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Analysis of the Flat Sided Volume of Elementary Mathematics Textbook Based on Praxeology

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ABSTRACT

Geometry is one of the materials that must be understands by students in mathematics. Even though, students still find difficulties while studying geometric, especially the concept of the volume of a cuboid. The difficulties experienced by students can be handled in various ways, one of which is by using books as a source of student learning. This study analyzed the mathematics textbooks for fifth-grade elementary school, which is the Electronic School Book (BSE). The result of this research is an analysis of the presented material on the concept of the volume of the cuboid. The volume of cuboid analyzed consisted of praxeology materials, which are types of tasks, technique, technology and theory.

Based on regulations issued by the Ministry of Education and Culture, building a flat side room is one of the materials that must be studied starting from elementary school to high school. This is regulated in both the *Kurikulum 2013* and the new curriculum, namely the *Kurikulum Merdeka*. The material for flat-sided geometry was first taught in class V. In the Kurikulum 2013, the material for flat-sided construction, which is taught at the elementary school level, is contained in Permendikbud Number 37 of 2018, which is regulated in Basic Competencies numbers 3.5 and 3.6, which contains explaining and determining the volume of a geometric figure using volume units and the cube relationship with the cube root, as well as being able to explain and determine the nets of cubes and cuboids. Meanwhile, for the *Kurikulum Merdeka*, the material for building a flat side is regulated in Phase C Learning Outcomes (CP) for class V and class VI. In phase C, learning outcomes on geometric elements, students are expected to be able to demonstrate an understanding of construction and descriptions related to spatial structures (cubes, cuboids, and their combination) as well as their visualization. Students are able to compare the characteristics of flat shapes. However, in this study, we will focus on the essential competencies in the *Kurikulum 2013*.

Geometry, especially the material for building flat sides, continues from elementary school to high school. Based on this, it can be seen that the shape of the flat side space, especially in the volume material of cubes and cuboids, is an important material to study. According to Van de Walle (2001), geometric material plays a vital role in learning other mathematical concepts. This is supported by the statement of French (2004), the volume material from cubes and cuboids is one of the essential materials to be studied. This is because the volume of cubes and cuboids is a geometric concept that underlies other aspects of mathematics at the next level, such as the concept of volume from curved side spaces.

The importance of studying the concept of the volume of the cube and cuboid is still inversely proportional to the facts. According to Sung and Shih (2015), students also experience difficulties because they have not been able to build an understanding to change representations from flat shapes to spatial representations. Battista and Clements (Sung & Shih, 2015) also argue that students still find it challenging to solve problems related to the calculation of the surface area of geometric objects that involve the integration of students' geometry and spatial abilities. Therefore, according to Chang, et al. (2007), many students in elementary school only have the ability to determine the nature of the shape in question but are unable to solve more abstract problems. In other words, students still have learning difficulties.

The opinion given by Schneider & Stern (2006), is that there are at least two pieces of knowledge that construct one's understanding; the first is knowledge of concepts and knowledge of procedures in particular materials or concepts. The understanding in question is not only about how concepts or skills are acquired but, according to Carpenter and Lehrer (Sisman & Aksu, 2016), activities that involve complex and diverse mental activities. The success or failure of students in learning mathematics largely depends on how students interpret the procedures and concepts they are learning. Building students' understanding of the material cannot be separated from the role of books or learning resources that students use. Nicol and Crespo (2006), argue that books have an essential role in learning activities both in primary and secondary schools. Books become student facilitators who facilitate a learning framework to build an understanding of what, how, when, and for whom material is studied. Therefore, facilities related to teaching materials in the form of books should have good quality.

Textbooks have an essential role in learning activities for students and teaching activities for teachers (Fan et al., 2013). The quality of textbooks not only affects the efficiency of teacher teaching activities but also affects student learning outcomes and presentations (Heyder et al., 2020). According to Alim, et al. (2021), so far, mathematics books have a dominant role for teachers when designing learning activities that will be applied in the classroom. The use of textbooks that are not good will affect students' abilities. Students will have low mathematical ability and difficulty in solving mathematical problems. This is also in line with the opinion of Wang and Yang (2016), that various studies prove that mathematics textbooks have an essential role in the student learning process and the teacher's process when teaching. Baker, et al. (2010), argue that mathematics textbooks can be considered accountable and historically important proof in curriculum development, research, and the overall history of mathematics education, which can help us in changing mathematics education in a country.

The Indonesian government itself launched the Electronic School Book (BSE), which is a teaching material that can be used in learning activities from elementary school to high school. BSE consists of student handbooks and teacher handbooks and is in the form of electronic books or e-books. According to Wijayanti (2022), this textbook has been approved by the National Education Standards Agency (BSNP).

Eligibility standards issued by BSNP include the feasibility of content/material, presentation, language, and legibility, the feasibility of BPG, feasibility of graphics and audio. On the feasibility of content/material and presentation, the proposed criteria focus on systematic presentation, logical presentation, coherence of presentation, coherence, depth of material, suitability, and updating with the development of science, but there is no standard that focuses on the presentation of teaching materials that discuss the type of task, completion techniques and theories that are carried out especially mathematics. If you follow the facts that have been described previously, one of the success factors for students in learning mathematics is how students understand the concepts being studied.

The results of a survey conducted by the international survey institute TIMSS and PISA stated that one of the causes of Indonesia's ranking at a low level was due to conceptual errors experienced during mathematics learning (Kusmaryono, et al., 2020). According to Agrawal (Kusmaryono, et al., 2020), the existence of textbooks in developing countries does not meet adequate concept coverage, resulting in the need for further identification of books. So, it is necessary to have a supporting theory related to understanding the concept. The theory referred to by Chevallard (Rizqi, et al., 2021) is a theory that is a step in understanding mathematical concepts. This theory can be studied more deeply with epistemology. Epistemology is a part of philosophy that deals with the occurrence of knowledge, limits, nature, methods, and validity of knowledge. The epistemological reference model is based on praxeological elements.

Praxeology consists of two words, namely *praxis* and *logos*. *Praxis* is practice, and *logos* is theory. The praxeological element consists of four components, including the type of question or type of task (T), technique (τ), technology (θ), and theory (Θ). The type of question in question is the type of question that is in the book, either expressly or in general. The technique in question is a technique or method of solving a given problem. The basis of the settlement technique used is technology, and the justification for the technique used is theory. This theory has no concrete definition. This is because a praxeological theory is used to analyze human activities in general (Wijayanti & Maharani, 2018).

The principles of praxeology proposed by Chevallard (2006) are; "no human action can exist without being", and "no human doing goes unquestioned." The student book published by the Ministry of Education and Culture, which has a didactic design, is a "human action", which was formed with the thoughts of the author of the book so that ideally, the "human action" has an explanation or justification for the "human action", either implicitly or indirectly. Written in the book, which was analyzed by the researcher. Because the design is a human action, then we refer to the second principle, using the theory of praxeology.

Research conducted on the analysis of elementary school mathematics books conducted by Quiroz and Rodríguez (2015), focuses on praxeological analysis. In this study, it was said that the elements contained in praxeology could be used as a model that represents the mathematical modeling cycle that appears in mathematical problems (Putra, et al., 2021).

Research related to book analysis with praxeology has been carried out several times. Like the research conducted by Rizqi, et al. (2021), which analyzed the set material with praxeology. The research focused on the class VII set material and only analyzed the theoretical block, which consisted of technology and theory only. Furthermore, the research conducted by Khoridah, (2018), analyzed the number pattern material using praxeology. In this study, the analysis focused on practical blocks consisting of task types and completion techniques. Research conducted by Rahayu, et al. (2022), analyzed the material using praxeology on fractional material and only analyzed the elements of technology and theory.

So far, there has been no research that analyzes the presentation of material at the elementary school level using the four elements of praxeology, especially on the volume material of flat-sided shapes. Therefore, this study will be conducted to analyze the presentation of the volume material of the flat side of the cube and the cuboid, which is analyzed from a praxeological perspective. The researcher wants to analyze the presentation of the volume concept of cubes and cuboids based on the type of task, completion technique, technology, and theory that underlies the task.

METHODS

This study uses a qualitative research approach with phenomenological methods. Quantitative research is built with a general formulation through a prior agreement that guides a researcher, while qualitative research has flexibility in research strategies and techniques. Research designs sometimes emerge as the research progresses. Qualitative research is described as another form of approach to scientific inquiry. This approach involves the study of specific cases to understand the character and context of each case studied (Fraenkel et al., 2012).

Meanwhile, according to Creswell, et al. (2018), qualitative research is research that relies on researchers as instruments in collecting data and uses data collection methods that are both inductive and deductive. This research is also based on the meaning of the participants and is comprehensive. Furthermore, according to Maxwell (2012), in a qualitative approach, every component of the design made there is the possibility to be reconsidered or modified during the research in response to new developments obtained or responding to changes in other components.

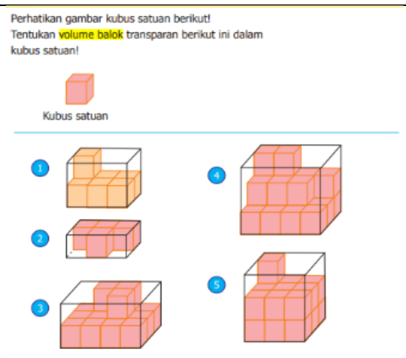
The research design used in this study is phenomenology. According to Chan, et al. (2013), a phenomenology is an approach from qualitative research that is more specifically focused on identifying the inherent meaning of the problem being studied. Philosophically, according to Sundler, et al. (2019), phenomenological research is a study related to a phenomenon. For example, something experienced or done by someone whose meaning is how these things appear in someone's experience. This research needs to be based on the fundamental assumptions needed to make critical methodological decisions. According to Gallagher (2012), phenomenology is a method that provides a description of the ways that appear in the experiences we experience.

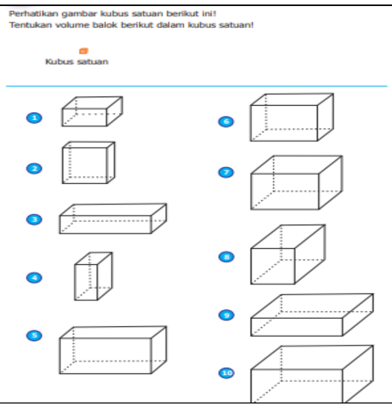
This study uses a qualitative approach with a phenomenological research design, where this study will identify a theory of a phenomenon. The phenomenon that will be seen is the design of the material presented in the fifth-grade elementary school mathematics textbook, namely the Electronic School Book (BSE) on the volume of a cuboid, which is analyzed using praxeological theory. Data collection techniques in this study will use observation and documentation techniques. The observation technique will be carried out to see the four elements of praxeology in the presentation of the volume of cubes and cuboids in the fifth-grade mathematics book. At the same time, the documentation technique is used to collect the four elements of praxeology based on previous observations.

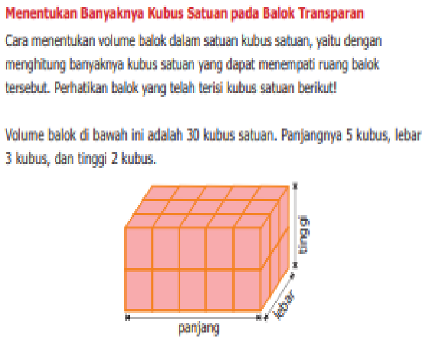
RESULT

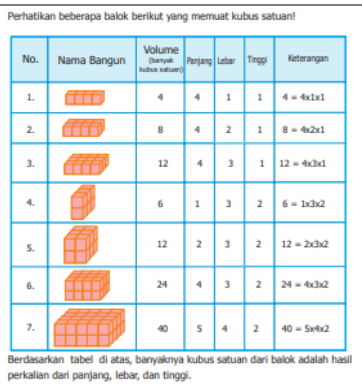
The results of this study are in the form of an analysis of material presentation from mathematics books of fifth-grade elementary school students on the concept material of volume of cuboids which were analyzed based on their mathematical praxeology. The analysis was carried out using four praxeological elements from the two blocks, namely the practical block consisting of type of task and technique, and the theoretical block consisting of technology and theory. The four elements of praxeology were then used as an analytical tool in this study. The focus of the material in this research is the concept related to the volume of the cuboid.

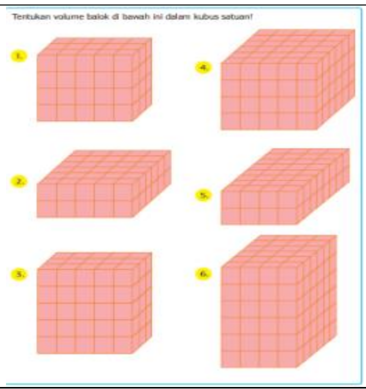
Table 1. Analysis of Material Presentation of the Concepts Volume of Cuboids

Type of Task	Technique	Technology	Theory
	τ1: perceptual technique Directs students to insert or substitute unit cubes into the cuboid until the cuboid is full.	The volume of the cuboid is the number of unit cubes that are inserted into the cuboid.	The volume of the cuboid is the total number of unit cubes that fill the cuboid.

<table>
<tr><th>Type of Task</th><th>Technique</th><th>Technology</th><th>Theory</th></tr>
<tr><td>
</td><td>τ1: perceptual technique

Direct students to insert or substitute unit cubes into the cuboid until the cuboid is full.</td><td>The volume of the cuboid is the number of unit cubes that are filled into the cuboid.</td><td>The volume of the cuboid is the total number of unit cubes that fill the cuboid.</td></tr>
<tr><td>
</td><td>τ1: perceptual technique

Confirm that to determine the volume of the cuboid, which is 30 units, is obtained by multiplying the length of the cuboid by 5 units multiplied by the width of the cuboid by 3 units and the height of the cuboid by 2 units.</td><td>The volume of the cuboid can be determined by counting the number of unit cubes in the cuboid.</td><td>The volume of the cuboid is the total number of unit cubes that fill the cuboid.</td></tr>
<tr><td>
Perhatikan beberapa balok berikut yang memuat kubus satuan!
<table><tr><th>No.</th><th>Nama Bangun</th><th>Volume (banyak kubus satuan)</th><th>Panjang</th><th>Lebar</th><th>Tinggi</th><th>Keterangan</th></tr><tr><td>1.</td><td></td><td>4</td><td>4</td><td>1</td><td>1</td><td>4 = 4x1x1</td></tr><tr><td>2.</td><td></td><td>8</td><td>4</td><td>2</td><td>1</td><td>8 = 4x2x1</td></tr><tr><td>3.</td><td></td><td>12</td><td>4</td><td>3</td><td>1</td><td>12 = 4x3x1</td></tr><tr><td>4.</td><td></td><td>6</td><td>1</td><td>3</td><td>2</td><td>6 = 1x3x2</td></tr><tr><td>5.</td><td></td><td>12</td><td>2</td><td>3</td><td>2</td><td>12 = 2x3x2</td></tr><tr><td>6.</td><td></td><td>24</td><td>4</td><td>3</td><td>2</td><td>24 = 4x3x2</td></tr><tr><td>7.</td><td></td><td>40</td><td>5</td><td>4</td><td>2</td><td>40 = 5x4x2</td></tr></table>Berdasarkan tabel di atas, banyaknya kubus satuan dari balok adalah hasil perkalian dari panjang, lebar, dan tinggi.</td><td>τ1: perceptual technique

Check with another example of finding the volume of a cuboid by multiplying the length of the cuboid by the width and height of the cuboid.</td><td>The volume of the cuboid can be determined by counting the number of unit cubes in the cuboid.</td><td>The volume formula: $p \times l \times t$.</td></tr>
<tr><td>
</td><td>τ1: perceptual technique

Determine the volume of the cuboid using the volume formula: $p \times l \times t$.</td><td>The volume of the cuboid can be determined by counting the number of unit cubes in the cuboid.</td><td>The volume formula: $p \times l \times t$.</td></tr>
</table>

DISCUSSION

Table 1 presents the presentation of material from the concept of the volume of a cuboid using a visual representation of a unit cube. The presentation of the material was analyzed with the four elements of praxeology. The material presentation is taken from the fifth-grade student book published by the Ministry of Education and Culture. Indicators of praxeological elements are adapted from indicators used by Bosch and Gascon (2014), Takeuchi and take (2020), which are presented in Table 2.

Table 2. Indicator of Material Presentation Analysis in Mathematics Elementary Textbook

Praxeology Element	Commentary	Indicator
Type of Task	A type of task (T) that is a collection of task which can be solved by some technique	Point praxeology
		Local praxeology
		Regional praxeology
Technique	A way of performing this type of task	Perceptual technique
		Physical technique
		Operational technique
Technology	A way of explaining and justifying or designing the technique	
Theory	To explain, justify, or generate whatever part of the technology that may sound unclear or missing	

The first task in Table 1 contains an example of an assignment that asks students to fill in cuboids with unit cubes to calculate the number of unit cubes that fill the existing cuboids. This problem is a starting point in building an understanding of the concept of the volume of a cuboid. The type of task that is analyzed is included in the point praxeology type because the task presented only focuses on the volume of the cuboid by using a unit cube. As for the technique used, it belongs to the perceptual technique type, where students only see and make observations on existing assignments without having to use measuring or drawing tools to complete the tasks presented. The technology that can be analyzed by researchers is that the volume of the cuboid is the sum of all unit cubes that are substituted into the cuboid. The presentation of this assignment has not yet been entered into a more abstract form using formulas, but it is still a task that builds the concept related to the volume of a cuboid. While the existing theory is used to clarify the identified technology, namely, the volume of a cuboid can be understood by the large number of cubes that can fill the cuboid.

The second task in Table 1 is a question that asks students to count the number of unit cubes that can fill the presented cuboids. This problem is included in the point praxeology type because it still carries a single type of task that focuses on the volume of the cuboid. The technique that can be analyzed from this problem is included in the perceptual technique because it does not require a measuring instrument to determine the number of unit cubes that must be inserted into the cuboid. However, there are shortcomings in the presentation of the questions, namely the incomplete instructions for solving the problems, namely the absence of a precise size on the unit cubes and cuboids whose volume must be calculated. This allows students to be confused in solving the problems that are given. Therefore, this problem requires improvisation from the teacher who teaches by giving the size of the cuboid and unit cube to the students when giving the question. The technology that can be analyzed from these questions is the same as the technology in task 1, as well as the underlying theory.

The third task in Table 1 is a task related to the volume of a cuboid with a more abstract concept. The existing assignments already use numbers in their presentation, but this type of task is still included in the point praxeology type because the tasks given still focus on one topic and only require one completion technique. The technique used in this task is to verify/check that the given cuboid sample has a volume of 30 by calculating the number of unit cubes based on the length, width, and height of the cuboid. This task can lead students to calculate the number of unit cubes based on the given cuboid size information. The technology that can be analyzed is to determine the number of unit cubes in the cuboid by first giving the dimensions related to the length, width, and height of the cuboid. The theory that underlies this task is that the sum of the unit cubes that fill the cuboid is the volume of the cuboid.

The fourth task in Table 1 is to determine the volume of the cuboid by calculating the number of unit cubes based on the information provided in the table. This task belongs to the type of local praxeology because it is a series of tasks in which students are asked first to determine/identify the length, width, and height of the cube, then calculate the volume using the volume formula of the cube. There are two techniques that can be used in completing this task. First, students calculate the total number of unit cubes, and second, students can use the volume formula by multiplying each side of the cube. The technology that can be analyzed from this task is the number of unit cubes that can be inserted into the cuboid, which is the volume of the cuboid.

In the fifth task in Table 1, the questions given are in the form of cuboid images that have been filled with unit cubes. Students are asked to determine the volume of the cuboid based on the number of cubes that fill it. This question belongs to the point praxeology type, where students are only asked to determine the volume of the cuboid based on the visual representation that is given. The technique used to solve this problem is to use the volume formula of the cuboid, which is to multiply the length, width, and height of the cuboid. This technique is also still included in the type of perceptual technique because it does not require tools to measure or draw in solving problems. The technology that can be analyzed from this problem is a formula from the same volume as the technology in the previous task. At the same time, the theory in this task is also the same as the previous task.

Of the five tasks presented, there are several problems that are assumed to be the cause of students' difficulties in completing or understanding the purpose of the given task. The first task and the second task are different from the other three tasks. The first two tasks asked students to insert the unit cube into the cuboid until it was full, while the last three assignments directly referred to the formula for the volume of the cuboid. In general, the characteristics of the tasks and techniques in the book do not form a structured learning trajectory in building students' understanding of the volume of cuboids. One of the criteria in the learning trajectory described in the research conducted by Fauzan and Diana (2020), is that the learning activities carried out for students can guide students to experience the process of horizontal mathematization and vertical mathematization. According to Treffers (Jupri & Drijivers, 2016), the horizontal mathematization process is an activity to transfer realistic problems to symbolic problems through observation, experimentation, and inductive reasoning activities. Activities that refer to horizontal mathematization include; identifying specific mathematical problems in a general context. Schematize, formulate, and visualize problems in different ways. Whereas vertical mathematization, vertical mathematization, is an activity of compiling and reconstructing in the context of symbols, which includes problem-solving, generalizing solutions, and further formalization. Activities that refer to vertical mathematization activities are refining mathematical models, using different mathematical models, and integrating or collaborating models. The following identified problem is in the second task. The task was felt to be incomplete and definite in terms of work orders. Students feel confused in understanding the purpose of the given task because there is no information related to the size of the unit cuboids and cubes provided.

CONCLUSION

The results of the analysis of the presentation of the material for the concept of the volume of cuboids in the fifth-grade elementary school students' books, based on the five types of tasks analyzed, four of the five questions fall into the point praxeology type, where the task is a single type of task, and one task is included in the type of local praxeology. The task is a series of tasks that asks students first to calculate the length, width, and height of the cuboid based on the number of unit cubes available, then calculate the volume of the cuboid using the formula for the volume of length multiplied by the width and height of the cuboid. Based on the author's identification, this assignment is given with the aim of confirming that the sum of the total unit cubes that fill the cuboid is the volume of the cuboid.

Perceptual technique dominates the complete technique of the given task. Of the five tasks, students do not need a measuring tool, or there is no command to draw in completing the given task. Therefore, the technique used is still included in the perceptual technique. The results of the analysis carried out also produce problems that can be identified. Among them are, there are pretty far differences in the presentation of the material that causes a "gap" so that it does not form a structured learning trajectory in building students' understanding of the volume of the cuboid. The lack of clarity regarding the information from the assignments given so will cause misinformation to students when completing the assigned tasks.

This study uses a critical paradigm in it because this research also criticizes the content or content of the material presented in the concept of the volume of cuboids in the book. This paradigm emphasizes more on the interpretation made by researchers of the books being analyzed so that there will be an aspect of subjectivity in the analysis carried out, and this cannot be avoided and may affect the results of the study. Therefore, it is necessary to conduct further studies as well as criticisms and suggestions related to the analysis carried out by researchers.

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