CHARACTERISTICS OF GEOMETRIC THINKING THROUGH VAN HIELE’S PHASE-BASED LEARNING USING GEOMETERS SKETCHPAD

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ABSTRACT
The purpose of this study was to describe the characteristics of VII grade students geometric thinking. This research was a descriptive qualitative research. The subject of this research was nine students of VII grade at SMP N 2 Rembang consist of three students from each level 1 (visualization), level 2 (analysis), and level 3 (informal deduction). Data in this research was the characteristics of geometric thinking obtained from test and interview. (1) Students of level 1 can define transformation based on the appearance; grouping the pictures; but can’t understand properties of each transformation or related to another; (2) students of level 2 can define, grouping transformation based on the appearance, and explain properties but can’t related to another; (3) students of level 3 define, grouping transformation, understand properties of each transformation, also admit relation from any kinds of transformation, but can’t locate vector translation or center of rotation, also can’t decompose transformation. These study suggest teacher to design instruction that encourage students’ thinking processes with Van Hiele’s Phase-Based Instruction using the Geometer’s Sketchpad (GSP) concern to their characteristics.

Keywords – Characteristics of geometric thinking | Geometers Sketchpad | Van Hiele’s phase-based learning

Introduction
Geometry is one of the important branch in mathematics. Geometry should be learned by students from primary school until university level in almost every country in the world. The study of learning geometry as an essential skill to learn other topics in mathematics was stressed by (Hwang et al, 2009; Idris, 2009; Al-Shehri et al, 2011; Alex & Mammen, 2012; Meng & Idris, 2012; Nurhasanah et al, 2013; Sunzuma et al, 2013; Kütluca, 2013; Aydoğdu, 2014; Bal, 2014; Tieng & Eu, 2014).

Although geometry provide numerous benefits, but in fact the performance of Indonesian secondary students in geometry was still unsatisfactory as highlighted in a number of reports on international assessment studies. Specifically, in the Third International Mathematics and Science Study (TIMSS) 2011 report that the average geometry achievement of Indonesian at 8th grade (377) less than the international score average achievement (500).

According to Idris (2009), the failure in learning geometry cause of individual’s cognitive development, instructional practices and materials and the mathematical system. Another factor is inappropriate instruction that does not encourage students’ thinking processes. It focuses only on recognising and naming geometric shapes and learning to write symbols for simple geometrical concepts (Abdullah & Zakaria, 2013). TIMSS reported that half or more of the lessons are spent memorising formulas and procedures (Mullis et al., 2000, 2004, 2008; Dogan & Icel, 2011) and didn’t concern student’s geometric thinking (Safrina et al, 2014). This because many teacher do not know the characteristics of their geometric thinking (Muhassanah, 2014). The best model in teaching and learning geometry and can enhance in
geometric thinking is phase based Van Hiele model (Crowley, 1987).

Usage of technology tools also have great influence in the teaching and learning process. Student could learn collaboratively and constructively through social interaction and self exploration (Shadaan & Eu, 2013). Several study had reported the effectiveness geometers sketchpad in enhancing student’s Van Hiele’s level of geometric thinking and found that its help the students to gain better understanding and increase their motivation of learning mathematics in class (Dogan & Icel, 2011; Meng & Idris, 2012; Meng & Sam, 2013; Abdullah & Zakaria, 2013). Therefore in this study, the researcher attempted to investigate students characteristics of geometric thinking through phased based van hiele learning using geometers sketchpad. Specifically, this study aimed to answer the research question: how is the students characteristics of geometric thinking through phased based van hiele learning using geometers sketchpad?

**Theoretical Review**

Dina and Pierre van Hiele, two Dutch educators in their doctoral study developed a model that may reflect how children learn geometry. The five levels of geometric thinking that also stated by Guven (2012) as follow.

**Level 1: Visualization/Recognition**, the student recognises geometric figures by their global appearance, identifies names of figures, but does not explicitly identify their properties.

**Level 2: Analysis**, the student analyses figures in terms of their components and properties, discovers properties and rules of a class of shapes empirically, but does not explicitly interrelate figures or properties.

**Level 3: Informal deduction**, the student logically interrelates previously discovered properties and rules by giving or following informal arguments.

**Level 4: Deduction**, the student proves theorems deductively, develops sequences of statements to deduce one statement from another, but does not yet recognise the need for rigour.

**Level 5: Rigour**, the student establishes theorems in different axiomatic systems and analyses and compares these systems. But in this study, researcher only focused on the first three levels. This also state on several study that most research also concentrated on lower levels since majority of high school geometry courses are taught at level 3 (Usiskin, 1982; (Burger & Shaughnessy, 1986; Crowley, 1987; Guven, 2012).

According to the van Hieles, the learner, assisted by appropriate instructional experiences, passes through the following five levels, each of which depends on successful achievement of the previous levels (Crowley, 1987). The five phases of learning (phase-based instruction) that also stated by Meng & Idris (2012) as follow.

**Phase 1: Information.** The teacher engages students in conversations about the topic to be studied, evaluates their responses, and provides them with some awareness of why they are studying the topic so as to set the stage for further study.

**Phase 2: Guided orientation.** Students actively explore the topic of study by performing simple tasks designed to elicit specific responses so as to become acquainted with the objects from which geometric ideas are abstracted.

**Phase 3: Explicitation.** Students learn to express their opinions about the structures observed during discussions in class. The teacher leads students’ discussion of the objects of study using their own words until a consensus is achieved so that they become explicitly aware of the objects of study. Then, the teacher introduces the relevant vocabulary.

**Phase 4: Free orientation.** Students are
challenged with more complex tasks that can be completed in different ways (Crowley, 1987). The teacher encourages students to solve and elaborate on these problems and their solution strategies, and to introduce relevant problem-solving processes as needed.

Phase 5: Integration. Students summarize what they have learned about the objects of study with the goal of forming an overview of the topic.

Crowley (1987) described the characteristics of the five levels of van Hiele model as follows: (1) The model is sequential in that a learner cannot function at a higher level without first progressing through the thought processes of all previous levels; (2) progress from one level to the next is not through biological development but rather depends on instruction; (3) the linguistic symbols of each level are unique, that is, each level is regarded as having its own language, and learners on different levels cannot understand one another; (4) the intrinsic characteristics of one level become the extrinsic objects of study of the next; and (5) the mismatch between the level of instruction and the level at which a student is functioning may restrict the desired progress.

Research Methods

This paper reports on the characteristics of students geometric thinking through phased based Van Hiele learning using GSP. Based on the aims of this research to describe the characteristics of students geometric thinking through phased based Van Hiele learning using GSP, this research can be considered as descriptive qualitative research (Creswell, 2008). The research involves 7th grade students in SMP N 2 Rembang consisting of 32 students, but only 9 students who are assigned as the subject of this research. These students were selected based on their achievement, performance, their communication skills, and the result of the test. First, those 32 students of VII-4 was given Van Hiele Geometry Test (VHGT) which was developed by the Cognitive Development and Achievement in Secondary School Geometry (CDASSG) group from the University of Chicago (Usiskin, 1982) and then the researcher analyse and grouping based on their geometric thinking. Then the students was taught with phased based Van Hiele learning using GSP and do test. From the result of the test then researcher choose nine students consisted of 3 students of level 1 (visualization), 3 students of level 2 (analysis), and 3 students of level 3 (informal deduction. The data were collected using observation, test, and interview. The observations were conducted in the class during learning process of transformation, assisted by GSP. During this process all students’ activities were observed and videotaped. In this class, the teacher used phased based van Hiele model using GSP. The observation was held by using a camera, particularly when the students explore the material using GSP and solved problems on transformation. The test was constructed in order to identify characteristics their geometric thinking. Then, the data from observation and test were analysed to determine the subject of this research and also to determine which students should be interviewed. Deep interview were conducted to nine student from each level for the sake of triangulation.

Results and Discussion

Based on VHGT result show that from 32 students at SMP N 2 Rembang only 4 students can achieve level 3 (informal deduction), 12 students at level 2 (analysis), and 16 students at level 1 (visualization/recognition). From those result also see that none of students can achieve level 4 or level 5. This also similarly with several study such as (Usiskin, 1982; Burger & Shaughnessy, 1986; Walle, 2001; Guven, 2012; Abdullah & Zakaria, 2013)
which state that most of geometric thinking achievement at secondary school is until level 3 (informal deduction).

From this study also can see that there are differences in characteristics of students geometric thinking. Its also state by (Budiarto & Sofyana, 2011) there are different characteristics of geometry skill based on Van Hiele levels and students need those geometry skill to solve problem in geometry.

Based on analysis of test and interview from 9 subjects, the characteristics of students geometric thinking from this study can describe as follow:

1. The characteristics of students geometric thinking at subject level 1 (visualization/recognition):
The subject at this level show that they can identifies transformation by the changes in the figure, subject at this level also can grouping the figure given based on the transformation occurred, but when they asked to explain the properties of the kind of transformation they still have some difficulties or does not explicitly identify their properties. The subject at this level also haven’t been able to differentiate between kinds of transformation each other based on the properties of its image. The subject of level 1 haven’t been able relates between kinds of transformation or able formulate the sentence which show the relationship.

2. The characteristics of students geometric thinking at subject level 2 (analysis):
The subject at this level have be able to identify and grouping kinds of transformation by the changes in the figure or by the properties of given transformation. The subject at this level also can state or explain the properties of given transformation explicitly. Specifically can say changing form, length measurement, angle measurement. This subject have been able interrelate the properties changes to a figure resulting from transformation. They also can performs composition of simple transformations. But they can’t decompose or recombine a transformation as a composition of simple transformations.

3. The characteristics of students geometric thinking at subject level 1 (visualization/recognition):
The subject at this level have be able to identify and grouping kinds of transformation by the changes in the figure or by the properties of given transformation. The subject at this level also can state or explain the properties of given transformation explicitly. Specifically can say changing form, length measurement, angle measurement. This subject have been able interrelate the properties changes to a figure resulting from transformation. They also can performs composition of simple transformations. But they can’t decompose or recombine a transformation as a composition of simple transformations.

The findings of this study are consistent with conclusions reached by Muhassanah (2014), who found that every level of geometric thinking skill have different characteristics. From the third result of the test also show that there are improvement understanding level on several students from level 1 (visualization) to level 2 (analysis), and from level 2 (analysis) to level 3 (informal deduction). From the score of the test show that there are 11 students who can achieve level 1, 15 students can achieve level 2, and 6 students can achieve level 3. This also can observe from the progress of the students in explore geometers sketchpad while learning concept and construct their knowledge about the concept learned.

There are several possible explanations for the students progress. First the use of instructional activities based on the van Hiele theory. This is consistent with the findings of previous studies on Van Hiele phase-based instruction using geometers sketchpad (Idris, 2009; Abdullah & Zakaria, 2013; Meng & Sam, 2013; Tieng & Eu, 2014). During Learning Period, in Information Phase students named transformation. They identified the properties of transformation using the manipulatives GSP in Guided Orientation.
Next, they presented the properties to the class using their own words and then learned the standard vocabulary for describing them in Explicitation. In Free Orientation, they solved problems involving properties of transformation and using the manipulatives. Finally, in Integration, they summarized the properties.

Second, the use of the manipulatives GSP based on the van Hiele theory provided the students with opportunities to first investigate visually the kinds of transformation, then analyze their properties, and finally develop arguments about relations among their properties. This also consistent with the findings of previous study which stated that Technology in mathematics classrooms must be an effective tool to enhance this interaction between students and the teacher by allowing them to investigate their conjectures (Koh & Sook, 2000). In addition, the opportunity to observe dynamically the features of geometric transformations in an exploratory environment increased students’ understanding of these features (Guven, 2012).

Third, scaffolding and guidance from the teacher also have contribute to the students’ progress. During Information, the teacher engaged the students in conversations to learn what they already knew. During Guided Orientation, teacher carefully sequenced the instructional activities for the students to investigate. During Explicitation, he encouraged the students to share their findings using their own words and introduced relevant vocabulary when appropriate. During Free Orientation, teacher chose open ended problems or problem-solving for the students to solve and elaborate solution strategies. Finally, teacher guided the students in summarizing the properties and relationship among properties of transformation in Integration.

This findings also consistent with previous study (Amiripou et al, 2012) which stated that scaffolding method can motivate to problem solving procedure for student, promote current level of student's capacities and social relations, increase self-confidence of student in difficult mathematical problem solving.

**Conclusions and Recommendations**

The conclusion of this study are; (1) the Van Hiele phased based learning using geometers sketchpad has positive effect to enhance the students levels geometric thinking; (2) the characteristics of geometric thinking at students level 1 (visualization) are can identifies transformation by the change in the figure, grouping transformation based on the figure, students level 2 (analysis) can discover and state the properties of transformation, uses the properties of changes to draw the pre-image or image of a given transformation, students level 3 (informal deduction) can describe changes to states image or pre image after composite transformation, performs composition of simple transformation, represents transformation using coordinates, interrelates the properties of changes to a figure resulting from transformation. In light of the findings of this study, the following recommendations can be suggested for geometry teaching: (1) the geometry understanding level of students can be improved with the help of computer assisted (GSP) so geometry course at secondary school should be design so its supportive and appropriate to van hiele geometric thinking level, (2) every students at the class have different level of geometric thinking so teacher can give appropriate task for students based on their characteristics such as: for students at level 1 (visualization) teacher should be give task not only focuse on visual but also that emphasise on analysis; for students at level 2 (analysis) teacher should be giving task that help students to improve their verbal skill and develop their inductive reasoning; for
students at level 3 (informal deduction) teacher should be give task that enable students to make conjecture and develop to deductive reasoning.

Bibliography


