United International Journal for Research & Technology
Volume 07, Issue 03, 2026 | Open Access | ISSN: 2582-6832

The Influence of Real Object-Assisted Demonstration Model on Understanding Cube and Rectangular Prism Concepts in Fourth Grade Elementary School Students

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Abstract**—** Mathematical concept understanding, particularly the concepts of cube and rectangular prism, remains a challenge in Indonesia, as international surveys such as PISA and TIMSS indicate low mathematical achievement. One of the reasons for this is the limitation of teaching methods that prioritize lectures and printed media, which make it difficult for students to visualize and understand three-dimensional concepts. This study aims to examine the influence of the concrete object-assisted demonstration method on understanding the concepts of cubes and rectangular prisms, as well as to explore the role of students' prior abilities in the learning process. The method used is a quasi-experiment with a Non-equivalent Control Group Design, involving two groups: the experimental group (demonstration method) and the control group (lecture method), which were given pretests and posttests. The results show that the concrete object-assisted demonstration method significantly improves understanding of the cube and rectangular prism concepts, with the posttest average of the experimental class being higher than that of the control class. Prior ability did not show a significant effect on concept understanding after the treatment, indicating that the demonstration method can reduce the gap in understanding between students with different prior abilities. This study suggests that the use of concrete objects in learning can be an effective solution to improve mathematical concept understanding in elementary schools, without relying on students' prior abilities.

Keywords**—** Demonstration Method, Concrete Objects, Concept Understanding, Solid Figures.

I. INTRODUCTION

Mathematical concept understanding is a fundamental competence that needs to be developed from the elementary school level, as it serves as the foundation for the development of critical thinking skills in facing various everyday life problems (Saputra, 2024). PISA defines mathematical literacy/numeracy as students' ability to use mathematical concepts to solve real-world problems through analytical and critical approaches, not just performing calculations but also requiring interpretation and deep understanding of concepts in real contexts (OECD, 2018).

However, students' mathematical abilities in Indonesia remain concerning, as reflected in the results of international surveys such as the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS), which show that Indonesian students' mathematics achievements lag behind other countries (Puspendik Kemendikbud, 2019). Various findings indicate that Indonesian students' understanding of mathematical concepts is still relatively low. In TIMSS 2015, Indonesia's math score was recorded at 397, far below the international average of 500 (Kuswantod kk, 2025). This result shows that most students are at a low level, being able to answer questions requiring recognition of simple facts or procedures, but struggling with problems that require deep conceptual understanding, reasoning, and application in new contexts.

These findings are consistent with the TIMSS 2023 report, which emphasizes that conceptual mastery is a key factor distinguishing achievement between countries. Students with strong conceptual understanding tend to be able to connect mathematical representations such as images, tables, symbols, and verbal descriptions to solve problems, while students with weak conceptual understanding tend to memorize procedures without understanding the meaning, making them vulnerable to difficulties when faced with problem variations requiring reasoning (Lindquist et al., 2017). Therefore, TIMSS results serve as an important indicator of the need to shift teaching from procedural memorization to strengthening conceptual understanding through active learning strategies, the use of concrete objects, and linking lessons to real-life contexts.

The gap in conceptual understanding is more apparent in geometry, particularly in the concepts of cubes and rectangular prisms. Learning about solid shapes not only requires mastery of formulas but also spatial visualization skills and an understanding of the relationships between the elements of the shapes (edges, faces, and vertices). In practice, students often have difficulty visualizing three-dimensional shapes when the concepts are only presented through two-dimensional images in textbooks. As a result, students struggle to connect the elements of solid shapes and are prone to conceptual errors, such as distinguishing between surface area and volume or applying formulas in different contexts.

This condition is reinforced by field observations during the initial survey at an elementary school in Selogiri Subdistrict. On August 27, 2024, it was found that the mathematics teaching method commonly used by the teacher was lectures, with the aid of student activity sheets (LKPD). In a task that required converting word problems into mathematical models/methods using the LKPD guide, 76.67% of the 60 students understood the need to convert to a mathematical model, but their answers were incorrect, and 23.33% did not answer the question. This data indicates that students' understanding is not solid, especially when it comes to constructing meaning and linking concepts to solve problems.

Pedagogically, this condition is also related to the teaching approach that does not actively engage students. The frequently used lecture and drill methods make learning feel monotonous; as a result, motivation decreases, and understanding of the material becomes shallow (Siregar, 2025). In this context, a more innovative and interactive approach is needed to give students the opportunity to experience, observe, and construct concepts more meaningfully. One alternative is the concrete object-assisted demonstration method, where students can manipulate models of cubes or rectangular prisms to understand solid shape concepts directly (Ratnasari et al., 2024). This approach aligns with the principles of constructivism, which encourages students to build knowledge based on concrete experiences.

Strengthening learning based on concrete experiences is also relevant to the nature of mathematics as structured and interconnected knowledge (Lestari et al., 2025). The concepts being taught are interconnected with previous concepts, so learning that does not emphasize connections between concepts may lead to less profound understanding (Azis, 2020). Therefore, learning about cubes and rectangular prisms should ideally not stop at providing formulas, but should also facilitate students in constructing concepts through meaningful representations and experiences.

From a learning theory perspective, the demonstration method is suitable to help students move from concrete to abstract understanding. The demonstration method is a teaching technique that involves showing students how to do something through direct demonstration or using teaching aids related to the material (Ratnasari et al., 2024). Demonstration is also an approach that is relatively easy to apply because it involves steps that lead to the emergence of behaviors being modeled, so students can understand it concretely or imitate it (Sukmajati & Trisnawati, 2024). Thus, demonstrations can help students understand the concept of solid shapes through observation and manipulation of objects.

Several previous studies have also shown the effectiveness of the demonstration method in improving the understanding of mathematical concepts. Sun et al. (2020) reported that demonstrations supported by concrete aids can increase student engagement and result in a deeper understanding of concepts compared to groups that only learned through lectures. Additionally, Hidayat & Suryadi (2019) reported a 25% higher increase in conceptual understanding with the demonstration method compared to lecture-based teaching using print media. These findings reinforce the idea that concrete object-assisted demonstrations have the potential to bridge conceptual difficulties related to abstract concepts.

Many previous studies still focus on comparing teaching methods without considering other factors that affect learning outcomes, one of which is students' prior abilities. Prior ability is the knowledge and skills students possess before the learning process begins, and it is important because mathematics is structured hierarchically: understanding prerequisite concepts forms the basis for understanding subsequent concepts. If students have not mastered prior concepts, they tend to find it more difficult to grasp new material. Therefore, the effectiveness of the concrete object assistance method is likely to vary among students according to their initial abilities, necessitating more comprehensive research that considers variations in students' prior abilities.

Based on these conditions, this study is important to support the improvement of the quality of mathematics education in elementary schools, as good conceptual understanding at this level is the foundation for the development of mathematical abilities at the next level. This study is also expected to provide practical contributions for teachers in selecting and implementing more effective, varied, and adaptive learning methods according to students' needs, especially for the concepts of cubes and rectangular prisms. The novelty of this study lies in the analysis perspective that not only tests the influence of concrete object-assisted demonstrations on conceptual understanding, but also aims to show that the demonstration method works more optimally.

Based on the above discussion, the research problem formulation includes whether the demonstration method affects the understanding of solid shape concepts (cubes and rectangular prisms), whether students' prior abilities influence their understanding of these concepts, and whether there is an interaction between the demonstration method and prior ability in affecting understanding of these concepts; In line with this, the aim of this study is to prove the influence of the demonstration method, the influence of prior ability, and their interaction on understanding the concepts of cubes and rectangular prisms.

II. METHOD

This study is a quasi-experimental research, meaning it is an experimental study that still uses a control group but has limitations in controlling all variables that could affect the execution of the experiment (Sugiyono, 2019). In terms of design, this study uses a Non-equivalent Control Group Design, which is equivalent to a pretest and posttest control group design. Thus, two groups (experimental and control) are compared through initial measurement (pretest), treatment, and then final measurement (posttest). The study is also designed in a 2×2 factorial form, with the learning method as variable (A) and prior ability as variable (B), with prior ability grouped into high (≥70) and low (<70). Below is a description of the 2×2 factorial research design.

Table 1. *Description of the 2×2 Factorial Research Design*

Learning Method (A)	**Prior Ability (B)**	
	High Group (B1)	High Group (B2)
Concrete Object-Assisted Demonstration Method (A1)	A1 B1	A1 B2
Lecture Method with Printed Media (A2)	A2 B2	A2 B2

The research will be conducted at elementary schools in the Selogiri Subdistrict, Wonogiri Regency, Central Java, from September 2024 to May 2025, covering preparation stages through report preparation. This location was chosen due to its large population spread across many schools, making it feasible to apply cluster random sampling efficiently and remain representative.

The research population consists of 583 fourth-grade students from 31 public elementary schools in the Selogiri Subdistrict, Wonogiri, for the 2024/2025 academic year. The population is defined as the entire set of objects/subjects that possess specific characteristics for study and conclusion drawing (Sudaryono, 2016). The research sample consists of 172 students, selected using cluster random sampling because it is more practical for large, dispersed populations, and the learning occurs in relatively homogeneous class units. A sample is part of the total number and characteristics of the population (Sudaryono, 2016).

Data collection will be carried out through testing. The test used is a written test in the form of essays, conducted in three stages: (1) initial ability test, (2) pretest, and (3) posttest. The initial ability test consists of 5 essay questions with flat shape materials as prerequisite material for solid shape learning. The pretest stage consists of 10 essay questions to assess students' understanding of solid shape material. The posttest stage consists of 10 essay questions to assess students' memory ability after receiving the treatment.

Data analysis will be performed through prerequisite tests and hypothesis tests. Conceptually, data analysis includes data grouping, hypothesis testing, and answering the research problem formulation (Sugiyono, 2019). Prerequisite tests include the Liliefors normality

United International Journal for Research & Technology
Volume 07, Issue 03, 2026 | Open Access | ISSN: 2582-6832

test and the Bartlett homogeneity test, followed by a balance test using the t-test. Hypothesis testing will use two-way ANOVA with equal cells to assess the effect of methods, prior abilities, and their interaction. If further tests are needed, the Scheffe test will be used.

III. RESULTS AND DISCUSSION

Research Results

The results of the study are presented sequentially to show the initial condition of the students and the changes after the learning treatment. The presentation begins with the initial ability test as the basis for group equivalence, followed by the pretest to illustrate initial understanding of cubes and rectangular prisms based on high and low prior ability, and then ends with the posttest as an indicator of learning outcomes that will be discussed regarding the impact of the treatment. Table 2 presents the descriptive statistics of the initial ability test scores for the experimental and control groups as the basis to examine the equivalence of initial conditions before the learning treatment is applied.

Table 2. *Summary of Initial Ability Test Scores for Experimental and Control Groups*

Group	N	Min	Max	Mean	Std. Deviation	Variance
Experimental	86	50	100	69.13	16.018	256.583
Control	86	50	100	69.48	17.030	290.017

Based on Table 2, the initial ability test results show that the experimental and control groups have relatively equivalent characteristics. This is evident from the average (mean) score of the experimental group at 69.13 and the control group at 69.48, with the same score range of 50 to 100. The similarity in score range and the closeness of the average scores indicate that before the treatment, the initial abilities of the students in both groups were nearly the same.

Additionally, the distribution of scores in both groups is also quite similar. The standard deviation for the experimental group is 16.018, while for the control group, it is 17.030, with variances of 256.583 and 290.017, respectively. The small difference in distribution shows that the variation in students' initial abilities in both groups is not significantly different, suggesting that both groups are comparable and can be used as the basis for comparison in testing the effects of the treatment in the next phase.

Next, Table 3 presents the pretest results of understanding cube and rectangular prism concepts in the experimental and control classes, based on categories of high and low initial ability, to see if both classes started at an equal point before the treatment.

Table 3. *Summary of Pretest Scores for the Experimental and Control Classes*

Group	Criterion	N	Range	Min	Max	Mean	Std. Deviation
Experimental	High	46	35	45	80	61.52	8.998
Experimental	Low	40	35	40	75	60.12	9.093
Control	High	48	30	50	80	61.77	8.347
Control	Low	38	40	40	80	60.92	9.216

Based on Table 3, the pretest results show that the students' initial understanding of cube and rectangular prism concepts in both the experimental and control classes is relatively equivalent, both in the high and low prior ability groups. For the high prior ability criterion, the average (mean) score for the experimental class is 61.52, and for the control class, it is 61.77, with nearly the same score range (experimental 45 to 80, control 50 to 80). For the low prior ability criterion, the average score for the experimental class is 60.12, and for the control class, it is 60.92, so the difference in averages between the classes in the pretest stage is not significant.

Moreover, the distribution of pretest scores in both classes also shows relatively similar variation. The standard deviation for the high prior ability criterion is 8.998 (experimental) and 8.347 (control), while for the low prior ability criterion, it is 9.093 (experimental) and 9.216 (control). The similarity in averages and score distributions indicates that before the treatment was applied, the initial conditions of both classes were fairly balanced, so any changes observed in the posttest can be more strongly linked to the learning treatment.

Next, Table 4 presents the posttest results as an indication of the achievement of understanding concepts after the learning treatment was applied, both in the experimental and control groups, and analyzed based on high and low initial abilities.

Table 4. *Summary of Posttest Scores for the Experimental and Control Classes*

Group	Criterion	N	Range	Min	Max	Mean	Std. Deviation
Experimental	High	46	25	75	100	91.63	7.821
Experimental	Low	40	20	80	100	92.00	6.869
Control	High	48	35	65	100	80.52	8.887
Control	Low	38	35	65	100	79.74	10.263

Based on Table 4, the posttest results in the experimental class show a mean range of 91.63 to 92.00, while in the control class, it ranges from 79.74 to 80.52. This finding indicates that students in the experimental class achieved higher understanding of cube and rectangular prism concepts compared to students in the control class at the end of the learning process.

When viewed based on initial ability, the experimental class shows high achievement in both the high and low initial ability groups. The high initial ability group has a mean score of 91.63 (min 75, max 100), while the low initial ability group has a mean score of 92.00 (min 80, max 100).

The very small difference between these two groups suggests that the learning in the experimental class helps students with low initial abilities reach understanding that is comparable to those with high initial abilities.

Meanwhile, in the control class, the average posttest score for the high initial ability group is 80.52 and for the low initial ability group, it is 79.74, with score ranges of 65 to 100 for both. The score distribution in the control class tends to be more variable, especially in the low initial ability group, which has a larger standard deviation (10.263) compared to the other groups. Overall, the consistent difference in means between the experimental and control classes, along with the relatively more controlled distribution of scores in the experimental class, strengthens the indication that the treatment in the experimental class had a positive impact on understanding cube and rectangular prism concepts.

Subsequently, hypothesis testing was conducted using a two-way analysis of variance (ANOVA) to assess the main effects of the learning method and initial ability, as well as their interaction on the understanding of cube and rectangular prism concepts. The summary of the results is presented in Table 5.

Table 5. *Summary of Two-Way ANOVA Results*

Source of Variation	Sum of Squares	df	Mean Square	F-Calculated	F-Table	Decision
Learning Method (A)	5,813.95	1	5,813.95	80.52	3.91	Reject H0
Initial Ability (B)	0.10	1	0.099	0.001	3.91	Accept H0
Interaction (AB)	1,199,478.00	1	1,199,478	16,612.91	3.91	Reject H0
Error	12,202	169	72,20153846	0	0	
Total	1,217,494.11	172	0	0	0	

Based on Table 5, the ANOVA results indicate that the learning method significantly affects understanding of solid shape concepts, as the F-Calculated value for the learning method (80.52) is greater than the F-Table value (3.91). Meanwhile, initial ability does not show a significant main effect, as the F-Calculated value for initial ability (0.001) is smaller than the F-Table value (3.91). These findings confirm that the difference in conceptual understanding is more influenced by the treatment method than by differences in initial ability categories when viewed as a main effect.

When considering the direction of the effect, the concrete object-assisted demonstration method appears to result in higher outcomes compared to lecture-based/conventional learning. This is evident from the means in each cell: in the demonstration method, the means are 91.63 (high initial ability) and 92.00 (low initial ability), while in the lecture method with printed media, the means are 80.52 (high) and 79.74 (low). Additionally, the marginal means also show a consistent pattern: the demonstration method has a marginal mean of 91.815, while the lecture/conventional method has 80.13, reinforcing the idea that the concrete object-assisted demonstration method results in better conceptual understanding.

However, since the ANOVA results also show a significant interaction between the learning method and initial ability (F-Calculated 16,612.91 > F-Table 3.91), the effect of the learning method needs to be interpreted alongside the initial ability categories, not separately. This interaction condition is the reason for conducting post hoc tests (multiple comparisons) to track the differences between the combinations of cells (A1B1, A1B2, A2B1, A2B2) more specifically.

Discussion

The concrete object-assisted demonstration learning method has a better effect on understanding the concepts of cubes and rectangular prisms compared to lecture-based learning with printed media, as evidenced by the two-way ANOVA results where the F-observed (80.52) > F-table (3.91), and the marginal mean for demonstration (91.82) is higher than for the lecture method (80.13). The advantage of the concrete object-assisted demonstration method is explained by the fact that students directly observe the shape, size, and properties of solid shapes through real objects, making it easier to understand the relationships between the elements of solid shapes. The demonstration method also provides opportunities for exploration, manipulation, and testing of objects, which encourages cognitive processes that evolve from simple understanding to higher cognitive abilities (Setiawan, 2024).

This is consistent with Syahrani's (2018) view, which emphasizes that concrete object-assisted demonstrations can make abstract concepts more tangible and easier to understand, strengthen memory, and increase student interest in learning. Furthermore, Lestari (2021) explained that the use of demonstrations with concrete media provides a real learning experience because students can observe, touch, and manipulate concrete objects, making it easier for them to understand solid shape concepts.

On the other hand, initial ability does not significantly affect the understanding of solid shape concepts (cubes and rectangular prisms), as shown by the two-way ANOVA results with F-calculated for initial ability = 0.001 < F-table = 3.91. Moreover, in the concrete object-assisted demonstration learning method, the difference between high and low initial ability does not show a meaningful difference, as post hoc tests show F-calculated = 2.93 < F-table = 8.01. These findings indicate that the category of initial ability (high vs. low) is not strong enough as the main determinant of the variation in understanding the solid shape concepts at the end of the learning process. In other words, the achievement of conceptual understanding in students is more influenced by factors other than initial ability when initial ability is seen as the main effect.

One logical explanation is that during the learning process, especially when the teacher applies strategies that help students organize their knowledge, students with lower initial abilities can "catch up," reducing the gap between them. This may be due to the interrelated nature of mathematical concepts, where initial ability is understood as a prerequisite concept. However, learning outcomes are still highly influenced by how the learning process is designed to guide students in constructing new knowledge (Nurjannah, 2020). In other words, different initial abilities do not automatically result in different final understandings if the learning process provides adequate support.

Post hoc findings showing no significant difference between high and low initial abilities in the demonstration class (F-calculated 2.93 < F-table 8.01) reinforce the assumption that the concrete object-assisted demonstration method acts as a "bridge" for all categories of initial abilities. In this context, students who initially had lower abilities were given more concrete learning opportunities (observing and manipulating objects), allowing their conceptual understanding to improve and approach that of students with higher initial abilities.

Ozkan and Bal (2017) explain that initial ability is not always a significant predictor because the learning strategy/method can have a more dominant influence on the final achievement. Additionally, Rahayu and Fadilah (2021) concluded that initial ability does not significantly affect learning outcomes in mathematics, specifically in solid shape topics, because other factors such as learning motivation and innovative teaching models play a more determining role in shaping conceptual understanding.

There is an interaction between the learning method (concrete object-assisted demonstration vs. lecture) and initial ability regarding understanding solid shape concepts, shown by F-calculated = 16,612.92 > F-table = 3.91. Since the interaction is significant, the effect of the learning method needs to be interpreted alongside the initial ability categories, prompting post hoc ANOVA testing. A significant interaction means that the effectiveness of the learning method is not independent but is related to the students' initial ability. Descriptively, the combination of demonstration with high initial ability (mean 91.63) and demonstration with low initial ability (mean 92.00) is both higher than the combination in the lecture method (mean 80.52 for high initial ability and 79.74 for low initial ability).

These findings show that, in the demonstration method, the difference in initial abilities tends to be "reduced" because students receive the same concrete support to build concepts. In contrast, in the lecture method, the learning process tends to move directly to formal/abstract stages, making the difference in initial ability more apparent, as explained, where initial ability has a different effect on high and low criteria. In other words, demonstration is more accommodating for variations in initial readiness, while the lecture method is more dependent on students' prior knowledge.

Syahrani (2018) explains that concrete object-assisted demonstrations can make abstract concepts more tangible and easier to understand, strengthen memory, and increase student interest in learning. This supports the findings that in the demonstration method, the difference in initial abilities is more reduced because all students have the opportunity to observe and manipulate concrete objects, which supports the development of deeper understanding. Meanwhile, Lestari (2021) emphasized that concrete media provides a real learning experience and helps students understand difficult concepts. On the other hand, in the lecture method, as explained by Radiusman (2020), the learning process is more abstract and moves quickly to formal stages, which requires higher prior knowledge for students to understand the material well. This explains why the difference in initial abilities is more evident in lecture-based learning, while in the demonstration method, the difference is reduced because all students receive a more concrete learning experience.

Post hoc tests also reinforce the presence of this interaction: comparing demonstration–high initial ability with lecture–high initial ability shows a significant difference (F-calculated 2899.34 > F-table 2.67), and comparing demonstration–high initial ability with lecture–low initial ability also shows a significant difference (F-calculated 238.34 > F-table 2.67). This pattern confirms that the superiority of the demonstration method remains evident when compared with lecture, even with different initial abilities, so the interaction is not just a small difference, but a consistent difference across cell combinations.

Theoretically, these findings support the view proposed by Syahrani (2018), who states that concrete object-assisted demonstrations are effective in transforming abstract concepts into more tangible and understandable ones, allowing students with various initial abilities to achieve a better understanding. Additionally, Radiusman (2020) suggested that learning based on concrete objects moves from direct experience to abstract concepts, which can be accessed by students with more fundamental prior knowledge. This is relevant to the findings in this study, where the demonstration method provides stronger support for students with lower initial abilities to understand the material. In contrast, in the lecture method, as explained by Lestari (2021), learning quickly shifts to the abstract stage, which requires students to have higher prior knowledge to understand well. This clarifies why the difference in initial abilities is more evident in the lecture method, while in the demonstration method, the difference is more reduced because all students receive more concrete learning experiences.

IV. CONCLUSION

Based on the results of the study, the concrete object-assisted demonstration learning method proved to be more effective in improving the understanding of the concepts of cubes and rectangular prisms compared to the lecture method with printed media. The ANOVA analysis results show that the demonstration method has a significant effect on concept understanding, with the

F-calculated (80.52) being greater than the F-table (3.91). Students taught using the demonstration method showed higher understanding, both for students with high initial abilities (mean 91.63) and low initial abilities (mean 92.00), compared to students in the lecture class (mean 80.52 for high initial ability and 79.74 for low initial ability). This indicates that the demonstration method is more effective in helping students understand the concepts of cubes and rectangular prisms, especially by providing opportunities for exploration and manipulation of real objects.

This discussion also shows that students' initial abilities did not have a significant effect on understanding solid shape concepts after the treatment, as evidenced by the very small F-calculated value for initial ability (0.001). In other words, the difference in initial ability between students was not the main factor affecting learning outcomes, but rather the learning method applied. As explained by several experts, the concrete object-assisted demonstration method can reduce the differences in initial ability because it provides a more concrete and meaningful learning experience, allowing students with lower initial abilities to catch up and achieve understanding on par with those with higher initial abilities.

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