



## Ethnomathematics-Based Student Worksheets Assisted by Augmented Reality (AR) GeoGebra to Improve Mathematics Learning Outcomes

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**Abstract:** This study aimed to develop and evaluate ethnomathematics-based student worksheets assisted by Augmented Reality (AR) GeoGebra to enhance students' understanding of three-dimensional geometry. Using a Research and Development (R&D) approach with the ADDIE model, the student worksheet was validated by media and material experts, tested for practicality through student response questionnaires, and evaluated for effectiveness using N-Gain analysis based on pre-test and post-test results. Thirty-one junior high school students participated, divided into an experimental class (n = 15) and a control class (n = 16). The developed student worksheet demonstrated high validity—88.33% from the media expert and 91.28% from the material expert—and excellent practicality (88.13%). The experimental class achieved a higher N-Gain score of 0.78 (high category) than the control class's 0.48 (moderate category), with the difference significant at the 0.05 level. These findings indicate that the AR-integrated GeoGebra student worksheet is valid, practical, and effective in improving students' conceptual understanding and learning outcomes, offering a meaningful integration of technology and culture in mathematics education.

**Keywords:** augmented reality; development; geogebra; learning outcomes; student worksheet

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### INTRODUCTION

Mathematics is widely recognized as a fundamental yet challenging subject due to its high level of abstraction, particularly in three-dimensional geometry, where students often struggle to visualize and understand spatial relationships. Numerous studies have documented students' struggles in comprehending geometric concepts as they tend to rely on rote memorization of formulas without adequate conceptual grounding (Saripah & Fitrianna, 2021). These difficulties are further exacerbated by limited spatial reasoning, weak deductive reasoning, and low creative problem-solving abilities when dealing with geometric problems (Sahara & Nurfauziah, 2021). Additionally, classroom observations reported in recent research indicate that many schools still rely heavily on conventional instructional materials, such as printed textbooks and static two-dimensional images, which are insufficient for illustrating the complex properties of three-dimensional objects (Lestari & Dafik, 2025). This mismatch between instructional needs and learning resources contributes significantly to the persistence of students' misconceptions in geometry, underscoring the urgent need for more interactive, visually supported instructional media.

The integration of digital technology in education has been shown to enhance student engagement, facilitate conceptual understanding, and foster collaborative learning environments. Recent studies highlight that increasing students' access to mobile devices provides an opportunity to leverage technology for more effective, interactive learning (Buchori et al., 2024). Technological integration is particularly beneficial in subjects that require strong visualization, such as geometry, because it enables dynamic representations and real-time manipulation of objects that are not possible with traditional methods (Istofany et al., 2024). Furthermore, technology-enhanced learning environments have been found to improve student motivation, increase classroom participation, and support deeper cognitive processing (Purwaningrum & Faradillah, 2020). Therefore, the adoption of appropriate digital tools is essential for addressing existing gaps in students' mathematical understanding. One significant advancement in educational media is Augmented Reality (AR). According to Mustaqim (2016), AR blurs the boundary between the physical and virtual worlds, delivering digital content directly onto real-world objects. As a learning medium, AR offers interactivity that can increase students' engagement through experiential learning. AR enables multi-sensory interaction, which contributes to stronger conceptual understanding. Prior research supports the claim that AR-based mathematics learning enhances students' visualization abilities and helps them conceptualize difficult-to-imagine objects using conventional methods.

GeoGebra, an interactive mathematics software derived from the words "geometry" and "algebra," also features AR capabilities and supports visualization and conceptual development in mathematics (Fazar, 2022). When properly implemented, GeoGebra can enhance learning outcomes. Riyan (2021) emphasized that

appropriate alignment between instructional media and subject content leads to more effective learning. GeoGebra is also freely accessible and compatible with various devices, increasing its usability. Although previous research has explored AR and GeoGebra, most studies examined them separately or only as visualization aids, creating a research gap that underscores the need to integrate them directly into structured learning materials, such as student worksheets.

Observations at SMP Kesatrian 2 Semarang indicated that students were often disengaged and demonstrated low participation in mathematics classes. An interview with the mathematics teacher revealed that students tended to memorize rather than understand, resulting in low academic achievement. Instruction at the school primarily followed a teacher-centered approach. [Rozali et al. \(2022\)](#) found that teacher-centered learning limits student participation, promotes one-way communication, and emphasizes content delivery over student comprehension. Additionally, AR-based instructional media had not yet been introduced at the school. These findings reinforce the urgency of developing new instructional materials that are interactive, technology-assisted, and capable of increasing student engagement. To address these challenges, this study proposes the development of student worksheets for AR-assisted learning using GeoGebra. The integration of AR into student worksheets is expected to improve interactivity, engagement, and instructional effectiveness ([Novika, 2025](#)). This approach aligns with current technological trends and addresses gaps identified in previous studies that have not yet investigated the integration of AR and GeoGebra within an ethnomathematics-based student worksheet format designed for junior high school geometry learning ([Nadzri et al., 2023](#)).

Previous studies have shown that AR can enhance learning outcomes in geometry by improving visualization, strengthening memory retention, and providing immersive learning experiences ([Nadzri et al., 2023](#)). Other studies have reported positive student responses and increased interactivity through AR-based geometry applications, highlighting AR's potential to improve understanding of complex concepts ([Rohendi et al., 2025](#)). Furthermore, [Ruslau et al. \(2025\)](#) demonstrated that AR in GeoGebra can significantly support students' development of geometric thinking. AR can be utilized in mobile learning to enhance both the efficiency and effectiveness of mathematics instruction ([Maulida et al., 2024](#)). However, despite these advances, a clear research gap remains: no previous study has combined AR, GeoGebra, and ethnomathematics into a single, structured student worksheet to improve junior high school geometry learning.

Geometry learning, particularly on the topics of cubes and rectangular prisms, has great potential for contextualization through an ethnomathematics approach. Ethnomathematics-based e-modules make mathematics learning more meaningful and relevant by linking mathematical concepts with local culture ([Kurniasari et al., 2018](#)). A contextual and culturally relevant learning strategy can enhance students' understanding of mathematics in everyday life ([Putra & Ramdhani, 2025](#)). Thus, integrating ethnomathematics into geometry learning not only connects students to real-life contexts but also provides cultural meaning that enriches conceptual understanding. Therefore, the development of this student worksheet also incorporates elements of local culture. While most existing studies have explored AR and GeoGebra separately and primarily as visual aids, this study offers a novel approach by integrating AR directly into GeoGebra within a student worksheet format enriched with ethnomathematics elements. Accordingly, the present study seeks to examine: (a) the validity of student worksheets integrated with Augmented Reality (AR) GeoGebra, (b) their practicality within junior high school mathematics instruction, and (c) their effectiveness in enhancing students' learning outcomes.

## METHODS

This research employed a Research and Development (R&D) approach guided by the ADDIE instructional model, comprising the Analysis, Design, Development, Implementation, and Evaluation stages ([Sutarni et al., 2024](#)). Each stage was conducted as follows: 1) The Analysis stage involved identifying students' learning needs and difficulties in understanding three-dimensional geometry concepts, along with determining relevant instructional solutions; 2) The Design stage focused on developing instructional media in the form of student worksheets (student worksheet) assisted by Augmented Reality (AR) using GeoGebra. At this stage, ethnomathematical elements were integrated through contextual examples and visual illustrations inspired by local Javanese architecture and batik geometric motifs, allowing abstract geometry concepts to be connected with students' cultural and real-life contexts; 3) During the Development stage, the student worksheet and related research instruments were produced and validated by two experts one media expert and one material expert—to ensure content quality and visual feasibility; 4) The Implementation stage involved applying the AR-assisted GeoGebra student worksheet in the experimental class; 5) The Evaluation stage assessed the validity, practicality, and effectiveness of the developed media based on data from validation results, student responses, and pre-test-post-test outcomes.

The study was conducted at SMP Kesatrian 2 Semarang during the second semester of the 2024/2025 academic year. The participants were 31 eighth-grade students: 15 in the experimental class who used the AR-assisted GeoGebra student worksheet and 16 in the control class who were taught using traditional methods. Class selection employed cluster sampling, ensuring that students had similar initial academic abilities. The

learning topic developed was three-dimensional shapes with flat surfaces.

The data were collected using three main instruments: 1) validation sheets, student response questionnaires, and learning outcome tests. The validation sheets were designed to assess the feasibility of the media in terms of general appearance, design, content, language, and practicality; 2) Student response questionnaires were used to evaluate the practicality of the student worksheet after classroom use. Learning outcome tests, consisting of pre-tests and post-tests in essay format; 3) were developed according to learning indicators to measure the effectiveness of the media in improving students' achievement.

The interpretation of validation scores and student response results was based on a qualitative conversion system that categorized percentage ranges into specific criteria. A score of 81% to 100% was classified as Excellent, indicating that the assessed component met the highest level of quality. A percentage score between 61% and 80% fell into the good category, reflecting that the media or instrument performed well with only minor aspects requiring improvement. Scores between 41% and 60% were categorized as Fair, indicating that the evaluated component demonstrated moderate quality and required several enhancements. Meanwhile, scores in the 21% to 40% range were categorized as Poor, revealing that essential aspects were inadequate and required substantial revision. The lowest category, Very Poor, was assigned to scores between 0% and 20%, indicating that the component was not feasible without major modifications. The validation instruments and student response questionnaires were constructed using a 5-point Likert scale with responses ranging from Strongly Disagree to Strongly Agree (Sugiyono, 2017).

Data analysis in this study involved several stages. First, validity data from expert evaluation sheets were analyzed using percentage calculations and subsequently classified according to the qualitative criteria described above. Second, practicality data obtained from student response questionnaires after the implementation phase were analyzed using the same conversion system to maintain consistency between the two assessments. Third, to measure effectiveness, the N-Gain test was used to compare students' pre-test and post-test scores and determine the level of improvement in learning outcomes.

Before conducting the effectiveness analysis, prerequisite statistical tests were administered. The Liliefors normality test was used to determine whether the sample data followed a normal distribution, with the hypotheses formulated as follows (Budiyono, 2016):  $H_0$ : the sample follows a normal distribution;  $H_1$ : the sample does not follow a normal distribution.

The homogeneity test was performed to verify whether the sample was derived from a population with homogeneous variance. The hypotheses for the test were stated as follows (Budiyono, 2016):  $H_0$ : The population from which the sample is drawn has equal variances;  $H_1$ : The population from which the sample is drawn has unequal variances.

Additionally, the Bartlett homogeneity test was conducted to verify whether the sample originated from a population with homogeneous variance, using the hypotheses:  $H_0$  — the population has equal variances;  $H_1$  — the population has unequal variances (Budiyono, 2016). After fulfilling the prerequisite conditions, the N-Gain score was calculated using Equation (1) to assess improvement in students' learning outcomes.

**Table 1.** Interpretation of the N-Gain Index

| Gain (g) Score        | Criteria |
|-----------------------|----------|
| $g > 0,7$             | High     |
| $0,3 \leq g \leq 0,7$ | Medium   |
| $g < 0,3$             | Low      |

Furthermore, the effectiveness percentage was interpreted using standard criteria: values below 40% are categorized as not effective, percentages between 41% and 55% are considered less effective, scores of 56% to 75% indicate moderate effectiveness, and percentages above 76% are categorized as effective. These classifications were used to interpret improvements in student learning outcomes following the implementation of the AR-assisted GeoGebra student worksheet.

## RESULT AND DISCUSSION

This study employed a Research and Development (R&D) approach using the ADDIE model, which consists of five systematic phases: Analysis, Design, Development, Implementation, and Evaluation. Each phase was carried out sequentially to ensure the feasibility, practicality, and effectiveness of the developed learning media. The Analysis stage was conducted to examine students' needs and identify learning difficulties in three-dimensional geometry. Observations and interviews with the eighth-grade mathematics teacher at SMP Kesatrian 2, Semarang City, conducted from May 12–22, 2025, served as an initial diagnostic step. The analysis revealed that learning remained teacher-centered, relying heavily on textbooks and lacking the use of innovative, technology-based media such as Augmented Reality (AR) and GeoGebra. These limitations led to

low levels of student interaction, motivation, and conceptual understanding.

Therefore, the researcher developed ethnomathematics-based Student Worksheets (student worksheets) assisted by AR GeoGebra, following the Problem-Based Learning (PBL) approach, to create a more interactive and meaningful learning experience. The student worksheet was designed using Canva and the GeoGebra 3D Calculator, which includes AR functionality accessible via smartphones to support student-centered, technology-integrated learning. During the Design stage, the prototype student worksheet was structured according to the learning objectives and PBL syntax. The structure consisted of a cover page, introduction, learning objectives, instructions for using the GeoGebra 3D Calculator, PBL syntax, and practice exercises. The learning materials on three-dimensional shapes with flat surfaces were developed with contextual illustrations and ethnomathematical integration, such as batik geometric motifs and traditional Javanese architectural elements, to connect mathematical concepts with local culture and enhance conceptual relevance.

Research instruments, including expert validation sheets, student response questionnaires, and pre-test–post-test essay items, were also prepared. In the Development stage, the student worksheet and research instruments were developed and validated by two experts: a media expert and a materials expert. Validation used a 5-point Likert scale and was analyzed using percentage calculations to determine feasibility and quality. The introductory section presents the student worksheet cover, the material title, the learning objectives, the time allocation, and the usage instructions. It also introduces the topic and provides preliminary activities intended to activate students' prior knowledge before they engage with the main content. The core section is organized into three learning sessions following the syntax of the PBL model: (1) definitions and nets of three-dimensional shapes, (2) surface area, and (3) volume. Each session includes guided steps for utilizing AR GeoGebra to strengthen conceptual understanding through interactive visualization. This section contains guided activities that promote conceptual exploration, problem-solving, and manipulation of three-dimensional objects in AR.

The final section of the student worksheet provides evaluation tasks designed to measure students' cognitive understanding of the material after completing the learning activities. These questions were developed to train students' reasoning and to assess their comprehension of spatial geometry concepts in a contextual, problem-based framework. The AR feature can be accessed by creating a 3D model of a polyhedral shape and activating AR mode. The three-dimensional object appears within the real environment through the device's camera, enabling students to observe it from multiple angles and interact with it as though it were physically present, thereby supporting deeper conceptual understanding and enhancing spatial reasoning.

**Table 2.** Validation of AR GeoGebra-Assisted student worksheet by Media Expert

| Assessed Aspect     | Score Obtained | Maximum Score | Feasibility Percentage | Category  |
|---------------------|----------------|---------------|------------------------|-----------|
| General             | 53             | 60            | 88.33%                 | Very Good |
| Design              | 68             | 75            | 90.67%                 | Very Good |
| Content             | 52             | 60            | 86.67%                 | Very Good |
| Language & Literacy | 53             | 60            | 88.33%                 | Very Good |
| Media Practicality  | 39             | 45            | 86.67%                 | Very Good |
| Total               | 265            | 300           | 88.33%                 | Very Good |

**Table 3.** Validation of AR GeoGebra-Assisted student worksheet by Content Expert

| Assessed Aspect   | Score Obtained | Maximum Score | Feasibility Percentage | Category  |
|-------------------|----------------|---------------|------------------------|-----------|
| Content Substance | 69             | 75            | 92%                    | Very Good |
| Language          | 40             | 45            | 88.89%                 | Very Good |
| Usefulness        | 69             | 75            | 92%                    | Very Good |
| Total             | 178            | 195           | 91.28%                 | Very Good |

The media expert's evaluation yielded a score of 88.33%, categorized as "Very Good," indicating that the student worksheet is feasible for a trial implementation. In parallel, the material expert's evaluation yielded a score of 91.28%, placing it in the "Very Good" category and indicating that the content is suitable for classroom use. Accordingly, the Augmented Reality (AR) GeoGebra-assisted student worksheet developed in this study fulfills the required validity criteria. The validation process was conducted to ensure the feasibility and content accuracy of the developed learning media.

The media expert's evaluation yielded a score of 88.33%, categorized as "Very Good," indicating that the AR-assisted GeoGebra student worksheet is feasible for classroom implementation. Similarly, the material expert's assessment yielded a score of 91.28%, also categorized as "Very Good," indicating that the learning content, structure, and contextual integration are appropriate for use in mathematics instruction. Based on these results, it can be concluded that the Augmented Reality (AR) GeoGebra-assisted student worksheet meets the validity criteria, both in terms of media design and content quality, and is ready for practical implementation in the learning process.

The Implementation phase was carried out to test the practicality and effectiveness of the developed media through a limited classroom trial. This phase began with an item analysis conducted in Class IX A, which had previously learned the topic of *Three-Dimensional Shapes with Flat Surfaces*. The test instruments were evaluated based on four essential criteria: validity, reliability, level of difficulty (easy, medium, or difficult), and discriminating power (fair, good, or very good). The summary of the test item analysis results is presented in Table 4.

**Table 4.** Recap of Test Item Analysis Results

| Validitas |          | Reabilitas |          | Discrimination |           | Difficulty |          | Note     |
|-----------|----------|------------|----------|----------------|-----------|------------|----------|----------|
| Score     | Criteria | Score      | Criteria | Score          | Criteria  | Score      | Criteria |          |
| 0.541     | Invalid  | 0.795      | Reliable | 0.222          | Fair      | 0.872      | Easy     | Not Used |
| 0.307     | Invalid  |            |          | 0.125          | Poor      | 0.725      | Easy     | Not Used |
| 0.154     | Invalid  |            |          | 0.050          | Poor      | 0.938      | Easy     | Not Used |
| 0.644     | Valid    |            |          | 0.455          | Good      | 0.650      | Moderate | Used     |
| 0.581     | Valid    |            |          | 0.385          | Fair      | 0.757      | Easy     | Used     |
| 0.525     | Invalid  |            |          | 0.250          | Fair      | 0.857      | Easy     | Not Used |
| 0.662     | Valid    |            |          | 0.688          | Good      | 0.731      | Easy     | Used     |
| 0.688     | Valid    |            |          | 0.875          | Very Good | 0.454      | Moderate | Used     |
| 0.838     | Valid    |            |          | 0.875          | Very Good | 0.569      | Moderate | Used     |
| 0.710     | Valid    |            |          | 0.950          | Very Good | 0.454      | Moderate | Used     |

Based on the criteria for item feasibility, six test items were identified as meeting the established requirements: 4, 5, 7, 8, 9, and 10. These selected items demonstrated acceptable levels of validity, reliability, discrimination, and difficulty, and were therefore implemented in both the experimental and control classes during the product trial. Following instrument validation and selection, a pre-test was administered to both the experimental and control classes to determine students' initial understanding of the material. The results of the normality test indicated that the data from the experimental class ( $L_{count} = 0.166 < L_{table} = 0.220$ ) and the control class ( $L_{count} = 0.205 < L_{table} = 0.213$ ) were normally distributed. Furthermore, the homogeneity test results ( $B_{count} = 0.979 > B_{table} = 0.935$ ) confirmed that both classes were derived from populations with homogeneous variances, ensuring the reliability of the subsequent statistical comparisons.

The implementation of the developed product was conducted over three learning sessions. The experimental class received instruction using the Augmented Reality (AR)- assisted GeoGebra student worksheet, whereas the control class continued with traditional learning methods as a comparison. Upon completion of the treatment, a post-test was administered to both classes to evaluate students' final learning outcomes. The post-test normality test results showed that the data from the experimental class ( $L_{count} = 0.153 < L_{table} = 0.220$ ) and the control class ( $L_{count} = 0.120 < L_{table} = 0.213$ ) were also normally distributed. Similarly, the post-treatment homogeneity test results ( $B_{count} = 0.940 > B_{table} = 0.935$ ) indicated that the variances of both classes remained homogeneous, thus validating the statistical integrity of the results.

To measure the effectiveness of the developed learning media, the N-Gain method proposed by Hake (Maulida et al., 2024) was employed by comparing pre-test and post-test scores across both classes. The experimental class recorded an average N-Gain score of 0.78 (78%), categorized as *High*, indicating that the use of the AR GeoGebra-assisted student worksheet was effective in improving students' learning outcomes. In contrast, the control class achieved an average N-Gain score of 0.48 (48%), which was categorized as *Moderate*, suggesting that conventional learning was less effective at enhancing conceptual understanding. A detailed summary of the N-Gain analysis results is presented in Table 5.

**Table 5.** N-Gain Test Analysis Results

| Class        | Average | Percentage | Category | Meaning        |
|--------------|---------|------------|----------|----------------|
| Experimental | 0.78    | 78%        | High     | Effective      |
| Control      | 0.48    | 48%        | Low      | Less Effective |

The Evaluation stage was conducted to assess the overall quality of the developed product through field testing. The evaluated product was a student worksheet assisted by Augmented Reality (AR) GeoGebra, designed to enhance students' learning outcomes in geometry. The evaluation involved 15 students from the experimental class, who completed a student response questionnaire. The analysis of student responses produced an overall score of 88.13%, categorized as *"Very Good."* This result demonstrates that the developed AR-assisted GeoGebra student worksheet possesses a high level of practicality and is feasible for classroom implementation.

Based on the overall findings, the AR GeoGebra-assisted Mathematics learning media for junior high school were found to be valid, practical, and effective in improving students' learning outcomes. The validation results indicated that the learning media achieved a score of 88.33% from the media expert and 91.28% from

the material expert, both classified as "Very Good." These findings confirm that the learning media meet the validity standards required for educational implementation. According to [Sanaky \(2021\)](#), validity reflects the degree to which an instrument accurately measures the intended construct or variable. In a related study ([Sari & Sulisworo, 2023](#)), it was also demonstrated that an AR-based student worksheet is highly valid as instructional material due to its interactive, colorful, and engaging presentation, which motivates students to learn mathematics more effectively.

The developed AR GeoGebra-assisted student worksheet also proved effective in improving students' learning outcomes, as evidenced by the practicality test results from the student response questionnaire. The 88.13% practicality score, categorized as "Very Good," indicates that the media is easy to use, supports conceptual understanding, and provides an enjoyable learning experience. Practicality, as defined by [Milala et al. \(2022\)](#), refers to the level of accessibility and usability of learning media for teachers and students, enabling a learning process that is meaningful, engaging, and creativity-oriented. Similarly, [Damayanti and Sulisworo \(2022\)](#) found that AR-based student worksheets achieved a practicality level of 77%, supporting the claim that AR media provides flexibility and allows learning to take place at any time and place according to students' needs ([Mandala et al., 2025](#)).

The effectiveness of the AR GeoGebra-assisted learning media was confirmed through a one-tailed t-test, which showed that  $t_{count} = 1.726 > t_{table} = 1.699$ , leading to the rejection of  $H_0$ . This result indicates that the average learning outcomes in the experimental class were significantly higher than those in the control class. Moreover, the N-Gain analysis revealed that the experimental class achieved an average gain of 63% (Moderate), which was higher than the control class's 47% (Low). The learning mastery rate in the experimental class reached 73%, compared to 44% in the control class. These findings demonstrate that the AR GeoGebra-assisted student worksheet effectively enhances students' conceptual mastery and spatial reasoning in three-dimensional geometry. According to [Andini and Supardi \(2018\)](#), learning effectiveness is a purposeful process that enables students to acquire knowledge, skills, and attitudes in an engaging, goal-oriented manner. This finding aligns with [Arnoldus et al. \(2025\)](#), who reported that AR-based GeoGebra media significantly improved students' performance in learning solid geometry. Likewise, [Nindiasari et al. \(2024\)](#) confirmed that AR integration in mathematics instruction enhances students' problem-solving skills in geometry.

Compared with previous studies, the novelty of this research lies in integrating Augmented Reality and GeoGebra into an ethnomathematics-based student worksheet, which has not been widely explored in prior literature. Previous works typically examined AR or GeoGebra independently ([Sari & Sulisworo, 2023](#)), whereas this study successfully combines both technologies with cultural contextualization, thereby reinforcing conceptual understanding through interactive visualization. This integration is consistent with the findings of [Arnoldus et al. \(2025\)](#).

The impact and contribution of this study can be observed in three dimensions. Pedagogically, the AR-assisted GeoGebra student worksheet facilitates active learning, improved visualization, and reduced reliance on rote memorization, supporting previous evidence that AR fosters meaningful and enjoyable learning experiences ([Mandala et al., 2025](#)). Practically, the developed media aids teachers in implementing interactive, technology-oriented mathematics instruction, as suggested by [Damayanti and Sulisworo \(2022\)](#). Scientifically, this research provides empirical evidence of the effectiveness of AR-GeoGebra integration in enhancing students' spatial reasoning, learning gains, and conceptual understanding, supporting the findings of [Nindiasari et al. \(2024\)](#) that AR is instrumental in strengthening geometry learning and cognitive development.

## CONCLUSION

The ethnomathematics-based AR GeoGebra student worksheet developed in this study demonstrated high validity, practicality, and effectiveness in enhancing students' learning outcomes. Validation results showed scores of 88–91% in the "Very Good" category, while practicality reached 88% and was also categorized as "Very Good." The effectiveness test produced an N-Gain value of 0.78, indicating a high level of improvement in students' understanding of three-dimensional geometry. The integration of Augmented Reality and GeoGebra visualization successfully increased students' engagement, spatial reasoning, and conceptual comprehension. This media supports interactive, contextual, and technology-based learning in line with the Merdeka Curriculum. Teachers can apply it to create more engaging and meaningful learning experiences. In addition, this study provides empirical evidence of how AR and ethnomathematics can be integrated as an innovative approach in mathematics education. Future research is recommended to apply AR-assisted learning to other mathematical topics, larger samples, and long-term evaluations to measure its impact on students' critical and creative thinking.

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