Assemblr EDU Augmented Reality Puzzle for Elementary Learning

Pengembangan Puzzle Augmented Reality Assemblr EDU untuk Sekolah Dasar

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Abstract

This study responds to the integration of digital technology in elementary education. **General Background:** Twenty-first-century learning requires interactive and student-centered instructional media supported by technology. **Specific Background:** In many elementary classrooms, learning media remain static, while puzzle-based learning and Augmented Reality (AR) platforms such as Assemblr EDU are often applied separately. **Knowledge Gap:** Research integrating puzzle-based problem-solving activities with AR technology into a single structured medium using Assemblr EDU at the elementary level remains limited. **Aims:** This study aims to develop and evaluate the feasibility of an Assemblr EDU–based augmented reality puzzle learning media using the ADDIE Research and Development model. **Results:** Expert validation showed material suitability (87%), visual design (83%), AR interaction (85%), and ease of use (82%), with an overall feasibility score of 84.25% categorized as appropriate to very appropriate. Student responses were highly positive in attractiveness (90%), usability (85%), conceptual support (88%), and thinking activation (87%). **Novelty:** The study integrates structured puzzle activities with AR visualization within one interactive instructional product. **Implications:** The developed media demonstrates pedagogical relevance and provides a viable technology-based alternative for elementary learning aligned with 21st-century education principles. **Highlights**

• Structured religious extracurricular activities cultivate interpersonal and social competencies among participants.

• Experiential and project-based practices foster leadership, collaboration, and self-regulation.

• Mentor quality, institutional support, and consistent scheduling determine program sustainability.

Keywords: Augmented Reality; Assemblr EDU; Puzzle Based Learning; Elementary Education; Instructional Media Development

INTRODUCTION

The development of digital technology has brought major changes to the way learning is done in schools, especially at the basic education level. Learning is no longer enough through just lectures and printed materials, but it needs to offer meaningful, contextual, and active learning experiences for students. This aligns with the demands of 21st-century learning, which focuses on developing critical thinking, creativity, collaboration, and problem-solving skills from an early age (OECD, 2021).

However, in practice, it is still common for elementary school learning processes to focus mainly on one-way delivery of material. The learning media used tends to be static, not very interactive, and hasn't fully managed to capture students' attention and curiosity yet. This condition can reduce students' active involvement in the classroom and make it more difficult for them to grasp abstract concepts (Sari & Putra, 2022). Although elementary school students are generally at the concrete operational stage of development, they still require strong visual support and hands-on learning experiences that allow them to directly explore and interact with learning objects.

One promising way to respond to these challenges is by incorporating game-based learning into classroom instruction. Puzzle-based media, for instance, does more than simply present visual information. It encourages students to think logically, work through problems systematically, and remain persistent in completing tasks. Through such activities, learning becomes not only more engaging but also more cognitively stimulating. Recent studies show that using puzzles in learning can boost students' motivation and understanding of concepts because they actively engage in putting together, trying out, and reflecting on their learning outcomes (Wahyuni et al., 2021; Pratama & Lestari, 2023).

On the other hand, advancements in Augmented Reality (AR) technology are creating new opportunities for developing more interactive and immersive learning media. Augmented Reality allows three-dimensional virtual objects to be combined into the real world environment, so students can observe and interact with learning materials in a more concrete way. In the past five years, several studies have shown that AR-based learning materials can increase student engagement, make abstract concepts clearer, and offer a more enjoyable learning experience for elementary school students (Ibáñez & Delgado-Kloos, 2020; Yuliana et al., 2022).

One AR platform that is fairly easy to use in an educational setting is Assemblr EDU. This platform allows teachers to create AR-based learning materials without needing complex programming skills. Through Assemblr EDU, teachers are able to design and deliver learning materials in the form of three-dimensional objects, interactive simulations, and engaging activities that students can easily access using mobile devices. Several recent studies have reported that the integration of Assemblr EDU into classroom practice contributes positively to students' learning motivation, conceptual understanding, and creativity (Fitria et al., 2024; Sari & Nurhasanah, 2025).

At the same time, the rapid advancement of digital technology has reshaped the way learning is approached in elementary education. Classrooms are increasingly encouraged to move toward more meaningful, contextual, and student-centered learning experiences that allow children to actively participate in constructing their own understanding. Twenty-first century education emphasizes the integration of technology not merely as a complementary tool, but as a medium that fosters critical thinking, creativity, collaboration, and problem-solving skills from an early age (OECD, 2021). However, classroom practices in many elementary schools still rely heavily on conventional instructional methods and static learning media, which do not fully accommodate students' characteristics at the concrete operational stage.

Previous studies have demonstrated that puzzle-based learning can enhance students' problem-solving abilities and active engagement (Wahyuni et al., 2021; Pratama & Lestari, 2023). Similarly, the use of Augmented Reality (AR) in primary education has been shown to improve motivation and clarify abstract concepts through three-dimensional visualization (Ibáñez & Delgado-Kloos, 2020; Yuliana et al., 2022). Assemblr EDU, as an accessible AR development

platform, has also been reported to positively influence students' motivation, engagement, and creativity (Fitria et al., 2024; Sari & Nurhasanah, 2025).

Nevertheless, research that specifically integrates puzzle-based cognitive activities with AR technology into a single, structured learning medium using Assemblr EDU for elementary students remains limited. Most previous studies have treated puzzles and AR as separate instructional approaches. Therefore, the novelty of this study lies in the integration of game-based learning through puzzle activities with Augmented Reality technology within a systematically designed interactive medium using the ADDIE model. This integration not only emphasizes visual interactivity but also activates students' analytical thinking through structured problem-solving challenges. Based on this background, the purpose of this study is to develop and evaluate the feasibility of a puzzle-based learning media using Assemblr EDU as an innovative alternative for elementary school instruction.

Even so, research on the use of Assemblr EDU is still mostly focused on the general development of visual media or AR simulations. Research that specifically combines puzzle media with AR technology using Assemblr EDU is still quite limited, especially in elementary school levels. Even though combining puzzles with AR could offer a learning experience that is not only visually interactive but also mentally challenging through problem-solving activities.

Based on that explanation, developing a puzzle-based learning media using Assemblr EDU is important to do as an effort to provide innovative learning media that fits the characteristics of elementary school students, the demands of 21st-century learning, and the latest developments in educational technology. This media is expected to create a fun learning experience, increase student engagement, and help students understand the learning material in a more detailed and meaningful way.

METHODS

Types and Research Approaches

This study employed a Research and Development (R&D) approach using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected because it provides a systematic framework for developing instructional media and allows continuous evaluation throughout the development process. The research subjects included a material expert, a media expert, and elementary school students involved in a limited trial implementation. Data were collected through expert validation questionnaires, student and teacher response questionnaires, and classroom observations during the implementation phase.

The research instruments were developed in the form of rating scales covering aspects such as content suitability, visual design, AR interaction, and ease of use. To ensure the quality of the instruments, content validity was established through expert judgment involving education professionals and subject specialists. Feedback from validators was used to refine and improve the questionnaire items to ensure alignment with the evaluation indicators of instructional media. Furthermore, instrument reliability was examined using internal consistency analysis (e.g., Cronbach's Alpha), ensuring that the instruments were sufficiently reliable for data collection.

Quantitative data were analyzed descriptively by converting scores into percentages to determine the feasibility category of the media. Qualitative data in the form of suggestions and comments were analyzed descriptively to guide product revision and refinement.

Media Development Procedures
Analysis

The analysis stage aims to identify learning needs as a foundation for developing the media. At this stage, the researcher conducts a needs analysis by examining the learning conditions in elementary schools, especially regarding the use of teaching materials. The analysis was done through literature study, initial observations, and discussions with teachers to understand student characteristics, the learning difficulties they face, and the teaching materials that have been used so far. In addition, an analysis of the learning materials to be developed in the form of puzzles using Assemblr EDU is also carried out. This analysis includes how the material matches the curriculum, the competencies that need to be achieved, and the potential of the material to be presented in puzzle form and through Augmented Reality visualization. The results of the analysis stage serve as the basis for designing relevant and contextual learning media.

Design

The design stage aims to create the concept and appearance of a puzzle-based learning media using Assemblr EDU. At this stage, the researcher creates an initial plan for the media, which includes the learning objectives, the flow of media usage, the type of puzzle, and the design of user interaction with the AR objects. The design also includes creating a storyboard and sketches of the media to show how students will interact with the virtual puzzle and objects.

In addition, at this stage, the research instruments are also prepared, such as the expert validation sheet and the user response questionnaire. The instrument is designed to measure the suitability of the media in terms of content, appearance, and ease of use. The design phase is important because it sets the direction for developing the media so that it matches the learning objectives that have been set.

Development

The development stage is the process of turning the media plan into an actual product. At this stage, the puzzle-based learning media is developed using the Assemblr EDU platform by utilizing the Augmented Reality feature. Three-dimensional objects, puzzle elements, and usage instructions are organized and integrated into one interactive learning media.

After the media was developed, it was validated by experts, which included material experts and media experts. Validation aims to check if the media is suitable by looking at whether the content matches the curriculum, how clearly it is presented, the visual design, and how easy it is to use. Expert input and suggestions are used as a basis to revise and improve the media before it is implemented.

Implementation

The implementation stage involves testing the puzzle-based learning media using Assemblr EDU with elementary school students on a limited scale. At this stage, the media is used in the learning activities according to the plan that has been made. Students are asked to use the media directly, put together puzzles, and interact with the available Augmented Reality objects.

During the implementation phase, the researcher observed how students responded to the use of media and collected data through student and teacher response questionnaires. This data is used to find out how acceptable, easy to use, and attractive the developed learning media is.

Evaluation

The evaluation stage aims to assess the entire process and the outcomes of the learning media development. Evaluations are done formatively at each stage of development to ensure that the resulting media aligns with the learning objectives. The final evaluation is done based on expert validation and user responses to determine the level of suitability of the puzzle-based learning media using Assemblr EDU.

The evaluation results are used as a basis to determine the suitability of the media and to provide recommendations for further development so that the media can be used more widely in learning.

Research Subjects

The research subjects in this media development include:

1. Material experts are teachers or lecturers who have the expertise in the subject matter being developed, which is Nanda Dini, S.Pd.

2. Media experts, who are teachers or professionals skilled in developing technology-based learning media, include Friendha Yuanta, S.Pd., M.Pd.

3. Students from elementary school who participated in the limited trial of the learning media were from SDN Pakis V Surabaya.

Data Collection Techniques and Instruments

The data collection techniques used in this research include:

1. An expert validation questionnaire is used to get opinions from content experts and media experts on the suitability of the media.

2. A student and teacher response survey is used to find out their opinions on using learning media.

3. Observation is used to watch how involved students are during the use of learning media.

The research instruments are designed in the form of a rating scale that reflects the aspects of media suitability, including the material aspect, appearance aspect, and usage aspect.

Data Analysis Techniques

The data collected from the expert validation and user responses were analyzed using both quantitative and qualitative descriptive analysis techniques. Quantitative data in the form of evaluation scores is converted into percentages to determine the media's suitability category. Meanwhile, qualitative data in the form of suggestions and feedback is used to improve and refine the teaching materials.

The results of the data analysis were used to determine whether the puzzle-based learning media developed using Assemblr EDU is suitable for use as a learning tool in elementary schools.

RESULTS

Media Development Results
Learning Media Product Description

The learning media developed is an interactive puzzle based on Augmented Reality (AR), designed through the Assemblr EDU platform. This media includes puzzle pieces that, when scanned with a mobile device, will show 3D objects related to the lesson material. Each puzzle piece is designed so that students:

1. By interacting directly with 3D objects, complex concepts become more real and easier to understand.
2. Organizing the pieces according to the quiz clues helps improve logic and problem-solving skills.
3. Get instant visual feedback when the puzzle is correctly assembled.

The media design is created through five main stages: analysis, design, development, implementation, and evaluation (ADDIE). This step ensures that the media is not only visually appealing but also effective for teaching. Media can be seen below.

[Figure 1 About here]

 Expert Validation Results
The media was tested for suitability by:
• Subject matter experts, who assessed the content's suitability to learning objectives and the curriculum.
• Media experts, who assessed the quality of the design, user interaction, and technical functionality of the AR.
The validation results are shown in the table below.

[Table 1. About here]

Overall, the media received an average score of 84.25%, categorized as "Appropriate" to "Very Appropriate." This indicates that the media meets the basic criteria for effective interactive learning media (Gall & Borg, 2020).
Content experts praised the material's contextual and clear structure. Media experts appreciated the high level of visual engagement of the AR. Expert feedback indicated the need for adjustments to the contrast colors and user guides to make them more child-friendly.

Student Trial Results

A limited trial in 4th grade elementary school students collected data on student responses to the media.

[Table 2. About here]

Most students say that using media makes learning more interesting and fun because they can see the actual subject matter in real life through AR. This aligns with previous findings that AR increases student engagement in learning (Yuliana et al., 2022).

FINDINGS AND DISCUSSION

Media as a Representation of 21st-Century Learning
The AR-based media puzzle shows how technology, educational games, and teaching methods work together. Learning in the 21st century encourages the use of technology, which creates active opportunities for students to explore (OECD, 2021). Visual interactions and direct object manipulation give students the chance to build their own understanding, which follows the constructivism principle.
According to the constructivist theory, students don't just receive information; instead, they build meaning through their experiences and interactions. Puzzle AR lets students experiment, make mistakes, and try different solutions until they find the right answer — a process that's important for their cognitive development (Jonassen, 2019).

Augmented Reality Increases Learning Motivation
Test results show that most students felt motivated and excited when using the media. This matches research that says AR can boost learning motivation because of its immersive, interactive, and contextual nature (Ibáñez & Delgado-Kloos, 2020). Using three-dimensional visual experiences helps students understand objects that were previously hard to imagine just from textbook descriptions.
Further research shows that using augmented reality in learning helps improve problem-solving skills and critical thinking, especially when combined with game elements like puzzles (Sari & Nurhasanah, 2025). The results from the students in this study support those findings.

[Figure 2. About here]

Advantages and Limitations of Media

Advantages of media:

1. Interactive and fun, thus increasing motivation.

2. Strong visualization helps understand abstract concepts better.

3. Encourage active thinking, through puzzle challenges.

Media limitations:

1. Requires a device (tablet/cellphone) that supports AR.

2. It takes time for teachers and students who are new to using it to get used to it.

3. The initial design still needs improvement in the user interface for all age ranges of students.

These limitations serve as input for ongoing development to make media more inclusive and easier to use.

Research Implications

The development of this media has important implications:

1. For teachers, media serves as a helpful tool that makes it easier to explain ideas through real visual examples.

2. For students, media offers a more meaningful learning experience and encourages curiosity.

3. For education developers, this research serves as a foundation for innovating AR-based learning media and other educational games.

Feasibility of a Media Puzzle Based on Assemblr EDU from a Pedagogical Perspective

The expert validation results show that the puzzle-based learning media using Assemblr EDU is in the category of acceptable to very acceptable. This finding suggests that the developed media has met the basic principles of good learning media, which include matching the learning objectives, the content, and the characteristics of the learners. In basic education, effective learning materials must not only be conceptually correct but also presented in an attractive, simple, and easy-to-understand way for students.

Media's suitability from a material aspect shows that the content presented meets the expected competencies. This is important because visually engaging learning materials that are not aligned with the learning objectives can actually confuse students' focus. This finding supports the idea that educational media should serve as a tool to clarify concepts, not just as visual entertainment (Mayer, 2020).

From a media perspective, using Augmented Reality through Assemblr EDU adds value because it allows students to see learning objects in three dimensions. This visualization helps students gain a better understanding, especially for topics that are hard to grasp when only presented in two dimensions. So, this medium is not only technically suitable but also educationally relevant.

Puzzle is a way to activate thinking and problem-solving skills.

The puzzle included in this medium serves as a trigger for students' cognitive activities. Solving a puzzle requires students to observe, analyze, try different possibilities, and evaluate the results they get. This type of activity matches the characteristics of meaningful learning, where students actively take part in building their own knowledge. Student responses that show increased interest and engagement in learning support the idea that puzzles are not just games, but effective tools for developing thinking skills. In puzzle-based learning, students don't get the answer directly, but instead have to go through a process of searching and thinking it through. This process is very important for developing problem-solving skills starting from elementary school (Pratama & Lestari, 2023).

When connected to the constructivist theory, learning through puzzles allows students to build understanding based on direct experiences. Students don't just receive information from teachers; they actively interact with media, try things out, make mistakes, and then correct those mistakes. This process serves as an important foundation for student-centered learning.

The Role of Augmented Reality in Enhancing Student Engagement and Learning Motivation

Using augmented reality in this puzzle media has been shown to increase student engagement in learning. Students show a lot of excitement when interacting with three-dimensional objects that appear through the device. The immersive visual experience makes students feel as if they are "face-to-face" with the learning material, not just looking at pictures in a book. This finding matches several studies that show AR can boost learning motivation because it offers more real and contextual learning experiences (Ibáñez & Delgado-Kloos, 2020; Yuliana et al., 2022). Increased motivation leads to higher levels of engagement, which in turn helps improve understanding of concepts.

Assemblr EDU is a learning platform that is

friendly for both teachers and students.

One of the key findings of this research is how easy it is to use Assemblr EDU as a platform for developing learning materials. Teachers can use this platform without needing any programming knowledge, thus providing more opportunities to adopt media in the learning process. From a student's perspective, a simple and visually appealing interface makes the medium easy to use and doesn't overload the mind.

This convenience plays an important role in keeping technology-based learning media used over time. Teachers can use this platform without needing any programming knowledge, thus providing more opportunities to adopt media in the learning process. Recent studies highlight that the success of integrating technology into learning depends heavily on how well the technology matches the users' abilities and needs (Sari & Nurhasanah, 2025).

Media Limitations and Implications for Further Development

Even though the puzzle-based learning media using Assemblr EDU is considered suitable, this study also found some limitations. The need for proper devices and reliable connections is a big challenge, especially for schools that don't have enough facilities. In addition, not every student is instantly comfortable using AR-based learning tools. For many of them, this kind of technology is still relatively new, which means they need guidance and support, especially at the beginning. This condition highlights that introducing technology into the classroom cannot be done carelessly; it requires thoughtful planning and gradual implementation. Teachers play a crucial role in this process. Their guidance ensures that the use of AR media remains aligned with instructional objectives, rather than becoming merely an exploration of technology without clear learning direction.

The results of this study also indicate that the media still has room for improvement. Future development could focus on refining the user interface to make it more intuitive for young learners, providing varied levels of puzzle difficulty to accommodate different abilities, and incorporating collaborative learning elements so students can interact and solve challenges together. With these enhancements, the media could become even more meaningful and inclusive in supporting classroom learning. With ongoing development, this medium has the potential to become one of the innovative learning alternatives that can be widely used in elementary schools.

The Meaning of Research Findings in the Context of Elementary Education

Overall, the results of this study show that developing a puzzle-based learning media using Assemblr EDU has significant importance in the context of basic education. This media not only provides more engaging learning experiences, but also encourages a shift in the learning approach from teacher-centered to student-centered. Learning that combines puzzles and Augmented Reality gives students a chance to learn through experience, exploration, and problem-solving. This aligns with the demands of 21st-century education that stress the importance of developing high-level thinking skills from an early age (OECD, 2021).

Thus, the learning media developed in this research can be seen as one form of pedagogical innovation that is relevant to the needs of current and future learning. The results show that the puzzle-based learning media developed through Assemblr EDU was rated as appropriate to very appropriate by both experts and students. This suggests that the product is not only technically sound but also well received in real classroom use. These findings are in line with earlier studies indicating that the integration of Augmented Reality in education can increase students' motivation and engagement (Ibáñez & Delgado-Kloos, 2020; Yuliana et al., 2022). However, what distinguishes this study from much of the previous research is that AR is not used merely as a visualization aid. Rather than using AR simply as a visual enhancement, this study combines it with puzzle-based activities that act as cognitive drivers. These activities encourage students to think more deeply, reflect on what they are learning, and actively work through problems instead of passively receiving information.

In contrast to many AR learning applications that primarily present simulations or three-dimensional visuals, the media developed in this research places students at the center of the learning process. Students are not just viewing virtual objects on a screen; they are required to arrange puzzle pieces, try different possibilities, recognize mistakes, and adjust their understanding accordingly. This kind of hands-on and reflective experience closely aligns with constructivist

learning theory, which emphasizes that knowledge is built through active involvement and meaningful interaction (Jonassen, 2019).

The strong positive feedback from students also suggests that incorporating game-like elements into elementary learning can effectively strengthen intrinsic motivation. When learning feels engaging and interactive, students are naturally more willing to participate and invest effort in understanding the material.Through puzzle-based activities, students are encouraged to think critically and participate more actively, rather than passively receiving information from the teacher. Even so, it is important to acknowledge that this study was conducted on a limited scale and primarily aimed to assess feasibility. It did not yet examine long-term learning outcomes or compare results through controlled experimental designs. Therefore, while the findings are promising, the study remains at a developmental and preliminary evaluation stage, opening opportunities for further research to test its broader effectiveness. Therefore, further research using experimental designs is recommended to examine the impact of this media on students' academic achievement and higher-order thinking skills. Overall, the developed media demonstrates pedagogical relevance and strong potential for broader implementation with further refinement.

CONCLUSIONS

Based on the results of this study, it can be concluded that the puzzle-based learning media developed using Assemblr EDU through the ADDIE model is feasible for use in elementary school instruction, as evidenced by expert validation and positive student responses categorized as appropriate to very appropriate. The media meets criteria in terms of content relevance, visual design, AR interaction, and ease of use, while also enhancing student engagement, motivation, and active thinking through the integration of puzzle-based problem-solving and Augmented Reality visualization. Therefore, the objective of this study to develop and evaluate the feasibility of a puzzle-based learning media using Assemblr EDU has been successfully achieved, and the product offers strong potential as an innovative instructional alternative in

supporting 21st-century learning in elementary education.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Figure 1/ Assemblr EDU-based Puzzle Media

Figure 2/ Students are enthusiastic about using Assemblr EDU-based puzzle media.

Table 1/ Validation Results

Aspek yang Dinilai	Rata-rata Skor (%)	Kategori
Kelayakan materi	87%	Sangat Layak
Desain tampilan	83%	Layak
Interaksi & AR	85%	Layak
Kemudahan penggunaan	82%	Layak

Table 2/ Student Response Data to the Media

Aspek yang Dinilai	Persentase Respon Positif
Menarik & menyenangkan	90%
Mudah digunakan	85%
Membantu memahami materi	88%
Mengaktifkan berpikir	87%