



Analysis of Geometry Concept Sequence in Student Textbooks Based on Van Hiele's Theory

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ABSTRACT

This study aims to analyze the order of textbooks based on van Hiele's theory. The research approach used is descriptive qualitative. The method used is content analysis or content study. The data subject in this research is junior high school mathematics textbook grade VIII curriculum 2013. The research was conducted by looking at the suitability of the characteristics at each van Hiele level with the textbook. Then if a discrepancy is found in the analysis, a solution is given according to the researcher's skills. The results showed that in general all the material "Surface Area of Cuboid and Cubes" in the Mathematics textbook of junior high school grade VIII curriculum 2013 material on the concept of surface area of cuboid and cubes has not fulfilled the order based on van Hiele's theory as a whole, namely there is an incomplete explanation in each level. The level of sequence analyzed in this textbook reaches level 2 (Ordering). So it is recommended for future research that the results of this analysis be used as a reference in teaching geometry material to students.

Keywords: concept coherence; surface area of spatial buildings; textbooks; van hiele

INTRODUCTION

Teaching materials have an important role in the implementation of learning in schools (Mappiara, Arif, & Munirah, 2020). The teaching material in question can be a textbook which is one of the sources of student learning. This is supported by the statement of Permendikbud Number 71 of 2013, that textbooks are one of the supporting sources for learning activities in schools that are still widely used. Textbooks are also educational resources that need to be adjusted in order to help students prepare for their future. One of the important adjustments to be considered is the sequence of textbook presentation.

Mathematics is one of the disciplines that studies many concepts. The main requirement in understanding mathematical concepts is hierarchical and sequential (Rohhani & Wiryanto, 2022). Understanding mathematical concepts is still an important point that is considered difficult by students, one of which is the concept of geometry (Yudianto et al., 2018). Research conducted by Cesaria et al. (2021) states that the difficulty in understanding the concept of geometry on the subject matter of "surface area of three-dimensional objects" is experienced by many students. In addition, this concept is important to understand because it is found in many everyday problems (Fatimah & Purwasih, 2020). So that coherent material is needed so that it is easy for students to understand and remember (Raneza & Widowati, 2020).

Furthermore, the novelty of this research lies in the additional aspects analyzed, namely the character components based on Van Hiele's theory. It is also added with the alleged solution if the textbook studied does not match the 21st century skills. This research

is important because there are several textbooks that do not contain 21st century competencies, so that the skills that students should have have not been met properly (Yusliani, Burhan, & Nafsih, 2019). The realization of student handbooks that are in accordance with 21st century skills can create learning that is more oriented towards developing the ability to apply concepts and various other life skills.

Based on previous research literature conducted by Dirgantoro (2019), it was found that difficulties in understanding the basic concepts of a material were caused by the unsuitability of the teaching materials used. Furthermore, research by Khoirunnisa et al (2020) states that there are difficulties for students in learning the definition and concept of the surface area of a space geometry, applying formulas, and difficulties in calculations. In line with the research of Mardia et al (2021), that there are students who have difficulty in calculating the surface area of cuboid as much as 14.08% and students who have difficulty in working on diagonal, diagonal plane, and space diagonal problems as much as 57.78%.

Based on some of the previous research, this study will discuss the analysis of the sequence of flat-sided space building material, especially the surface area of cuboid in junior high school textbooks grade VIII curriculum 2013. Sequence analysis conducted is based on Van Hiele's theory on the grounds that learning geometry should pay attention to the stages of student thinking. The stage of student thinking proposed by van Hiele consists of five levels, namely level 0 Visualization (basic visualization or recognition), level 1 Analysis (Description), level 2 Abstraction (informal deduction or ordering or relational), level 3 Deduction (Formal Deduction), level 4 Rigor (Vojkuvkova, 2012).

RESEARCH METHODS

Data analysis in this study is determined according to the formulation of the problem, namely the suitability the concept of surface area of cuboids and cubes based on Van Hiele's theory in the Mathematics Textbook of Junior High School/Islamic Junior High School students in grade III. Both aspects are analyzed with the following stages. Analyze the suitability of indicators in textbooks, namely to see whether textbooks have brought out student skills based on the specified indicators, describe the results of the analysis that has been carried out, if there is a discrepancy between the contents of the textbook and the indicators of the 21st century skills components, then alternative solutions will be provided based on the researcher's skills.

RESULT AND DISCUSSION

The characteristics of the five levels are, Level 0 describes student activities in recognizing geometric shapes based on their shape, comparing the shapes with everyday objects, then categorizing them based on the appropriate shapes. Level 1 describes students' activities in analyzing and naming the properties of geometric shapes, but not yet seeing the relationship between the properties. Level 2 describes students' activities in perceiving the relationship between the properties of the shapes found previously, creating meaningful definitions by providing simple arguments. Level 3 describes the activities of students who are able to provide deductive geometry proofs that are able to understand the role of definitions, theorems, axioms, and proofs, level 4 describes the activities of students who are able to describe the effects of adding or removing axioms on certain geometry systems.

Learners reach the levels of geometry thinking sequentially, but for the average many other shapes that are included in the types of cuboid and cubes. The command is expected to increase students' interest in learning more about cuboid and cubes.

Another activity that is included in level 0 according to Vojkuvkova (2012) is categorizing shapes that are cuboid or cubes and those that are not. This activity has not been included in the textbook so it can be added as follows.

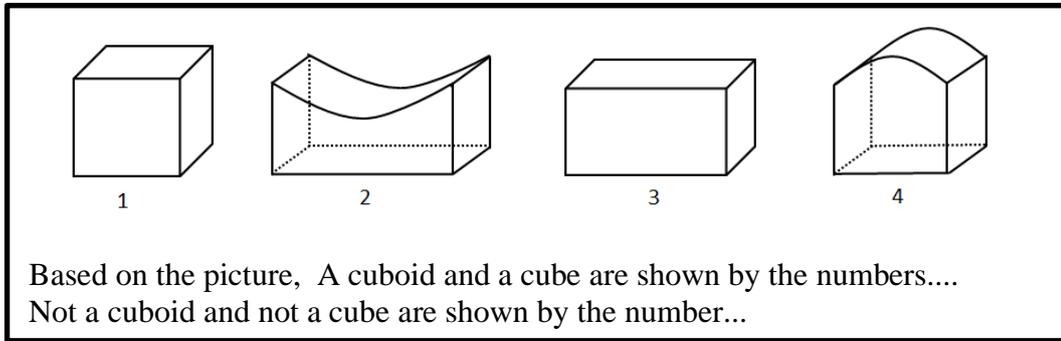


Figure 1. 1st Activity at Level 0

These activities can increase students' critical thinking in recognizing the shapes of cuboid and cubes. Students will carefully examine the cuboid and cube spaces that they have found in the surrounding environment with the existing problems. In addition, Cesaria (2021) said that students' understanding of cuboid spaces can be supported through commands to make cuboid or cube nets.

The activity contained in the textbook begins with a command to slice the shapes of cuboid and cubes from the cardboard provided and then lay them down into flat shapes. Based on Vojkuvkova (2012), in-depth understanding can be added with the activity of categorizing examples that are the nets of cuboid and cubes and which are not the nets of cuboid and cubes.

Give a check mark (✓) if the following nets are correct. And put a cross (✗) if the following net is incorrect and indicate the correct net in the "Remarks" column

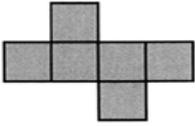
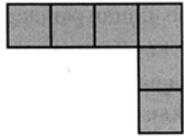
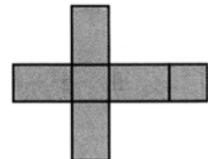
Nets	Description
	
	
	

Figure 2. 2nd Activity at Level 0

According to Piaget's theory that junior high school age children can already think abstractly, so they can perfectly imagine the shape of the cube nets without the help of props. In this activity students are instructed to identify the correct cube net. If a discrepancy is found, then students are instructed to provide a solution in the "description" column. In addition, these two examples can also improve students' imagination skills.

Level 1 (Analysis)

Activities at this level can be in the form of an order to analyze the properties of a building (Vojkuvkova, 2012). At the beginning of the explanation of this sub-chapter, there was a little mention of the properties of cuboid and cubes. However, the knowledge of the properties of cuboid and cubes related to the formulation of their surface area has not been included in the textbook. Knowledge of these properties can be packaged in the form of questions with the aim of training students' curiosity (Artinta & Fauziyah, 2021). However, the main goal is to support the understanding of the concept of cuboid and cubes. So that the following apperception can be added.

Based on the examples of cuboid you have found, answer the following questions.

1. What flat shapes are included in cuboid and cubes?
2. What is the formula for the area of the flat shape?
3. How many sides are there in a cuboid and a cube?
4. Are there any sides that face each other? Name them and explain!

Figure 3. 1st Activity at Level 1

Some of these questions aim to explore students' knowledge as a bridge in formulating the surface area of cuboid and cubes. If the four questions can be answered, then students will know that cuboid consist of rectangular flat shapes or some are also square flat shapes. While cubes consist of square flat shapes only. Students will know that the area of a rectangle is length times width. While the area of a square is side by side. Students can also recognize that cuboid and cubes have six sides. Then students will know that cuboid have three pairs of sides facing each other. Furthermore, the edges can be explained in detail as in the following figure.

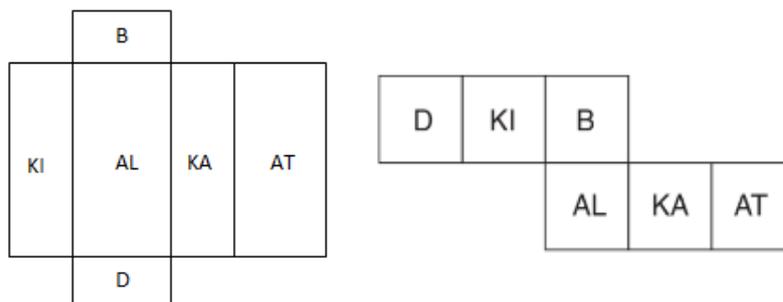


Figure 4. Nets Cuboid and Cubes

Based on the figure, it is known that the beam has three pairs of sides facing each other, namely side B (Back) and side D (Front), side KI (Left) and side KA (Right), and side AL (Base) and side AT (Top). While the sides of the cube in Figure 4. have the same area. Furthermore, the definition of the surface area of cuboid and cubes is also not included in the textbook. This knowledge is important because not all students know the correct understanding of the surface area of cuboid and cubes. In line with Khoirunnisa's research (2020) that when interviews were conducted related to the definition of the surface area of a space, students had difficulty in answering. Thus, it is necessary to add an explanation related to the surface of cuboid and cubes in the textbook as follows.

The surface of a cuboid and cube is all the sides of the cuboid and cube. So the surface area of cuboid and cubes is the sum of all the sides.

Figure 5. Definiton the Surface area

Thus, if the textbook already contains all the properties of cuboid and cubes with coherent and complete as described, then the textbook can support the developmental stage of students' geometric thinking at level 1.

Level 2 (Ordering)

Vojkuvkova (2012) said that van Hiele's theory at level 2 consists of informal deduction or ordering or relational. This stage can be interpreted as the stage of connection between properties and between spatial shapes. The activity that corresponds to this level is to build concepts through observation of the relationship of the properties that have been described previously (Vojkuvkova, 2012). Level 0 has been explained related to the nets of cuboid and cubes. While at level 1 it has been explained related to the elements and surfaces of cuboid and cubes. So at this level it can be concluded that the area. The surface area referred to in the cube is the six sides that the cube has. While the surface area that is meant on the beam is the three paired sides that face each other on the beam. After students successfully understand the definition of the surface of a space obtained by paying attention to its net, then students can formulate the surface area of cuboid and cubes as in the following figure.

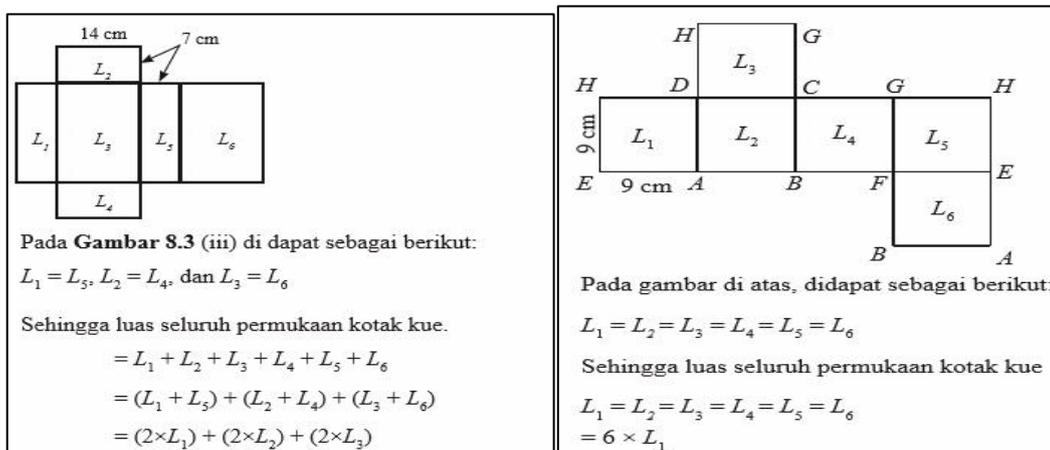


Figure 6. Surface Area of Cuboid and Cubes

Based on this explanation, it can be added with the conclusion of the surface area of the cuboid and cubes themselves. This is so that students can understand firmly and thoroughly related to the calculation of the surface area of cuboid and cubes. The conclusion can be written as follows.

Cuboid Surface Area

A cuboid consists of six sides with three pairs of parallel and congruent sides. So the surface area of a cuboid is twice that of each of the three paired sides. It can be written as follows

$$(2 \times L_1) + (2 \times L_2) + (2 \times L_3) = 2(p \times l) + 2 \times (l \times t) + 2 \times (p \times t)$$

Figure 7. Surface Area of Cuboid

Cube Surface Area

A cube consists of six congruent sides. So the surface area of a cube is six times the sides. It can be written as follows

$$6 \times L_1 = 6 \times (s \times s)$$

Figure 8. Surface Area of Cubes

Based on the explanation of the analysis of the book, the data obtained shows that the material on the concept of the surface area of the beam has not fulfilled the sequence at each level based on van Hiele's theory as a whole.

The results of this study are in line with the research of Hidayah & Muhroji (2024) who conducted an analysis of teacher and student books regarding the 2017 revised 4C competency. This is in line with Ahdhianto (2016) who stated that material arranged sequentially based on van Hiele's theory can help students discover the concept of spatial shapes. It has been stated that the importance of this suitability is because not all teachers have 4C competency by themselves. So that the existence of activities that support these competencies can be used as a reference in the learning process.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the overall textbook of Junior High School Mathematics grade VIII curriculum 2013 published by Kemendikbud has not been arranged coherently based on van Hiele's theory level. The sequential analysis conducted on the textbook reached level 2 (Ordering).

1. The characteristics of level 0 that are not included in the book are the activity of comparing spatial figures with everyday objects, the activity of categorizing spatial figures and their corresponding nets.
2. The level 1 characteristics that are not included are the explanation of surface area and knowledge of properties related to the formulation of the surface area of cuboid and cubes.
3. Level 2 characteristics are already included in the textbook, but could be added to the conclusion of the formula for the surface area of cuboid and cubes in general.

This lack of completeness is feared to cause difficulties for students in understanding geometry concepts. So it is suggested for future research that the results of this analysis can be used as a reference in teaching the material to students. Because the organization of content, materials, and teaching and learning activities is an important factor in influencing the speed of moving from one level to the next.

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