



Development of assemblr edu-based augmented reality 3D learning media for IPAS subjects in elementary schools

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ABSTRACT

Education in the digital age requires teachers to create creative and modern learning materials in line with technological advancements. However, teachers at Garatengah Public Elementary School still predominantly use textbooks and two-dimensional images, causing students to struggle with understanding the abstract nature of the IPAS curriculum and leaving them unmotivated to learn. This study introduces an innovation in the form of the development of Augmented Reality (AR) learning media based on Assemblr Edu for the 5th-grade IPAS subject, Unit 5, Topic A: "How Breathing Helps Me Perform Daily Activities." This interactive and contextual AR technology aims to enhance understanding of scientific concepts and learning motivation through digitally accessible 3D displays. The study aims to describe the development stages and test the feasibility and effectiveness of the media. The method used is Research and Development (R&D) with the ADDIE model and a one-group pretest-posttest design, involving 20 fifth-grade students from Garatengah Public Elementary School. Validation results showed that the media received a feasibility score of 91% from media experts and 88% from subject matter experts, both classified as "highly feasible." The effectiveness test, using an N-Gain score of 59%, indicated the category "moderately effective." This study contributes to improving 21st-century learning quality through media that is valid, feasible, effective, and replicable for other subjects.

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1. INTRODUCTION

The most fundamental and essential need in life is education. It serves as the cornerstone for improving the quality of human resources and national progress. Teachers, students, resources, methods, and facilities all play crucial roles in determining the success of education (Kusumawati & Sutisna, 2021). The curriculum establishes guidelines and the direction of education, aimed at producing high-quality individuals and improving the quality of education (Sutisna et al., 2023). Therefore, to achieve this, the education system must be strengthened starting from the elementary level, where students' potential needs to be developed through the vital role of teachers in managing the classroom to ensure learning is of high quality, meaningful, and certainly not monotonous.

In the 21st century, education is no longer solely focused on the transfer of knowledge but also on the development of critical, creative, collaborative, and communicative thinking skills. These changes require teachers to be able to adapt to technological developments and integrate digital innovations into the learning process. In line with this, the digital era demands the creation of learning media that is interactive, contextual, and capable of facilitating meaningful learning

experiences for students. One way teachers can do this is by effectively optimizing the various learning resources and media already available (Darmawan et al., 2024).

The latest learning tool being implemented in the field of education is Augmented Reality (AR). Augmented Reality (AR) is a technology capable of adding or integrating digital objects into the physical environment using a smartphone or other electronic devices (Azibah & Ulia, 2025). These digital objects can be 2D or 3D (Berlian et al., 2024) and possess clearly observable characteristics, with the ability to be rotated and viewed from various and comprehensive perspectives.

One platform that can be used to create Augmented Reality (AR) as a medium is Assemblr Edu, which can be accessed via an app or website. Assemblr Edu is an editing space specifically designed for educators, serving as a tool for 3D-based learning and Augmented Reality (AR). It supports the creation of interactive and engaging learning environments that stimulate students' creativity and imagination through dynamic and enjoyable learning experiences (Wahyuni et al., 2024).

However, the reality on the ground shows that the use of digital technology in learning is still not optimal. Interviews with fifth-grade homeroom teachers at Garatengah Public Elementary School revealed that the media used are still limited to textbooks, two-dimensional images, and YouTube videos. Such teaching tends to make students quickly bored and less motivated. Observations also indicate that students struggle to understand abstract concepts in the Natural and Social Sciences (IPAS) curriculum, particularly regarding the human respiratory system—a topic that requires concrete visual representations since the subject matter cannot be directly observed. Education in the digital age demands that teachers create creative and modern learning materials aligned with technological advancements. However, teachers at Garatengah Public Elementary School still predominantly use textbooks and two-dimensional images, causing students to struggle with abstract IPAS material and feel unmotivated to learn. This study introduces an innovation in the form of developing Augmented Reality (AR) learning media based on Assemblr Edu for the IPAS subject in Grade 5, Unit 5, Topic A: “How Breathing Helps Me Perform Daily Activities.” This interactive and contextual AR technology aims to enhance understanding of scientific concepts and learning motivation through digitally accessible 3D displays. The study aims to describe the development stages and test the feasibility and effectiveness of the media. The method used was Research and Development (R&D) employing the ADDIE model and a one-group pretest-posttest design, involving 20 fifth-grade students from Garatengah Public Elementary School. Validation results showed the media received a feasibility score of 91% from media experts and 88% from content experts, both classified as “highly feasible.” The effectiveness test, using an N-Gain score of 59%, indicated the “moderately effective” category. This study contributes to improving 21st-century learning quality through media that is valid, feasible, effective, and replicable for other subjects (Tawil et al., 2024).

In 2023, the Programme for International Student Assessment (PISA) released data showing that Indonesia ranked in the bottom 12th percentile in numeracy, the bottom 11th percentile in literacy, and the bottom 15th percentile in science. This data indicates that Indonesian students' achievement in these three skills remains below the international average (PISA, 2022). Based on this PISA data, Indonesian students' science proficiency can still be categorized as low.

A study conducted by Nugraha in 2022 revealed that the science literacy levels of fifth-grade students at Sayan Elementary School were below the intermediate standard. Of the total student population, only 14% were able to meet the science literacy proficiency targets, and only 18% achieved adequate science learning outcomes (Nugraha, 2022). On the other hand, Nurdin et al.

(2024) research by states that students' learning outcomes are often low because teachers have not yet maximized the use of available facilities. Some teachers rely solely on conventional methods using textbooks as learning media (Susanti & Sutisna, 2024), which can hinder the learning process.

Ideally, a teacher should be literate, understand, and master technology-based learning media, as this serves as a key indicator of teacher professionalism (Mulyosari & Khosiyono, 2023). This is also emphasized in Law No. 14 of 2005 on Teachers and Lecturers, Article 20b, which states:

"In carrying out their professional duties, teachers are obligated to continuously improve and develop their academic qualifications and competencies in line with advancements in science, technology, and the arts" (Law No. 14 of 2005).

The clarity of this provision implies that a teacher's value is not solely based on their understanding of the subject matter, but also on their ability to integrate it with increasingly advanced technology. A teacher is not merely a source of learning, but also someone who can create, implement, and evaluate learning outcomes to achieve educational goals (Sutisna & Listriyani, 2023).

This situation highlights a gap that underscores the need for digital learning media capable of providing interactive and contextual visualizations, such as through Augmented Reality (AR) technology. This technology allows students to interact directly with 3D objects in real time, thereby enabling abstract concepts to be visualized in a tangible way. Previous research, such as (Faiza, Yani & Suprijono, 2024), indicates that the implementation of Augmented Reality can enhance learning outcomes and student engagement in social studies (IPS) content. Research by (Primadona et al., 2024) also demonstrates the effectiveness of Assemblr Edu-based Augmented Reality media in middle school biology education, with high levels of validation and practicality. Integrating Augmented Reality into problem-based learning models can enhance students' critical thinking skills.

Nevertheless, research on the application of Assemblr Edu-based Augmented Reality in social studies learning at the elementary school level remains very limited. Previous studies have mostly focused on social studies, biology, or economics at the middle and high school levels. It is from this gap that the scientific novelty of this study emerges, namely the development of Assemblr Edu-based Augmented Reality learning media for the IPAS subject in Grade 5 at Garatengah Public Elementary School, specifically for the material "How Breathing Helps Me Perform Daily Activities."

This research is important because it addresses a key challenge in 21st-century learning: how technology can be used meaningfully to enhance elementary school students' understanding and motivation to learn. With the availability of easily accessible Augmented Reality media, this study offers a practical solution for teachers to deliver engaging lessons aligned with the Merdeka Curriculum. This research contributes to strengthening the application of constructivist theory and experiential learning within the context of Augmented Reality-based digital learning, while also providing a replicable model for developing educational media that teachers can adapt across various other subjects.

Based on the above discussion, the researcher concludes that there is a need to develop Augmented Reality (AR) learning media based on Assemblr Edu for the IPAS subject in Grade 5 at SDN Garatengah. Thus, the objective of this study is to develop and test the feasibility and effectiveness of Augmented Reality learning media based on Assemblr Edu for the IPAS subject in Grade 5 at SDN Garatengah.

The novelty of this study lies in the integration of Augmented Reality technology within the context of IPAS learning at the elementary school level, which has not been extensively studied previously, as well as in the use of Assemblr Edu as an interactive platform supporting the visualization of Augmented Reality for the human respiratory system material. The results of this study are expected to contribute to the development of more interactive and concrete learning media, particularly for abstract topics in the IPAS curriculum regarding the human respiratory system, while also providing a model for learning media that can be utilized by teachers in other grade levels and subjects.

2. METHOD

This study employed the Research and Development (R&D) method, which aligns with the research objectives focused on developing and testing the feasibility of an Assemblr Edu-based Augmented Reality (AR) learning medium to enhance students' understanding of IPAS and their learning motivation. The ADDIE model was used in this study because it provides systematic steps for producing valid, feasible, and effective learning products, employing a one-group pretest-posttest experimental design, thereby allowing the effectiveness of the media to be measured by comparing learning outcomes before and after its use. This research on the development of Augmented Reality (AR) media began with several stages in accordance with the ADDIE development model. The first stage is Analyze, followed by Design, Development, Implementation, and Evaluation.

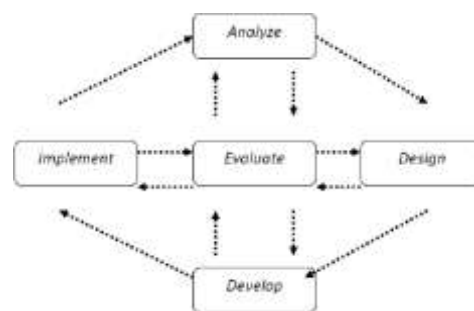


Figure 1. Stages of the ADDIE Model

The population for this study consists of all fifth-grade classes at Garatengah State Elementary School, totaling 139 students. A sample of 20 students from the fifth-grade class at Garatengah State Elementary School was selected. The sample was determined using purposive sampling as the technique, which involves considering specific characteristics only (Sugiyono, 2023), based on the consideration that this school, particularly the fifth grade, had not yet implemented digital technology-based learning media, specifically Augmented Reality, in IPAS instruction. The data collection techniques in this study were observation, interviews, questionnaires, and tests.

Table 1. Stages of Media Development

Stage	Main Activities	Results Achieved
Analysis	Observation and interviews with teachers and students	Identification of needs: teachers still use conventional media, and students quickly become bored; many struggle to understand the complex IPAS material
Design	Design of materials and storyboard	Initial design of AR media.
Development	Creation of 3D objects and integration into Augmented Reality based on Assemblr Edu	AR media prototype, accessible via a QR code and located within the teaching module.
Implementation	Pilot test in 5th grade at Garatengah	Collection of response data and learning outcomes
Evaluation	Expert validation and revision product	A suitable final medium for use.

3. RESULT AND DISCUSSION

This study produced a 3D Augmented Reality learning media product based on Assemblr Edu for the IPAS subject in the fifth grade at Garatengah Public Elementary School. The use of Augmented Reality (AR) media and the results of the effectiveness analysis conducted on the development of this media are considered highly suitable, quite effective, and engaging. The following is a detailed discussion:

Media Development Process

The first stage was analysis; the researcher analyzed the problems and needs of students and teachers during the learning process through observation and interviews with the fifth-grade homeroom teacher at Garatengah Public Elementary School. The results of the researcher's observations revealed that teachers still primarily use conventional media such as books and two-dimensional images, occasionally supplementing these with videos from YouTube. "I often use books and images; for digital content, I use videos from YouTube," the teacher responded when asked about the media frequently used in the learning process. Students easily become bored, lack enthusiasm, and many still struggle to grasp the complex IPAS material.

The second phase is design, in which the researcher prepares learning materials tailored to the Merdeka Curriculum and creates 3D models of the respiratory organs, backgrounds, icons/buttons, audio assets such as sound effects for click interactions, animated video assets depicting breathing, and other supporting assets/elements. Next is the creation of a storyboard. A storyboard is a sketch that illustrates a sequence and serves as an execution guide (Ariyana et al., 2022).

During the development phase, a prototype of an Assemblr Edu-based Augmented Reality (AR) media was produced, featuring interactive 3D elements accessible via QR codes and markers embedded within the prepared instructional module pages; when scanned, these automatically redirect to the Assemblr Edu website containing the created media. Below is an image of the QR code and AR media marker



Figure 2. Display of QR Code and *Marker*

The fourth stage is implementation. The researcher conducted a direct implementation or trial with fifth-grade students at Garatengah Public Elementary School, using Assemblr Edu-based Augmented Reality (AR) media containing Unit 5 Topic A material: “How Does Breathing Help Me Perform Daily Activities?”. Subsequently, the researcher distributed a student and teacher response questionnaire () after the media was used.

The fifth stage is evaluation. In this stage, the researcher evaluates the effectiveness of the Augmented Reality (AR) media using a questionnaire administered to media experts. The feedback, suggestions, and critiques provided by these validators are necessary to improve the Augmented Reality (AR) media, as are the pretest and posttest results that the researcher has administered to the students.



Figure 3. *Augmented Reality* Media Display

Feasibility of Augmented Reality Media

The validation test by media experts yielded a score of 91% in the “highly feasible” category, while the material experts scored 88% in the “highly feasible” category. The average media feasibility score was 89.5%. Suggestions received included: the content aligns with instructional needs, the media is ready for implementation, improve the visual presentation, and use brighter colors. Additionally, the media achieved an 87% approval rate from teachers and an 89% approval rate from students, both of which fall into the “highly suitable” category.

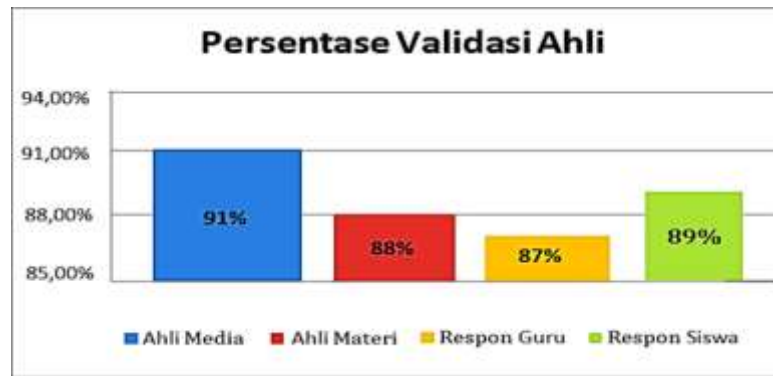


Figure 4. Validation Results Diagram

Effectiveness of Augmented Reality Media

The effectiveness of Augmented Reality (AR) learning media in improving student learning outcomes was assessed through pre-tests and post-tests. Based on the results of the study on IPAS learning in fifth grade, which was attended by regular students with varying abilities, the students' scores before using the media (pre-test) yielded an average score of 67.75 out of 20 students, with the lowest score being 25 and the highest 95. Scores after using the developed media (posttest) yielded an average of 85 out of 20 students, with the lowest score being 55 and the highest 100. There was a difference of 17.25 in the average pretest and posttest scores.

Table 2. N-Gain Score

Test Type	Average Score	N-Gain	Category
Pretest	67.75		
Posttest	85.00	59%	Fairly Effective

An N-Gain of 59% indicates an improvement in students' abilities after using the Assemblr Edu-based AR media. The results of the hypothesis test using the t-test showed a sig. value (2-tailed) of $0.000 < 0.05$, meaning there is a significant difference between learning outcomes before and after the use of Assemblr Edu-based Augmented Reality media.

Table 3. Hypothesis Test Results

Paired Samples Test									
Paired Differences									
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Paired Sample 1	Pre Test - Post Test	-13,000	6,569	1,469	-16,075	-9,925	-8,850	19	,000

The results of this study support constructivist learning theory, which emphasizes the importance of interactive learning experiences in building conceptual understanding (Sugihartono, 2013). These findings also support the results of studies (Primadona et al., 2024; Padang et al., 2022) showing that Assemblr Edu-based Augmented Reality media is proven to be valid, practical, and effective in improving learning outcomes. The high feasibility score (89.5%) demonstrates that the integration of Assemblr Edu-based Augmented Reality into learning aligns with the findings (Azibah & Ulia, 2025), which state that Augmented Reality technology effectively stimulates engagement and focus in elementary school students' learning.

The developed media is relevant to the characteristics of elementary school students who think concretely. The 3D visualization of the respiratory organs makes abstract concepts easier to understand. The use of QR codes directly linked to Assemblr Edu makes the media more accessible and encourages active student engagement in learning. Student motivation and attention increase because learning is no longer centered solely on the teacher's verbal explanations but also involves visual exploration and direct interaction with digital objects. Thus, Assemblr Edu-based Augmented Reality media can enrich learning resources while strengthening students' conceptual understanding of IPAS material.

This study offers a new contribution to the application of Augmented Reality in elementary-level science education. While previous research has largely focused on biology or social studies at the secondary level, this study demonstrates that Assemblr Edu-based Augmented Reality media can be effectively adapted for elementary school education, particularly for teaching the human respiratory system. These findings expand our understanding of how AR technology can serve as a contextual and constructive learning medium to address students' conceptual limitations regarding abstract material.

Based on these results, it can be concluded that Assemblr Edu-based Augmented Reality learning media is considered highly suitable and sufficiently effective for enhancing students' conceptual understanding and learning motivation in the IPAS subject at the elementary school level.

4. CONCLUSION

This study confirms that the development of Assemblr Edu-based Augmented Reality (AR) media for the 5th-grade IPAS curriculum in elementary school is capable of providing a more interactive,

contextual, and engaging learning experience for students. This finding is significant because it demonstrates that the integration of AR technology can bridge the gap between abstract concepts and students' concrete understanding, particularly in topics requiring the visualization of scientific processes such as the human respiratory system.

This study expands the application of constructivist theory in the context of digital learning in elementary schools. Augmented Reality has proven to be an effective tool for developing experience-based learning and enhancing students' cognitive and affective engagement. This study also makes a new contribution by demonstrating that Assemblr Edu-based Augmented Reality can be adapted not only for science subjects at the middle school level but also for IPAS learning at the elementary level. The findings of this study also offer an alternative for teachers to utilize AR-based learning technology to boost students' motivation, creativity, and conceptual understanding. This medium can be used as part of active, project-based learning strategies or visual exploration that fosters curiosity and independent learning.

As for the direction of educational policy that can be taken, there is a need for training and mentoring for teachers so they can develop and integrate Augmented Reality media into the curriculum. Strengthening digital literacy capacity in elementary school environments is key to expanding the implementation of innovative technology-based learning. Further research is recommended to develop Augmented Reality media for other IPAS materials or different subjects by involving more schools and a diverse student population. Additionally, research can expand the analysis to long-term impacts, such as improvements in students' critical thinking, collaborative skills, and digital literacy.

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