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Development of Augmented Reality-Based Media for Polyhedron Materials

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ABSTRACT

There are difficulties for students in understanding concepts and illustrating polyhedron. Furthermore, the lack of learning media and the absence of technology based-media that can illustrate the material is an urgent problem that needs to be solved. Furthermore, the lack of learning media and the absence of technology-based media that can illustrate the material is an urgent problem that needs to be solved. Therefore, we developed *Augmented Reality* (*AR*) based learning media as a tool to help students visualise the material. This study used the *Research and Development* (*R&D)* model with the involvement of secondary school students (29 eighth-grade students). Before being tested, the media was validated by subject material experts and media experts with a minimum rating of good. The implementation was carried out twice, in small and large classes. The media was considered feasible if the minimum rating from each subject material expert, media expert, and student response was good. The results of the study showed that the subject material expert gave a score of 4.54 with a very good category, while the media expert gave a score of 4.31 with a very good category, and student responses scored 4.12 with a good category. Thus, the Augmented Reality (AR)-based learning media can be used in the learning process and can be further researched for its effectiveness. The novelty of this study lies in the development of AR-based learning media specifically focused on flat-sided spatial structures. The developed media enables students to visualise spatial structures in three dimensions, interactively, and contextually, thereby overcoming the limitations of conventional static media.

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Introduction

Technological advances in the current era have influenced educational activities through the learning process. This has encouraged the use of information technology to keep pace with advances in science and improve the quality of the learning process. According to Rozi (2021) developing technology influences people's mindsets and lives. According to Herrington (2008) simple mobile phones have evolved into sophisticated smartphones that are not only used for calls and messages but also for taking photos, recording activities, sharing information, and even as a learning tool. In line with the research by Ma'arif & Murdiono (2021), Kahar & Fadhilah (2019), and Kasman & Nurindah (2021) which states that smartphones have the potential as learning tools that can help students understand lesson material and have an influence on student learning outcomes.

The development of technology and communication cannot be separated from the role of mathematics as a universal science. Mathematical thinking skills, from simple to complex, are always used in everyday life, making mathematics very important for humans (Tampubolon et al., 2014). However, students' mathematical thinking skills in Indonesia are still low and have not developed optimally, as shown by the results of the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA). The Trends in International Mathematics and Science Study (TIMSS) is an international study that assesses the development of mathematics and science achievement, organised by the International Association for the Evaluation of Educational Achievement (IEA). TIMSS results show that Indonesian students' mathematics skills are still very low. In 2015, Indonesia ranked 44th out of 49 countries with an average score of 397, far below the international average of 500. From 2003 to 2015, Indonesia's ranking and scores remained stagnant and consistently placed it among the bottom 10 countries. Similar results were shown by the Programme for International Student Assessment (PISA), where Indonesia consistently ranked in the bottom 10 from 2000 to 2018 with average scores below international standards. Particularly in geometry, which measures visualisation, modelling, and spatial ability, only 33.4% of Indonesian students were able to answer correctly, indicating a weak understanding of space and shape (Rumiati, 2011; Chintia et al., 2021). This condition indicates that Indonesian students' spatial and geometry skills still require attention and reinforcement through appropriate learning strategies. One learning strategy is the availability of learning media that suits students' needs. In line with Wulandari et al. (2024) and Pasaribu et al. (2024) stated that learning media that suits students' needs is an effective learning strategy.

Various studies indicate that visual learning media play a significant role in strengthening geometric concept understanding, improving spatial abilities, and stimulating students' interest in learning (Khoriyani & Suhendra, 2022; Manik et al., 2024). However, the ASPD results for mathematics at SMP Negeri 1 Panggang show significant challenges in students' mastery of geometric material and spatial abilities. Out of six classes, the highest score was only 68 and the lowest was 13, reflecting a serious gap in mathematical understanding. Geometry not only requires calculation skills but also spatial skills to visualise, rotate, and understand the relationships between objects in space (Azustiani, 2017). These limitations make it difficult for students to think critically and analytically when solving geometry problems. This condition indicates that conventional teaching methods have not been effective in developing students' spatial abilities. Therefore, a more interactive and innovative learning approach is needed through the use of visual media, technology, and 3D simulations, as well as exercises that involve visualisation and manipulation of objects. The results of this ASPD serve as a warning that geometry teaching strategies need to be improved so that students can better understand abstract mathematical concepts and improve their overall learning outcomes.

Augmented Reality (AR) is a technology that combines the real and virtual worlds in 2D or 3D form through devices such as smartphone cameras and computers, creating interactive visualisations that support the learning process (Wardani et al., 2015). In learning about polyhedron, students require media that help them visualise shapes concretely. However, observations and surveys at SMP Negeri 1 Panggang indicate that many students struggle to

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understand and illustrate prisms and pyramids because the available learning media are limited to books and worksheets that are not interactive. Research conducted by Saleh et al. (2023), Chahande & Deshmukh (2022), and Taiwo & et al. (2022) states that the use of Augmented Reality-based learning media can help students better understand geometric concepts, visualise complex concepts such as spatial geometry, and interact with 3D objects from spatial figures. Therefore, the development of AR-based learning media is a solution because AR offers real visualisation, is interactive, cost-effective, easy to operate, and can facilitate teachers in delivering geometry material efficiently (Rachmawati et al., 2020; Mustaqim & Kurniawan in Arifin et al., 2020). This AR-based media is expected to help students better understand polyhedron. The novelty of this research lies not only in the application of AR to polyhedron, but also in the effort to integrate the aspects of visualisation, interactivity, and the context of mathematics learning in junior high school. The implication of this research is to provide an alternative innovative learning media that can be implemented by teachers in the classroom to improve the quality of students' learning experiences. The contribution of this research is evident in the provision of media that is suitable for supporting the mastery of geometric concepts, particularly polyhedron. The objectives of this study were to develop and produce AR-based learning media that is suitable, practical, and useful for eighth-grade junior high school students, as well as to provide an empirical basis that AR technology can be optimally integrated into mathematics learning in junior high schools.

Method

Settings

The method used in this study is Research and Development (R&D) with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. According to Branch (2009) the ADDIE development model provides clear guidelines for media developers, guiding them from needs analysis to evaluation. This study uses the ADDIE development model because it has systematic stages, starting from analysis, design, development, implementation, to evaluation. This model is flexible and allows for revisions at every stage so that the resulting media is more suitable for use in learning. The development model used is ADDIE (Analysis, Design, Development, Implementation, Evaluation). The following is a step-by-step explanation of the ADDIE development model, starting with the first stage, which is *Analysis*, where the researcher analyses the needs by identifying the problems faced by students, especially difficulties in visualising polyhedron. Additionally, a curriculum analysis is conducted to ensure that the developed materials align with the Learning Outcomes (CP) and competencies that students must master. Furthermore, an analysis of student characteristics is conducted through observations and interviews with teachers, so that the developed media can be tailored to the students' learning conditions and needs. This aligns with Safitri (2015) and Chotimah & Manoy (2021) who state that a thorough needs analysis, including curriculum, learning outcomes, and student characteristics, is necessary to ensure that the developed media align with students' needs and conditions and can be maximally utilised for the learning process. The second stage is the design stage, where the researcher develops an initial design of the educational media in the form of a storyboard. This design includes the application navigation flow, interface display, and features to be included, such as the material menu, *AR (Augmented Reality)* visualisation menu, quizzes, and help and information features. At this stage, the researcher also determines the flow of user interaction with the application so that the application is easy to use and in accordance with the learning objectives. The third stage is development, which involves realising the design into a tangible product. The researcher created an augmented reality-based application in accordance with the design that had been previously designed. The resulting product was then validated by subject matter experts, media experts, and teachers to ensure the suitability of the content, visual appearance, navigation, and the suitability of the media for the learning objectives. After the product was revised, the next stage was implementation. At this stage, the application was tested on eighth-grade students at Panggang 1 Public Junior High School. The final stage is evaluation, which is conducted to assess the results of the application implementation. Researchers conduct evaluations based on data obtained from assessment questionnaires filled out by subject matter experts, media experts, and student responses. The data obtained is analysed to determine the level of product feasibility.

Subjects

The subjects of this study were 29 students in class VIII E at SMP Negeri 1 Panggang. The participating students are aged 13–14 years, consistent with the cognitive development characteristics of early adolescents. Of these, 14 students are male and 15 are female. They served as respondents in both small-classes and large-classes trials to provide feedback on the feasibility and usefulness of the developed learning media

Instruments

The instruments used in this study were interview guidelines and questionnaires. The interview guidelines developed were semi-structured interview guidelines for pre-research needs analysis of teachers and students. Meanwhile, the questionnaires included a pre-research questionnaire for students, an assessment questionnaire for subject material experts and media experts, and a student response questionnaire. The questionnaires were designed based on a grid covering aspects of content, language, and presentation for subject material experts. Meanwhile, aspects of ease of use, visual appearance, media integration, and media benefits were assessed for media experts. As for the student response questionnaire, the grid covers aspects of material, language, and interest for students. This is done in order to obtain complete data in assessing the feasibility of the developed media. Table 1 below is a questionnaire for subject materials experts, media experts, and student responses.

Table 1. Questionaire of materials, media and student respon

No	Questionaire	Aspect	Indicator
1	Materials	Content	Appropriateness of material to basic competencies
			Accuracy of material
			Timelineness of material materi
			Encourages curiosity
		Language	Effective and efecient use of language
			Ability to encourage curiosity in student
			Alignment with Indonesian language rules
			Readability
		Presentation	Coherence of presentation
			Supporting elements of presentation
			Completeness of presentation
2	Ahli Media	Ease of Use and Navigation	Media installation
			Navigation
		Visual Display	Attarctivenss of media display
			Use of fonts
			Regulaity of media design
			Colour Selection

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		Media Integration	Appropriateness of images, animations and materials
			Clarity of animation and text
			Use of audio
		Benefit of Media	Benefit for students
3	Student	Student Respon	Material
			Language
			Interest

Data Collection

Data collection methods in this study were conducted through interviews and questionnaires. Interviews were conducted in a structured manner with eighth-grade mathematics teachers at SMP Negeri 1 Panggang to obtain preliminary data related to problems in learning. Meanwhile, questionnaires were used to collect data from various respondents, including students, comprising pre-assessment questionnaires for students, assessment questionnaires for subject materials experts and media experts, as well as student response questionnaires after the use of learning media.

Analysis

Data analysis techniques in this study were carried out by converting qualitative data obtained from questionnaires completed by experts and students into quantitative data using a Likert scale with the following provisions.

Table 2. Likert Scale

Description	Score
Very Good	5
Good	4
Fair	3
Poor	2
Very Poor	1

Then, the scores obtained will be averaged to determine the overall assessment of the media, using the following formula.

$$\bar{x} = \frac{\sum x}{n}$$

Description:

$\bar{x}$ = Average score

$\sum x$ = total score obtained

n = number of respondents

The formula above is used to determine the average score obtained. Next, the data is converted into qualitative data based on ideal assessment. The results of the data analysis are used as a basis for determining the quality of the media. The ideal assessment criteria are as follows.

Table 3. Assessment Criteria

Score	Criteris
$\bar{X} > \bar{X}_i + 1{,}8\,SB$	Very Good
$\bar{X}_i + 0{,}6\,SB < \bar{X} \leq \bar{X}_i + 1{,}8\,SB$	Good
$\bar{X}_i - 0{,}6\,SB < \bar{X} \leq \bar{X}_i + 0{,}6SB$	Fair
$\bar{X}_i - 1{,}8\,SB < \bar{X} \leq \bar{X}_i - 0{,}6\,SB$	Poor

$\bar{X} \leq \bar{X}_i 1{,}8\ SB$	Very Poor

Description

$\bar{X}\ = Validity\ score$

$\bar{X}_i$ = Ideal average score

$\bar{X}_i = \frac{1}{2}$ (ideal maximal score + ideal minimal score)

$SB = \frac{1}{6}$ (ideal maximal score - ideal minimal score)

ideal maximal score $= \sum item\ criteria\ \times highest\ score$

ideal minimal score $= \sum item\ criteria\ \times\ lowest\ score$

The feasibility of the developed media was determined based on the average score from the subject materials experts, media experts, and students. If the average score met the minimum criteria, the media was deemed feasible for use in teaching eighth-grade mathematics on polyhedron.

Results

Analysis

During the analysis stage, researchers conducted a series of activities to obtain an overview of the needs for developing augmented reality-based learning media at SMP N 1 Panggang. The needs analysis was conducted through interviews with teachers and five students and the distribution of questionnaires to 32 students, which showed that 90.62% of students had difficulty learning mathematics, especially polyhedron, due to the limitations of learning media that only relied on textbooks. Students found it difficult to illustrate the shapes of spatial figures and wanted innovative and interesting learning media. In addition, there was no Android-based learning media available to facilitate students' understanding. Material analysis showed that polyhedron were chosen as the focus of development because they were considered difficult to understand, especially in imagining the shapes of pyramids and prisms, as well as determining space diagonals and diagonal planes. Furthermore, a curriculum analysis was conducted to ensure that the developed learning media align with the Merdeka Curriculum implemented at SMP N 1 Panggang, ensuring that the resulting media are truly relevant to the school's learning needs.

Design

At this stage, researchers collect information about the things needed to create augmented reality-based learning media, search for reference materials, and look for examples of applications that are in line with the learning media to be developed. Next, the application to be created is designed, and the elements to be used in the application are determined, including the home page, assessment criteria, settings, application usage instructions, researcher identification, augmented reality camera menu, content, and quiz menu.

Development

This stage involves developing the learning media that was designed in the previous stage. The first process in developing augmented reality-based learning media is to create materials and quizzes using Microsoft Word. Then, brainstorm the technology to be used and the general overview of the application, create a wireframe of the application to be made, align the

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wireframe with input or revisions, start creating the initial application system according to the wireframe (login, application tabs, and simple system), start the advanced application creation process (create a question system, create a 3D preview system, and create an AR preview), converting initial assets into application assets, designing 2D and 3D assets, and exporting them into the application system, integrating the application asset system with the main application (including AR and 3D previews), revising, and finally completing the development of the educational media. Below is the design of the educational media developed.

Figure 1. Instructional Media Design

After the media has been developed, the next stage is media validation by subject materials experts and media experts from lecturers and teachers.

Implementation

At this stage, researchers conducted trials on the developed media to determine its suitability as learning media. The trials were conducted on two scales, namely small class trials and large class trials. The small class trials involved five students from class VIII E who were selected based on the recommendations of their mathematics teacher. This activity was conducted offline at the school, where the learning media was presented by the teacher to the students for them to try out directly.

Evaluation

At this stage, researchers analysed the results of trials of *Augmented Reality*-based learning media on polyhedron geometry material for eighth-grade junior high school students. This stage aimed to improve the media that had been developed so that it would meet the feasibility criteria before being used in learning. The evaluation process began with validation by subject matter experts and media experts, who provided input on the content and appearance of the media. This feedback serves as the basis for researchers to revise the media. Subsequently, a trial is conducted with students to obtain direct feedback from users, which is also considered in the final refinement of the product.

Data Analysis

To determine whether a product is feasible or not, data analysis is carried out as a follow-up to the evaluation stage. The data obtained is quantitative data, which is then processed into qualitative data. The data consists of three parts, namely, assessment by subject materials experts, assessment by media experts, and student response questionnaires. The results of the assessment are presented as follows.

Quality of Product Based on Subject Material Experts

The Quality the material developed by the researchers was assessed by two material experts, namely a mathematics lecturer at Ahmad Dahlan University and a mathematics teacher at SMP N 1 Panggang. The Table 4 shows the results of the material assessment for the media developed by the researchers.

Table 4. Product Feasibility Based on Material Experts

No	Aspect	Average	Criteria
1.	Content	4,41	Very Good
2.	Language	4,69	Very Good
3.	Presentation	4,58	Very Good
	Total Average	4,56	Very Good

Based on Table 4, the average score was 4.56. This result shows that the learning media developed met the criteria of very good in terms of material.

Quality of Product Based on Media Experts

The quality of the learning media developed by the researchers was assessed by two media experts, namely a mathematics lecturer at Ahmad Dahlan University and a mathematics teacher at SMP N 1 Panggang. Table 5 below shows the results of the media assessment of the learning media developed by the researchers.

Table 5. Product Feasibility Based on Media Experts

No	Aspect	Average	Criteria
1.	Ease of Use and Navigation	4,25	Very Good
2.	Tampilan Visual AR	4,33	Very Good
3.	Visual Display	4,33	Very Good
4.	Manfaat Media	4,33	Very Good
	Total Average	4,31	Very Good

Based on Table 5, the average score was 4.31. The results indicate that the learning media developed met the criteria for excellent learning media in terms of very good.

Quality of Product Based on Students Response

Respon Student responses can be seen from the assessment results based on questionnaires that were distributed directly and filled out by 29 students in class VIII E at SMP N 1 Panggang. The following are the results of the student response questionnaire

Table 6. Result of Students Response

No	Sample Test	Average	Criteria
1.	Test of small classes	4,24	Very Good
2.	Test of large classes	4,04	Good
	Total Average	4,14	Good

Based on Table 6 above, it can be seen that the results of the student response calculations for the small class trial were 4.24 on average. These results indicate that the developed product

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meets the criteria for very good. Then, for the large class trial, the average score was 4.04 with a good criteria. Thus, the average student response score was 4.14 with a good criteria. To help students understand the concept of block nets more concretely, interactive 3D visual learning media is used. Through this display, students can see how blocks can be opened into flat nets and reassembled into their original shapes. Figures 2 and Figure 3 show examples of visualisations of block nets that can be opened and closed virtually.

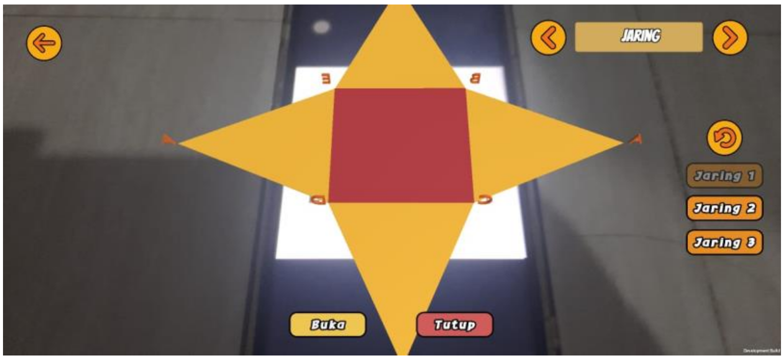

Figure 2. AR Display on smarthphone

Figure 2 shows the Augmented Reality (AR) view of a polyhedron pyramid-shaped space construction net. This net consists of a red square in the centre as the base of the pyramid, and four yellow isosceles triangles attached to each side of the square as the vertical sides. Each corner of the net is labelled A, B, C, and D to facilitate understanding of the relationship between the sides. On the AR interface, there are left and right navigation buttons in the form of orange arrows to change the type of net, 'Open' and 'Close' buttons to display or fold the net into a three-dimensional shape, and options for Net 1, Net 2, and Net 3, which display variations of the pyramid net. There is also a circular arrow button to rotate or reset the view. With AR technology, the net is visualised on the phone screen, making the three-dimensional object appear as if it is in the real world, helping students understand the process of transforming the net into a three-dimensional shape.

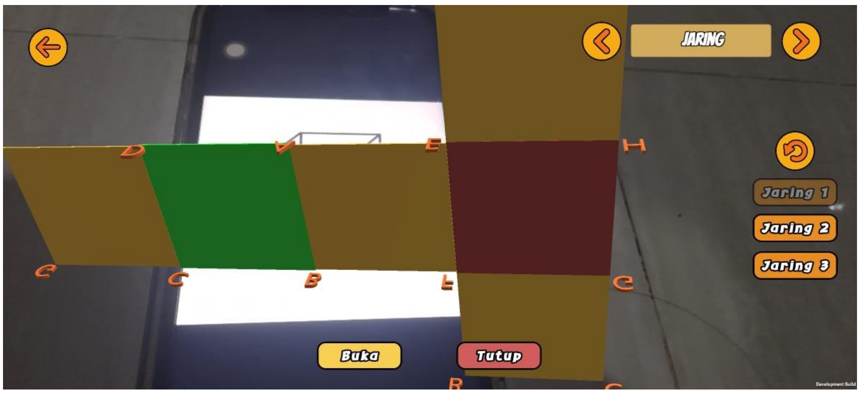

Figure 3. AR Displays of cube grids on smartphone

Figure 3 shows an interactive application display showing a 3D block grid that can be opened and closed virtually. The screen shows several rectangular fields of different colours (brown, green, and maroon) that are interconnected to form a grid. Each side has letter markers such as C, D, V, B, E, L, H, and R, which indicate the corners or edges of the blocks. On the right side of the screen, there are navigation buttons to select different grid variations (Grid 1, Grid 2, Grid 3) and arrow icons to switch views. At the bottom are two main buttons: 'Open' in yellow to open the net and 'Close' in red to close it, allowing users to easily visualise the transformation of the three-dimensional shape into a flat net. The visualisation of the block nets in Figure 3 shows that three-dimensional shapes can be opened into a flat arrangement. This presentation aims to make it easier for students to understand the relationship between spatial shapes and the flat shapes that compose them. Through this medium, abstract concepts become more tangible, enabling students to identify the parts of the rectangular prism more easily.

Discussion

At this analysis stage, interviews and questionnaires were conducted to identify the needs and difficulties experienced by students and teachers. This is necessary because, according to Subiyantoro (2018) the media developed must be relevant to the needs and problems faced by students. Additionally, it is important to identify the curriculum and materials that are relevant and aligned with the learning outcomes that students must achieve (Fatimah et al., 2024). Meanwhile, the design phase involves creating an initial design that includes the interaction flow, user interface, and other important features. Research by Putra & Murniati (2023) and Chahande & Deshmukh (2022) shows that a systematic design in the ADDIE model can encourage the development of media that integrates various components well. During the development stage, designing wireframes and paying attention to user interface navigation is crucial because, according to Purnama & Alfian (2021), wireframe alignment is done to ensure user needs are met. Meanwhile, for the implementation stage, small-scale classroom trials are necessary because, according to Wulandari et al (2022) and Al Hilal & Auliya (2021) initial trials with a small number of participants prevent larger errors and identify needs that need to be improved before implementation in larger classrooms. The final stage of the ADDIE model is evaluation, which focuses on assessing the developed learning media before they are used in broader learning processes. Hidayat & Nizar (2021) state that through evaluation, the quality of the developed learning media can be improved and ensure that the content is relevant to the current curriculum.

Based on Table 3, the average score from subject matter experts was 4.56. This result indicates that the developed learning media met the criteria for excellent in terms of content. According to Sulfiyah et al. (2020) media that can visualise content can improve students' conceptual understanding. Meanwhile, based on Table 4, the average score was 4.31. This result shows that the developed learning media achieved excellent criteria in terms of media. This is in line with Munir et al. (2022) who stated that Augmented Reality (AR) can help visualise geometric structures from the virtual world to the real world, which is useful in education. Additionally, the indicators for media display and media integration in Table 4 show a score of 4.33, indicating very good criteria. These indicators include statements regarding 3D display and interactivity. The media display indicator, which includes statements about 3D display, received the highest score of 4.33, indicating that the 3D objects visualised by the media are able to display realistic details, proportions, and colours. This finding aligns with the research by Rossano et al. (2020) which states that accurate 3D visualisation can enhance students' spatial perception and accelerate the process of understanding geometric concepts.

Table 4 shows indicators of media integration, namely integration with learning materials, which also scored high at 4.33, indicating that the AR model has been designed to be relevant to basic competencies and learning indicators. According to Panwar et al. (2024) AR-based media should be in line with applicable curriculum standards in order to increase student engagement. Expert validation of the content and media yielded consistent scores in the 'very good' category, consistent with previous research findings that AR can present content in a more dynamic and engaging manner, visualising 3D models (Maulida et al., 2024). This

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impacts the learning process, improving students' literacy, interactive learning experiences, and interest (Pujiastuti, 2023; Nugroho et al., 2024) thereby enhancing the quality of the learning process (Qomario et al., 2022). Thus, the development of AR-based learning media in this study not only provides a solution to the limitations of conventional media but also strengthens technology-based learning practices relevant to the digital era.

The novelty of this study lies in the development of an Augmented Reality (AR)-based learning media specifically focused on flat-sided shapes for eighth-grade junior high school students. Until now, the use of AR in mathematics learning has been mostly directed at general geometry topics or different education levels, so that specific application to polyhedron at the junior high school level is still rare. The developed media enables students to visualise three-dimensional shapes in an interactive and contextual manner, thereby overcoming the limitations of conventional static media. The development process was carried out systematically using the ADDIE model, supplemented by validation from subject matter experts, media experts, and trials in small and large classes, which showed excellent criteria for subject matter and media experts and good criteria for the average response of students in small and large classes. This aligns with recent findings Pujiastuti (2023) and Dilek (2025) who state that AR media, with its three-dimensional object visualisation and interactivity, is effective in enhancing spatial reasoning skills, learning motivation, and student engagement in geometry learning.

Conclusion

Based on the results of research and development of augmented reality learning media on flat-sided spatial figures for Grade VIII students at SMP N 1 Panggang, it was concluded that the development process was carried out in five stages, namely needs analysis, media and assessment instrument design, creation of augmented reality-based media, trial implementation with students, and evaluation through expert validation and student responses. The feasibility assessment results showed that the learning media obtained an average score of 4.56 from subject matter experts, 4.31 from media experts, and 4.14 from student responses. Based on the existing criteria, the augmented reality-based learning media obtained a very good rating from experts and a good rating from student responses. It can be concluded that the learning media is suitable for use in the learning process. The researchers suggest that this media can be used in teaching and learning activities to facilitate students' understanding of polyhedron and as a reference in the development of similar learning media with better quality in the future. This study has several limitations, including the fact that the trials conducted emphasised the feasibility and student responses, so that the effectiveness of the media in improving learning outcomes was not fully evaluated in depth. Additionally, the limited availability of devices among students poses a challenge, as not all students have devices with specifications that support the optimal use of AR media. Therefore, future research is expected to involve a larger sample size, include effectiveness tests, and integrate AR media with a variety of devices to obtain more comprehensive results.

Conflict of Interest

The authors declare that there are no conflicts of interest influencing the planning, implementation, analysis, or writing of the results of this study.

Author Contributions

S.W.P. comprehended the presented research ideas and collected the data. The other authors (S.F. and S.B.) actively participated in the development of the theory, methodology, organization and analysis of the data, discussion of the results, and approval of the final version of the manuscript. All authors declare that they have read and approved the final version of this paper. The total percentage contributions to the conceptualization, preparation, and revision of this manuscript are as follows: S.W.P.: 45%, S.F.: 30%, and S.B.: 25%.

Data Availability Statement

The authors state that the data supporting the findings of this study are available from the corresponding author, [S.W.P.], upon reasonable request.

References

Al Hilal, A. Y., & Auliya, N. N. F. (2021). Pengembangan Media Pembelajaran Multimedia Interaktif Menggunakan Microsoft PowerPoint pada Materi Peluang Pendidikan merupakan upaya mencerdaskan kehidupan masyarakat. 227–242. 10.21043/jmtk.v4i2.12131.

Arifin, A. M., Pujiastuti, H., & Sudiana, R. (2020). Pengembangan media pembelajaran STEM dengan augmented reality untuk meningkatkan kemampuan spasial matematis siswa. *Jurnal Riset Pendidikan Matematika*, *7*(1), 59–73. https://doi.org/10.21831/jrpm.v7i1.32135

Azustiani, H. (2017). Kemampuan Spasial Siswa SMP kelas VIII Ditinjau Dari Kemampuan Matematika Siswa. 1(1), 293–298. Available at: https://conferences.uin-malang.ac.id/index.php/SIMANIS/article/view/92

Branch. (2009). Instructional Design: The ADDIE Approach. (Vol. 722, p. 84). New York: Springer.

Chahande, J., & Deshmukh, S. (2022). Perception of undergraduate dental students about use of smartphones in dentistry : an efficient teaching-learning tool during covid. 3(2), 138–152. https://doi.org/10.55662/AJMRR.2022.3205

Chintia, M., Amelia, R., & Fitriani, N. (2021). RUANG SISI DATAR. 4(3), 579–586. https://doi.org/10.22460/jpmi.v4i3.579-586

Chotimah, S. C., & Manoy, J. T. (2021). Pengembangan media pembelajaran berbasis powerpoint visual basic for Application (VBA) Untuk Mendukung Kemampuan Spasial Siswa. 10(2). *MATHEdunesa*, *10*(2), https://doi.org/10.26740/mathedunesa.v10n2.pPDF_374-384

Dilek Eryigit, C., Kucuk, S. & Tasgin, A. Impact of augmented reality technology on geometry skills and motivation of preschool children. *Educ Inf Technol* (2025). https://doi.org/10.1007/s10639-025-13631-4

Fatimah, F., Asmawati, A., & Rahamd, R. (2024). Pengembangan Media Ular Tangga Pop Up Tema 3 Makanan Sehat Untuk Peserta Didik Kelas 5 Di Mi Darul Mu'allaf Kota Palangka Raya. *Jurnal Pelita Ilmu Pendidikan*, *2*(2), 72-75.

Herrington, Anthony (2008). Adult educators' authentic use of smartphones to create digital teaching resources. University of Wollongong. Journal contribution. https://hdl.handle.net/10779/uow.27689901.v1

Hidayat, F., & Muhamad, N. (2021). Model Addie (Analysis, Design, Development, Implementation and Evaluation) Dalam Pembelajaran Pendidikan Agama Islam Addie (Analysis, Design, Development, Implementation and Evaluation) Model in Islamic Education Learning. *J. Inov. Pendidik. Agama Islam*, *1*(1), 28-37.

Indah, N., & Kasman, K. (2021). Android-based learning media implementation on indonesian learning outcomes. *Akademika*, *10*(01), 1-12. https://doi.org/10.34005/akademika.v10i01.1311

Kahar, A. P., & Fadhilah, R. (2019). *Pengembangan perangkat pembelajaran biologi SMA berbasis potensi lokal, literasi lingkungan dan sikap konservasi. Pedagogi Hayati, 2 (2), 21–32.*

Khoriyani, R. P., & Suhendra, M. (2022). Meningkatkan kemampuan spasial siswa dengan pembelajaran melalui media visual. *Educatioanl Journal: General and Specific Research*, *2*(3), 479-487.

Ma'arif, M., & Murdiono, M. (2021). Pengaruh Pemanfaatan Aplikasi Google Classroom Terhadap Karakter Kemandirian dan Hasil Belajar Peserta Didik di Sekolah Menengah Pertama. *Belantika Pendidikan*, *4*(1), 21-28.

Manik, S. A. R., Humairoh, A. P., Annisa, S., Mailani, E., & Ketaren, M. A. (2024). Peran Media Visual Dalam Meningkatkan Pemahaman Geometri Siswa Sekolah Dasar. 1(2), 759–763. https://doi.org/10.57235/arrumman.v1i2.4425

Maulida, A. S., Wahyudin, Turmudi, & Nurlaelah, E. (2024). The effect of experiential learning and. 13(2), 553–568.

Munir, N. P., Anas, A., Suryani, L., & Munir, F. S. (2022). The Practicality of Geometry Learning Media based on Augmented Reality. *Al-Khwarizmi : Jurnal Pendidikan Matematika Dan Ilmu Pengetahuan Alam*, *10*(1), 75–84. https://doi.org/10.24256/jpmipa.v10i1.2241

Nugroho, M. A., Yulandari, I., & Cahyono, A. N. (2024). Project-based learning through augmented reality-assisted math trails at Blenduk Church to promote mathematical literacy. *Jurnal Elemen*, *10*(2), 363–377. https://doi.org/10.29408/jel.v10i2.25333

Panwar, D., Patel, A., Sharma, R., Raj, R., Aryan, A., & Singh, M. (2024). Augmented Reality Based Elevated Learning Procedure Design for School Students to Improve Their Education. https://doi.org/10.1109/ICESC60852.2024.10690013

Pasaribu, F. T., Gustiningsi, T., Syafmen, W., Theis, R., Nusantara, D. S., & Sainuddin, S. (2024). Pendampingan Pembuatan Media Pembelajaran Berbasis AR untuk Guru SMP di Kota Jambi. *Jurnal Abdimas Indonesia*, *4*(4), 1588-1596. https://doi.org/10.53769/jai.v4i4.1061

Pujiastuti, H. (2023). Enhancing mathematical literacy ability through guided inquiry learning with augmented reality. 10(1), 43–50. https://doi.org/10.20448/jeelr.v10i1.4338

Purnama, H., & Alfian, A. N. (2021). Penerapan Augmented Reality Sebagai Media Pembelajaran Sejarah Indonesia Berbasis Android di SD Negeri Jatimulya 11. *INFORMATICS FOR EDUCATORS AND PROFESSIONAL: Journal of Informatics*, *6*(1), 21-32. https://doi.org/10.51211/itbi.v6i1.1664

Putra, D. P., & Murniati, M. (2023). Media Pembelajaran Berbasis STEAM: Membantu Mengembangkan Keterampilan Anak. *Jurnal Pelita: Jurnal Pembelajaran IPA Terpadu*, *3*(2), 83–100. https://doi.org/10.54065/pelita.3.2.2023.331

Qomario, Q., Tohir, A., & Prastyo, C. (2022). Math poster with augment reality to increase learning outcome of students' high school. *International Journal of Trends in Mathematics Education Research*, *5*(1), 69-73. https://doi.org/10.33122/ijtmer.v5i1.106

Rachmawati, R., Wijayanti, R., & Anugraini, A. P. (2020). Pengembangan eksplorasi MAR (Matematika Augmented Reality) dengan penguatan karakter pada materi bangun ruang sekolah dasar. *Delta-Pi: Jurnal Matematika dan Pendidikan Matematika*, *9*(2), 92-1.

Rossano, V., Lanzilotti, R., Cazzolla, A., & Roselli, T. (2020). Augmented Reality to Support Geometry Learning. June. https://doi.org/10.1109/ACCESS.2020.3000990

Rozi, F., Kurniawan, R. R., & Sukmana, F. (2021). Pengembangan media pembelajaran pengenalan bangun ruang berbasis augmented reality pada mata pelajaran matematika. *JIPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika)*, *6*(2), 436-447. https://doi.org/10.29100/jipi.v6i2.2180

Rumiati. (2011). Better Education through Reformed Management and Instrumen penilaian hasil belajar matematika smp : Belajar dari PISA dan TIMSS.

Safitri, I. (2015). Pengembangan E-Module Dengan Pendekatan pembelajaran matematika realistik berbantuan flipbook maker pada materi bangun ruang sisi datar kelas VIII SMP. *AKSIOMA: Jurnal Matematika dan Pendidikan Matematika*, *6*(2), 1-10. https://doi.org/10.26877/aks.v6i2.1397

Saleh, A., Wetik, J. D., & Sumaedi, S. (2023). Smartphone Apps-Based Health Communication Media Usage among Older Individuals During the COVID-19 Pandemic : The Role of System Quality Factors. 16, 1–13. https://doi.org/10.1177/21582440231210376

Subiyantoro, S., & Nugroho, A. (2018, October). Android-based instructional media development procedure to enhance teaching and learning in the age of disruption 4.0. In *International Conference on Applied Science and Engineering (ICASE 2018)* (pp. 152-155). Atlantis Press. https://doi.org/10.2991/icase-18.2018.41

Sulfiyah, R., Baiduri, B., & Ismail, A. D. (2020). Analysis of Student's Conceptual Understanding on Visualization Phase in Learning Geometry by Using Spinning Wheel Media. *Mathematics Education Journal*, *3*(2), 139. https://doi.org/10.22219/mej.v3i2.11071

Taiwo, D. O., Adebayo, O. C., & Yekeen, A. Y. Perception on Smart Phone Usage in Sustainable Learning among the Students of the Federal Polytechnic, Ado-Ekiti, Nigeria. https://doi.org/10.47191/ijmra/v5-i7-31

Tampubolon, J., Atiqah, N., & Panjaitan, U. I. (2019). Pentingnya konsep dasar matematika pada kehidupan sehari-hari dalam masyarakat. *Program Studi Matematika Universitas Negeri Medan*, *2*(3), 1-10. https://doi.org/10.31219/osf.io/zd8n7

Wardani, S., & Sari, M. W. (2015). Pemanfaatan Augmented Reality Pada Katalog Geometri. http://repository.upy.ac.id/id/eprint/467

Wulandari, O. A., Wardhani, I. S., Madura, U. T., & Inda, P. T. (2024). Media dan gaya belajar siswa : strategi dalam. 2(11). *Jurnal Media Akademik (JMA)*, *2*(11). https://doi.org/10.62281/v2i11.1021

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