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Development of Assemblr Edu Learning Media based on Augmented Reality to Improve Elementary School Students' Mathematics Problem Solving Ability

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Abstract: This study aims to develop educational media using Augmented Reality (AR) through the Assemblr Edu platform to enhance students' mathematical problem-solving skills related to flat geometric at Gugus Tengku Umar Elementary School, Central Java Province. The research method used Research and Development (R&D), following the Borg & Gall model, has been applied and streamlined into seven strategic stages. With a purposive sampling technique, the research subjects included experts, teachers, and students. Data were gathered through interviews, observations, surveys, and assessments. The techniques used for data analysis included the qualitative descriptive study of observation and interview results and the quantitative descriptive study to assess product feasibility scores. The findings indicated that the developed learning media demonstrated a high feasibility level, receiving an average score of 91% from material experts, 90% from media experts, and 82% from language experts. In addition, there was an increase in students' math problem-solving ability with an N-Gain of 0.72, which showed the effectiveness of the media in learning. This research confirmed that the utilization of the Assemblr Edu platform in education can enhance engagement and make the learning experience more interactive and enjoyable.

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Introduction

The advancement of digital technology has brought major transformations to education, especially in elementary school mathematics learning. The utilization of digital technology as a learning media is one of the effective methods to increase learners' understanding, participation, and interaction (Aini Jaafar et al., 2022). The selection of effective educational media plays a crucial role in achieving educational goals during the learning process. The integration of immersive technologies, including *virtual reality*, *augmented reality*, and *mixed reality*. Education offers numerous substantial advantages, especially in creating meaningful learning experiences for learners (Su et al., 2022). However, with the rapid technology that supports learning, problem-solving skills in learning mathematics in elementary schools are still a challenge that needs to be overcome. This condition indicates a gap between the potential utilization of learning technology and the efficiency of its implementation in improving elementary school students' mathematical problem-solving skills.

Problem-solving abilities are essential in helping students grasp, relate, and apply mathematical concepts in real-life situations. However, empirical data indicates that students' mathematical problem-solving abilities remain relatively low, one of which is caused by the lack of familiarization with problem-solving activities in mathematics learning in elementary schools. (Maulyda et al., 2019). This situation becomes more complex in topics that contain

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abstract material, such as geometry. (Hui et al., 2024). In response to this challenge, the incorporation of technologies like Augmented Reality (AR) offers a potential solution due to its ability to visualize abstract theories into more perceptible representations and interactive representations.

Augmented reality technology opens a new paradigm in learning media development through its proficiency in integrating virtual elements with the physical world in real time. From a technical perspective, *Augmented reality* encompasses a technology that amalgamates and projects digital 2D or 3D objects integrated into the real environment in the form of interactive 3D animation. (Riza et al., 2023). In mathematics learning, *Augmented Reality* technology has significant transformative potential, not only in creating a more interesting and enjoyable learning experience but also regarded as a strategic approach capable of enhancing students' problem-solving abilities (Guntur & Setyaningrum, 2021).

Based on the observation at an elementary school in the Gugus Tengku Umar, Central Java province, it was found that the learning strategies used were less interactive and varied. The learning process is dominated by lectures, assignments, and question-and-answer methods, with a linear teaching pattern where the educator explains the material, gives examples of problems, and then students practice problems with the opportunity to ask questions if they have difficulties. In addition, The use of media in education is still minimal. Learning patterns like this have less space for students' creativity and problem-solving skills. Learning geometry, especially flat geometry, has not achieved the optimal results expected by educators. Learners still have difficulty connecting their mathematical knowledge with real-world situations and linking it to previous knowledge of mathematical concepts.

Numerous studies have validated the effectiveness and efficiency of learning media in mathematics education based on technology. Research conducted in Turkish secondary schools highlighted a significant change in the adoption of technology in mathematics teaching, with a substantial increase in students' academic achievement, showing an increase in math assessment scores of up to 20% compared to conventional approaches (Wahyudin, 2024). The research findings confirm that the integration of technology in mathematics learning does not merely provide a variety of methods but fundamentally transforms the learning experience, increasing learners' motivation, active participation, and conceptual understanding of mathematics materials. Supporting these findings, (Limbong & Arizona Matondang, 2022) revealed that the implementation of Augmented Reality-based learning media facilitated by Macromedia Flash significantly enhances students' comprehension of flat geometric concepts, as evidenced by an average n-gain value of 0.53 in the high category while creating more interesting and innovative learning. In line with that, experimental research conducted by (Guntur & Setyaningrum, 2021) on 70 elementary school students showed improved problem-solving skills and mathematical spatial ability through the use of *Augmented reality* learning media and *Geogebra.* A systematic review conducted by (Hui et al., 2024) of 14 Studies concerning the application of *Augmented reality* in primary school mathematics education corroborates the Advantageous influence of this technological innovation on spatial visualization and mathematical problem-solving skills.

Although many studies have investigated the integration of AR technology within the domain of mathematics learning, the exploration of the potential of the *Assemblr Edu* platform in developing flat geometric learning media integrated with mathematical problem-solving strategies is still limited. *Assembler Edu* media as an *Augmented reality* application is specifically designed for educational needs and offers the potential to enhance the learning and teaching experience, elevating the level of engagement and fun in learning. (Majid et al., 2023). Developing AR-based learning media holds significant potential to address the

demand for educational media that can convert Theoretical mathematical concepts mathematical concepts into tangible, interactive experiences.

In addition, with the adoption of a learning methodology grounded in van Hiele's stages, which include (l) conceptual introduction and preliminary understanding (*Information)*, (2) structured guidance and directed inquiry (*Guided Orientation)*, (3) systematic clarification and analytical explanation (*Explicitation)*, (4) independent cognitive structuring and self-regulated inquiry (*Free Orientation)*, (5) knowledge internalization and higher-order application (*Integration)* (Nur'aeni, 2008), it becomes an alternative learning opportunity that can aid students in comprehending the basic concepts of geometry and is expected to improve their skills in applying methods to solve mathematical problems. Given this need, the research aims to develop AR technology into geometry teaching, especially in flat geometry, to enhance students' skills for solving mathematical problems at the fourth-grade elementary school level in Gugus Tengku Umar, Central Java Province.

Research Method

The research used the development research method (Research and Development) with a Borg & Gall model. Research focused on development is oriented toward the development of innovative products through the process of discovering potential problems and designing and developing a product with a series of systematic tests and revisions, resulting in a product that is valid for use (Waruwu, 2024). This development research aims to test the theory and to create practical solutions to optimize the effectiveness of the educational process. The resulting product was an Augmented Reality-based learning media designed to enhance educational experiences with *Assemblr Edu* flat geometric material that can be accessed through smartphone and laptop devices. The research adopted the Borg & Gall method (Sugiyono, 2021), which was simplified into eight strategic stages: (1) Data acquisition and preliminary investigation (*Research and Information Collecting),* (2) Strategic design and preparation (*Planning),* (3) Initial product development and conceptualization (*Development of a Preliminary Form of Product)*, (4) Pre-implementation testing (*Preliminary Field Testing),* (5) Refinement of prototype based on pilot feedback *(Main Product Revision)*, (6) Wider-scale field experimentation (*Main field testing)*, (7) Extensive post-field review and revision (*Operational Revision Products), and (8) Product* Deployment and operationalization *(Dissemination and Implementation).* Using this systematic approach allows the product to be analyzed comprehensively for needs, product performance, and the usefulness of the product for users.

The research subjects included three main groups: experts, teachers, and learners. Experts acted as validators who assessed the feasibility of the developed media from the perspective of material, design, and language. This research took place in the elementary school environment of Gugus Tengku Umar, located in Winong District, Pati Regency, Central Java Province. The study employed a *purposive sampling* technique, a limited trial involving nine students from SDN Blingijati, and a large-scale trial involving 21 students from SDN Karangsumber 01.

The methods of data collection in the present research included conversations, observations, and questionnaires. Conversations were implemented in a structured manner to explore problems and analyze the needs of using learning media. Non-participant observation with a structured approach allows researchers to make independent observations that have been systematically designed. The research instrument includes a closed questionnaire addressed to material, media, language, teacher, and learner expert validators. The main purpose of the questionnaire is to evaluate the feasibility of *Assemblr Edu* media that

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integrates *Augmented Reality-based* technology. In addition to the questionnaire, the study also used a test method Presented in the format of descriptions to assess the students' skills in solving mathematical problems individually.

The data in this research were evaluated through the following methods: 1) Descriptive qualitative analysis was applied to analyze data obtained from observations and interviews, and the suggestions given by expert validators and teachers were reviewed when assessing product feasibility. 2) Quantitative descriptive analysis was applied to process product feasibility scores through validation questionnaires of material experts, media experts, linguists, educators, and students. This approach uses *Likert* scale-based measurement instruments to produce measurable and objective assessment ratings. The feasibility of the media tested using the assessment instrument will be evaluated through the application of the formula (Arifin, 2010).

$$NP = \frac{R}{SM}\ x\ 100\%$$

Description:

NP : percent value sought or expected

R : score obtained

SM : maximum score

The percentage results of the feasibility data are subsequently converted according to the criteria outlined below according to (Sugiyono, 2018) and (Arikunto, 2010).

Table 1. Interpretation criteria for media feasibility results

No.	Eligibility Criteria	Feasibility Level
1.	81-100%	Very Feasible
2.	61-80%	Worth
3.	41-60%	Decent Enough
4.	21-40%	Less Feasible
5.	<20%	Not Feasible

Results and Discussion

This research and development produces *Augmented Reality* (AR) based digital learning media that can be accessed through laptops and smartphones. At the stage of analysis and potential problems, observations of learning activities, learning media, interviews, and needs analysis were carried out at Gugus Tengku Umar Elementary School. Based on observations, several problems were indicated, namely: 1) The students' difficulty in understanding the concept of flat geometry, 2) The difficulty of students in visualizing and solving geometry problems, 3) Learning media utilization in teaching and learning activities is still restricted, 4) the application of internet and digital literacy-based learning is still not optimal. The tendency of students to memorize formulas and look for practical methods in solving problems without a deep conceptual understanding has an impact on the low enthusiasm for learning. This is following the research carried out by (Mahendra Halim et al., 2024), which identified some of the main difficulties faced by students in learning mathematics, including difficulty understanding abstract mathematical concepts, struggles with problem-solving and formulating comprehensive mathematical problems, as well as obstacles in modeling and planning effective strategies for mathematical problem-solving. This situation is exacerbated by the limited learning resources that still rely on textbooks and have not optimized the use of learning media, particularly technology-based teaching media.

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These problems indicate the urgency of developing technology-based learning media aimed at enhancing students' understanding of flat geometry, so it is expected that the mathematical problem-solving skills of Grade IV students will also improve. This is reinforced by a study executed by (Nadzri et al., 2023). This demonstrates that *Augmented Reality* technology can help students master geometry concepts, improve visualization skills, Enhance long-term memory, and provide cognitive engagement and a deeper conceptual grasp through Augmented Reality-based experiences. (Sumarwati et al., 2020) It also revealed that digital learning platforms effectively encourage learners to develop advanced cognitive skills, including the ability to understand, interpret, analyze, and manipulate geometric information. This method does not simply transfer knowledge but creates an interactive learning space that triggers learners' creativity and critical thinking. This innovative approach is expected to advance fourth-grade students' mathematical reasoning and problem-solving skills and present a more meaningful and contextual learning experience.

In the planning and development stage, learning media is carried out systematically, including determining product design, making *storyboards*, collecting material content, and developing digital applications. *The* learning media developed is the utilization of the *Assemblr Edu* platform, which is designed by combining animation, text, and images. This *Assmblr Edu* media contains a learning objectives menu, introduction menu (lighter), material menu, quiz menu, and developer identity. The media design is developed with the *Augmented Reality* approach for flat geometric materials, focusing on interactive content and made as interesting as possible to motivate students to learn. The following is the *Assemblr Edu* media design on the mathematics learning content of Flat Geometric material.

Figure 1. Display of *Assemblr Edu* Learning Media

The *Assemblr Edu* media was validated to assess its feasibility. The product feasibility test in this study involved evaluations by subject-matter specialists, media consultants, and linguistic experts, who are lecturers from the Elementary School Teacher Education Study Program at FIPP, Semarang State University. This test aimed to evaluate the developed product in terms of content, media, and language. The feasibility testing process included the following steps: 1.) The product and questionnaire were given to each expert material, media, and language to provide assessments and feedback; 2.) Expert evaluations were analyzed using *Likert* scale guidelines; 3.) Revisions were made based on expert suggestions. The table below presents the tabulated feasibility test results from subject-matter specialists, media consultants, and linguistic experts.

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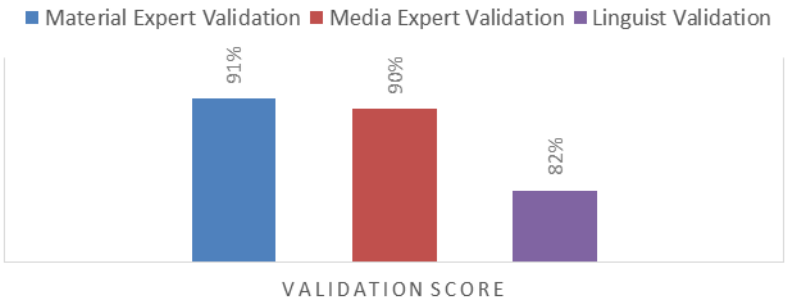

Figure 2. Diagram of Media Feasibility Test Validation Results

The diagram of expert validation results shows the acquisition of expert validation scores in providing assessments and responses to *Assemblr* Edu-based Flat Geometric learning media. The quality of the material in the *Assemblr Edu* media developed aims to determine the feasibility of Flat Geometric material that suits the needs of students. The material expert test aspects consist of 2 aspects with 17 indicators, including aspects of the functionality and exactness of the educational material and the suitability of learning with the competencies to be achieved with an average assessment score of 91% with a very feasible category. Furthermore, the media expert assessment is used to evaluate the suitability and viability of the media needed for learning. The media test aspect consists of 3 aspects with 20 assessment indicators, including aspects of convenience and interactivity, aspects of practicality, and aspects of design and appearance, with an average score of 90% with a very feasible category. A linguist assessment was conducted to determine the feasibility of linguistic aspects of the media with 12 assessment indicators, and an average score of 82% was obtained for a very feasible category. Following the assessments by material experts, media experts, and linguists, revisions were carried out following their recommendations. Subsequently, an effectiveness test of the media in the learning process was conducted.

The small group trial stage was conducted after the Assemblr Edu media product was validated and revised. This trial aimed to assess the feasibility of the developed Assemblr Edu media before its implementation in a field test with a larger group. (Assyauqi, 2020). The value of math problem-solving ability is obtained from the *pretest* and *posttes*t results using *Assemblr Edu* media on flat geometric. The scores for math problem-solving abilities from the pretest and posttest, with samples drawn from 9 fourth-grade students of SDN Blingijati, are illustrated in the following chart.

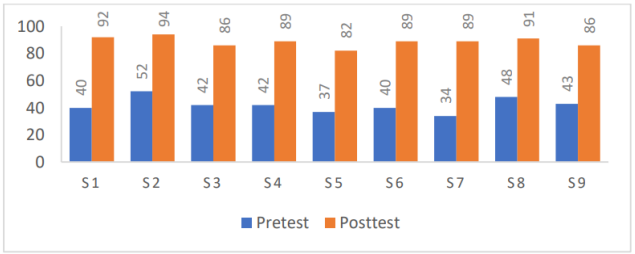

Figure 3. Preliminary Field Testing Pretest Posttest Score Diagram

Based on the data obtained from the small group trial, an evaluation was carried out to ascertain the feasibility of developing the *Assemblr Edu media*. The analysis includes a normality test of pre-assessment evaluation (*pretest)* and after-evaluation assessment (*posttest)* data, a Paired Sample T-test, an average increase test (*Gain*), an educator feedback form analysis, and a learner response survey analysis. Normality testing revealed that the pre-assessment evaluation (*pretest)* and after-evaluation assessment (*posttest)* scores were normally distributed with a significance of 0.200, and the probability value of 0.05 met the

prerequisites for further analysis. The paired t-test produces a significance value with a Sig (2-tailed) value <0.05, confirming the research hypothesis, so Ha is accepted. The average increase (n-gain) in math problem-solving ability was 0.80. Indicating the effectiveness of *Assemblr Edu* media in improving math problem-solving skills on flat geometric material. Teacher and learner responses also showed a positive response with a feasibility percentage of 91% and 82% rated as very feasible. So, it is evident from the validation results that the validation of the quality of learning media is in the appropriate category and allows the research to continue to the large group field test stage.

Product testing in large groups is taken from a larger sample than the sample in the small-scale trial. The large group field trial was intended to identify the impact of the *Assemblr Edu* media developed for use as an educational media in flat geometric math subjects for teachers and students in the knowledge acquisition process. As in the small group trial, empirical evidence obtained from the main field testing in *pretest* scores, *posttest* scores, learner response survey, and educator feedback forms were assessed to measure the effectiveness of the educational media developed by researchers. The following are the mathematical problem-solving skills scores from pretest and posttest evaluations collected from 21 fourth-grade students of SDN Karangsumber 01.

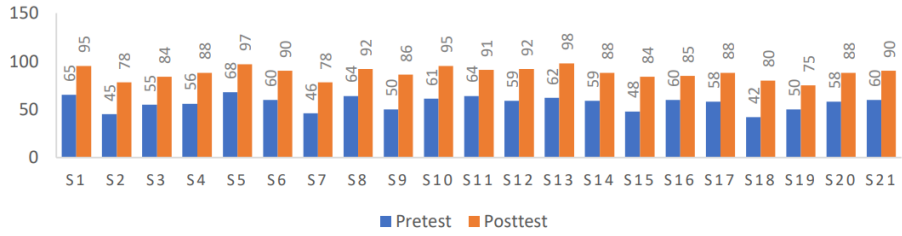

Figure 4. Main Field Testing Pretest Posttest Score Diagram

To determine the appropriate statistical technique, the pre-assessment evaluation (*pretest)* and after-evaluation assessment (*posttest)* results from the main field testing were analyzed for normality to be used in processing the data and is one of the requirements to continue the next calculation so that the calculation can be accounted for the accuracy of its content. The normality test results for the large-group trial are displayed in the subsequent table.

Table 2. Normality Analysis of Main Field *Pretest* and *Posttest*

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.193	21	.041	.935	21	.176
Postest	.137	21	.200*	.966	21	.639

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The use of *Assemblr Edu* media in a large group involving 21 students of SDN Karangsumber 01 showed significant results. Based on the normality test data obtained, using the *Shapiro-Wilk* normality test shows a significant result of 0.176 for the *pretest* and for the *posttest* 0.639 (probability 0.05), which analysis confirms that the data adheres to a normal distribution, so then perform calculations applying the paired t-test. The hypothesis was tested using a Paired T-test analysis using *Assemblr Edu* media. The effectiveness of using this media can be seen by looking at the significant average difference between the math problem-solving ability scores before and after using *Assemblr Edu* media on flat geometric material. Statistical analysis using the Paired T-test reveals a significant difference in pre-

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assessment evaluation (*pretest)* and after-evaluation assessment (*posttest)* scores when the Sig (2-tailed) value is <0.05. The detailed analysis is demonstrated in the subsequent table.

Table 3. Comparative Analysis of *Pretest* and *Posttest* Using *Paired T-Test* in Main Field Experiment

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Pretest - Postest	-31.048	3.584	.782	-32.679	-29.416	-39.694	20	.000

Based on the analyzed data, a Sig (2-tailed) value of <0.05 indicates the Invalidation of H0 and the admittance of Ha, or it means that *Assemblr Edu* media is effective for improving grade IV math problem-solving skills in Flat Geometric material. Then, the increase in math problem-solving skills after using Assemblr Edu media was determined by applying the N-gain test. The following are the results of the media usage trial with the N-gain test.

Table 4. N-gain of Large Group Usage Test Results

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
n_gainscore	21	.50	.95	.7289	.10927
n_gainpercent	21	50.00	94.74	72.8947	10.92730
Valid N (listwise)	21				

As shown in Table 4, the application of *Assemblr Edu* media resulted in a notable improvement in students' problem-solving proficiency with an average N-Gain of 0.72, classified as a high level. This increase confirms that *Assemblr Edu* learning media is very effective in learning Mathematics, especially on flat geometric material, to enhance mathematical problem-solving skills. This is further supported by teacher responses, which achieved a percentage of 92%, reflecting a positive assessment of the pedagogical aspects, learning content, and usability of the media. Students' responses reached 85%, indicating a high level of learner engagement and incentive to learn. Learning media is essential in the educational process, as its utilization facilitates effective knowledge transfer and engagement can increase motivation and interest, and facilitate student learning (Nazari et al., 2024) The derived conclusions confirm the feasibility of Assemblr Edu media as an effective and adaptive learning solution.

Other relevant research, such as that conducted by (Suaib & Sutriyani, 2024), indicates that the *Assemblr Edu* application digital educational media, which is based on *augmented reality* (AR), is proven to be more effective than learning that does not use teaching media in optimizing student understanding in mathematics subjects, especially geometry material in elementary schools, with an average increase in N-Gain reaching 0.74, which also shows a high category. In addition, research by (Mahendra Halim et al., 2024) Indicates that the development and the advancement of mobile-based educational resources leveraging *Assemblr Edu* enhance the processes of concept formation, interaction, and reflection, improving students' mathematical problem-solving skills. If the material presented is considered interesting and relevant, it can significantly improve learning outcomes and the advancement of participants' mathematical abilities (Maqfiroh & Munahefi, 2022). Students' interest in the material presented will create a more dynamic and interactive learning atmosphere, thus facilitating a deeper understanding of concepts.

The presence of multimedia technology helps students learn to be more interested and improve their understanding of math compared to conventional learning. (Rachmiazasi Masduki et al., 2020). Learning media based on technology, such as *Assemblr Edu* provides a clear visualization of flat geometric shapes. By seeing and interacting with objects directly, students can associate abstract concepts with real objects, which supports a deeper understanding. (Shi et al., 2023). In this context, students not only passively receive information but also participate in the exploration and discovery of concepts. By seeing and interacting with flat shapes directly, students can more easily understand the properties and relationships between flat shapes and geometric.

Education today is increasingly focusing on cultivating Skills for the 21st century, including problem-solving, collaboration, and creativity. The results show that the integration of AR technology in math learning can help students understand geometry concepts better. With interactive visualization, students can see and interact with flat shapes directly which can strengthen their understanding of the properties of flat shapes and improve their mathematical problem solving skills. In addition, the utilization of the *Assemblr Edu* platform as an interactive and interesting learning media provides a more in-depth learning experience so that students are more motivated and have better learning outcomes in learning. Innovative learning media such as *Assemblr Edu* supports the development of these skills, making it an increasing trend. By using media like *Assemblr Edu*, students not only learn math concepts but also critical and collaborative thinking skills that are important for their future.

Conclusion

Based on the results of this research, it can be concluded that the developed learning media demonstrated a high feasibility level, receiving an average score of 91% from material experts, 90% from media experts, and 82% from language experts. In addition, there was an increase in students' math problem-solving ability with an N-Gain of 0.72, which showed the effectiveness of the media in learning. This research confirmed that the utilization of the *Assemblr Edu* platform in education can enhance engagement and make the learning experience more interactive and enjoyable.

Recommendation

For future research, it is recommended that the development of learning media based on *Augmented Reality* (AR) be carried out with more varied and interactive content. Trials in various educational contexts are also important to evaluate the effectiveness of the media more broadly. However, obstacles such as unstable internet connections and limitations of adequate *smartphones* can impact the study data. Moreover, the readiness of educators and participants to use new technology is also an important factor that needs to be considered to ensure the successful implementation of AR media in learning. Teachers should actively participate in training programs focused on AR technology and Stay updated with the latest developments in AR educational technology. By overcoming these obstacles, it is expected that AR media can contribute more effectively to the enhancement of students' mathematics problem-solving skills.

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