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Effect of 3D Unit Cube Board Media on Students' Understanding of the Concepts of the Volume of a Cube and a Rectangular Prism

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ABSTRACT

Elementary school students still struggle to understand the concepts of the volume of a cube and a rectangular prism due to the abstract nature of these concepts and the lack of concrete learning materials. This study aims to analyze the effect of 3D unit cube boards on students' understanding of the concepts of the volume of a cube and a rectangular prism, the effect of conventional media in the form of instructional videos, and the differences in the effects between these two types of media. The study employed a quantitative approach using a quasi-experimental method and a nonequivalent control group design. The sample consisted of 67 fourth-grade elementary school students in Cisitu Subdistrict, Sumedang Regency, comprising 30 students in the experimental class and 37 students in the control class. Data were collected using a conceptual understanding test consisting of 6 complex multiple-choice items and 8 essay items that measured students' ability to interpret, provide examples, classify, summarize, conclude, compare, and explain the concept of volume. Data analysis was conducted using the Wilcoxon test, the Mann-Whitney test, and N-Gain analysis. The results of the Wilcoxon test showed that there was a significant increase in conceptual understanding in both the experimental and control classes (p = 0,000 < 0.05). The results of the Mann-Whitney test showed a significant difference in effect between the two groups (p = 0,002 < 0,05). The N-Gain analysis showed an average increase of 0,40 in the experimental class, which falls into the moderate category, while the control class showed an increase of 0,24, which falls into the low category. These findings indicate that the use of unit cube 3D board media results in a higher improvement in conceptual understanding compared to conventional media in the form of instructional videos. Therefore, unit cube 3D board media can be recommended as an alternative learning medium for teaching the volume of cubes and rectangular prisms in elementary school.

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Introduction

Conceptual understanding is one of the primary goals of mathematics education because it serves as the foundation for students to develop logical and critical thinking skills, as well as the ability to solve problems systematically. This competency does not merely require students to memorize formulas, but also to explain, connect, and apply mathematical concepts in various situations (Widayati et al., 2025). Understanding mathematical concepts is characterized by students' ability to accurately construct the meaning of a concept, rephrase it in their own words, connect it to other concepts, and apply it in various learning contexts and problem-solving situations (Salsabila & Rini, 2026).

Introducing the concept of volume to students should be done through learning activities that encourage their active engagement. Such engagement involves the use of the senses and cognitive activities (Maulana, 2025). The volume of a cube and a rectangular prism represents the number of unit cubes that can completely fill the space inside those shapes without any gaps or overlap (Awal & Pongoliu, 2021). Volume is a quantity used to express the capacity or amount of space contained within a three-dimensional shape (Isrok'atun, 2021). In elementary school mathematics, the concept of volume should be introduced through concrete and gradual learning experiences, given that students are still in the concrete operational stage of cognitive development (Mukmilah & Khoiri, 2023).

However, in actual classroom practice, students still face various difficulties in understanding abstract concepts. According to Marasabessy (as cited in Maulana & Sudihartinih, 2025) these learning difficulties are particularly evident in the topic of the volume of three-dimensional shapes because the concepts being studied are abstract, while the limited use of concrete models in the classroom prevents students from fully visualizing the shapes and elements of three-dimensional figures. Low learning achievement in this subject is also influenced by the predominant use of the lecture method in instruction, as well as the lack of connection between the material and students' real-world experiences (Ratnawati et al., 2025). This situation causes students to struggle when faced with problems that require a deep conceptual understanding.

In addition to having difficulty understanding the concepts, students also frequently make various mistakes when solving problems involving the volume of cubes and rectangular prisms. Common errors include an inability to distinguish between the concepts of surface area and volume, mistakes in determining units of volume, and a tendency to memorize formulas without understanding their underlying meaning. Students also often have difficulty relating the measurements of length, width, and height to the number of unit cubes that fill a three-dimensional shape. As a result, when faced with problems that require conceptual reasoning, students tend to make mistakes in determining solution strategies and in interpreting the results of their calculations.

According to Jean Piaget's theory of cognitive development, elementary school students are in the concrete operational stage-a phase in which children find it easier to understand concepts through real objects and direct experience than through abstract explanations (Putri et al., 2024). This situation poses a challenge in mathematics instruction because elementary school students find it easier to grasp concepts through concrete experiences (Fitriyani & Putri, 2024). Therefore, mathematics instruction at the elementary school level requires instructional media capable of transforming abstract concepts into more concrete ones by using real objects or concrete materials such as wooden blocks, cardboard, used boxes, water bottles, and other objects found in the surrounding environment (Mailani et al., 2025). The use of concrete, engaging, and easily implementable learning media in the learning process can help students

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build conceptual understanding more effectively and meaningfully (Batubara et al., 2025). Meaningful learning in this context emphasizes the selection of engaging activities, materials, methods, and forms of assessment that can increase students' interest in learning, create enjoyable learning experiences, and make the learning process more effective for students (Syahid, 2019).

Various studies have shown that the use of concrete learning materials can help improve students' understanding of mathematical concepts. A study conducted by Siregar et al., (2025) found that the PANJARBARU learning material was effective in improving elementary school students' understanding of three-dimensional shapes. Research by Hugo & Sinaga, (2025) also found that the use of the Snakes and Ladders learning medium can help students better understand the concepts of the volume of cubes and rectangular prisms. Additionally, Hasan et al., (2025) found that the BUNGKER medium effectively helps students understand the concepts of the volume of cylinders and cones. Research by Mukmilah & Khoiri, (2023) found that the use of the VOKUSA learning medium can help students understand the concepts of the volume of cubes and rectangular prisms. However, these studies generally focus on the use of concrete learning media that function as visual aids and educational games to improve learning outcomes and conceptual understanding. The PANJARBARU, Snakes and Ladders, BUNGKER, and VOKUSA media help students understand the material through engaging learning activities; however, they do not specifically represent the concept of volume through an arrangement of three-dimensional unit cubes that students can manipulate directly. Consequently, the relationship between length, width, height, and volume-as the number of unit cubes filling a three-dimensional shape-has not been optimally illustrated.

Based on a review of previous research, there remains a research gap regarding the use of learning media that explicitly represent the concept of volume through arrangements of unit cubes that students can observe and manipulate. Unlike the concrete materials used in previous studies, the 3D unit cube board was designed to directly illustrate the relationship between length, width, height, and volume through the arrangement of unit cubes in three dimensions. Through this medium, students not only see visual representations of three-dimensional shapes but can also arrange, count, and observe the number of unit cubes that fill a three-dimensional shape. Thus, students are expected to be able to understand the origins of the volume formulas for cubes and rectangular prisms more meaningfully, in accordance with the characteristics of cognitive development at the concrete operational stage. Consequently, this study aims to analyze the differences in the improvement of students' conceptual understanding of the volume of cubes and rectangular prisms between students who learn using the 3D unit cube board and those who learn using instructional videos.

Method

Type of Research

This study employed a quantitative approach using a quasi-experimental method. This method was chosen because the researchers were unable to fully randomize the subjects when assigning them to research groups. A quantitative approach is a research method that uses numerical data as the basis for analysis. The data obtained were analyzed using statistical techniques to test hypotheses and explain the relationships among the variables under study (Muhajirin et al., 2024). The design used was a Nonequivalent Control Group Design involving two groups: an experimental class and a control class. The research design to be implemented is as follows:

O_1	X_1	O_2
O_3	X_2	O_4

Figure 1. The Nonequivalent Control Group Design

Source: (Abraham & Supriyati, 2022)
Notes:
O_1 : Pretest for the experimental class group
O_2 : Posttest for the experimental class group
O_3 : Pretest for the control class group
O_4 : Posttest for the control class group
X_1 : Treatment using 3D unit cube blocks
X_2 : Treatment using educational videos

This design was chosen because the study was conducted in existing classes, so the researcher could not fully randomize the subjects. This design involved two groups: an experimental class that received instruction using 3D unit cube boards, and a control class that used conventional instructional videos. Pretests and posttests were administered to determine the effect of the interventions on students' conceptual understanding.

Population and Sample

The study population comprised all fourth-grade students in public elementary schools in Cisitu Subdistrict, Sumedang Regency. The selection of fourth grade was based on the alignment of the material on the volume of three-dimensional shapes with the mathematics learning outcomes at that level, as well as the cognitive developmental characteristics of students who are in the concrete operational stage. Purposive sampling is a sampling technique conducted based on specific criteria established by the researcher in accordance with the research needs (Khoiroh et al., 2026). The research sample was selected using purposive sampling based on criteria relevant to the research objectives. The research sample was selected using purposive sampling based on several criteria, namely: (1) public elementary schools located in Cisitu Subdistrict; (2) implementing the Merdeka Curriculum in fourth grade; (3) having one fourth-grade class that allows for the study to be conducted in its entirety; (4) not yet using 3D unit cube boards or similar concrete materials in the teaching of the volume of three-dimensional shapes; (5) having relatively comparable student characteristics, learning facilities, and learning resources; and (6) having obtained permission from the school administration to conduct the study.

Based on these considerations, Nanggerang Public Elementary School and Corenda Public Elementary School were selected as the research sites. The selection of these two schools was based on several factors aimed at minimizing differences in characteristics between the schools. Both Nanggerang Public Elementary School and Corenda Public Elementary School are public elementary schools located in Cisitu Subdistrict; they implement the same curriculum, have relatively comparable learning facilities, and use similar learning resources in mathematics instruction. In addition, the fourth-grade teachers at both schools have appropriate educational backgrounds and relatively comparable teaching experience. The mathematics lesson schedules at both schools were also implemented according to the time allocations specified in the curriculum. The results of the pretest difference test showed no significant difference between the initial abilities of students in the experimental class and the control class (p > 0,05); thus, both groups can be considered to have equivalent initial abilities before the

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intervention was administered. The fourth-grade class at Nanggerang Public Elementary School was designated as the experimental class, which received instruction using the 3D unit cube board as a teaching aid, while the fourth-grade class at Corenda Public Elementary School was designated as the control class, which received instruction using conventional teaching aids in the form of instructional videos. The study sample consisted of 67 students, comprising 30 students in the experimental class and 37 students in the control class.

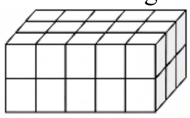
Table 1. Demographic Table of the Study

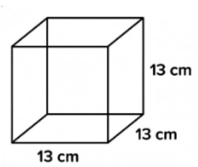
Characteristics	Experimental Class	Control Class	Total
Number of Students	30	37	67
Male	13	19	32
Female	17	18	35
School	SDN Nanggerang	SDN Corenda	-

Instruments

Research instruments are measurement tools used to obtain the data needed in a study to measure the variables under investigation in a systematic and objective manner (Pujiharti & Isnaini, 2025). The instrument used in this study was a test of conceptual understanding of the volume of cubes and rectangular prisms, consisting of 6 complex multiple-choice questions and 8 essay questions. The test instrument was used because it is suitable for measuring students' level of conceptual understanding before and after the intervention was administered. The test was designed based on indicators of volume concept understanding that refer to the "understanding" category of the cognitive domain, according to Anderson and Krathwohl, which includes the ability to interpret, provide examples, classify, summarize, conclude, compare, and explain the concept of volume (Sudianto et al., 2024).

Table 2. Test Instrument Outlinz

No.	Anderson & Krathwohl's Indicators	Indicators of Understanding the Concept of Volume in Three-Dimensional Shapes	Sample Questions
1.	Interpreting	Interpreting arrangements of unit cubes as representations of the volumes of cubes and rectangular prisms	Look at the figure below!  The correct statement regarding the arrangement of these cubes is…. ☐ A. The volume of the block is 30 unit cubes ☐ B. Each unit cube represents one unit of volume ☐ C. The volume of the block is determined solely by the area of its base ☐ D. The arrangement of the cubes shows the volume of the block ☐ E. The unit cubes only show the shape, not the volume
2.	Exemplifying	Provide examples of cubes and rectangular prisms in everyday life	Give three examples each of cubes and rectangular prisms that you can find in your surroundings?
3.	Classifying	Classifying cubes and rectangular prisms based on	Consider the following statements! 1. A shape with all edges of equal length 2. A shape where length ≠ width ≠ height

No.	Anderson & Krathwohl's Indicators	Indicators of Understanding the Concept of Volume in Three-Dimensional Shapes	Sample Questions
		their shapes and how their volumes are measured	3. Its volume is calculated using unit cubes 4. Its volume is calculated using a formula The correct grouping is…. ☐ A. Cube → (1) and (3) ☐ B. Rectangular prism → (2) and (4) ☐ C. Cube → (1) and (4) ☐ D. Cube → (2) and (3) ☐ E. All shapes are cubes
4.	Summarizing	Summarize or restate the concept of the volume of a cube and a rectangular prism	Read the text below! In math class, Ms. Cika brought a toy box shaped like a rectangular prism and several unit cubes. Ms. Cika asked the students to fill the toy box with unit cubes until it was full. It turned out that the toy box could hold 24 unit cubes. Ms. Cika explained that volume is the amount of space that an object can fill. The volume of the toy box can be determined by counting the number of unit cubes that fill it. In addition, Ms. Cika also demonstrated another way to determine the volume of a rectangular prism, which is by multiplying the length, width, and height of the toy box. Write a summary in your own words regarding the concept of the volume of three-dimensional shapes, based on the story text above!
5.	Inferring	Calculate the volume of a cube and a rectangular prism based on data or an arrangement of unit cubes	Consider the following statements about two three-dimensional shapes! • Shape A is composed of 24 unit cubes. • Shape B has dimensions p = 4 cubes, l = 2 cubes, and t = 3 cubes. Each unit cube = 1 cm^3. The correct conclusion regarding the volumes of these two three-dimensional shapes is…. ☐ A. The volume of shape A = 24 cm^3 ☐ B. The volume of shape B = 24 cm^3 ☐ C. The volume of shape A is greater than that of shape B ☐ D. The volume of shape A is equal to that of shape B ☐ E. The volume of shape B is smaller than that of shape A
6.	Comparing	Comparing the volumes of two three-dimensional shapes: a cube and a rectangular prism	Two blocks have the following dimensions: • Block A: 4 cm long, 3 cm wide, 2 cm high • Block B: 5 cm long, 3 cm wide, 2 cm high a. Determine the volume of both blocks? b. Compare the blocks: which one has the larger volume?
7.	Explaining	Explaining the steps for determining the volume of a cube and a rectangular prism	Look at the figure below!  Explain the steps for finding the volume of a cube using the formula shown in the figure above!

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Source: (Qasimah et al., 2025)

Before being used in the study, the test instrument was first validated by three experts to ensure its alignment with the study's objectives. Expert validation was conducted to assess the test instrument's alignment with learning outcomes, content appropriateness, item construction, and language appropriateness. The following are the results of the content expert validation:

Table 3. Summary of the Results of the Subject Matter Expert Validation

Validator	Total Score	Maximum Score	Average	Eligibility Criteria
Validator 1	12	12	3,00	Suitable for use
Validator 2	11	12	2,75	Suitable for use
Validator 3	10	12	2,50	Suitable for use

Based on the summary of the subject matter experts' validation results, Validator 1 assigned a score of 12 out of a maximum of 12, with an average score of 3,00, which falls within the acceptable category. Validator 2 awarded a score of 11 out of a maximum of 12, with an average rating of 2,75, which also falls within the acceptable for use category. Validator 3 awarded a score of 10 out of a maximum of 12, with an average of 2,50, indicating that the instrument falls within the acceptable for use category. These results indicate that the instrument has met the acceptability criteria regarding content for use in research. To ensure the quality of the instruments used in the study, validity and reliability tests were conducted on the results of the instrument pilot test. The validity test aimed to determine the suitability of each test item, while the reliability test aimed to determine the instrument's consistency in measuring students' conceptual understanding. The results of the validity and reliability analyses of the instrument are presented in the following table:

Table 4. Validity Test Results for the Complex Multiple-Choice Test Instrument

Item Number	Pearson's r	Critical r Value	*Sig.*	Decision
1	0,848	0,367	0,000	Valid
2	0,813	0,367	0,000	Valid
3	0,697	0,367	0,000	Valid
4	0,857	0,367	0,000	Valid
5	0,881	0,367	0,000	Valid
6	0,676	0,367	0,000	Valid

Table 5. Validity Test Results for the Essay Test Instrument

Item Number	Pearson's r	Critical r Value	*Sig.*	Decision
1	0,744	0,367	0,000	Valid
2	0,722	0,367	0,000	Valid
3	0,649	0,367	0,000	Valid
4	0,686	0,367	0,000	Valid
5	0,825	0,367	0,000	Valid
6	0,849	0,367	0,000	Valid
7	0,676	0,367	0,000	Valid
8	0,774	0,367	0,000	Valid

Table 6. Results of the Reliability Test for Complex Multiple-Choice and Essay Test Instruments

Cronbach's Alpha	Number of Items	Criteria
0,879	6	High Reliability
0,847	8	High Reliability

Based on the results of the validity analysis using IBM SPSS Statistics, all complex multiple-choice items and essay questions were found to be valid. This is indicated by the correlation coefficient (Pearson's r) for each item being greater than the r-table value of 0,367 and a significance level (Sig.) < 0,05. Thus, all items meet the validity criteria and can be used to measure students' understanding of the concepts of the volume of a cube and a rectangular prism. Furthermore, the reliability test results indicate that the instrument exhibits a high level of consistency, with a reliability coefficient of 0,879 for the complex multiple-choice questions and 0,847 for the essay questions. Both values fall within the high-reliability category; therefore, the research instrument is deemed reliable and suitable for use as a data collection tool in this study.

Data Collection

The study was conducted in three main phases: the preparation phase, the implementation phase, and the final phase. During the preparation phase, the researcher developed instructional materials, including teaching modules, 3D unit cube boards, and a concept comprehension test, and conducted validation and pilot testing of the research instruments. The implementation phase consisted of four sessions, each lasting 2 × 35 minutes. The first session began with administering a pretest to the experimental and control classes to assess the students' initial abilities. The second, third, and fourth sessions were used to teach the material on the volume of cubes and rectangular prisms. In the experimental class, instruction was conducted using the 3D unit cube board. The teacher guided the students to observe the visual aids, arrange unit cubes on a 3D grid, count the number of unit cubes filling the three-dimensional shapes, identify the relationships between length, width, height, and volume, and draw conclusions about the formulas for the volume of a cube and a rectangular prism based on their observations. Meanwhile, in the control class, instruction was conducted using conventional media in the form of instructional videos. The teacher played a video explaining the concepts of the volume of a cube and a rectangular prism, provided additional explanations, guided discussions, and assigned practice problems related to the material covered. The fifth session was used to administer a posttest to both classes to assess students' conceptual understanding after receiving the treatment. To ensure consistency in treatment, instruction in both the experimental and control classes was conducted by the same teacher using equivalent materials, learning objectives, time allocations, and assessment instruments. The only difference in treatment lay in the instructional media used: 3D unit cube blocks in the experimental class and instructional videos in the control class. The final stage of the study involved the collection, processing, and analysis of the research data using statistical tests designed to answer the research questions.

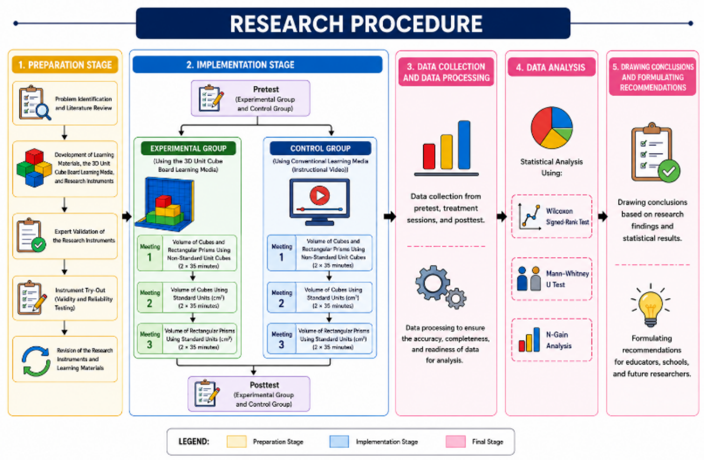

Figure 2. Research Procedure Diagram

Treatment 1 Treatment 2 Treatment 3

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Figure 3. Documentation of the Experimental Class

Data Analysis

The research data were analyzed using descriptive and inferential statistics. Descriptive statistical analysis was used to obtain an overview of the data through the mean, maximum, minimum, and standard deviation of both the pretest and posttest results. Next, normality and homogeneity tests were conducted as prerequisites for the analysis. Given that the research data were not normally distributed, hypothesis testing was performed using nonparametric statistics. The effect of using the unit cube 3D board as a teaching aid in the experimental class and conventional teaching aids in the control class was analyzed using the Wilcoxon Signed-Rank Test. Meanwhile, differences in the effects between the two groups were analyzed using the Mann-Whitney U test based on N-Gain values. Additionally, N-Gain analysis was used to determine the level of improvement in students' conceptual understanding after receiving the treatment. All data analyses were performed using IBM SPSS Statistics software with a significance level of 0.05.

Research Findings

The study was conducted with fourth-grade students at Nanggerang Public Elementary School as the experimental class and Corenda Public Elementary School as the control class. The research activities were carried out over five sessions, including a pretest, three learning sessions, and a posttest. In the experimental class, instruction utilized 3D unit cube blocks, where students observed, arranged, and counted the unit cubes to understand the relationships between length, width, height, and the volume of cubes and rectangular prisms. Meanwhile, in the control class, instruction utilized educational videos accompanied by the teacher's explanations. The only difference between the two classes lay in the instructional media used; the content, time allocation, and assessment instruments were kept identical. Documentation of the research implementation is presented in the following figure.

Pretest Treatment 1 Treatment 2 Treatment 3 *Posttest*

Figure 4. Documentation of the Experimental Class

Figure 5. Control Class Documentation

This study aims to determine the effect of 3D unit cube blocks on fourth-grade elementary school students' understanding of the concepts of cube and rectangular prism volume, the effect of conventional teaching materials on students' understanding of the concepts of three-dimensional shape volume, and the differences in the effects between these two teaching materials. The research results are presented based on descriptive statistical analysis and hypothesis testing.

Table 7. Descriptive Statistics of the Research Results

Data Group	N	Min	Max	Mean	Standard Deviasi
Experimental Group Pretest	30	0	60	28,47	12,47
Experimental Group Posttest	30	36	100	61,67	19,64
Control Group Pretest	37	8	57	28,30	12,76
Control Group Posttest	37	13	89	47,41	23,85

Source: SPSS Data Analysis Results.

Based on the descriptive statistics of the research results in Table 7. the initial abilities of students in the experimental and control classes were relatively equivalent, with pretest averages of 28,47 and 28,30, respectively. After the intervention, the experimental class's posttest average increased to 61,67, which was higher than the control class's score of 47,41. These findings provide an initial indication that the use of 3D unit cube boards as a teaching medium has the potential to yield better results in students' understanding of the concepts of the volume of cubes and rectangular prisms compared to conventional teaching media. To gain a deeper understanding, the research results are further presented based on each research question through the hypothesis testing that was conducted.

Effect of 3D Unit Cube Manipulatives on Fourth-Grade Elementary School Students' Understanding of the Concepts of the Volume of a Cube and a Rectangular Prism

The results of the descriptive analysis show that there was an increase in the average conceptual understanding scores of students in the experimental class after participating in instruction using the 3D unit cube board. The students' average pretest score of 28.47 increased to 61.67 on the posttest. These findings indicate a change in students' conceptual understanding of the volume of three-dimensional shapes after receiving the intervention. To determine the significance of this change, a hypothesis test was conducted using the Wilcoxon Signed-Rank Test. The test results are presented in Table 8.

Table 8. Results of the Wilcoxon Signed-Rank Test for the Experimental Class

Data	Sig.	Notes
Experimental Group Pretest-Posttest	0,000	H_0 is rejected

Source: SPSS Data Analysis Results.

Based on Table 8. a significance value of 0,000 was obtained. Since the significance value is *sig.* < 0,05, H_0 is rejected and H_1 is accepted. These results indicate that the use of 3D unit cube boards as teaching aids has a significant effect on fourth-grade elementary school students'

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understanding of the concepts of the volume of a cube and a rectangular prism. After testing the hypotheses, the analysis continued with calculating the effect size to determine the magnitude of the effect of the 3D unit cube board teaching aid on students' understanding of the concepts of the volume of a cube and a rectangular prism. The effect size was calculated based on the Z-value from the Wilcoxon test using the formula $r = \frac{|Z|}{\sqrt{N}}$. The results of the effect size calculation are presented in Table 9.

Table 9. Effect Size Test Results

Z	N	Effect Size	Criteria
-4,783	30	0,873	Large

Based on Table 9. the effect size calculation yielded a value of 0.873. According to Cohen's interpretation criteria, this value falls into the large effect category. This indicates that the use of the 3D unit cube board has a significant impact on fourth-grade students' understanding of the concepts of the volume of a cube and a rectangular prism. Thus, in addition to yielding a significant improvement based on the results of the Wilcoxon test, the 3D unit cube board also has a strong impact on enhancing students' conceptual understanding.

Effect of Conventional Media on Fourth-Grade Elementary School Students' Understanding of the Concepts of the Volume of a Cube and a Rectangular Prism

The results of the descriptive analysis show that there was an increase in the average conceptual understanding scores of students in the control class after participating in instruction using conventional media in the form of instructional videos. Students' average pretest score of 28,30 increased to 47,41 on the posttest. These findings indicate a change in students' conceptual understanding of the volume of three-dimensional shapes after participating in the learning process. To determine the significance of this change, a hypothesis test was conducted using the Wilcoxon Signed-Rank Test. The test results are presented in Table 10.

Table 10. Results of the Wilcoxon Signed-Rank Test for the Control Group

Data	Sig.	Notes
Control Group Pretest-Posttest	0,000	H_0 is rejected

Source: SPSS Data Analysis Results.

Based on Table 10. a significance value of 0,000 was obtained. Since the significance value is *sig.* < 0,05, H_0 is rejected and H_1 is accepted. These results indicate that the use of conventional media has a significant effect on fourth-grade elementary school students' understanding of the concepts of the volume of a cube and a rectangular prism.

After testing the hypotheses, the analysis continued with calculating the effect size to determine the magnitude of the effect of instructional video media on students' understanding of the concepts of the volume of cubes and rectangular prisms. The effect size was calculated based on the Z-value from the Wilcoxon test using the formula $r = \frac{|Z|}{\sqrt{N}}$. The results of the effect size calculation are presented in Table 11.

Table 11. Effect Size Test Results

Z	N	Effect Size	Criteria
-5,161	37	0,848	Large

Based on Table 11. the effect size calculation resulted in a value of 0,848. According to Cohen's interpretation criteria, this value falls into the large effect category. This indicates that the use of instructional video media has a significant impact on fourth-grade students' understanding of the concepts of the volume of a cube and a rectangular prism. Thus, in addition to yielding a significant improvement based on the results of the Wilcoxon test, instructional video media also has a strong influence on enhancing students' conceptual understanding.

Differences in the Effects of 3D Unit Cube Models and Conventional Teaching Aids on Fourth-Grade Elementary School Students' Understanding of the Concepts of the Volume of a Cube and a Rectangular Prism

The difference in the effects of using 3D unit cube boards versus conventional teaching aids was analyzed using N-Gain scores. The results of the descriptive analysis showed that the average N-Gain score for the experimental class was higher than that for the control class. These results are presented in Table 12.

Table 12. Average N-Gain for the Experimental Class and the Control Class

Group	Average N-Gain	Category
Experiment	0,40	Moderate
Control	0,24	Low

Source: SPSS Data Analysis Results.

Based on Table 12. the average N-Gain for the experimental class was 0,40, which falls into the moderate category, while the average N-Gain for the control class was 0,24, which falls into the low category. These findings indicate that the improvement in conceptual understanding of the volume of cubes and rectangular prisms was greater in the experimental class than in the control class. To determine the significance of this difference, a hypothesis test was conducted using the Mann-Whitney U test. The test results are presented in Table 13.

Table 13. Results of the Mann-Whitney U Test: N-Gain Values

Data	Sig.	Notes
N-Gain Experiment and Control	0,002	H_0 is rejected

Source: SPSS Data Analysis Results.

Based on Table 13. a significance value of 0,002 was obtained. Since the significance value is sig. < 0,05, H_0 is rejected and H_1 is accepted. These results indicate that there is a significant difference in the effect of using unit cube 3D boards versus conventional teaching aids on fourth-grade elementary school students' understanding of the concepts of the volume of a cube and a rectangular prism. This difference is reinforced by the higher average N-Gain in the experimental class compared to the control class, leading to the conclusion that the 3D unit cube board medium has a more positive effect than conventional media in improving fourth-grade elementary school students' understanding of the concepts of the volume of a cube and a rectangular prism.

After testing the hypotheses, the analysis continued with calculating the effect size to determine the magnitude of the difference in the impact of using unit cube 3D boards and instructional videos on students' understanding of the concepts of the volume of a cube and a rectangular prism. The effect size was calculated based on the Z-value from the Wilcoxon test using the formula $r = \frac{|Z|}{\sqrt{N}}$. The results of the effect size calculation are presented in Table 14.

Table 14. Effect Size Test Results

Z	N	Effect Size	Category
-3,058	67	0,374	Moderate

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Based on Table 14. the calculated effect size was 0,374. According to Cohen's interpretation criteria, this value falls into the medium effect category. This indicates that the difference in effect between the use of unit cube 3D board media and conventional instructional video media falls into the medium category. In other words, the 3D unit cube board media provides a greater improvement in conceptual understanding compared to instructional video media, even though the magnitude of the difference in effect between the two media is classified as moderate.

Discussion

Effect of 3D Unit Cube Manipulatives on Fourth-Grade Elementary School Students' Understanding of the Concepts of the Volume of a Cube and a Rectangular Prism

The results of the study show that the use of unit cube 3D models influences elementary school students' understanding of the concepts of the volume of a cube and a rectangular prism. These result show indicate that presenting the concept of volume through concrete materials helps students understand the relationship between units of volume and the space occupied by unit cubes. Through activities involving direct observation, arrangement, and counting of unit cubes, students gain a more meaningful learning experience compared to receiving only verbal explanations. These findings align with Jean Piaget's theory of cognitive development, which states that elementary school students are in the concrete operational stage. At this stage, conceptual understanding is more easily formed when students interact directly with objects that can be observed and manipulated. Therefore, the use of concrete materials allows students to build an understanding of the concept of volume based on real-world experiences, making the concept-which was initially abstract-easier to understand (Nuryati & Darsinah, 2021).

The results of this study support the findings of Siregar et al. (2025) which concluded that the use of concrete materials can improve students' understanding of three-dimensional shapes. The similarity between the two studies lies in the use of media that provides students with opportunities to engage in manipulative activities during the learning process, whereas this study emphasizes how students construct an understanding of the concept of volume through the manipulation of unit cubes, enabling them to understand the relationship between length, width, height, and volume more deeply. Thus, the findings of this study further reinforce the importance of using concrete media in mathematics instruction in elementary school. Based on the N-Gain analysis for each concept comprehension indicator, the greatest improvement occurred in the providing examples indicator, with an N-Gain value of 0,66, followed by the interpreting indicator at 0,61 and the classifying indicator at 0,56. These results indicate that the unit cube 3D board medium is more effective in helping students recognize and provide examples of the concept of volume through the representation of unit cubes that can be directly observed and manipulated. Through activities involving assembling, disassembling, and counting unit cubes, students not only memorize the volume formula but also understand how a three-dimensional shape is formed from an arrangement of unit cubes. This learning experience makes it easier for students to provide examples, interpret the relationships between length, width, height, and volume, and classify three-dimensional shapes based on their characteristics. Conversely, the indicator for explaining concepts yielded an N-Gain value of 0,40, indicating that students' ability to verbally restate concepts still requires further practice, despite having shown improvement.

Effect of Conventional Media on Fourth-Grade Elementary School Students' Understanding of the Concepts of the Volume of a Cube and a Rectangular Prism

This study also shows that conventional media in the form of instructional videos can help improve students' understanding of the concepts of the volume of a cube and a rectangular prism. The use of instructional videos is also considered effective in helping teachers present material in a more contextual manner and in increasing students' interest in learning (Andani et al., 2025). These results indicate that visual media can still support the learning process because they present material in a more engaging way and help students visualize the concepts being studied. However, the learning process that takes place through instructional videos tends to position students as mere recipients of information. Students gain learning experiences through visual observation but do not have the opportunity to interact directly with the objects being studied. This situation prevents the process of conceptual understanding from occurring optimally, particularly for material requiring concrete representations, such as the volume of three-dimensional shapes. These findings indicate that visual media contribute to improving students' understanding, but their effectiveness is still influenced by the characteristics of the material and the students' stage of cognitive development. This suggests that concrete media are more appropriate for elementary school students because, at the concrete operational stage, conceptual understanding is more easily developed through direct interaction with real objects than through visual observation (Nuryati & Darsinah, 2021).

Differences in the Effects of 3D Unit Cube Models and Conventional Teaching Aids on Fourth-Grade Elementary School Students' Understanding of the Concepts of the Volume of a Cube and a Rectangular Prism

The results of the study show that the 3D unit cube board medium has a more positive effect than conventional media on students' understanding of the concepts of the volume of a cube and a rectangular prism. These findings indicate that students' direct engagement in manipulating learning objects plays a crucial role in helping them develop an understanding of mathematical concepts. This difference arises because the 3D unit cube board provides students with the opportunity to directly observe, assemble, disassemble, and count unit cubes. Through these activities, students can see the relationship between length, width, height, and volume in a tangible way, enabling them to understand the origin of the volume formula rather than merely memorizing it. In contrast, instructional videos only present visual representations, which limits students' interaction with the learning objects. These results are consistent with studies by Hugo & Sinaga (2025), Hasan et al. (2025), and Mukmilah & Khoiri (2023) which show that the use of concrete materials can help students understand the concept of the volume of three-dimensional shapes more effectively. The similarity between these studies and the present study lies in the use of materials that provide concrete learning experiences. However, the materials used in previous studies did not specifically represent the concept of volume through a three-dimensional arrangement of unit cubes that students could assemble and disassemble. Therefore, this study presents a different finding: the 3D unit cube board not only enhances conceptual understanding but also helps students grasp the conceptual relationships between length, width, height, and volume through hands-on activities.

The novelty of this study lies in the use of a 3D unit cube board, which is specifically designed to represent the concept of volume through the arrangement of unit cubes in three dimensions. This medium not only helps students achieve better learning outcomes but also helps them understand the origins of the concept of volume and the relationships between length, width, height, and the number of unit cubes that form a three-dimensional shape. Thus,

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this study provides empirical evidence regarding the effectiveness of unit cube-based manipulative media in supporting elementary school students' understanding of the concept of volume of three-dimensional shapes, in accordance with the characteristics of Piaget's concrete operational stage.

Conclusion

This study shows that the unit cube 3D model has an effect on fourth-grade elementary school students' understanding of the concepts of the volume of a cube and a rectangular prism. This model helps students understand the concept of volume more concretely through activities involving direct observation, arrangement, and calculation of unit cubes. The results show that the average N-Gain score in the experimental class was 0,40, falling into the moderate category, while the control class scored 0,24, falling into the low category. The results of the Mann-Whitney test also showed a significant difference between the two groups Sig. = 0.002, indicating that the 3D unit cube board medium resulted in a greater improvement in conceptual understanding compared to the instructional video medium. Thus, the 3D unit cube board medium is more effective in helping students understand the concepts of the volume of cubes and rectangular prisms, particularly through concrete representations of the relationships between length, width, height, and volume. This study contributes to the development of mathematics learning materials tailored to the characteristics of elementary school students at the concrete operational stage. However, this study has several limitations: it was conducted only on the topics of the volume of cubes and rectangular prisms; it involved a relatively small sample size; it used two different schools as the experimental and control classes, which means there is still the potential for differences in school characteristics; it did not use randomization in sample selection because it employed a quasi-experimental design; and the treatment duration was relatively short, so it cannot yet illustrate the long-term effects of the media. Therefore, future research is recommended to test the effect of the 3D unit cube board on other three-dimensional shapes, involve a larger sample size from a more diverse range of schools, implement a randomized research design where possible, extend the duration of the intervention to observe the long-term impact of the media, and compare the effect of the 3D unit cube board with various manipulatives or other innovative learning media.

Conflict of Interest

The authors declare that there are no conflicts of interest.

Auhor Contributions

D.A.L. understood the research concept presented and collected the data. The other two authors (I. and A.A.S.) actively participated in the development of the theory and methodology, the organization and analysis of the data, the discussion of the results, and the approval of the final version of the paper. All authors confirm that they have read and approved the final version of this paper. The total percentage of contributions to the conceptualization, drafting, and revision of this paper are as follows: D.A.L.: 40%, I.: 30%, and A.A.S.: 30%
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Data Availability Statement

The authors state that the data supporting the results of this study will be provided by the corresponding author, [D.A.L], upon reasonable request.

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