Analysis of the Geometric Understanding Ability of Junior High School Students in Congruence Subject Based on the Level of Van Hiele Thinking

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Abstract. The purpose of this study was to analysis and examine the geometrical understanding of Junior High School students on the topic of congruence based on Van Hiele's thinking level. The research method was descriptive qualitative. The research subjects were grade IX students in one of the State Junior High Schools in Pontianak. Data collection used geometric understanding tests and placement tests of Van Hiele think level. The data is analysed using descriptive analysis. The results showed that the mean score at level 1 is 47.3; at level 2 is 53.6; and at level 3 is 60.1. Overall the average geometric understanding of students was still low, at the means of 53.67.The importance of knowing the level of students' geometric thinking is to minimize the same errors in understanding geometry. So that it is easier to achieve maximum success in learning geometry.

Keywords: geometric understanding, and Van Hiele thinking level

1 Introduction

The geometric understanding is one of the abilities that must be possessed by students. It comes from the ability of mathematical understanding. The students will have the ability to understand if the student is able to construct meaning from oral, written and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining[1]. Understanding mathematics is a process that can be understood and to some extent taught with building and enriching a knowledge base [2]. Students are said to understand a mathematical concept when they build relationships between new knowledge and prior. Understanding is the primary ability that must be mastered by students before continuing to discuss a more in-depth subject. It is the lowest level in the cognitive aspect. Understanding is an essential goal in learning because students can be better in understanding the concepts of the subjects.

Geometry is the science among various branches of mathematics which touches most aspects of our lives. The low geometric abilities of students can be seen from several results of previous studies that found the fact that there are still many middle school students who have difficulty in learning geometry [3]–[6]. It is also caused by the understanding of students' geometrical concepts in geometry problem solving that is still weak. It is because students in learning mathematics do not build their knowledge of concepts because students tend to learn by memorising definitions without regard to the relationship between concepts so it cannot be

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stored and incorporated into students' understanding networks. However, the concept stands alone without any connection with other concepts. So, the new concept is not well stored in students' memories.

Consequently, the students cannot use the new concept and it has no meaning. The meaning of concepts comes from relationships with other concepts. For example, if students only memorise the area of a geometric form, students do not know anything and have not been able to use their abilities. Therefore, understanding a concept is very important. Students are said to have a deep understanding if students can associate the concept of one with the other concepts and know each procedure used to solve a problem.

Based on the description above, this study is to find out how the ability to understand geometry at junior high school students in the concept of congruence on the level of van Hiele geometry thinking. The purpose of this study is to describe the analysis of the ability of students to understand the geometry of junior high school students on the concept of congruence based on the level of Van Hiele geometry thinking. Also, the expected benefits of this research are to give an overview and know the level of students 'geometry thinking that they must possess to improve the ability.

Geometric Understanding Ability

Understanding is an aspect of ability that belongs to the cognitive domain. There are several types of understanding in learning mathematics. It is meaningful if students themselves build it. Therefore, it cannot deliver by force but the teacher gives concepts and logic of mathematics. Students cannot solve the problems when they forget the algorithm or formula. Mathematical understanding has been viewed both as a process of achieving understanding and as the result of having achieved understanding [7]. In fact, in both Chinese and English, the word understanding has dual meanings being both the present participle of the verb to process and a gerund acting as a product.

There are two comprehension abilities of understanding, i.e. instrumental and relational [8]. Instrumental is "knowing rules without reasons" and relational is "knowing what to do and why". It means that instrumental understanding is the knowledge to do something by knowing the procedure regardless of why using it. In other words, memorising something separately or being able to apply to routine or easy calculations and doing algorithmically only. Whereas, relational understanding means knowing what should do and why they do that. In other words, they can link things with other correctly and be aware of the process carried out. Students are said to have an in-depth understanding if students can associate one concept with the other and know each procedure used to solve a problem.

Based on the explanation above, understanding the concept of geometry is the ability of students to understand the basic principles in building geometry and the correlation between them. It will form a full knowledge to achieve a comprehensive level of mastery. For describing the ability to occur, we must develop the indicators. The indicators for instrumental are the ability to; 1) apply formulas in simple algorithmic calculations, and 2) memorise concepts without regard to other concepts. The indicators for relational are the ability to; 1) use specific procedures or operations in solving problems, and 2) link various concepts/principles (internal and external geometry).

The congruency material is a geometric material of grade 9 students who are expected to identify congruent flat buildings and the properties of two congruent triangles and use the concept of triangular congruence in problem-solving. So, congruent material indicators adjust the geometric understanding indicators that you want to achieve in this study.

Geometry Thinking Level of van Hiele

Van Hiele’s theory was first developed by Pierre Marie van Hiele and Dina van Hiele-Geldof in a separate dissertation at Utrecht University in 1957. This theory explains the development of students' thinking in learning geometry. In Van Hiele’s theory, they argue that to study geometry, students experience the development of the ability to think through certain stages. They have identified these stages of spatial concepts in which students move sequentially in the course of their geometrical thinking. The stages of thinking development in van Hiele geometry learning are level 1 (visualization), level 2 (analysis), level 3 (simple deduction), level 4 (deduction), and level 5 (rigour) [4], [9]–[12]. There are five levels, which are sequential and hierarchical. They are [10]: Level 1 (Visualization): Students recognize figures by appearance alone, often by comparing them to a known prototype. The properties of a figure are not perceived. At this level, students make decisions based on perception, not reasoning. Level 2 (Analysis): Students see figures as collections of properties. They can recognize and name properties of geometric figures, but they do not see relationships between these properties. When describing an object, a student operating at this level might list all the properties the student knows, but not discern which properties are necessary and which are sufficient to describe the object. Level 3 (Abstraction): Students perceive relationships between properties and between figures. At this level, students can create meaningful definitions and give informal arguments to justify their reasoning. Logical implications and class inclusions, such as squares being a type of rectangle, are understood. The role and significance of formal deduction, however, is not understood. Level 4 (Deduction): Students can construct proofs, understand the role of axioms and definitions, and know the meaning of necessary and sufficient conditions. At this level, students should be able to construct proofs such as those typically found in a high school geometry class. And level 5 (Rigor): Students at this level understand the formal aspects of deduction, such as establishing and comparing mathematical systems. Students at this level can understand the use of indirect proof and proof by contrapositive and can understand non-Euclidean systems.

2 Method

This research was descriptive with the qualitative approach. Intended to describe the geometry understanding of Junior High School students on the concept of congruency 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 the van Hiele Geometry Test (VHGT) of 25 multiple choice questions to 38 students.

The subject selection is using the VHGT, i.e. the VHGT level placement test with 25 multiple choice questions given to 38 students. In this study, the authors interpreted the VHGT test that has been compiled by Usiskin which has been tested for its validity and reliability into Indonesian, making it easier for the author to use the VHGT test. From the test results, students grouped according to their level of thinking. So the subjects in this study were grade IX students in one of the Junior High Schools in Pontianak, amounting to 38 students. Then, the researcher gave the students a geometry understanding test. Furthermore, we concluded the description of the geometric understanding of each student at level 1, 2 and three based on the data obtained.

3. Result And Discussion

Based on the data validation, it found that most students did not have the maximum ability of geometric understanding in the congruence material. It found that the highest level of van Hiele geometry thinking students can achieve that is level 3 (informal deduction level). From 38 students there are three levels of van Hiele geometrical thinking, which are nine people in level 1 (level of visualisation), 17 people in level 2 (level of analysis), and 12 people for level 3 (simple deduction). For more details, the level of van Hiele thinking is described in percentages as shown in Figure 1.

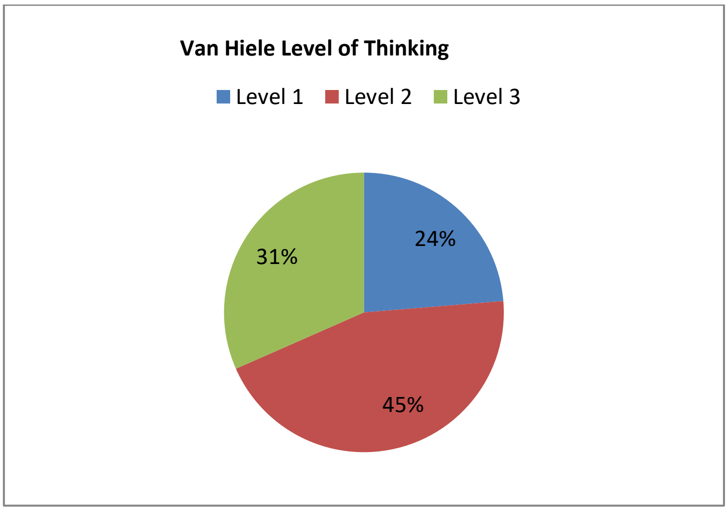

Fig 1. Percentage of van Hiele Thinking Levels from Middle School Students

From the figure above, it appears that more students enter the second level, namely the level of analysis. For the third level (informal of deduction), it is quite a lot compared to the first level. It means that the level of thinking of students has become better. Of the four indicators of instrumental and relational of congruence subject, the researcher describes the analysis based on the level of students' geometry thinking or van Hiele's thinking level. For more details, the results of the analysis are as shown in Table 1.

Table 1. Average Geometric Understanding Scores of Students Based van Hiele Thinking Level

Thinking Level of Van Hiele	Geometric Understanding Indicator				Total
	Understanding Instrumental		Understanding Relational		
	Indicator 1	Indicator 2	Indicator 1	Indicator 2	
Level 1	12,4	16,2	10,5	8,2	47,3
Level 2	13,2	14,6	13,8	12	53,6
Level 3	15,5	17,2	14,6	12,8	60,1
Total	41,1	48	38,9	33	53,67

Table 1 above shows that the overall score of geometric understanding of students is equal to 53.67 in average, where the level of visualization is 47.3, the level of analysis is 53.6, and the level of informal deduction is 60.1. The overall results are not maximal, but it has been able to describe the extent to which students 'geometric understanding is assessed based on students' Van Hiele thinking level.

Based on Table 1, the first indicator for the instrumental understanding which is an ability to memorize geometric concepts without any relation to other concepts, the average score is 41.1. The average score at level 1 is 12.4, level 2 is 13.2, and level 3 is 15.5. It means that students are weak in understanding geometric concepts by distinguishing between a two-dimensional object that is similar or congruent. For the second indicator which is also an instrumental understanding, a total average is 48, with a description of the average score at level 1 is 16.2, level 2 is 14.6, and level 3 is 17.2. The achievement of this indicator describes the ability of students' geometric understanding for applying geometric formulas in simple algorithmic calculations. The expectation is when the teacher gives a picture of a series of triangles, students can distinguish the similarity and congruence. However, in reality, few students understand it.

Whereas for the relational understanding of the third indicator, namely the ability to use specific procedures or operations in solving geometry problems, overall score average is 38.9. While based on the level of geometry thinking students, an average at level 1 is 10.5, level 2 is 13.8, and level 3 is 14.6. This unsatisfactory result illustrates the ability of students' geometric understanding to use the principles of congruence to determine the side length of two objects in a two-dimensional. Furthermore, the last indicator for the second relational understanding is the ability to link various geometrical concepts/principles. The results of the analysis were obtained as a whole as much as 33, and based on the level of thinking obtained the average at level 1 is 8.2, level 2 is 12, and the average for level 3 is 12.8. These results are still far from expectations because students are expected to be able to solve the problems given in similarity objects by linking concepts that are in geometry well.

4. Conclusion

From the results of data analysis, the students were at level 1, level 2, and level 3 of van Hiele think level. Overall the average geometric understanding of students was still low, at the means of 53.67. Whereas based on van Hiele's thinking level, the mean score at level 1 is 47.3; at level 2 is 53.6; and at level 3 is 60.1. The importance of knowing the level of students' geometric thinking is to minimize the same errors in understanding geometry. So that the teacher can prepare lessons that are more in line with the process of thinking of their students so that it is easier to achieve maximum success in learning geometry.

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References

[1] Forehand, M. BloomsTaxonomy-Emerging Perspectives on Learning, Teaching and

Technology, (2011)

[2] Michener, E. R. Understanding Understanding Mathematics, vol. 383, pp. 361–383, (1978)

[3] Baffoe, E. and Mereku, D.K. The van Hiele levels of understanding of students entering senior high school in Ghana, vol. 8, pp. 51–62, (2010)

[4] Connolly, S. The Impact of van Hiele-based Geometry Instruction on Student Understanding The Impact of van Hiele-based Geometry Instruction on Student," (2010)

[5] Eraso, M. Connecting visual and analytic reasoning to improve students â€™ spatial visualization abilities : a constructivist approach, (2007)

[6] Sujadi, I. Analisis Keterampilan Geometri Siswa dalam Memecahkan Masalah Geometri Berdasarkan Tingkat Berpikir Van Hiele, vol. 2, no. 1, pp. 54–66, (2014)

[7] Cai, J and Ding, M. On mathematical understanding: perspectives of experienced Chinese mathematics teachers, *J. Math. Teach. Educ.*, no. December, (2015)

[8] Skemp, R. Relational Understanding and Instrumental Understanding 1, pp. 20–26, (1976)

[9] Fuys, D., Geddes, D., and Tischler, R. The Van Hiele Model of Thinking in Geometry among Adolescents, vol. 3, no. 1988, (2013)

[10] Mason, M. The van Hiele Levels of Geometric Understanding, vol. 4, pp. 4–8.

[11] Vojkuvkova, I. The van Hiele Model of Geometric Thinking Van Hiele theory, pp. 72–75, (2012)

[12] Salifu, A., S. Van Hiele Geometric Thinking Levels of Pre-Service Teachers ' of E . P . College of Education , Bimbilla-Ghana, vol. 9, no. 23, pp. 108–119, (2018)