

ENHANCING STUDENTS' MATHEMATICAL CONCEPT UNDERSTANDING ABILITY THROUGH AUGMENTED REALITY BASED LEARNING MEDIA

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ABSTRACT

The mathematical concept understanding ability of eighth-grade students at SMP Negeri 1 Botupingge on cube and block topics remains low, with daily average scores only reaching 28.57% over the past three years due to monotonous conventional learning and a lack of interactive media. The use of Augmented Reality (AR)-based media is proposed as an innovative solution to visualize 3D objects more concretely. This study aims to improve the mathematical concept understanding ability of class VIII-C students through the implementation of AR-based learning media on cube and block materials. This Classroom Action Research (CAR) using the Kemmis and McTaggart model was conducted with 24 students from the 2025/2026 academic year at SMP Negeri 1 Botupingge in September 2025. Data collection techniques included observations of teacher and student activities as well as concept understanding tests, conducted over two cycles (planning, implementation, observation, reflection). The AR media enabled student interaction with 3D cube and block models via a mobile application. Data analysis employed average percentage formulas for observation scores and learning completeness (KKM 75). Cycle I results showed concept understanding at 59.68%, teacher activities at 72.53%, and student activities at 64.62%, all below the 80% success indicator. After improvements in Cycle II, significant increases were observed to 83.3% (concept understanding), 96.07% (teacher activities), and 97.7% (student activities), with 20 out of 24 students (83.3%) achieving KKM completeness. In conclusion, AR-based learning media effectively enhances students' mathematical concept understanding. This improvement is supported by more interactive learning activities and optimal teacher management.

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INTRODUCTION

Mathematics is a branch of science that studies concepts which enable students to be actively involved in discovering concepts, applying them, and solving mathematical problems (M. Ismail et al., 2025). The fundamental goal of mathematics learning is conceptual understanding.

When students understand mathematical concepts, they are able to solve problems in learning more easily. Conceptual understanding allows students to relate and solve problems by using the concepts they have learned (Sakinah & Astriani, 2024). With the ability to understand concepts, students do not merely memorize formulas, but are able to truly comprehend the meaning of mathematical material (Sari et al., 2022).

According to Lestari et al (2023), mathematical conceptual understanding is one of the basic competencies in learning mathematics, which includes the ability to absorb a theory, remember formulas and mathematical concepts and apply them to similar cases, estimate the validity of a statement, and apply formulas and theorems in problem solving. The ability to understand mathematical concepts is also the first essential ability required to achieve systematic instructional goals.

The success of mathematics learning can be seen from the level of students' understanding, mastery of the material, and learning achievement. The higher the level of understanding, mastery of the material, and student achievement, the higher the level of learning success (Kurniyanthi et al., 2019). However, in reality, the success of mathematics learning achieved by students is still low. According to Pauweni et al (2019), an unstable understanding of concepts will cause students to experience difficulties in solving problems. Students are suspected to still have difficulty determining which formula should be used when solving problems if they rely solely on memorization without understanding the concepts. One of the factors causing students lack of conceptual understanding of the material is the suboptimal use of learning media. Lecture-based methods that are not balanced with the use of instructional media often make it difficult for students to visualize mathematical concepts. This is in line with the findings of Riyadi et al (2025), who suggest that one of the reasons students struggle to understand concepts is the suboptimal use of learning media. Many students feel supported when teachers utilize learning aids; unfortunately, this is not consistently practiced and is often rare in daily sessions. Consequently, students miss the opportunity to develop a deeper conceptual understanding and are forced to rely solely on verbal instructions or notes on the whiteboard

The low level of students mathematical conceptual understanding can be observed at one school in Botupingge District, namely SMP Negeri 1 Botupingge. Based on the results of initial observations and interviews with mathematics teachers at the school, it was found that class VIII-C in particular still has a low level of mathematical conceptual understanding of cube and block material. This is based on students' daily test scores on cube and block material in the 2021/2022, 2022/2023, and 2023/2024 academic years, where the mastery percentage remained at 28.57%. Many students have not yet reached the minimum mastery criterion (KKM) set by the school, which is 75. This is supported by data from the daily test score lists for cube and block material in class VIII-C at SMP Negeri 1 Botupingge.

Factors contributing to the low level of students conceptual understanding in class VIII-C at SMP Negeri 1 Botupingge in mathematics, particularly on cube and block material, include students feeling bored with monotonous learning, limited use of learning media, teachers generally using only textbooks and the blackboard as the main learning resources, less relevant learning methods that rely solely on lectures, students mostly memorizing formulas without understanding the material so that they forget when facing problems, lack of student attention during learning, low student response and activity in the learning process, and limited ability of students to express ideas or opinions during instruction. Field facts indicate that the suboptimal use of learning media also contributes to the low level of students' mathematical conceptual understanding, because conventional learning makes students feel bored and have difficulty understanding the material in depth. This is in line with research conducted by Utami (2025)

the lack of use of learning media causes students to experience difficulties in understanding concepts, which in turn affects their ability to comprehend mathematical concepts.

To overcome this problem, solutions are needed to improve students' mathematical conceptual understanding skills. One solution to enhance students' mathematical conceptual understanding is the use of appropriate learning media, one of which is Augmented Reality–based learning media. According to Mursyidah and Saputra (2022), Augmented Reality (AR) is a technology that integrates 2D or 3D virtual objects into a real 3D environment and projects these virtual objects in real time. By utilizing AR, students can interact with three-dimensional geometric models in a more concrete manner, which is expected to help them better understand difficult concepts.

Several studies have explored the potential of AR in influencing the understanding of mathematical concepts. AR can enhance students' understanding of spatial geometry by providing interactive visual representations (Sheharyar et al., 2020). AR can help students visualize abstract mathematical concepts and improve their problem-solving skills (Cai et al., 2019). AR can also be used to increase student engagement in mathematics lessons, making the material more interesting and relevant to them, thereby facilitating the understanding of mathematical concepts (Zhang et al., 2023).

Based on the explanation above, the researcher is interested in conducting classroom action research with the aim of determining whether the use of Augmented Reality–based learning media can improve students' mathematical conceptual understanding abilities on cube and block material in class VIII-C of SMP Negeri 1 Botupingge.

METHOD

The type of research used in this study is Classroom Action Research (CAR) employing the model proposed by Stephen Kemmis and McTaggart (Abdillah et al., 2021). The Classroom Action Research design based on the Stephen Kemmis and McTaggart model involves several stages, namely planning, action, observation, and reflection. The subjects of this study were students of class VIII-C at SMP Negeri 1 Botupingge. The selection of this class was based on the results of preliminary observations, which indicated a low level of students' mathematical conceptual understanding. To obtain research data, two data collection techniques were employed, namely observation and tests. The data analysis techniques used in this study include:

Analysis of Observation Data on Teacher and Student Activities

In the analysis of observation data on teacher and student activities (Kosilah & Septian, 2020), the formula used to calculate the average percentage is:

$$\text{Average} = \frac{\text{obtained score}}{\text{maximum score}} \times 100\%$$

The observation results are then categorized based on specific criteria according to the table below.

Table 1. Criteria for Observasion Results of Teacher and Student Activities

Percentage Result Range	Criteria
85% - 100%	Very Good
75% - 84%	Good
61% - 74%	Fairly Good
0% - 60%	Less Good

(E. Ismail et al., 2025)

Analysis of Mathematics Concept Understanding Test Data

Analysis was also conducted on the test results of students' mathematics concept understanding abilities. To calculate the average score, the researcher used the average percentage formula:

$$\text{Average} = \frac{\text{Total student test score}}{\text{Number of students taking the test}} \times 100\%$$

Meanwhile, the results of students' mathematics concept understanding abilities were calculated using the formula (Hubulo et al., 2022) as follows:

$$\text{Percentage of student concept mastery aspect} = \frac{\text{obtained score}}{\text{maximum score}} \times 100\%$$

Table 2. Criteria for Mathematics Concept Understanding

Score Range	Criteria
> 70%	High
$55\% \leq x \leq 70\%$	Medium
< 55%	Low

(Baina et al., 2022)

Then, to determine the improvement in students' mathematics concept understanding results, the researcher calculated using the classical completeness percentage formula:

$$\text{Classical Completeness} = \frac{\text{Number of students who completed}}{\text{Total number of students in the class}} \times 100\%$$

With the following student completeness criteria:

Table 3. Student Completeness Criteria

Score	Criteria
< 75	Incomplete
≥ 75	Complete

To determine whether the research was successful, the following success indicators were established:

1. At least 80% of the observation results across all aspects of teacher and student learning activities achieve a minimum "Good" criterion.
2. At least 80% of students achieve mastery of mathematical concepts, with learning completeness scores of at least 75.

RESULTS AND DISCUSSIONS

Results

This Classroom Action Research was conducted in Class VIII-C at SMP Negeri 1 Botupingge, involving 24 students as research subjects. The research aims to improve students' mathematical concept understanding abilities, specifically on the material of cubes and blocks, using Augmented Reality-based learning media. The research was carried out in September 2025 through two cycles: the first cycle (two meetings for material and one meeting for the test) and the second cycle (two meetings for material and one meeting for the test). The data includes observations of teacher activities, student activities, and test results on students' mathematical concept understanding abilities.

Cycle I*Observation Result of Teacher Activities*

The observation results of teacher activities in Cycle I covered 25 assessment aspects: 7 preliminary aspects, 13 core aspects, and 5 closing aspects. The following table shows the observation results of teacher activities in Cycle I for Meetings 1 and 2.

Table 4. Results of Teacher Activity Observation in Cycle I

Assessment Criteria	Percentage of Number of Aspects				Average
	Meeting 1		Meeting 2		
	Number of Aspects	Percentage	Number of Aspects	Percentage	
Very Good	4	16%	4	15,38%	15,69%
Good	14	56%	15	57,69%	65,845%
Fairly Good	6	24%	7	26,93%	25,465%
Less Good	1	4%	0	0%	2%
Total	25	100%	26	100%	100%

Based on Table 4 above, it shows that the observation results of teacher activities in managing learning using Augmented Reality-based learning media with the available lesson plan implementation, the teacher's ability to manage learning in Cycle I for the first and second meetings achieved "Good" and "Very Good" criteria at 72.53%. This indicates that the observation results of teacher activities during the Cycle 1 learning process using Augmented Reality-based learning media have not yet reached the predetermined success indicator of 80%. Therefore, teacher activities need to be improved in the next cycle to achieve the established success indicator.

Observation Results of Student Activities

The following table shows the data from the observation results of student activities, covering 25 assessment aspects during the learning process using Augmented Reality-based learning media, including 7 preliminary aspects, 13 core aspects, and 5 closing aspects.

Table 5. Results of Student Activity Observation in Cycle I

Assessment Criteria	Percentage of Number of Aspects				Average
	Meeting 1		Meeting 2		
	Number of Aspects	Percentage	Number of Aspects	Percentage	
Very Good	2	8%	1	3,846%	5,923%
Good	13	52%	17	63,384%	58,629%
Fairly Good	9	36%	8	30,769%	33,339%
Less Good	1	4%	0	0%	2%
Total	25	100%	26	100%	100%

From the table above, it shows that the student activity assessment results during the learning process using Augmented Reality-based learning media, with "Good" and "Very Good" criteria, reached 64.615%. Thus, this indicates that the observation results of student activities during the learning process using Augmented Reality-based learning media have not yet reached the

predetermined success indicator of 80%. Therefore, student activities need to be improved in the next cycle to achieve the established success indicator.

Student Test Results

In Cycle 1, the researcher administered a written test to 24 students with a total of 6 questions. Individual completeness aligns with the established success indicator, namely a minimum of 80% achieving the Minimum Competency Criterion (KKM) score of 75. The recapitulation of the percentage of test completeness for students' mathematical concept understanding results in Cycle 1 is presented in the following table.

Table 6. Recapitulation of Percentage of Mastery Test Results on Students' Mathematical Concept Understanding in Cycle I

Score	Number of Students	Percentage	Completeness
≥ 75	11 students	45,83%	Complete
< 75	13 students	54,16%	Incomplete
Total	24 students	100%	

Based on the table above, the mathematics concept understanding test results after using Augmented Reality (AR)-based learning media show that from the analysis conducted by the researcher on 24 students, 11 students achieved completeness with a percentage of 45.83% (scores ≥ 75), while 13 students did not achieve completeness with a percentage of 54.16% (scores < 75). This indicates that the learning process needs improvement as it has not yet reached the established success indicator.

Cycle II

Observation Results of Teacher Activities

Based on the observation results of teacher activities during the learning process in Cycle II, the first meeting consisted of 25 assessment aspects: 7 preliminary activity aspects, 13 core activity aspects, and 5 closing activity aspects. Then, for the second meeting, it consisted of 26 assessment aspects: 7 preliminary activity aspects, 14 core activity aspects, and 5 closing activity aspects. Thus, the observation results of teacher activities in Cycle II are presented in the following table.

Table 7. Results of Teacher Activity Observation in Cycle II

Assessment Criteria	Percentage of Number of Aspects				Average
	Meeting 1		Meeting 2		
	Number of Aspects	Percentage	Number of Aspects	Percentage	
Very Good	8	32%	11	42,30%	35,15%
Good	17	68%	14	53,84%	60,92%
Fairly Good	0	0%	1	3,84%	3,92%
Less Good	0	0%	0	0%	0%
Total	25	100%	26	100%	100%

Based on the table above, the observation results of teacher activities in Cycle II during learning using Augmented Reality-based learning media, with "Good" and "Very Good" criteria, reached 96.07%. The aspects that were not optimal in Cycle I have been improved in Cycle II. Thus, this shows that the observation results of teacher activities during the learning process in

Cycle II using Augmented Reality-based learning media have achieved the predetermined success indicator of 80%.

Observation Results of Student Activities

The table below presents the observation results of student activities during Cycle II. The first meeting consisted of 25 assessment aspects: 7 preliminary activity aspects, 13 core activity aspects, and 5 closing activity aspects. Then, for the second meeting, it consisted of 26 assessment aspects: 7 preliminary activity aspects, 14 core activity aspects, and 5 closing activity aspects.

Table 8. Results of Student Activity Observation in Cycle II

Assessment Criteria	Percentage of Number of Aspects				Average
	Meeting 1		Meeting 2		
	Number of Aspects	Percentage	Number of Aspects	Percentage	
Very Good	8	32%	14	53,84%	42,92%
Good	16	64%	12	46,15%	55,07%
Fairly Good	1	36%	0	0%	2%
Less Good	0	4%	0	0%	0%
Total	25	100%	26	100%	100%

From the table above, it shows that the student activity assessment results during the learning process using Augmented Reality-based learning media in Cycle II, with "Good" and "Very Good" criteria, reached 97.9%. Thus, this indicates that the observation results of student activities during the learning process using Augmented Reality-based learning media in Cycle II have achieved the predetermined success indicator of 80%.

Student Test Results

In Cycle II, the researcher administered a written test to 24 students with a total of 5 questions. Individual completeness aligns with the established success indicator, namely a minimum of 80% achieving the Minimum Competency Criterion (KKM) score of 75. The percentage results of test completeness for students' mathematical concept understanding abilities in Cycle II are presented in the following table.

Table 9. Recapitulation of Percentage of Mastery Test Results on Students' Mathematical Concept Understanding in Cycle II

Score	Number of Students	Percentage	Completeness
≥ 75	20 students	83,3%	Complete
< 75	4 students	16,6%	Incomplete
Total	24 students	100%	

Based on the table above, the mathematics concept understanding test results after using Augmented Reality (AR)-based learning media show that 20 students (83.3%) achieved completeness (scores ≥ 75), while 4 students (16.6%) did not achieve completeness (scores < 75). Thus, the learning process using Augmented Reality-based learning media was successful, as the students' mathematics concept understanding test results have met the action success indicator, namely that the assessment of mathematics concept understanding shows that at least 80% of all students achieved the Minimum Competency Criterion (KKM) of 75.

Discussions

In Cycle I, the learning results showed that teacher activities during learning using Augmented Reality-based learning media achieved a fairly good success level. Similarly, student activities also reached the fairly good category according to observation results. However, students' mathematical concept understanding abilities did not meet the established success indicator of 80%. From the total of 24 Class VIII-C students, only 11 students achieved completeness, while 13 others did not meet the completeness criteria. The use of Augmented Reality-based learning media in Cycle I had not yet achieved optimal results. Therefore, the researcher and teacher agreed to proceed to Cycle II to improve the aspects that were not achieved in Cycle I.

In Cycle II, the observation results of teacher activities in managing learning using Augmented Reality-based learning media showed that all aspects met good to very good criteria, as did student activities. This occurred because several suboptimal aspects from Cycle I, both in teacher and student activities, were improved in Cycle II. Improvement was also evident in students' mathematical concept understanding abilities, where the number of students not meeting completeness decreased from 13 students (54.16%) to 4 students (16.6%).

Similar results were found in research by Ardiningtyas and Azis (2024), who developed AR-Geo modules for high school students. They reported that after AR use, the number of students scoring below KKM decreased significantly, along with substantial improvement in spatial abilities. This success was also influenced by the quality of teacher management and active student engagement during learning. Individual support should be provided to students who have not achieved completeness. This aligns with research by Widyasari and Mastura (2020), who stated that AR media greatly helps students understand geometry concepts, but differentiated learning approaches are still needed for students with learning difficulties or below-average abilities.

Comparable findings emerged from Buchori et al (2024), who developed interactive AR-GeoGebra media for transformation geometry in a blended learning context. Their study showed high validity (90%) and practicality, with an N-gain of 0.39 in spatial understanding for the experimental group, far surpassing the control group, emphasizing AR's role in effective geometry visualization when integrated well. Likewise, Mandala et al (2025) created GEMBI AR, a mobile game for eighth graders' spatial reasoning in geometry. Post-intervention tests revealed moderate N-gain improvements (0.576) in spatial perception, mental rotation, and visualization, confirming AR's practicality and positive impact, though teacher feedback highlighted the need for guided implementation. Further support comes from Abd Rahman & Abd Halim (2025) whose review of AR in geometry noted enhanced achievement, visualization, and motivation via 3D interactions. They stressed that AR bridges abstract concepts to real-world applications but requires addressing challenges like device access for equitable gains.

CONCLUSION

From the research results, it can be concluded that using Augmented Reality (AR)-based learning media can improve the mathematical concept understanding abilities of Class VIII-C students at SMP Negeri 1 Botupingge on cube and block material. This can be seen from teacher activities improving from Cycle I to Cycle II, from 72.53% to 96.07%, and student activities from 64.615% to 97.7%. Meanwhile, students' mathematical concept understanding abilities improved from 56.675% in Cycle I to 83.3% in Cycle II. Thus, the success indicators for teacher activities, student activities, and students' mathematical concept understanding abilities have been achieved according to the target of 80%. Therefore, learning using Augmented Reality-based learning media has a positive impact and potential in enhancing students' mathematical concept understanding abilities. Future research is recommended to explore AR-based learning

media on other solid geometry topics as well as students' mathematical problem solving abilities.

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