this study, the scoring criteria for students' thinking ability tests in geometry were based on the scoring developed by Usiskin [10]. Each level has five questions, if the student answers three, four, or five questions on the visualization level correctly, he or she reaches the level (0) visualization. If the student (a) answers three or more questions from level (1) of analysis; (b) meet the criteria for level (0) of visualization; and (c) did not answer three or more questions correctly, from level (2) informal deduction, level (3) deduction, and level (4) rigor, then the student is classified at the level of analysis.

After the test and interview instruments were declared valid, these instruments were tested on the research subject and obtained several data from the test results to the subject, the test and interview test data were analyzed to answer the problem formulation/achievement of research objectives. The data of the students' thinking ability test results in quadrilateral were analyzed according to the scoring criteria. Students are said to have reached a certain level at the van Hiele level if the student can answer at least 3 out of 5 questions at each particular level correctly. If a student has failed at a certain level, then that student is considered to have failed at the next level.

Test result data were analyzed to select students who were deemed capable of being able to describe their thought processes in solving quadrilateral problems properly to answer the problem formulation/achievement of research objectives. Interview data were analyzed and compared with test results to describe students thought processes based on Van Hiele's theory in solving questions according to indicators.

Data analysis was carried out in three stages, namely the stage of data reduction, data exposure,
and drawing conclusions. This data analysis was the main objective of the research which aimed to describe the thinking process of 7th class students in understanding quadrilateral concepts based on the van hiele theory.

![Research procedure diagram](image)

**Figure 2.** Research procedure

3. Results and Discussion

The study was conducted by giving the first VHGT (*Van Hiele Geometry Test*) to all students. Furthermore, every 1 student from each level are determined as research subjects. After giving the first test, the next step is to give the second test, which is a test of students’ thinking processes with understanding the concept to 3 specific students. The selected subjects completed the second test questions. That was the thought process test with understanding the concept which was then analyzed. The following is a description of the thinking process of students at the Van Hiele level. The results of the analysis show that every student at Van Hiele's level is different in their thinking processes.

![Answer footage](image)

**Figure 3.** Answer footage from S1 Subject (Student of Informal Deduction Level)

In the preparation stage, the results of interviews with students related to the preparation stage showed that S1 was quite clear with the questions given. This can be seen when S1 answers the problem quite clearly. Since the beginning, S1 received S1 questions, there was no confusion. S1 undergoes an
assimilation process when S1 correctly chooses which shape is a rectangular shape. This assimilation process is followed by equilibration because S1 can correctly state the reasons for choosing these shapes. This shows that S1 has met level 0 (visualization) of van Hiele's theory.

The accommodation stage has also been passed by S1 when S1 can mention the properties of the quadrilateral. The equilibrium stage occurs in S1 when S1 can link between the properties of the quadrilateral which is seen when S1 can mention the same properties between the rectangular shapes. Then S1 has met level 1 (analysis).

S1 begins to experience a disequilibrium when S1 is asked whether a rectangle and a rhombus are also included in the ladder. An expression of confusion is shown by his statement, namely: ummm... what yes ". To overcome his confusion, S1 tries to answer the problem by experimenting with the questions. S1 remains confused. However, after being given an understanding of the concept of the relationship between the S1 figures, they begin to understand and there is an equilibrium. Then S1 experienced accommodation when he said the kite and trapezoid were also included in the rectangle. Understanding of geometric shapes that relates the relationship of the properties that exist in a rectangular shape will lead S1 to level 2 of Van Hiele's theory, namely informal deduction.

When S1 can mention the relationship between the properties of a quadrilateral, S1 experiences an equilibrium process because S1 can answer this question after going through the accommodation process when mentioning the relationship between the properties of each of these shapes. However, S1 does not yet understand why something is used as a theorem, axiom or definition of the shape. When S1 cannot connect the two shapes properly, then S1 does not meet level 3 of Van Hiele's theory, namely deduction.

Thinking Process of Students at Analysis Level (S2) in Solving Geometry Problems

![Figure 4. Answer footage from S2 Subject (Student of Analysis Level)](image)

S2 can easily determine the shapes which include the quadrilateral. S2 can choose a rectangular shape in various sizes and positions. S2 assumes that the shapes are rectangles seen from S2's answer when working on the problem, S2 determines 5 types of rectangular shapes by looking at the picture of a collection of shapes combined into 1 shape. This shows that S2 has met level 0 (visualization) of van Hiele's theory because even though S2 does not know the properties of the quadrilateral as a whole, S2 can determine which shapes are included in the quadrilateral.

S2 began to experience disequilibrium when researchers asked about the properties of the quadrilateral indicated by "long silence and frowning". However, after being given an understanding of the concept of the properties of the quadrilateral, S2 began to understand and assimilation occurred. S2 looks slowly starting to accept knowledge, then it appears S2 can state that he has answered wrongly when working on the given problem. Understanding of geometric shapes that relate the properties of the rectangle will lead, S2 to level 1 van Hiele, namely analysis.
S2 has also passed the accommodation stage when S2 can show the elements from a quadrilateral. After S2 could show the elements from the quadrilateral, the researcher began directing S2 to name the properties of the quadrilateral. When S2 understands the properties and elements of the quadrilateral, then S2 has met level 1 van hiele, namely (analysis). The equilibrium stage occurs in S2 when S2 can relate between the properties of the quadrilateral which is seen when S2 can list the same properties between the rectangular shapes. Although S2 can mention the same properties between the properties of the quadrilateral, S2 cannot yet relate the relationship of these shapes. This can be seen when S2 states that rectangles and rhombuses are not included in the range. When S2 cannot connect the two shapes, then S2 does not meet van Hiele's level 2 (informal deduction).

Thinking Process of Students at Visualization Level (S3) in Solving Geometry Problems

Since the beginning, S3 has undergone an assimilation process because S3 was able to determine the shapes which were included as rectangles based on S3's knowledge. This shows that S3 meets level 0 (Visualization) of Van Hiele's theory, because although S3 can determine 5 types of rectangular shapes by looking at the image of a collection of shapes combined into 1 shape S3 cannot determine the properties of the rectangle.

In addition, S3 also experiences a disequilibrium when it comes to problems related to the properties of the quadrilateral. S3 simply can't solve it; he was confused. His confused expression is shown by "scratching his head". This confusion shows that the thought process and understanding of S3 in understanding the concept of rectangles has not been formed as a whole. If S3 has understood the elements and properties of the rectangle, level 1 (analysis) has been fulfilled, but because S3 is still in disequilibrium, S3 has not yet met level 1 (analysis).

S3 undergoes an assimilation stage when the researcher provides new knowledge about the properties of the quadrilateral. S3 looks slow in starting to receive knowledge, then it appears that S3 can state that it has answered wrongly when working on the given questions. From S3's answer regarding the properties of rectangles, it can also be seen that S3 is not quite right when answering the questions in the questions given. Then level 1 (analysis) of S3 has not fulfilled.

S3 has also passed the accommodation stage when S3 can show the elements from a quadrilateral. When showing the elements and properties of the rectangle, S3 still has to be assisted by researchers. This indicates that S3 has not yet met van Hiele's level 1 (analysis).

The equilibrium stage occurs in S3 when S3 can relate between the properties of the quadrilateral which is seen when S3 can name the same properties in the properties of the quadrilateral. S3 already understands the relationship between rectangular shapes where S3 can say that a rectangle and a rhombus are also included in the levels and if it is related to van Hiele's theory, S3 actually meets level 2 (informal deduction). However, in the interview transcript, S3 still uses a rote system in understanding the concept of rectangles. Therefore S3 has not yet met level 2 (informal deduction) from van Hiele's
theory.

Different from relevant research was conducted by Lestari [9]. The results showed that the two subjects experienced disequilibrium when the subject was silent and unable to answer questions and did not use props. Furthermore, relevant research was also conducted by Nurani et al. [10], the results showed that grade VII students of Hasanudin Islamic Junior High School were at level 0 (visualization) and level 1 (analysis). This research is viewed from gender. High and moderate female students are at level 1 (analysis) while low-ability female students are at level 0 (visualization). High-skilled male students are at level 1 (analysis), while moderate and low-ability male students are at level 0 (visualization).

4. Conclusion

Based on the results of the analysis and discussion, it was concluded that the three subjects experienced a state of disequilibrium when they did not understand the meaning of the problem regarding the relationship of the quadrilateral. Then the subject gets new knowledge about the relationship of the properties of the quadrilateral, an equilibrium process occurs. After understanding the new knowledge, the subject undergoes a process of accommodation. After that there is a balance between assimilation and accommodation which is indicated by the ability of the subject to express the reasons for the subject's answer, then the subject experiences equilibrium.

S1 begins to experience a disequilibrium when S1 is asked whether a rectangle and a rhombus are also included in the parallelogram. However, after being given an understanding of the concept, S1 begins to understand and there is an equilibrium. When viewed from Van Hiele's theory, students have met level 0 (visualization) of Van Hiele's theory which is shown by the ability of students to determine quadrilateral. For level 1 (analysis) the students' Van Hiele theory has fulfilled it because students can mention the properties of the rectangular shape well. For level 2 (informal deduction) the students' Van Hiele theory has fulfilled as well because students can mention the relationship of the properties in a shape that is in a rectangular shape well. However, students have not met level 3 (deduction) of Van Hiele's theory because students do not understand why something is used as a theorem. Therefore, it can be concluded that these students are at level 2 of Van Hiele's theory, namely informal deduction.

In addition, S2 can restate the properties of the quadrilateral. S2 has gone through the accommodation stage because there has been an adjustment between the knowledge that S2 already knows with the new knowledge that has been provided by the researcher. S2 has also passed the accommodation stage when S2 can show the elements from a quadrilateral. After S2 could show the elements from the quadrilateral, the researcher began directing S2 to name the properties of the quadrilateral. When S2 understands the properties and elements of the quadrilateral, then S2 has met level 1 Van Hiele, namely (analysis).

Since the beginning, S3 has undergone an assimilation process because S3 was able to determine the shapes which were included as quadrilateral based on S3's knowledge. This shows that S3 meets level 0 (Visualization) of Van Hiele's theory, although S3 can determine 5 types of quadrilateral by looking at the image of a collection of shapes combined into 1 shape S3 has not been able to determine the properties of the quadrilateral. In addition, S3 also experiences a disequilibrium when it comes to problems related to the properties of the quadrilateral. This confusion shows that the thought process and understanding of S3 in understanding the concept of quadrilateral has not been formed as a whole. If S3 has understood the elements and properties of a quadrilateral, level 1 (analysis) has been fulfilled, but because S3 is still in disequilibrium, S3 has not yet met level 1 (analysis).

As for suggestions that can support for further research, discuss more time with the school for research during interviews, so that you can get more data so that the results are maximized. There should also be specific learning media in helping students understand the concept of geometry in the learning process in understanding material related to geometric shapes.
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