PIONIR Jurnal Pendidikan
P-ISSN 2339-2495
E-ISSN 2549-6611

PIONIR: JURNAL PENDIDIKAN
VOLUME 15 No 1 2026
P-ISSN 2339-2495/E-ISSN 2549-6611

INTEGRATION OF AUGMENTED REALITY AND ETHNOMATHEMATICS: INNOVATION IN INTERACTIVE LEARNING MEDIA FOR SPATIAL GEOMETRY MATERIAL

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Received 22 January 2026, Accepted 21 April 2026, Published 30 April 2026

Abstract

The purpose of this study is to develop an interactive learning medium based on Augmented Reality (AR) and ethnomathematics for fifth-grade solid geometry at MIN 2 Pontianak, as well as to determine the validity and practicality of the developed medium. This study falls under the category of Research and Development (R&D), utilizing the 4D development model. The data sources for this study were fifth-grade teachers and students at MIN 2 Pontianak. Data collection techniques included interviews using a structured interview instrument as well as questionnaires consisting of a validity questionnaire and a practicality questionnaire. Data analysis techniques included validity analysis and practicality analysis. Based on the research results, during the definition phase, it was found that students require interactive visual media connected to the local cultural context. The design phase resulted in an AR-based media design that integrates traditional buildings such as the Pontianak Grand Mosque and the Radangk House to visualize the structures of cubes and blocks. The development phase demonstrated that this media is highly valid and practical, with a practicality score of 82.2%. During the dissemination phase, the media was distributed in the form of digital links via WhatsApp. Overall, this media is considered suitable for use because it effectively combines technology, culture, and students' learning needs.

Keywords: Media Development, Augmented Reality, Ethnomathematics, Spatial Construction

Abstrak

Tujuan penelitian ini adalah untuk mengembangkan media pembelajaran interaktif berbasis Augmented Reality (AR) dan etnomatematika untuk geometri ruang kelas lima di MIN 2 Pontianak, serta untuk menentukan validitas dan kepraktisan media yang dikembangkan. Penelitian ini termasuk dalam kategori Penelitian dan Pengembangan (R&D), menggunakan model pengembangan 4D. Sumber data untuk penelitian ini adalah guru dan siswa kelas lima di MIN 2 Pontianak. Teknik pengumpulan data meliputi wawancara menggunakan instrumen wawancara terstruktur serta kuesioner yang terdiri dari kuesioner validitas dan kuesioner kepraktisan. Teknik analisis data meliputi analisis validitas dan analisis kepraktisan. Berdasarkan hasil penelitian, pada fase definisi, ditemukan bahwa siswa membutuhkan media visual interaktif yang terhubung dengan konteks budaya lokal. Fase desain menghasilkan desain media berbasis AR yang mengintegrasikan bangunan tradisional seperti Masjid Agung Pontianak dan Rumah Radangk untuk memvisualisasikan struktur kubus dan balok. Fase pengembangan menunjukkan bahwa media ini sangat valid dan praktis, dengan skor kepraktisan sebesar 82,2%. Selama fase diseminasi, media didistribusikan dalam bentuk tautan digital melalui WhatsApp. Secara keseluruhan, media ini dianggap cocok untuk digunakan karena secara efektif menggabungkan teknologi, budaya, dan kebutuhan belajar siswa.

Kata kunci: Pengembangan Media, Realitas Tertambah, Etnomatematika, Konstruksi Spasial

INTRODUCTION

Students in the 21st century are expected to master critical thinking, creative thinking, collaboration, and communication skills, known as the 4Cs (Trilling & Fadel, 2009). To support these competencies, the learning process must be directed towards the use of technology and contextual approaches that can bridge abstract concepts to make them more tangible, meaningful, and relevant to students' daily lives.

One way to create interactive and meaningful learning is by designing technology-based learning media that helps students understand the material through enjoyable and interesting learning experiences. Media that can display concepts visually and interactively will have a positive influence on students' understanding of concepts and motivation to learn (Shaghaghian et al., 2024). In addition, the use of creative and innovative learning media can stimulate students' minds, emotions, attention, and interest, making the learning process more effective (Salsabila et al., 2023).

Azizah et al (2024) emphasize that the integration of Information and Communication Technology (ICT)-based learning media in mathematics learning is crucial to improve the quality of learning and provide effective guidance in the use of ICT media. One of the rapidly developing technologies with great potential for use in learning is Augmented Reality (AR).

AR is a technology that combines three-dimensional virtual objects with the real environment in real time, thereby creating a more interactive and immersive learning experience (Peddie, 2017). AR in mathematics learning can make it easier for students to understand abstract concepts by presenting them in a more concrete form, facilitating the exploration of mathematical objects, increasing appeal, and improving concept understanding. In line with Mailani et al (2024) in their research, which states that the use of AR in education has also been proven effective in strengthening the appeal of learning and supporting students' understanding of material that is difficult to visualize, including abstract and conceptual mathematics learning. In addition, Shaghaghian et al (2024) also stated that the use of AR has been proven effective in improving mathematical concept understanding, especially spatial concepts. Recent studies show that AR applications for understanding spatial concepts significantly maximize learning outcomes and student engagement.

Furthermore, meaningful learning can also be achieved through the integration of the ethnomathematics approach, which links mathematical concepts to elements of local culture. Learning that incorporates cultural elements allows students to understand mathematical concepts while instilling values of respect and preservation of local culture.

Sulisti et al (2025) states that the ethnomathematics approach provides a unique perspective by exploring how mathematical concepts are integrated into the culture and daily activities of a community. Ethnomathematics provides an opportunity for students to master mathematical concepts through cultural experiences and values that are closely related to their lives. According to Rustanuarsi et al (2025), this effort can be realized by connecting mathematical concepts with local cultures that are familiar to students. By connecting mathematical material with local wisdom values, students can see the relevance of mathematics in real life and be motivated to learn. This approach makes learning more contextual because it originates from the students' own environment and culture (Pangadongan & Dimpudus, 2024). Ethnomathematics objects can be found in various forms, such as traditional games and crafts, artifacts, and activities that reflect culture (Hermawati et al., 2025).

The integration of AR technology and ethnomathematics offers great hope for the creation of learning media that is not only technically innovative but also culturally contextual. Such media can accommodate various learning styles of students and increase their interest in learning mathematics (Partasiwi et al., 2023). Fathuloh et al (2025) argue that learning media that combines AR and ethnomathematics elements can help students better understand spatial figures because the learning process becomes more interesting and meaningful.

However, in reality, various problems are still often encountered in mathematics learning, especially in the subject of spatial figures. This subject covers constructing and analyzing spatial figures, as well as recognizing spatial visualization (front, top, and side), which naturally requires a high level of spatial visualization skills. In fact, most students face obstacles in understanding the concept of object construction because this material is presented in a static form through textbooks or two-dimensional images (Presmeg, 2006). As a result, learning is less interesting and does not provide concrete experiences, which then affects students' understanding and lowers their learning outcomes.

Furthermore, most mathematics learning in schools has not linked geometric concepts to the context of students' lives or local culture. As a result, students find it difficult to find connections between the material being studied and their daily experiences, making learning abstract and disconnected from their reality (Mailani et al., 2024).

Based on preliminary observations and interviews with fifth-grade teachers at MIN 2 Pontianak, data shows that 45% of fifth-grade students have mastered the material on spatial figures. This fact shows that the majority of students have difficulty learning the formulas for the area and volume of solid figures. In addition, mathematics learning to date has not provided a strong contextual experience, such as using interactive learning media and linking material concepts to the local culture of students. As a result, the learning process tends to be less interesting and ineffective in building meaningful conceptual understanding among students.

In fact, the city of Pontianak, as an area with diverse local cultures, has great potential that can be integrated into mathematics learning, such as the architectural forms of traditional houses (Faruq, 2023), traditional food (Putra et al., 2022), and traditional games (Yuniarni et al., 2024). The unique architecture of the Kadariah Palace, Radakng House, Masjid Jami, and Dayak and Malay carving motifs can be used as media to introduce spatial concepts such as cubes and blocks. These cultural elements contain strong geometric values that are highly relevant to be highlighted in an ethnomathematics approach (Pangadongan & Dimpudus, 2024).

Although the use of Augmented Reality (AR) has proven effective in visualizing abstract objects (Shaghaghian et al., 2024) and the ethno-mathematics approach has been recognized as capable of enhancing the relevance of learning (Sulisti et al., 2025), the integration of these two approaches into a single mathematics learning medium remains very limited, particularly in terms of highlighting the local characteristics of Pontianak City. Most AR media currently available remain generic and have not addressed students' sociocultural aspects, so the potential of AR in visualizing geometry has not been optimally utilized to strengthen cultural identity. Furthermore, research on developing geometry media for elementary school students in Pontianak City still tends to rely on conventional physical teaching aids that are difficult to replicate. This gap between the need for advanced visualization (AR) and the need for local context (ethnomathematics) is a crucial gap that needs

to be filled so that geometry learning is not only technologically advanced but also culturally meaningful for students at MIN 2 Pontianak.

Seeing the urgency of developing media that supports abstract visualization, the lack of use of local cultural approaches in mathematics learning, and the great local potential of the city of Pontianak, it is necessary to develop an interactive learning media based on AR and Ethnomathematics that can visualize spatial concepts while introducing and preserving local culture. Unlike traditional educational tools that focus only on technology or only on culture, this media merges Augmented Reality (AR) with an Ethnomathematics approach. The development of this media will refer to the 4-D development model from Thiagarajan, et al (1974), which includes the stages of Define, Design, Develop, and Disseminate. Therefore, this study aims to describe the Define, Design, Develop, and Disseminate processes in developing "AR-based interactive media and ethnomathematics" for fifth-grade spatial geometry material at MIN 2 Pontianak. With the support of learning media that integrates AR and ethnomathematics, mathematics learning in spatial geometry material is expected to be more meaningful, more interesting, easier to understand, and increase student engagement and sense of belonging to their local culture.

METHODS

The research was conducted in 2025. This research is development research or Research and Development (R&D). The R&D research method is a method used to develop certain products (Sugiyono, 2011). There are several types of models in the R&D method. The model used in this study is the 4-D model by Thiagarajan, et al (1974) namely: Define, Design, Develop, Disseminate.

The data sources in this study were fifth-grade teachers and students at MIN 2 Pontianak. Data collection used interview techniques with interview sheets as instruments; and questionnaire techniques with validation questionnaire sheets and teacher and student response questionnaires as instruments. The data analysis techniques included validity analysis and practical analysis.

Validity analysis in this study used content validity. According to Gregory (2015) in his book *Psychological Testing: History, Principles, and Applications*, content validity can be measured through the agreement of two experts. The results of their evaluations are entered into a 2x2 matrix to calculate the content validity coefficient. If both evaluators assign relevant scores to the same items, the instrument is considered to have strong content validity. The validation data was obtained from the tabulation of all data obtained from the validators and calculating the validity score using Gregory formula, namely:

$$C = \frac{D}{(A + B + C + D)}$$

Explanation :

CVI = *Content Validity Index*

A = Both validators stated it was irrelevant.

B and C = Difference of opinion between validators.

D = Both validators stated that it was relevant .

The percentage value categories used are as follows:

Table 1. Learning Media Validity Criteria

Coefficient	Criteria
0,80 ≤ CVI ≤ 1	Very High Validity
0,60 ≤ CVI < 0,80	High Validity
0,40 ≤ CVI < 0,60	Moderate Validity
0,20 ≤ CVI < 0,40	Low Validity
0,00 ≤ CVI < 0,20	Very Low Validity

Source : *Gregory, 2015*

Interactive AR-based learning media products and ethnomathematics are considered valid if the assessment of subject matter, media, and language experts is at least in the valid category.

This questionnaire was intended for fifth-grade students at MIN 2 Pontianak to assess the practicality of the learning media that had been used. The questionnaire was compiled based on practicality indicators. According to Nurfa et al., (2022), these indicators include ease of use, attractiveness, and time efficiency in using the media. In this questionnaire, the assessment was carried out using a Likert scale. The analysis of media practicality used descriptive statistics, namely calculating the average percentage of practicality scores using the following formula (Hamdunah, 2015):

$$P = \frac{f}{N} \times 100\%$$

Explanation:

P = Percentage of responses from students and teachers

f = Total score from respondents

N = Maximum score

The practicality percentage results are then categorized based on the following table:

Table 2. Product Practicality Criteria

Qualification Value Range	Category
$8\ \% < P \leq 1\ \%$	Very Practical
$6\ \% < P \leq 8\ \%$	Practical
$4\ \% < P \leq 6\ \%$	Fairly Practical
$2\ \% < P \leq 4\ \%$	Not Practical
$0\% < P \leq 2\ \%$	Very Impractical

Source: *Hamdunah, 2015*

AR-based learning media products and ethnomathematics are considered practical if the assessment of students and teachers of the product is at least in the practical category.

RESULTS AND DISCUSSION

This research report is compiled based on the stages of developing Interactive Learning Media that combines AR and the Ethnomathematics approach. The development of this media refers to the 4D model proposed by Sivasailam Thiagarajan, Dorothy S. Semmel, dan Melvyn I. Semmel pada tahun 1974, which consists of four main stages: define, design, develop, and

disseminate. The details of the results obtained and the discussion at each stage will be explained below.

1. Define

The define stage was carried out through interviews with fifth-grade teachers at MIN 2 Pontianak on July 1, 2025. This stage involved an in-depth needs analysis to identify relevant issues as the background for the research. The five stages of define include:

a. Initial Analysis

This preliminary analysis was conducted to obtain information on the needs for developing media. The first step was to seek information about teachers' planning in the learning process, the media they often use, and the types of media that are difficult to present during learning. The interview results showed that in mathematics learning activities, concrete media in the form of cubes and blocks made by teachers themselves from available materials had been used. The limitations of these tools were a major obstacle to implementing equitable and optimal learning. To date, teachers have never used technology-based interactive learning media, such as AR or ethnomathematics approaches. In addition, teachers also reported technical constraints, such as limited tools and media, which were obstacles to implementing more innovative technology-based learning media. This indicates a need for interactive, accessible, and contextual learning media to improve students' understanding of mathematical concepts in a more comprehensive and enjoyable way.

The results of the analysis show that the limitations of concrete media are still a major challenge (Ponte et al., 2023). Teachers tend to use simple homemade tools, such as cubes and blocks, which are limited in number and quality. This condition has an impact on the suboptimal understanding of students of geometric concepts, especially in terms of surface area and volume. This is in line with Arsyad (2019) who emphasizes that limitations in learning media can reduce the effectiveness of learning.

b. Student Analysis

This analysis was conducted to map the characteristics of the students who were the subjects of the study, so that they could be adjusted to the learning model designed. Through interviews, it was found that students generally have active learning characteristics, especially when the learning process involves interesting media. According to teachers, the use of learning media is very influential in attracting students' attention, especially in mathematics lessons, which are often considered challenging. However, even though students' interest in learning is high, there are some mathematics materials that are considered difficult, especially multiplication and division, as well as spatial geometry materials, particularly those related to the concept of surface area. These difficulties are generally caused by a lack of understanding of basic spatial geometry concepts and the limitations of concrete media that can help visualize these concepts. This situation indicates that students need interactive, visual, and contextual learning media to support their understanding of mathematical concepts. Therefore, the development of a learning model that integrates interactive media, such as AR and the ethnomathematics approach, is considered appropriate to

support the active characteristics of students while overcoming obstacles in understanding spatial geometry concepts.

The results of the analysis of student characteristics indicate that students are very responsive to visually appealing media. They find it easier to understand the material when learning is contextual and interactive. Research by Sutomo & Aini (2024) also supports the need to map student characteristics so that the media developed can be tailored to their learning needs, especially in understanding abstract mathematical concepts. The obstacles experienced by students in understanding spatial figures, especially surface area and volume, are the main factors driving the need to develop innovative AR-based learning media that incorporates local culture.

c. Task Analysis

The teacher explained that in order for students to fully understand the material on cubes and blocks, there are a number of important learning tasks that they need to master. First, students must understand the basic properties of three-dimensional shapes, such as the number of sides, edges, and vertices in cubes and blocks. In addition, they also need to be able to relate real-life shapes around them to the concepts of cubes and blocks. The ability to calculate volume and surface area is a very important aspect and often the main focus in learning this material. However, to be able to calculate correctly, students need to have the skills to visualize three-dimensional shapes and understand the structure and nets of three-dimensional shapes. In addition, they also need to be trained to think logically and systematically in organizing data and carrying out calculation steps. Teachers also emphasize the importance of developing understanding gradually, from concrete to abstract, so that students do not just memorize formulas but truly understand the concepts behind them. Therefore, a visual, interactive, and contextual learning approach is needed to help students carry out these learning tasks effectively and meaningfully.

From the interview results, it was found that students need to master important tasks such as recognizing the properties of shapes, calculating surface area and volume, and connecting geometric shapes to real objects. According to Prastowo (2021), gradual learning from concrete to abstract will help students understand concepts meaningfully, rather than simply memorizing formulas. Therefore, learning media must be able to present three-dimensional visualizations of shapes and support the systematic development of students' logical thinking.

d. Concept Analysis

According to the fifth-grade teacher at MIN 2 Pontianak who was interviewed, the core material that is important to convey in spatial learning in fifth grade includes the surface area and volume of cubes and blocks. These materials are considered essential because they form the basis for understanding more complex spatial geometry concepts in the next level. Surface area and volume require both conceptual understanding and calculation skills. Considering these requirements, the development of AR-based interactive learning media and ethnomathematics will focus on two main sub-topics, namely: (1) calculating the surface area of cubes and blocks, and (2) calculating the volume of cubes and blocks. This interactive media is expected to be able to present real visualizations based on local culture, thereby increasing student

engagement, understanding, and interest in learning spatial geometry material in a more contextual and meaningful way.

The focus of media development is directed at two important sub-topics: the surface area and volume of cubes and blocks. This selection is appropriate, considering that this material forms the basis of advanced spatial geometry at higher levels. The ethnomathematics approach is considered capable of deepening the meaning of learning by connecting mathematical concepts to the local culture that is closely related to the daily lives of students (D'Ambrosio, 2001; Rosa et al., 2017.).

e. Formulation of Learning Objectives

The main objective of teaching spatial geometry in fifth grade is for students to fully understand the concepts of surface area and volume in cubes and blocks. Teachers believe that one of the key factors in achieving this goal is the availability of interactive and visual learning media, which can help students visualize three-dimensional concepts more clearly and concretely. Teachers also stated that the use of AR-based interactive learning media combined with an ethnomathematics approach was considered very helpful in supporting the achievement of these learning objectives. The combination of these two approaches is believed to be able to provide learning that is not only interesting but also contextual, because it links mathematical concepts with culture and local objects that are familiar to students. Thus, the design of the content and appearance of this interactive learning media must emphasize the visualization of cubes and blocks in real contexts and local cultures, the presentation of steps for calculating surface area and volume in stages, and interactive features that facilitate student exploration. This will ensure that the media developed is truly capable of meeting comprehensive learning needs, both in terms of conceptual understanding, learning engagement, and achievement of competency objectives.

The learning objectives formulated from the results of the teacher's analysis are to provide a comprehensive understanding of the surface area and volume of spatial figures. To that end, the media developed must be able to accommodate the needs of visualization, interactive engagement, and a culturally-based contextual approach. The combination of AR and ethnomathematics is considered capable of addressing these challenges because it is both modern and locally relevant (Fathuloh et al., 2025). Thus, this media is expected to optimally increase students' motivation, conceptual understanding, and learning outcomes.

The define stage in the 4D development model (Thiagarajan et al., 1974) is the initial step aimed at identifying learning needs and problems so that the developed product is truly relevant and effective. In the study at MIN 2 Pontianak, this stage was carried out through interviews with fifth-grade teachers to obtain a comprehensive picture of the real conditions of mathematics learning, especially spatial geometry material. Overall, the results of this define stage show the importance of developing innovative, contextual learning media that are appropriate to the characteristics of the students, so that mathematics learning can be more effective, enjoyable, and meaningful.

2. Design

The design stage for the media that the researcher will develop is divided into three steps, namely:

a. Media Selection

The decision to develop AR-based interactive learning media and an ethnomathematics approach was based on the interview results, which showed that students have active characteristics, need visual aids to understand spatial concepts, especially the area and volume of cubes and blocks, and that interactive and contextual learning media are needed to support the optimal achievement of learning objectives. Therefore, the researcher felt compelled to develop and introduce AR-based and ethnomathematics-based learning media in the school.

The selection of learning media was based on the results of an analysis of the needs and characteristics of students at the define stage. In this context, students showed a high interest in visual, interactive, and contextual media. Therefore, the decision to develop AR-based media combined with an ethnomathematics approach was considered appropriate to meet learning needs.

According to Verdiatmoko & Pinandita, (2025), through realistic 3D visual displays, AR is one of the technologies that is effective in encouraging student engagement during the learning process. On the other hand, the ethnomathematics approach deepens the relationship between mathematical concepts and local culture so that learning feels more meaningful and relevant (Rosa et al., 2017). The combination of the two not only strengthens conceptual understanding but also increases students' interest in learning through enjoyable and meaningful learning experiences.

b. Format Selection

The selection of format refers to determining the type or form of media to be developed, with the aim of ensuring that the format is in line with the learning material content. In developing AR-based interactive media and ethnomathematics, this process was carried out by compiling a preliminary draft that included content planning and visual display design.

At this stage, the researchers determined the format of digital interactive media based on the Assemblr World application, which supports the display of AR objects directly through mobile devices. The format was selected by considering the alignment between the type of media and the learning content to be delivered, namely the surface area and volume of spatial figures (cubes and blocks).

In this process, planning was carried out for the content material (formulas, sample questions, concept explanations); visualization of geometric objects; integration of local cultural elements (traditional Pontianak buildings); navigation mechanisms (menu, back, next, interactive animations); and additional resources (links to YouTube for cultural history).

c. Initial Design

The next stage in the design phase is the preparation of a preliminary design. The media to be developed is first designed conceptually at this stage. The design of AR- based interactive media and ethnomathematics must be tailored to the needs and

characteristics of the students, which were previously analyzed in the define stage before proceeding to the further design process.

The initial step in drafting the design was carried out using the Assemblr World application. The researchers began by selecting traditional buildings in the city of Pontianak as the main objects, namely the Pontianak Jami' Mosque and the Radangk House. Next, they designed the shape of the space relevant to these objects. In this case, the spatial structure resembling the body of the Pontianak Grand Mosque is a block, and the spatial structure resembling the hall of the Radangk House is a cube. This was followed by a brief historical overview of the traditional buildings linked to YouTube, the placement of explanatory text and material descriptions, and the arrangement of spatial structure animations that construct and deconstruct the spatial structures. The final step is to create a back and next menu to go to the next page containing further material.

The initial design (prototype) of the learning media was created to serve as the basis for further development in the development stage. The media was designed using the Assemblr World application, which enables realistic visualization of three-dimensional AR objects. The initial design includes the integration of local cultural objects: the Jami' Mosque in Pontianak (represented by a block) and the Radangk House (represented by a cube); mathematical content: the concepts of surface area and volume; interactive features: animations of the construction and decomposition of spatial structures, audio narration, explanatory text, and page navigation; and cultural context: a brief history of the buildings linked to external sources (YouTube). This approach supports the view D'Ambrosio (2001) that states that ethnomathematics can bridge mathematical concepts with local culture, making learning more grounded and applicable. Visualization in AR allows students to see and interact with spatial structures directly from various perspectives, which is very helpful in understanding three-dimensional structures that are usually difficult to understand through two-dimensional media (Akçayır & Akçayır, 2017).

This stage is aimed at developing a preliminary design for learning media based on the previously obtained needs data. The researchers took three crucial steps at this stage, namely media selection, format selection, and preliminary design development.

3. Develop
   a. Expert Evaluation

      At this stage, an expert appraisal or assessment is carried out. This assessment aims to validate the learning media, which covers three aspects, namely media, material, and language. Each aspect is validated by two validators who are experts in their fields. This assessment is carried out to ensure that the learning media is suitable and to obtain input for improvement before it is used by students. The following are the results of the validation of several aspects that have been assessed.

      In the media expert validation, there were two validators, namely Roikhatul Janah, M.Pd., and Vidya Setyaningrum, M.Pd, as lecturers at IAIN Pontianak. Based on the results of the media expert validation using the Gregory scoring method, a CVI score of 1 was obtained. This score confirms that interactive media has a very high

level of validity, so it can be declared suitable for use in learning. However, there were a number of suggestions and notes from the media validators that needed to be considered in the revision process. Some of these suggestions were that on the first page, a "close" menu could be added to the block display so that the decomposed blocks could be reconstructed. Meanwhile, on page 2, the space could also be decomposed as on page 1, and the explanation of the surface area formula was located in that space.

In terms of content, there were two validators involved in the assessment process, namely Mrs. Desty Septianawati, M.Pd., and Mrs. Ressy Rustanuarsi, M.Pd, as lecturers in the Mathematics Education (TM) study program at IAIN Pontianak. The results of the validation conducted by subject matter experts show that the CVI score obtained is 1. This score reflects that the interactive media has high validity. However, there are several inputs and criticisms from subject matter experts that need to be used as material for revision. One of them is an error in the writing of the surface area formula, which is written as $L = 2(p \times p + lt)$, is should be $L = 2(p + p + lt)$. Also the variable description changes into p = length, l = width, t = height.

In terms of language, there were also two validators, namely Mrs. Istmia Udaybiah, S.Pd and Mrs. Umrati, S.Pd., as Indonesian language teachers. The results of the language expert validation showed that the CVI score obtained was 1. The score obtained indicates that the interactive media developed has very high validity However, in this aspect, there were several inputs and criticisms from language experts that needed to be revised. One of them was in the description of the S symbol, where there was a typo in the word "panjanag" (cube edge).

A Content Validity Index (CVI) score of 1 represents the maximum possible score in content validity testing. This result indicates perfect agreement among all validators regarding every item or aspect evaluated. All items in the validation instrument were rated as “Highly Relevant” or “Appropriate” by all validators. This proves that the indicators compiled in the development instrument truly represent the needs of spatial geometry material.

The implication for the quality of the media is that its ability to transform abstract objects into concrete ones is guaranteed. Since the subject matter and media experts agree (score of 1), the visualization of spatial figures through Pontianak cultural objects in the AR is assured to be geometrically accurate.

b. Development Trial

The trial of AR-based interactive media and ethnomathematics was conducted on a limited basis. This test was to assess the practicality of the validated media in delivering learning materials. The product trial in this study was conducted with 1 fifth-grade teacher and 33 fifth-grade students at MIN 2 Pontianak. The trial results are shown in the following table:

Table 3. Results of the Student Practicality Questionnaire Calculation

Indicator	Score	Pecentage	Category
Ease Media Usage	252	76,4%	Practical
Media Appeal	294	89,1%	Very Practical
Time Efficiency	268	81,2%	Very Practical

Based on the table above, the three indicators received different scores. The media usability indicator received a score of 76.4% in the Practical category. The media appeal indicator received a percentage score of 89.1% in the Very Practical category, and the media usage time efficiency indicator received a percentage score of 81.2% in the Very Practical category. The total overall indicator score was 82.2% in the Very Practical category.

The development stage consists of two steps, namely expert assessment and development testing. The product validation process includes expert assessment, which is important to ensure the quality, feasibility, and suitability of media content before it is used in learning. This validation is carried out on three main aspects, namely media, material, and language, by validators who have expertise in their respective fields.

In this study, two validators from among the lecturers (Roikhatul Janah, M.Pd., and Vidya Setyaningrum, M.Pd.) validated the media aspect. The results of the calculations using the Gregory method showed a CVI value of 1, which is in the very high validity category (Gregory, 2015). This value indicates a perfect level of agreement between the validators, so that the interactive media is declared very suitable for use in learning.

However, the notes and suggestions from the validators are an important part of the development process. Several suggestions, such as adding a "close" button to return the shape to its original condition, placing the formula directly on the shape, and presenting consistent visuals between pages, are forms of formative evaluation. This is in line with Tessmer (1993), opinion that expert validation is not only intended to assess feasibility but also to provide improvements for product refinement. Considering the suggestions, developers made improvements to the media, resulting in media that is more interactive, informative, and aligned with the pedagogical principles of visualizing mathematical concepts.

After validation, the media was tested on a limited basis with one fifth-grade teacher and 33 students in class VB at MIN 2 Pontianak. The purpose of this trial was to determine the level of practicality of the media in the real context of learning. The trial assessed the media based on three practicality indicators according to Nurfa et al (2022), namely: Ease of use at 76.4% (Practical), Attractiveness of the media at 89.1% (Very Practical), and Time efficiency of use at 81.2% (Very Practical). The overall indicator score was 82.2%, which falls into the Very Practical category. These findings indicate that the media is practical for use by teachers and students without complicated technical guidance; the media is visually appealing and interactive, encouraging students' interest in learning; it helps save time, as AR visualization accelerates the understanding of geometric concepts compared to conventional methods. These results are in line with previous research by Verdiatmoko & Pinandita (2025), which shows

that the use of AR provides an interactive and manipulative learning experience, thus helping students to more easily understand the relationship between elements in spatial figures. In addition, the ethnomathematics approach used in the media adds a relevant and meaningful local context for students, in line with D'Ambrosio (2001) view of the importance of cultural context in mathematics learning.

4. Disseminate

The final stage of developing the 4D model is dissemination. At this stage, the researchers limited the dissemination of the media by distributing and promoting it only at the research location, namely MIN 2 Pontianak. Dissemination has two steps, namely packaging and diffusion and adoption.

a. Packaging

The packaging of interactive AR-based learning media and ethnomathematics products is in the form of links that can be accessed using a PC or *mobile phone.* The links are as follows: Block Material (https://bit.ly/44QwyV2) and Cube Material (https://bit.ly/4lM6nF1).

b. Difffusion and adoption

In the diffusion and adoption stage, the researcher disseminated and distributed the media to fifth-grade teachers and fifth-grade students at MIN 2 Pontianak through a WhatsApp group.

The main objective of this stage is to disseminate the developed media so that it can be used by the target audience, while also obtaining feedback on the practicality of the product in the real context of learning. In this study, the dissemination stage was divided into two sub-stages, namely: packaging and diffusion and adoption, both of which focused on only one research location, namely MIN 2 Pontianak.

The learning media is packaged in the form of digital links that can be accessed via PCs and mobile devices. This format was chosen to facilitate distribution and accessibility by teachers and students, given the limitations of hardware in schools. By providing media in digital form, teachers and students do not need special devices other than gadgets connected to the internet. In this context, interactive link-based packaging is considered appropriate because it is practical and flexible: it can be used anytime and anywhere; device-friendly: compatible with various operating systems and devices; and minimal additional costs: no need to install additional applications, just use a browser or built-in application. The use of link-based digital formats also supports the principle of distribution efficiency in technology-based learning (Munir, 2017).

At this stage, the media was distributed to all classroom teachers and fifth-grade students through a WhatsApp Group. The choice of WhatsApp as the distribution channel was based on its popularity and ease of use among teachers and students. According to Rogers (2003) in his theory of diffusion of innovation, the adoption of educational innovations will occur more quickly if the media is distributed through familiar communication channels; the target users have direct access to the innovation; and the media provides tangible benefits that can be immediately felt.

WhatsApp as a community-based communication medium supports the informal yet effective process of media dissemination and adoption. The use of this platform also accelerates interaction between users and developers and enables direct feedback. This is

reinforced by the results of research by Setyaningrum & Sulistyaningrum (2025), which shows that WhatsApp has a significant effect on student engagement. WhatsApp groups are very effective in quickly reaching students and teachers and increasing their participation in accessing media.

The results of this study indicate a significant shift from physical-concrete to digital-concrete. Until now, teachers have used physical teaching aids (handmade cubes/blocks) that are limited in both quantity and quality. The use of Augmented Reality (AR) through the Assemblr World app addresses the limitations of these teaching aids. A critical analysis reveals that this medium does not merely replace physical teaching aids but expands their scope. Students do not merely observe shapes; they can interactively engage in the process of "deconstruction" (networks), a task that is difficult to perform with rigid physical teaching aids.

The success of this medium is driven by the combination of two concepts often considered contradictory: cutting-edge technology (AR) and traditional values (ethnomathematics). AR provides powerful 3D visual input, while narratives and text provide verbal input. This integration strengthens students' long-term memory of the concepts of volume and surface area. By using the Jami' Mosque and the Radakng House, this media applies the theories of Jean Piaget and Lev Vygotsky. Students build knowledge based on structures they are already familiar with in their environment (scaffolding through local culture). The use of the Thiagarajan model ensures that this media is not merely designed but rooted in real-world needs. A CVI score of 1 is evidence that the Define phase was executed with great precision, ensuring that the instrument and product are on target.

Based on the findings from the Define phase, students at MIN 2 Pontianak had never used AR technology before. The appearance of 3D objects on the desk via mobile devices provided a "wow factor" that automatically boosted motivation. Using icons of their own city (Pontianak) fostered a sense of pride and connection. Students felt they were learning about "their own home" rather than simply constructing abstract spaces from a textbook. Additionally, teachers typically spend a long time drawing 3D perspectives on the whiteboard or assembling paper nets. With AR, the visualization process occurs instantly and can be viewed from multiple angles, allowing more class time to be allocated to problem-solving rather than simply trying to imagine shapes.

CONCLUSION

This development research successfully produced an interactive learning medium based on Augmented Reality (AR) and ethnomathematics covering cubes and rectangular prisms, which meets validity criteria (CVI 1) and demonstrates very high practicality (82.2%) through the 4D development model. This medium provides significant practical benefits for teachers in overcoming the limitations of physical teaching aids and for students in creating an immersive learning experience that bridges abstract concepts with the local wisdom of Pontianak, such as the Jami' Mosque and Rumah Radakng. Its main contribution lies in pedagogical innovation that synergizes cutting-edge technology with cultural context to strengthen students' spatial abilities and learning motivation. As a direction for further development, the scope of this media's content can be expanded by adding gamification features, and its effectiveness needs

to be tested on a larger scale to empirically measure its significant impact on students' learning outcomes and critical thinking skills.

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