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STUDENTS' GEOMETRIC THINKING BASED ON VAN HIELE'S THEORY

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Abstract

The current study aims to identify the development level of students' geometric thinking in mathematics education department, Universitas Ahmad Dahlan based on van Hiele's theory. This is a descriptive qualitative research with the respondents as many as 129 students. In addition to researchers, the instrument used in this study is a test consisting of 25 items multiple choice questions. The data is analyzed by using Milles and Huberman model. The result shows that there were 30,65% of students in pre-visualization level, 21,51% of students in visualizes level, and 29,03% of students in analyze level, 16,67% of students in informal deduction level, 2,15% of students in deduction level, and 0,00% of student in rigor level. Furthermore, findings indicated a transition level among development levels of geometric thinking in pre-analyze, pre-informal deduction, pre-deduction, and pre-rigor that were 20%; 13,44%; 6,45%; 1,08% respectively. The other findings were 40,32% of students were difficult to determine and 4,3% of students cannot be identified.

Keywords: Geometric Thinking Development, Thinking Level, Van Hiele Theory.

Abstrak

Penelitian ini bertujuan untuk mengidentifikasi level perkembangan berpikir geometri mahasiswa prodi pendidikan matematika UAD berdasarkan teori van Hiele. Pendekatan penelitian yang digunakan adalah deskriptif kualitatif dengan jumlah responden sebanyak 129 siswa. Selain peneliti, isntrumen yang digunakan dalam penelitian ini adalah tes yang terdiri dari 25 butir soal pilihan ganda. Analisis data menggunakan model Milles dan Huberman. Hasil penelitian menunjukkan bahwa terdapat 30,65% mahasiswa pada level pravisualisasi, 21,51% mahasiswa pada level visualisasi, 29,03% mahasiswa pada level analisis, 16,67% mahasiswa berada pada level deduksi informal, 2,15% mahasiswa pada level deduksi, dan 0,00% mahasiswa pada level rigor. Selain itu, ditemukan terdapat level transisi di antara level perkembangan berpikir geometri berturut-turut dari pra analisis, pra deduksi informal, pra deduksi dan pra rigor yaitu 17,20%; 13,44%; 6,45%; 1,08%. Temuan lainnya lagi adalah sebanyak 40,32% mahasiswa sulit diklasifikasikan dan 4,3% mahasiswa tidak bisa diklasifikasikan.

Kata Kunci: Level Berpikir, Perkembangan Berpikir Geometri, Teori Van Hiele.

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INTRODUCTION

Geometry is part of mathematics that has been taught to students since elementary school. Learning geometry can train students' logic, systematic, and creative thinking skills. Such skills are indispensable for studying other branches of mathematics as well as for solving problems in everyday life. Therefore, it is necessary to have a good geometric thinking skill. Nevertheless, students still have difficulty in geometric thinking (Hardianti, Priatna & Priatna, 2017; Abidin, 2010) which is indicated by the level of geometric concept mastery is still not maximized at the elementary school (Yudianto, 2011), Junior High School (Lestariyani, 2013; Apriyanti & Fitriyani, 2017; Amimah & Fitriyani, 2017), high school (Sunardi, 2016) and Higher Education (Jupri, 2005; Utomo & Wardhani, 2015; Darta, 2013; Rafianti, 2016; Noto, 2015). Therefore, as students of mathematics education department are prepared to become teachers in schools after graduation, it is very important to understand their geometric thinking skills so that their geometric thinking can be maximized.

Based on researchers' experiences during the course of geometry in the mathematics education program UAD, it was found that students' understanding of the concepts of geometry is very lacking. This can be seen from the number of graduated students who take geometry courses is still less than 65%. This is allegedly due to the students' geometric thinking ability is low so they tend to avoid the courses. To help the students develop their geometric thinking then a reasearch is needed to investigate students' level so that counter measurers can be prepared.

In relation to geometric thinking, Van Hiele (Van de Walle, 1998; Crowley 1987) proposed a theory of geometric thinking which includes 5 levels of level 0 (visualization), level 1 (analysis), level 2 (informal deduction), level 3 (deduction), and level 4 rigor (accuracy). At level 0 (Visualization), according to Van de Walle (1998) "*The objects of thought at level 0 are shapes and what they look like*". The characteristic of students at this level is that they begin to learn to understand the shapes of geometrical objects in general, but not yet know their properties. In addition, Van de Walle (1998) also stressed that "*The products of thought at level 0 are classes or groupings of shapes that seem to be alike.*" It means that at level 0 students will group abjects with similar shapes.

Level 1 (analysis) according to Van de Walle (1998) is "*The objects of thought at level 1 are classes of shapes rather than individual shapes*". This means that students have begun to learn the properties of the geometrical objects. In addition, students have been able to mention the regularity contained in these objects. But, at this stage students have not yet been able to know the relation among these geometrical objects.

Level 2 (informal deduction), according to Van de Walle (1998), is that "*The objects of thought at level 2 are the properties of shapes*". It means what is thought at level 2 is the objects' properties. At this level, students have begun to carry out conclusions called deductive thinking. But this ability is not fully developed yet. In addition, students at this stage have begun to sort, determine the relationship between one object and another objects. In other words, "*The products of thought at level 2 are relationships among properties of geometric objects*" as presented by Van de Walle (1998).

As for level 3 (Deduction), Van de Walle (1998) states that "*The objects of thought at level 3 are relationships among properties of geometric objects*". At this level, students are able to deductively draw conclusions from general into more specific. In addition, students have understood the importance of the role of undefined elements in addition to defined elements. At this stage, students also have begun to use the axioms or postulates to prove many things. But, the students still do not understand why it is a postulate or a theorem. Specifically, Van Walle (1998) adds that "*The products of thought at level 3 are deductive axiomatic systems for geometry*".

At level 4 (Rigor) according to Van de Walle (1998), the target of thinking is "*The objects of thought at level 4 are deductive axiomatic systems for geometry*". At this level students have begun to realize how important the precision of the basic principles in a proof. For example, he knows the importance of axioms or postulates from Euclid's geometry. Accuracy stage is a high stage of thinking, complicated and complex. Therefore, it is not surprising that students, even if they are already in high school or even college students, still have not reached this stage of thinking. Level 4, according to Van de Walle (1998), is "*The products of thought at level 4 are comparisons and contrasts between different axiomatic systems of geometry*".

Before students start teaching geometry, it is better to identify their level of geometric thinking based on Van Hiele's theory. Students' level of geometric thinking need to be studied to determine the extent to which their geometric thinking so that we can help them to develop more. The result of the study of Rafianti (2016) stated that geometric thinking level of elementary school teachers candidate according to van Hiele's theory is mostly only reached phase 1 or introduction stage that is 50%. From this study, it is necessary to identify also the level of students' geometric thinking in mathematics education program to prepare better mathematics teachers in the future.

METHOD

This study is a descriptive research with qualitative approach. The subjects of the study were students of mathematics education program class of 2014, amounting to 129 students. Data collection techniques in this study consist of two methods of test and interview. The instrument used to collect data on the level of the students' development of geometry concepts is a test developed by Usiskin (1982) and it has been translated into bahasa by Yudianto (2011). This test is designed to measure and identify the developmental levels of students' geometric thinking based on van Hiele's theory and constructed to classify students into five levels. The test consists of 25 items where each 5 items will indicate van Hiele geometry thinking from level 0 - 4. Criteria for determining the levels of student geometric thinking, according to Yudianto (2011), is stipulated by the following rules:

1. Students are classified at the n^{th} level if: at least 3 out of 5 items at the n^{th} level are answered correctly and also in previous levels too. If the student does not meet the criteria, then the student is classified into the pravisualization level.
2. Students are classified transition level between the n^{th} and $(n + 1)^{th}$ level if:
   a. at least 3 out of 5 items are answered correctly at the n^{th} level and every previous level, and
   b. 2 out of 5 items are answered correctly at the $(n + 1)^{th}$ level
3. Students are difficult to classify if:
   a. at least 3 out of 5 items are answered correctly at the n^{th} level and every previous level,
   b. a maximum of 2 out of 5 items are answered correctly on the $(n + 1)^{th}$ level, and

c. at least 3 out of 5 items are answered correctly at the n^{th} level $(n + 2)^{th}$ or any subsequent level.

4. Students can not be classified, if less than or equal to 1 of 5 items are answered correctly at the n^{th} level and consistent for the next level.

Data analysis used to reveal the level of students' geometric thinking based on Van Hiele theory refers to Miles and Huberman (2014) model which are data reduction, data presentation, and drawing conclusion.

RESULTS AND DISCUSSION

The results showed that the geometric thinking level of mathematics education students is spread over level 0 (visualization), level 1 (analysis), level 2 (informal deduction) and level 3 (formal deduction). On the other hand, no single student has reached level 4 (rigor). The number of student that is difficult and can not be classified or identified is significant enough to be at the level of pravisualization (before visualization). Table 1 shows the result of data analysis of the development levels of students' geometric thinking.

Tabel 1. Level of development of students' geometric thinking

Level	%
Pravisualization	30,65%
Level 0	21,51%
Level 1	29,03%
Level 2	16,67%
Level 3	2,15%
Level 4	0,00%
Total	**100,00%**

Based on Table 1, most students of mathematics education program are at level 1 (analysis). Only few students (2.15%) have fulfilled level 3 (deduction) while no students meet level 4 (rigor) (0%), and 30.67% was not at the level of the development of geometry van hiele. This data shows that most of the development of students' geometric thinking is at the level of analysis that is understanding the concept of geometry done by informal analysis of parts of the geometrical objects. The ability of students in doing deductive thinking is still weak and similar to the result of Jupri (2005) and Darta (2013). For sixth semester students who have taken all geometry courses consisting of geometry, space geometry, analytical geometry of the field, space analytic geometry and transformation geometry are supposed to be at higher level than this result. Especially, if the student has taken the optional course of geometry systems. Ideally, their development level of geometric thinking shall be already at the top level. But that is not the case. This shows that learning activities in geometry courses need to be improved so that the development of students' geometric thinking can be boosted.

Tabel 2. Level of transition between developmental levels of student geometry

Transition Level	f	%
Pra 1	32	17,20%
Pra 2	25	13,44%

Transition Level	**f**	**%**
Pra 3	12	6,45%
Pra 4	2	1,08%
Total	**71**	**38,17%**

Of the 129 respondents who have beend identified, 71 respondents (38.17%) are at the transition level between the levels of geometric thinking. The results of the transition level analysis are presented in Table 2. The highest percentage of transition level at pre-1 level (pre-analysis) is 17.2% and the lowest percentage at pre-rigor level is 1.08%. Students who have reached the transition level can improve their geometric thinking level through learning that supports the improvement of geometric thinking. In addition to students who are at transition level, there are also students who are difficult to classify their level of geometric thinking that is as many as 75 students (40.32%). This number is quite significant considering almost half the total number of students are difficult to identify their level of thinking. These findings support the findings of Sunardi (2002) and Yudianto (2011). This is possible because the respondents are less serious in doing the test, especially if the test is not in accordance with their development of thinking. There were also 8 students (4.3%) who could not be classified in any category from the development of geometric thinking. This is because the respondent did not seriously take the test given so that they answered randomly or cheated during the test, or it could be because their development of geometric thinking have not met any level on van Hiele's theory.

CONCLUSION

Based on the discussion, it can be concluded that the development of geometric thinking of mathematics education students still have not yet reached rigor level based on van Hiele's level of geometric thinking. Most students are still at the analytical level. In addition, there was found students at transition level between the level of development of geometric thinking in pre-analysis, informal pre-deduction, pre-deduction and pre-rigor which are 17,20%; 13.44%; 6.45%; 1.08% respectively. Another finding is that 40.32% of students are difficult to classify and 4.3% of students can not be classified or identified.

Based on the results of this study, the researchers suggested that lecturers consider the development of students' geometric thinking in preparing and planning activities in Geometry courses. In addition, it is also suggested that lecturers apply learning strategies that can stimulate and assist students to develop their geometric thinking. Researchers can examine further about the development of student geometric thinking, especially new enrolled students which are still in transition from high school to college life.

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