Analysis on geometry skills of junior high school students on the concept congruence based on Van Hiele’s geometric thinking level

Reni Astuti1,2,a, Didi Suryadi1 and Turmudi1
1School of Postgraduate Studies, Universitas Pendidikan Indonesia, Jl. Setiabudi 229 Bandung, Indonesia
2Department of Mathematics Education, IKIP PGRI Pontianak, Jl. Ampera No.88, Pontianak, Kalimantan Barat
E-mail: areniastuti@student.upi.edu

Abstract. Analysis of geometry skills using Van Hiele's geometric thinking level is an attempt to overcome students’ difficulties in studying geometry especially the topic of similarity. The purpose of this study is to describe the geometry skills of junior high school students on the concept of similarity based on the level of thinking geometry of Van Hiele. The research method is qualitative descriptive with the subject of research is the students of SMP Negeri 2 Pontianak class IX as many as six people. The data collection instrument is a geometry skill test. The results of the analysis show that students at level one, two, and three from Van Hiele's geometric thinking level have all the skill such as visual, verbal, drawing, logic, and applied but different in characteristics for each level.

1. Introduction
Geometry is a branch of mathematics that often exists in our daily lives. According to Galileo, geometry is the key to understanding nature [2]. Many of the objects around us that resemble the shape of geometry plane or solid. For example, table surfaces, windows, doors, floor tiles, roof shapes, and others. Informally, geometry has been known to children through visual and manipulative objects around them every day. This situation can be useful for students who like to study mathematics concretely rather than learning by symbols.

When studying mathematics students must recognize and understand mathematical objects. According to Ruseffendi [11], objects directly related to mathematics learning activities include facts, skills, concepts, and rules / principles. These four direct objects can be clearly distinguished from each other because each of these direct objects can be clearly defined. From the explanation it is seen that in learning mathematics not only the concepts and principles needed, but also skill (skills).

Some studies find that there are still many high school student who have difficulty in learning geometry. Connolly [4] found that the knowledge and understanding of students who received traditional geometry learning were still low. While his research conducted Eraso [5] explains that not a few students who have difficulty in showing the properties of geometry presented in the form of images. The geometry skills of the students have not been maximized because students are still in the low Van Hiele’s thinking level [4, 9]. Their geometric skills were far from good and varied based on Van Hiele's thinking level. Students need mastering geometric skills and concepts to recognise plane
or solid geometry, visualising, describing and sketching images, labelling specific points, and have the ability to know differences and similarities between geometry object.

According to Hoffer [6], there are five fundamental skills for mastering geometry: (1) visual, an ability to recognise a variety of figure and space, the centre of the object and the interconnection of a part with the other, the symmetry, classify the object, and visualise the model; (2) verbal, the ability to classify objects of geometry by name, visualise them with their verbal descriptions, making the definitions appropriately, show relationships between objects, can formulate generalisations and abstractions, and know the logical structure of oral problems; (3) drawing skills, that is, the ability to sketch plane and label certain points, sketch according to verbal descriptions, to construct picture based on its properties, add useful elements to an image, knows the limitations of the image sketch, and construct a geometry model; (4) logical skills, the ability to recognise differences and similarities between geometric objects, can classify by their properties, understand and apply the essential properties of definitions, exhibit logical consequences of data, develop logical proofs, and recognise the role and limitations of deductive methods; and (5) applied skills, the ability to recognise the physical model of the geometry object, construct the geometry model based on its physical object, apply the properties of the geometry model to the physical object, develop geometric models for natural phenomena and apply them in problem-solving.

Meanwhile, the ability of students in learning mathematics seen from the process of thinking, because in learning, students have different ways of thinking. The application of Van Hiele's theory in learning geometry is believed to overcome students 'difficulties in learning because the theory explains the development of students' thinking in learning geometry. According to Van Hiele's theory, there is five level of the students' thinking in understanding geometry: level 1 (recognition/visualisation): students can name and recognise geometrical object shapes, but cannot specifically identify the properties of the geometry object. Level 2 (analysis): is a descriptive stage in which there is already an analysis of the concept and its properties, but students have not explained the relationship between these traits, and cannot understand the definition. Level 3 (abstraction): students can see the relationship of properties on one or many geometry objects, students can create abstract definitions, discover the properties of various objects using informal deduction, and classify them hierarchically. Level 4 (deduction): At this stage students can construct the evidence, construct the theorem in an axiomatic system and have the opportunity to develop evidence in more than one way; and level 5 (rigour): the last level which is the highest level in van Hiele's hierarchy where students can work in different geometric or axiomatic systems, and students can compare systems based on different axioms and can examine geometry without presents a concrete model [3, 8, 10, 13]. These levels explain how we think and what kind of geometric ideas we have in our mind, not how much knowledge we have. In Van Hiele's theory, the level of thinking of students in studying geometry cannot rise to a higher level without passing a lower level. According to Van Hiele's theory, one would go through the five stages of Van Hiele's thinking in learning geometry [10]. Jackson reveals that there is a transition from level one to higher level, for example students who are already at level 1 and start thinking to level 2 but not yet complete [7]. In other words, the student is in transition from level 1 to 2 or level 2 that is not maximized (pre-analysis). So the level of thinking of students in Van Hiele's theory can develop more widely.

Each level has different characteristics. For the level of visualisation, students can only use different images in general while at the level of analysis can use images based on the properties it has. The question in this research is how the geometry ability of junior high school students on the concept of similarity based on the thinking level of geometry from Van Hiele. The purpose of this study is to describe the geometry analysis of junior high school students in solving geometry problems on the concept of similarity based on the level of geometry thinking from Van Hiele. This research is useful to give overview and suggestion to teacher and researcher about basic ability of geometry which must a student have so they can increase geometric capability.
2. Method
This research is descriptive with the qualitative approach. Intended to describe the geometry skills of junior high school students on the concept of similarity based on the level of geometry thinking from Van Hiele. In this study, the selection of subjects using purposive samples. Selection of subjects by giving a class of thinking level tests using Van Hiele Geometry Test (VHGT) of 25 multiple choice questions to 38 students.

The author translates the VHGT test compiled by Usiskin [12] which has been tested for its validity and reliability into the Indonesian language, making it easier to use. From the test results, we classify students according to their level of thinking. In each level, two students are selected at level 1 (visualization), level 2 (analysis), and level 3 (abstraction or informal deduction). The total subject of this study is six students. They are from class IX SMP Negeri 2 Pontianak. The data were collected by giving validity test of geometry skill to the six research subjects. Then the researcher conducted an oral test to ask for an explanation of the student’s answers and to conduct in-depth interviews.

3. Result and Discussion
From the implementation of geometry thinking placement test, VHGT in class IX in SMPN 2 Pontianak with 38 respondents students, obtained the test result data as follows.

Table 1. Results of categorization of thinking level of Van Hiele Student geometry.

| Level Thinking Van Hiele Geometry | The number of students | %    |
|----------------------------------|------------------------|------|
| Level 1 (Visualization)         | 9                      | 23.7 |
| Level 2 (Analysis)              | 17                     | 44.7 |
| Level 3 (Abstraction/informal deduction) | 12                     | 31.6 |
| Total                            | 38                     | 100  |

Based on table 1, the highest level of geometry thinking from van Hiele that can be achieved by students is level 3 (informal deduction level). After testing the geometry thinking level of students using Van Hiele Geometry Test (VHGT), 9 students (23.7%) were included in the level 1 (visualization), 17 students (44.7%) level 2 (analysis), and 12 students (31.6%) were categorized as level 3 (informal deduction). After that, selected students who will be the subject of research are students who are in the third category of thinking level. Students selected for each category were taken by two students with consideration of having good communication.

After the VHGT test, then the second test is a geometry skill test which is given to the 6 selected students. For accurate results, researchers conducted interviews on the six subjects. Based on the analysis of test results and interviews obtained description of students' geometry skills in completing the concept of congruence as follows: Students geometry skill level 1 (visualization) on visual skills, students can only recognize different images of the plane geometry based on the appearance of the shape. In verbal skills, students can group correctly for plane geometry that is similar or not similar and congruent or not congruent, but students have not been able to state similarity and congruent requirements. Students are able to create a sentence that describes the image. In drawing skills, students can only make a triangle and label the name of the image, but have not been able to create an image according to the characteristics and properties assigned to the problem, so that the student has not been able to determine the corresponding triangular pair, which is congruent and not congruent with the image he made. In logical skills, students can recognize the difference and similarity of the
image by looking at the angle and sides. They understand the shape of each pair of images in various positions. In applied skills, students can draw a sketch from a question, but not be able to solve the problem with applying geometry model.

At level 2 (analysis), the characteristic of the students' skills is as follows. In the visual, students able to classify the similarity and congruence of a geometry plane. In verbal skills, students able to explain the similarity and congruence of the image provided in accordance with its properties. In the drawing skills, students able to draw triangles that are similar and congruent by translating the verbal information provided. In logic skills, students can name differences between similarity and congruence, and realise that traits can be used to distinguish images. In applied skills, students able to explain the geometrical properties by determining the length and width of the paperboard as a rectangular size. They also can use the geometry model to solve the problem.

At level 3 (informal deduction), the characteristic of the students' skills is as follows. In visual skills, students have the ability to relate the properties of similarity and congruence in the geometry plane, so they know the general properties. In verbal skills, students are able to explain the similarity and congruence by formulating sentences that show the interrelationships the images and the properties. In drawing skills, students have been able to draw similar and congruent triangles using the terms of similarity and congruence. Students can show or determine similar pairs of triangles as well as congruent triangular pairs. In logical skills, students have been able to use the properties or conditions of the similarity and congruence to form similar or congruent triangles. In applied skills, students have been able to understand the concepts of mathematical models that represent the relationship of two objects (photographs and paperboard). They can develop them in geometric models (applying the concept of similarity). Students also can explain the geometric characteristics of physical objects.

Based on the above discussion, the students' geometry abilities have different characteristics based on the geometric thinking level of each student. This is appropriate with Budiarto [1], geometric thinking based on Van Hiele's theory of level 0 (visualisation), level 1 (analysis), and level 2 (informal deduction) have different geometry technique characteristics. Geometry skill at level 3 (abstraction/informal deduction), meaning the student also master geometry skill at level 2 (analysis) and level 1 (visualisation). While for students who are at level 2 also master the geometry skills at level 1, but the student does not master the skills of level 3. For example, in visual skills at level 3 where students have been able to relate between the characteristics on the similarity and congruence of the geometry plane, it means that students have been able to recognise and group them.

4. Conclusion
Based on the research results, students' geometry skills have different characteristics with each level of geometry thinking. Geometric skills at level 3 (abstraction/informal deduction) mean that the students also master geometry skills at level 2 (analysis) and level 1 (visualisation). While for students who are at the level 2 also master the geometry skills at level 1 but not master at level 3.

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