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Development of Augmented Reality-Based Rotametry Learning Media for 3D Shape Topics in Elementary Schools

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ABSTRACT

This research is motivated by the limitations of interactive learning media on spatial building materials in elementary schools, which cause students to have difficulty visualizing the abstract concepts of spatial buildings. This research aims to develop and determine the feasibility and practicality of the Rotametri learning media based on Augmented Reality (AR) for spatial building material in fifth grade at UPT SDN 12 Pinrang, UPT SDN 9 Pinrang, and UPT SDN 172 Pinrang. The method used is Research and Development (R&D) with the ADDIE model, limited to the Analysis, Design, and Development stages. In the Development stage, a limited trial is conducted to determine the practicality of the product. Data were analyzed descriptively quantitatively by calculating the percentage of validation results and practicality tests. The Rotametri media was developed in the form of a tube that can rotate 360° and is equipped with AR technology to help students visualize spatial geometry material more concretely and interactively. The results of the validation by subject matter experts and media experts each obtained a percentage of 100% with very feasible criteria. The practicality test involving 3 teachers and 61 students obtained percentages of 91.12% from teachers and 92.93% from students with very practical criteria. Thus, the AR-based Rotametri media meets the feasible and practical criteria based on the results of limited trials in the fifth-grade elementary school spatial building learning.

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Introduction

Mathematics is a fundamental discipline that plays an important role in shaping students' abilities to think logically, analytically, and systematically. Mathematical ability from an early age predicts future academic success because it involves and strengthens executive functions that support the understanding of complex concepts (Braak et al., 2022). One of the

mathematics subjects taught at the elementary school level is geometry. However, at the elementary school level, students' spatial abilities are still at a relatively early stage of development, often leading to difficulties in understanding the concept of three-dimensional shapes (Saputra et al., 2025). These difficulties are further complicated because geometry learning requires students to transform two-dimensional representations into three-dimensional forms through the process of spatial imagination (Tarng et al., 2024). In this context, teachers tend to rely on two-dimensional images, which are often ineffective in helping students deeply understand the shapes, structures, and characteristics of three-dimensional objects (Saputra et al., 2025). Therefore, this condition needs special attention, considering that a proper initial conceptual understanding is an important foundation for students to optimally comprehend subsequent material (Mukhlisa, 2021).

The problem of understanding basic concepts does not only occur at the classroom level but is also reflected in national and international achievements. Data from the International Mathematical Olympiad (IMO) shows that Indonesia dropped from 38th place in 2022 to 39th in 2023, with a decrease in the number of medals. In addition, the results of the 2022 Program for International Student Assessment (PISA) recorded Indonesia's mathematics score at 366, down from 379 in 2018, placing it at level 1a. This data indicates that improving the quality of mathematics education in Indonesia remains a challenge that needs attention, necessitating innovative and relevant teaching efforts that align with the characteristics of the material and the needs of the students. Factors that contribute to the low understanding of students, especially in understanding the abstract concepts of spatial shapes, include the presentation of material provided by the teacher. As a result, the learning process becomes less meaningful and fails to provide the concrete learning experiences needed by students to build a deep understanding of geometry. In fact, educators play the role of integrating all components of learning, thereby creating effective, efficient, and competency-oriented learning for students (Nasrulloh et al., 2021).

The problem was also found based on the results of a needs analysis conducted at three elementary schools, namely UPT SDN 12 Pinrang, UPT SDN 9 Pinrang, and UPT SDN 172 Pinrang. The needs analysis involved 61 fifth-grade students through observations, interviews with teachers, and the distribution of questionnaires to students. The survey results show that 50 students still often have difficulty understanding mathematics material, while 53 students feel they do not fully understand spatial building material when explained verbally by the teacher. From the aspect of media availability, 42 students stated that the teacher has not yet used learning media when explaining spatial building materials, while 52 students stated that the media used is still in the form of two-dimensional images. This condition indicates that the presentation of spatial building materials at the school where the research is conducted is still not fully supported by media that can provide a three-dimensional visual experience. On the other hand, the students' need for more concrete and interactive media is evident from the 58 students who are interested in studying spatial building materials using three-dimensional media and the 60 students who are interested in using media that can be viewed from various angles through mobile phones. Additionally, 56 students stated that they find it easier to understand spatial geometry material when it is related to objects found in their surroundings. These findings reveal a gap between the current learning conditions, which are still dominated by two-dimensional presentations, and the students' need for media that can present three-dimensional objects concretely and allow for visual exploration from various perspectives.

One alternative that can be done is to maximize the use of learning media. In the era of rapid technological development, teachers are required to design and present innovative and engaging learning experiences to enhance students' interest and understanding through the use

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of learning media (Zainal et al., 2025). Learning media are tools used in the learning process to stimulate students' thinking, attention, and skills, thereby supporting effective and enjoyable learning (Sidyawati et al., 2021). Compared to learning without media, the learning process that uses media can significantly increase students' motivation, participation, and understanding of geometry (Utami & Irawati, 2024). Because fundamentally, learning media play an important role in helping and supporting the learning process to run effectively (Zainal et al., 2021).

However, the use of media alone is not sufficient if the media is not designed according to the material needs and characteristics of the students. Therefore, a systematic process of developing learning media is necessary so that the resulting media is truly relevant to the needs of the students. One of the learning media that can represent the shape of three-dimensional objects is a diorama. Its three-dimensional form allows students to observe the structure of spatial shapes directly through models presented in a tangible way (Rahmiati et al., 2020). Meanwhile, Augmented Reality is a technology that combines three-dimensional virtual objects with the real environment (Syafril et al., 2021). In the context of teaching geometric objects, Augmented Reality can be utilized to present interactive 3D models of cubes and rectangular prisms, allowing students to rotate, zoom in, and explore the structures from various perspectives (Lestari & Dafik, 2025). In addition to supporting concept visualization, the use of Augmented Reality in mathematics education also receives positive feedback because it can enhance motivation, learning experience, and student engagement in the learning process (Saraswati et al., 2026). Based on these characteristics, dioramas and Augmented Reality have complementary functions in representing three-dimensional geometric objects. Dioramas provide a visual experience through concrete objects that can be directly observed, while Augmented Reality offers virtual visualizations that can be explored interactively. The integration of these two forms of representation serves as the foundation for the development of Rotametri, an Augmented Reality-based media that combines three-dimensional concrete media with interactive digital technology. Rotametri is an educational media that integrates physical dioramas with Augmented Reality (AR) technology into a single medium. The name "Rotametri" comes from the combination of two words, namely "rota," derived from the term rotation, which means a spinning movement, and "metri," taken from the word geometry. The distinctive character of Rotametri lies in the use of dioramas as concrete representations of three-dimensional shapes, equipped with AR features to display virtual visualizations of three-dimensional objects. Thus, Rotametri does not rely solely on physical forms like ordinary dioramas or digital visualizations like AR media, but combines both to provide a more concrete, interactive, and flexible learning experience.

Previous research shows that diorama media can help provide a learning experience through the presentation of objects in a concrete manner. The development of diorama media on the water cycle material shows effective and practical results in supporting students' understanding (Humaira & Ninawati, 2023). Other research also shows that the use of dioramas can have a positive impact on students' creative thinking abilities, learning enthusiasm, as well as their psychomotor and cognitive skills (Melinda & Ariyani, 2024; Yusup et al., 2024). Meanwhile, research on Augmented Reality (AR)-based media shows that this technology can help present objects visually and interactively. AR-based learning media is considered very feasible and can enhance students' learning enthusiasm (Tuta et al., 2022), while the application of 3D AR in mathematics learning is deemed appropriate for use and can support students' learning motivation (Putrie & Syah, 2023). Based on several studies, dioramas emphasize the presentation of objects in a concrete manner, while AR provides students with the opportunity to explore objects virtually and interactively. Thus, both media have advantages that can complement each other, but in previous research, their use has still tended to be developed separately.

The pedagogical gap in this research lies in the separation between concrete and digital representations in previous learning media. Diorama media provides a learning experience through physical objects, while AR emphasizes virtual visual exploration. Rotametri presents itself by integrating both representations, allowing students to observe and understand the characteristics of spatial shapes through concrete objects while also exploring them in the form of 3D visualizations virtually. Some of these findings indicate that diorama and Augmented Reality media have the potential to support the learning process. However, based on previous research studies that have been reviewed, there is still limited research that integrates dioramas and Augmented Reality (AR) into a single learning media for spatial building materials in elementary schools. Therefore, this study focuses on the development of Rotametri media based on Augmented Reality that integrates three-dimensional concrete media with interactive digital technology on spatial building materials for fifth-grade elementary school students. This research aims to develop Rotametri media based on Augmented Reality for fifth-grade elementary school spatial building materials and to determine the feasibility and practicality of the developed media.

Method

Type of Research

This research is a Research and Development (R&D) study aimed at producing a product in the form of Rotametri learning media based on Augmented Reality for spatial building materials in elementary schools. The development model used is the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation (Rusmayana, 2021). The ADDIE model was chosen because it has systematic and structured development stages, making it suitable for the process of developing technology-based learning media that requires stages of needs analysis, design, and gradual product development. This research adapts the ADDIE model by limiting its implementation to the development stage. The limitation was made because the research focused on the development of a product that meets the criteria of feasibility and practicality, so the implementation and evaluation stages were not conducted comprehensively. After the product is declared feasible through expert validation in the development stage, a limited trial is conducted to obtain practicality data from teachers and students. This limited trial is part of the development stage and is not intended as the implementation stage in the ADDIE model. Thus, the research stages include analysis, design, and development, with the development stage encompassing expert validation and a limited trial to determine the practicality of the developed media.

Population and Sample

The subjects in this study consist of 1 content expert, 1 learning media expert, as well as 3 fifth-grade homeroom teachers and 61 fifth-grade students from three selected elementary schools in Pinrang Regency, South Sulawesi Province. The media that was designed and deemed ready or complete by the researcher was then validated. At this validation stage, the media is tested for its feasibility, and input from validators is taken as a step for development and improvement. Validation is carried out by subject matter experts, media experts, and practicality instrument experts. After the validation of the material and media on the rotametry learning media, a practicality test is conducted by teachers and students to assess the level of practicality in using the AR-based Rotametry media. The information on the field of expertise and specialization of each validator can be found on Table 1.

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Table 1. Validators

Initial	Field of Study	Area of Expertise
A.M	Mathmatics Education	Subject Matter Expert
A.N.A.	Magister of Education	Media Expert
M.	Educational Evaluation	Practicality Instrument

The selection of research locations is based on the differences in characteristics of the three schools that are the subjects of the study. UPT SDN 12 Pinrang, Watang Sawitto District, Pinrang Regency, is an exemplary school that has integrated technology into the learning process. Meanwhile, UPT SDN 172 Pinrang, Paleteang District, Pinrang Regency, is at the initial stage of introducing technology to students and is striving to adapt to the times. As for UPT SDN 09 Pinrang, Watang Sawitto District, Pinrang Regency, it has limited facilities and infrastructure, so the application of technology in learning is still restricted. Considering these differing conditions, it is hoped that the developed product can be implemented in various situations and levels of technological readiness. Teachers and students were chosen as test subjects because they are the end users of the developed learning media, thus they can provide an assessment of the practicality of using the media.

Instrument

The questionnaire instrument in this study was developed using two types of scales, namely the Likert scale and the Guttman scale. The five-point Likert scale with a score range of 1–5 was used in the expert validation questionnaire for content and media learning experts to assess the feasibility aspect of the media, as well as the teacher response questionnaire to assess the practicality aspect of the media. Meanwhile, the student response questionnaire used the Guttman scale with yes/no answer choices to facilitate elementary school students in understanding and responding to each statement provided. The instruments used in this study are modifications of previous research instruments and have undergone content validation before being used in data collection. Instrument validation is conducted through expert review to ensure the alignment of content, construct, and indicators measured with the research objectives. The content expert validation instrument is validated by content experts, the media expert validation instrument is validated by media experts, while the teacher and student practicality test instruments are validated by experts in the relevant field. The results of the validation are used as a basis for making improvements to the instruments before they are used in the data collection stage. The assessment instrument grid by content experts can be seen in Table 2, media experts in Table 3, teacher response questionnaires in Table 4, and student response questionnaires in Table 5.

Table 2. Assessment Instrument Grid For Media Evaluation By Mathematics Content Experts

Aspect	Indicator
Curriculum	Alignment with competency standards
	Well-structured material
	Attractive presentation that aids in the delivery of the material
	Completeness of the material
	Material is clearly readable
	Presented material can enhance students' understanding
Language Use	Accuracy of Language Use (no double meanings, easy to understand, and in accordance with EYD rules)

Modified by: Jamilah, (2021)

Table 3. Media Assessment Instrument Grid By Learning Media Experts

Aspect	Indicator
Visual Design	Simplicity of appearance Well-structured material Ease of use of features in AR learning media Layout Quality Image and animation quality
Software Engineering	The suitability of 3D media as a learning support Ease of media operation Error tolerance level
Feasibility	Can be used at any desired time and place Helps students learn independently
Language Use	Accuracy of Language Use (not ambiguous, easy to understand, and in accordance with EYD rules)

Modified by: Jamilah, (2021)

Table 4. Questionnaire Instrument Grid Regarding Teacher Response To Augmented Reality-Based Rotametry Media

Aspect	Indicator
Visual Design	The Appearance of Rotametry Media is Attractive Clarity of Text in Rotametry Media Ease of Using Features in the Assemblr Edu Application on Rotametry Media Quality of Images and AR Animations in Rotametry Media
Presentation of Material	The Role of AR-Based 3D Media in Helping Students Understand Spatial Geometry The Suitability of 3D Animations with Spatial Geometry Material
Software Engineering	Ease of Operating the Assemblr Edu Application Program Reliability AR-Based Rotametry
Feasibility	Media as an Alternative Solution to Enhance Students' Understanding of Spatial Geometry AR-Based Rotametry Media Assists Teachers in Explaining Spatial Geometry Material AR-Based Rotametry Learning Media Supports Students to Learn Actively and Independently

Modified by: Jamilah, (2021)

Table 5. Questionnaire instrument grid regarding student response to augmented reality-based rotametry media

Aspect	Indicator
Visual Design	Attractive Appearance Clarity of text Ease of using features in the Assemblr Edu application Quality of images and animations
Presentation of Material	The role of 3D media in helping students understand spatial concepts Presentation of material that is easy to learn Presentation of material related to everyday life
Implementation	Accuracy of language use (no double meanings, clear and easy to understand, in accordance with EYD rules) Use of supporting media for students to learn independently or in groups 3D image supporting media helps increase students' learning motivation

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Aspect	Indicator
	Practicality of media use
	Ease of accessing Augmented Reality media
	Pleasure in using Augmented Reality-based rotametri learning media

Modified by: Jamilah, (2021)

Data Collection

The research procedure includes three main stages. The analysis stage is conducted to identify learning needs, analyze the curriculum, student characteristics, and learning problems in spatial geometry material. The design stage includes the design of the physical media rotameter, augmented reality marker design, and the preparation of research instruments. The development stage includes the creation of media products, validation by subject matter experts and learning media experts, product revision based on validator suggestions, and the implementation of limited trials to determine the practicality of the media before producing the final product.

Analysis

The data analysis techniques used are quantitative descriptive analysis and qualitative descriptive analysis. The data obtained from expert validation questionnaires and practicality test questionnaires are analyzed using quantitative descriptive analysis through the calculation of achievement level percentages with the following formula:

$$\text{Feasibility percentage (\%)} = \frac{Score\ Obtained}{Maximum\ Score} \times 100\%$$

The obtained percentages are then converted into categories of media feasibility and practicality criteria to provide meaning to the data and support decision-making through qualitative descriptive analysis. The media feasibility criteria can be seen in Table 6, and the media practicality criteria can be seen in Table 7

Table 6. Media Eligibility Criteria

Percentage Score	Eligibility Category
>80% - 100 %	Very Worthy
>60% - 80%	Worthy
>40% - 60%	Somewhat Worthy
>20% - 40%	Not Worthy
>0% - 20%	Very Unworthy

Source: Adapted from Daryono et al., (2020)

Table 7. Practicality Criteria For The Media

Percentage Score	Practicality Category
>80% - 100 %	Very Practical
>60% - 80%	Practical
>40% - 60%	Fairly Practical
>20% - 40%	Not Very Practical
>0% - 20%	Not Practical

Source: Adapted from Fransisca et al., (2019)

Results

Analysis Phase

The development of augmented reality-based rotametry media on spatial building materials in elementary schools is carried out using the ADDIE model, specifically the first stage, which is the analysis stage. In this study, there are three types of analysis: curriculum analysis, which is conducted to identify the curriculum applied in the learning process and adjusted to the developed product; needs analysis, which is conducted to identify and analyze emerging problems and determine the needs that must be met in product development; and content analysis, which is conducted to identify the alignment between the scope of the material to be developed and the curriculum demands as well as the students' learning needs. The curriculum analysis was conducted through interviews and documentation, concluding that the school implements the Merdeka curriculum. The needs analysis was conducted through observations and interviews with fifth-grade teachers and the distribution of questionnaires to students. Based on the results of the needs analysis, it was found that the use of learning media by teachers is still limited to two-dimensional media. In addition, students still have difficulty understanding spatial building materials and show interest in using digital-based learning media. In the content analysis conducted through interviews with fifth-grade teachers, it was found that there are still limitations in the presentation of spatial building materials, as it is not yet supported by the use of adequate learning media.

Design Phase

The design stage begins with creating a conceptual design that will be included in the development product, such as determining the materials, specifying the components contained in the spatial media rotameter, which uses acrylic and will be decorated with A4-sized sticker paper. The Augmented Reality-based rotameter media design is also consulted with the supervising lecturer to obtain feedback and suggestions for improvement.

Development Phase

The development stage is carried out by realizing the Rotametri media product based on Augmented Reality (AR) according to the design plan that has been prepared in the design stage. The development of the media began with preparing learning activities and materials on the three-dimensional shapes of cubes and rectangular prisms that would be presented in the media. Next, the AR content is developed using the Assemblr Edu application by adding various two-dimensional and three-dimensional visual elements to support the visualization of the material. Other supporting elements, such as spatial illustrations and the visual design of each media section, are designed using the Canva application, while the audio narration to clarify the presentation of the material is edited using CapCut.

The technical development process includes creating AR material content, designing the visual layout of the physical Rotametri media, integrating visual elements with the AR platform, creating QR Codes for each media section, and printing the designs using sticker paper. The generated QR Codes are directly linked to the content on the Assemblr Edu platform, allowing users to access augmented reality visualizations conveniently through their smartphones. The next stage is the assembly of the physical Rotametri media by preparing the necessary tools and materials, such as rulers, stationery, scissors, cutters, sticker paper, and glue. In the final stage, all visual elements are attached to the physical media framework, and the QR Code is installed according to the designed partitions, resulting in an AR-based Rotametri product ready for validation and testing.

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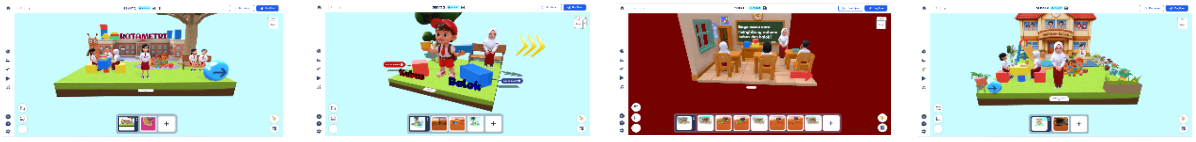

Figure 1. Augmented Reality Design on Each Partition

Figure 2. Rotametry Media Design

After the development of the Rotametri learning media product based on Augmented Reality (AR), validation was conducted by subject matter experts using a rating scale questionnaire to assess the product's feasibility. The results of the expert validation showed a feasibility percentage of 100% with a very feasible category, as indicated in Table 6. Based on the media feasibility criteria, the score falls within the range of X > 80%, thus the media is declared to meet the feasibility standards for use in the learning process. The high level of feasibility is supported by the alignment of the material with learning objectives, the presentation of the material arranged in a gradual and systematic manner, and the clarity in conveying the concept of three-dimensional shapes through the combination of concrete objects such as cubes and rectangular prisms as part of the diorama media with AR-based three-dimensional visualization. The division of the material into four sections allows for the sequential presentation of the material, starting from the introduction of basic concepts, characteristics of three-dimensional shapes, visualization of three-dimensional forms, to the application of concepts in everyday life. Additionally, the integration of QR codes on each section connected to AR visualization through Assemblr Edu provides students with the opportunity to explore spatial objects from various perspectives. These characteristics are considered to support the presentation of spatial material in a more concrete, interactive manner, and in accordance with the learning characteristics of elementary school students. Although it received a very feasible category, the validator still provided some suggestions for product improvement. Revisions were made according to the validator's suggestions, namely replacing the scene explaining the cube formula with a scene explaining how to calculate the volume of a cube so that the presented material aligns better with the learning objectives. Additionally, revisions were made to improve the clarity of the material presentation in the learning media.

Next, validation by media learning experts is conducted to assess the feasibility of the Augmented Reality-based Rotametri based on aspects of media visual design, software engineering, feasibility, and language use. The main constraints lie in the ease of use of the AR feature and the readability of the text. Initial assessment results indicate that the AR visualization accessed through QR code scanning has a relatively long loading time, which can hinder the smooth use of the media in the learning process. Additionally, the text size in the AR material explanations is still considered to need adjustment so that the information can be read more easily by users. Based on the assessment results, the AR-based Rotametri media received

a feasibility percentage of 97% with a very feasible category. Although it has met the eligibility criteria, the validator's feedback was followed up by making improvements to the media, namely reducing the number of scenes and elements on Assemblr Edu to speed up AR visualization access and increasing the font size to enhance text readability. After the improvements were made, the media was revalidated to ensure that the previously identified issues had been resolved. The subsequent validation results show a feasibility percentage of 100% in all assessed aspects, namely media visual design, software engineering, feasibility, and language use, with a very feasible category. The improvement in the validation results indicates that the enhancements made successfully increased the accessibility of AR features and text readability, allowing the use of AR-based Rotametri media to be more optimal and efficient in learning.

The instrument used to measure the level of practicality is a questionnaire for teacher and student responses, which first goes through a validation stage by instrument experts. The validation process aims to assess the content appropriateness, clarity of wording, and the feasibility of each statement used. After the instrument is declared valid, the questionnaire is subsequently used in the practicality test phase through completion by teachers and students. The practicality test was conducted in two forms, namely the teacher response questionnaire using a rating scale and the student response questionnaire using a Guttman scale. Before being used in the data collection stage, the practicality instrument was first revised based on the validator's suggestions to ensure that all statement items were in accordance with the assessment indicators. The validation results show a percentage of 100%, indicating that all indicators in the instrument have met the feasibility criteria and are suitable for use in the research. The practicality test results of the Augmented Reality-based rotameter media for teachers obtained a percentage of 91.12%, while for students, it obtained a percentage of 92.93%. Based on the obtained percentages, the developed product falls into the very practical category, as shown in Table 7. The results indicate that the media has a high level of practicality in terms of ease of use, clarity of usage steps, and the effective implementation of learning activities.

Overall, the development results show that the Augmented Reality (AR)-based Rotametri learning media has the characteristic of integrating three-dimensional concrete media with AR technology into a single learning product. The physical part of the Rotametri includes diorama media in the form of cubes and blocks that allow students to observe spatial objects concretely, while the AR feature provides a three-dimensional visualization of objects that can be interactively explored through smartphones. The integration of these two forms of representation is the main characteristic of Rotametri in presenting spatial material, as students gain the experience of directly observing objects while also exploring their virtual representations. This characteristic distinguishes Rotametri from diorama media, which only presents objects concretely, and AR media, which only presents objects virtually. However, the implementation of this media still faces several challenges, particularly related to the need for a stable internet connection and the availability of adequate supporting facilities. Therefore, before being implemented on a larger scale, adequate support in terms of facilities and infrastructure is needed so that the use of augmented reality-based rotametry learning media on spatial building materials in elementary schools can run optimally, effectively, and sustainably.

Discussion

The developed media is based on a needs analysis that shows students require three-dimensional learning media to help visualize the abstract concepts of spatial shapes. Learning media play a role in supporting the learning process because they can transform abstract concepts into more concrete ones, aligning with the psychological development characteristics

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of elementary school children (Pagarra et al., 2022). This rotametry learning media is designed using acrylic materials with an attractive visual appearance, consisting of four sections with different material presentation focuses, and equipped with QR Code features on each section that are directly connected to Assemblr Edu. Spatial material is presented through three-dimensional animations integrated with Augmented Reality (AR) technology on the Assemblr Edu platform, and is accompanied by explanatory text and audio tailored to the characteristics of the students and the substance of the material. The design of this AR-based rotameter media aligns with the explanation by Saputra et al. (2025) that the application of AR as an interactive learning medium allows students to understand concepts more visually and engagingly, as students can directly interact with three-dimensional geometric objects. This is reinforced by the explanation of Yang et al., (2025) that technologies like AR offer opportunities for representation and interaction that can support mathematics learning. The designed product was then realized in a tangible form, resulting in a product that could be validated to determine the feasibility of the media.

These characteristics indicate that the novelty of Rotametri lies not only in the use of AR technology but also in the integration of three-dimensional concrete media with virtual visualization in a single learning product. Diorama media provides students with the opportunity to observe three-dimensional objects directly through physical forms, while AR allows students to explore three-dimensional objects virtually from various angles. When used separately, dioramas emphasize the experience of observing concrete objects, whereas AR offers an interactive exploration experience of virtual objects. Through Rotametri, these two forms of experience are combined so that students can connect the objects they observe in reality with their digital representations. Thus, the integration of concrete and virtual media in Rotametri provides a different learning experience compared to the use of dioramas or AR separately, as students have the opportunity to observe, explore, and connect two forms of representation in studying the shapes and characteristics of three-dimensional objects.

Based on the validation results by subject matter and media experts, the AR-based rotametry media received a very good qualification because it met all assessment aspects. This is in line with the opinion of Dwinitia et al., (2023), who state that a development product is considered valid if there is consistency between the aspects of content, language, and appearance, the accuracy of which can be scientifically proven. The feasibility of this AR-based rotametry media is also in line with the opinion of Lestari & Dafik, (2025), who explain that the development of AR-based interactive learning media on the topic of three-dimensional space has been proven effective in enhancing students' understanding of geometric concepts, particularly in terms of spatial visualization and student engagement.

This is also supported by the results of limited trials conducted to determine the practicality level of the product for teachers and students. The results of the practicality test of the AR-based Rotametri media based on teacher responses obtained a percentage of 91.12% with a very practical category. The results indicate that the AR-based Rotametri media is considered easy to use and can assist teachers in presenting abstract spatial material through more concrete and interactive visualizations. This is in line with (Fauziyah et al., 2024) who state that AR-based learning media can assist teachers in explaining abstract objects through the simultaneous presentation of text, audio, images, and animations. Thus, the integration of various forms of representation in Rotametri can support teachers in explaining spatial concepts more easily and engagingly. Meanwhile, the practicality test results based on student responses obtained a percentage of 92.93% with a very practical category. The percentage indicates that the AR-based Rotametri media is easy to use and can provide an engaging learning experience for students. The use of media that allows students to observe three-dimensional objects concretely and explore three-dimensional visualizations from various perspectives can help

students understand the shapes and structures of three-dimensional objects more easily. These results are in line with Rohendi et al. (2025), who explain that the application of AR-based learning media is effective for representing three-dimensional shapes because it can enhance interactivity, responsiveness, and students' understanding of abstract geometric concepts. These findings indicate that the practicality of Rotametri is not only evident from its ease of use but also from its ability to provide an interactive visual experience for students in learning spatial concepts.

Conclusion

Based on the research results, it can be concluded that the three schools need technology-based 3D learning media to help represent the abstract concept of spatial shapes. The AR-based Rotametri media is designed in the form of a block that can be rotated 360°, consisting of four sequential sections containing spatial material, and equipped with a QR Code to access AR content. The media was developed through the stages of analysis, design, and development, followed by limited testing. The validation results from material experts and media experts each obtained a percentage of 100% with the category of very feasible. In the practicality test results, a percentage of 91.12% was obtained based on teacher responses and 92.93% based on student responses, both categorized as very practical. Thus, the AR-based Rotametri media meets the criteria of being feasible and practical for use as a learning medium for spatial structures in limited trials. Nevertheless, this research is limited to the development and limited trial stages, so it has not yet tested the media's effectiveness on learning outcomes and has not involved a broader scope of schools and subjects. Subsequent research is recommended to implement the media on a wider scale and test its effectiveness on student learning outcomes by involving a comparison group if possible.

Conflict of Interest

The authors declare no conflict of interest.

Auhor Contributions

Z.Z. contributed to research design, media development, instrument design, data collection/analysis, and manuscript drafting. N.H and A.F.. contributed to research supervision, methodological guidance, and manuscript editing. A.T.A.M. contributed to instrument validation, result review, and final manuscript revision. All authors read and approved the final version. Contribution proportion: Z.Z.: 20%, N.H.: 20%, A.T.A.M.: 40%, and A.F.: 20%.

Data Availability Statement

Data supporting the findings of this study are available from the corresponding author, A.T.A.M., upon reasonable request.

References

Braak, D. ten, Lenesa, R., Purpurab, D. J., Schmittb, S. A., & Størksen, I. (2022). Why do early mathematics skills predict later mathematics and reading achievement? The role of executive function. *Journal of Experimental Child Psychology*, *214*(105306), 1–18. https://doi.org/10.1016/j.jecp.2021.105306

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https://doi.org/10.51574/kognitif.v6i3.5797 Volume 6, No 3, July - September 2026, pp. 1409 –1423

Daryono, R. W., Rochmadi, S., & Hidayat, N. (2020). Development and validation of video-based learning media to increase competency achievement in civil engineering education. *Journal of Physics: Conference Series*, *1833*(1). https://doi.org/10.1088/1742-6596/1833/1/012022

Dwinitia, S., Hartati, Y. S., & Melita. (2023). Validity of Learning Module Development Designing Scientific Work Proposals Based on Project Based Learning. *Journal of Asian Studies: Culture, Language, Art and Communications*, *4*(2). https://ojs3.haqipub.com/index.php/jas/article/viewFile/320/153

Fauziyah, S., Sudatha, I. G. W., & Sudarma, I. K. (2024). Interactive Learning Multimedia Using Contextual Approach for Students in Fifth Grade of Elementary School. *Jurnal Pedagogi Dan Pembelajaran*, *7*(2), 369–380. https://doi.org/10.23887/jp2.v7i2.82398

Fransisca, M., Yunus, Y., & Sutiasih, A. D. (2019). Practicality of E-Learning as Learning Media in Digital Simulation Subjects at Vocational School in Padang Practicality of E-Learning as Learning Media in Digital Simulation Subjects at Vocational School in Padang. *Journal of Physics: Conference Series*, *1339*(1). https://doi.org/10.1088/1742-6596/1339/1/012077

Humaira, T., & Ninawati, M. (2023). Development of Contextual Media Diorama of Water Cycle in Science Subject in Elementary School. *Jurnal Cakrawala Pendas*, *9*(4), 631–641. https://doi.org/10.31949/jcp.v9i4.5653

Lestari, W., & Dafik. (2025). Development of learning media based on augmented reality. *JDIME : Journal of Development and Innovation In Mathematics Education*, *3*(1), 48–56. https://doi.org/10.1201/9781003353423-11

Melinda, W., & Ariyani, Y. D. (2024). Development of diorama based learning media to improve Eeementary school students' creative thinking ability. *Indonesian Journal of Classroom Action Research*, *2*(20), 5–9. https://reposister.almaata.ac.id/id/eprint/461/4/Bukti Kinerja_Artikel Penelitian.

Mukhlisa, N. (2021). Miskonsepsi Pada Peserta Didik. *SPEED Journal : Journal of Special Education*, *4*(2), 66–76. https://doi.org/10.31537/speed.v4i2.403

Nasrulloh, I., Rahadian, D., Hamdani, N. A., Imania, K. A. N., & Rikaldi, P. B. R. (2021). A comparative study: Multimedia interactive use on contextual and cooperative approaches in increasing mathematical understanding. *Journal of Physics: Conference Series*, *1987*(1). https://doi.org/10.1088/1742-6596/1987/1/012015

Pagarra, H., Syawaluddin, A., Krismanto, W., & Sayidiman. (2022). Media Pembelajaran. In *Badan Penerbit UNM*. Badan Penerbit UNM.

Putrie, S. N., & Syah, M. N. S. (2023). Development of 3D Math AR Applications as Mathematics Learning Media Augmented Reality Based. *Hipotenusa : Journal of Mathematical Society*, *5*(1), 72–81. https://doi.org/10.18326/hipotenusa.v5i1.6401

Rahmiati, D., Sarwi, Sudarmin, & Cahyono, A. N. (2020). The Use of Augmented Reality Diorama Media in Natural and Social Sciences Subjects for Fourth Grade Elementary School. *JOURNAL LA EDUSCI*, *01*(04), 16–25. https://doi.org/10.37899/journallaedusci.v1i5.256

Rohendi, D., Ramadhan, M. O., Rahim, S. S. A., & Zulnaidi, H. (2025). Enhancing student's interactivity and responses in learning geometry by using augmented reality. *Eurasia Journal of Mathematics, Science and Technology Education*, *21*(1), 1–14. https://doi.org/10.29333/ejmste/15796

Rusmayana, T. (2021). *Model Pembelajaran ADDIE Integrasi Pedati Di SMK PGRI Karisma Bangsa Sebagai Pengganti Praktek Kerja Lapangan Di Masa Pandemi Covid-19* (R. Hartono.Bogor: Widina Bhakti Persada Bandung.

Saputra, R. A., Alfarizi, M., Saputri, F. H., & Ferawati. (2025). Development of Augmented

Reality-Based Learning Media with MDLC Model for Solid Geometry for Elementary School Students. *Jurnal Dan Penelitian Teknik Informatika*, *9*(2), 615–624. https://doi.org/10.33395/sinkron.v9i2.14601

Saraswati, S., Nugroho, M. W., Saraswati, E., & Hartiningrum, N. (2026). Pembelajaran PBL Berbasis Ethno-STEM dan Augmented Reality : Proses dan Respon Mahasiswa PBL Learning Based on Ethno-STEM and Augmented Reality : Student Process and Response. *Jurnal Axioma: Jurnal Matematika Dan Pembelajaran*, *11*(1). https://doi.org/10.56013/axi.v11i1.5372

Sidyawati, L., Masruroh, R., & Siregar, I. E. (2021). Development of Diorama Learning Media for Fourth Grade Elementary School. *Journal of Teaching and Learning in Elementary Education (Jtlee)*, *4*(2), 211. https://doi.org/10.33578/jtlee.v4i2.7897

Syafril, S., Asril, Z., Engkizar, E., Zafirah, A., Agusti, F. A., & Sugiharta, I. (2021). Designing prototype model of virtual geometry in mathematics learning using augmented reality. *IOP Conference Series: Earth and Environmental Science*, *1796*(1). https://doi.org/10.1088/1742-6596/1796/1/012035

Tarng, W., Huang, J. K., & Ou, K. L. (2024). Improving Elementary Students' Geometric Understanding Through Augmented Reality and Its Performance Evaluation. *Systems*, *12*(493), 2–28. https://doi.org/10.3390/systems12110493

Tuta, B. B., Harta, J., & Purwasih, S. S. (2022). Development of Assemblr Edu-Assisted Augmented Reality Learning Media on the Topic of Effect of Reactant'S Concentration and Catalyst on Reaction Rate. *JCER (Journal of Chemistry Education Research)*, *6*(1), 58–71. https://doi.org/10.26740/jcer.v6n1.p58-71

Utami, N. F., & Irawati, R. K. (2024). Effectiveness of Ethnomathematics-Based Learning Media on Students ' Understanding of Geometry Material Concepts in Grade IV. *Journal of Educational Research and Practice*, *2*(3), 21–34. https://doi.org/https://doi.org/10.70376/jerp.v2i3.203

Yang, Y., Du, W., Mavrikis, M., & Geraniou, E. (2025). Spatial Skill Development Through Augmented Reality in Mathematics Education : A Scoping Review. *Digital Experiences in Mathematics Education*, *0123456789*. https://doi.org/10.1007/s40751-025-00187-8

Yusup, M., Fathurohman, I., & Khamdun. (2024). Development of Diorama Media Containing Psychomotoric and Cognitive Skills in Science Learning Based on Local Wisdom in Fourth Grade Students of Baturno State Primary School. *ICCCM-Journal Of Social Sciences And Humanities*, *3*(3), 94–99. https://doi.org/10.53797/icccmjssh.v3i3.14.2024

Zahrah Jamilah. (2021). *Pengembangan Media Pembelajaran Mobile Apps*. Skripsi dipublikasikan. Universitas Islam Negeri Syarif Hidayatullah.

Zainal, Z., Halik, A., Sultan, M. A., & Resa, A. (2021). Development of Geometry Flipbook Multi 4533 Words Journal of Educational Science and Technology Development of Geometry Flipbook Multimedia Learning Media for Elementary School Students. *Journal of Educational Science and Technology*, *7*(2), 207–215. https://doi.org/10.26858/est.v0i0.20443

Zainal, Z., Rudy, S., & Hasan, K. (2025). Development of Pop-Up Book Geometry Integrated with. *AIP CONFERENCE PROCEEDINGS*, *020029*. https://doi.org/https://doi.org/10.1063/5.0262335

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