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Innovation of Augmented Reality Learning Media Using Assemblr Edu to Improve Science Learning Motivation and Outcomes of Sixth Grade Students

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Abstract
The development of digital technology necessitates innovation in learning media, particularly to enhance students' motivation and learning outcomes in science education. One proposed solution is the use of augmented reality (AR)-based learning media through the Assemblr Edu platform. This study aims to develop and evaluate the feasibility of Assemblr Edu as a learning medium to improve the motivation and science learning outcomes of 30 sixth-grade students at SDN 218/IV Kota Jambi. This research is a development study (R&D) utilizing the ADDIE model, which includes five stages: Analyze, Design, Develop, Implement, and Evaluate. Data collection techniques included observation, interviews, questionnaires, and learning outcome tests. The validation results indicated that the media was highly feasible, with validation scores of 95% from material experts and 93.89% from media experts. The practicality test yielded scores of 96% from teachers and 97% from students. The effectiveness test results showed a significant improvement in students' motivation and learning outcomes (Sig. 0.000 < 0.05). Therefore, the Assemblr Edu learning media is proven to be feasible, practical, and effective for use in science instruction to enhance students' motivation and learning outcomes.

INTRODUCTION

The advancement of digital technology has brought about significant changes in various aspects of life, including education. In the context of 21st-century education, the use of information technology has become a pressing need to enhance the effectiveness and quality of learning. Abas (2025) emphasizes that the integration of technology in education has a sustained impact on the teaching and learning process, particularly in providing more dynamic and contextual learning media. Innovative learning media not only facilitate content delivery but also foster learning motivation and encourage active student engagement (Putri, 2024). Therefore, technology-based media have become a strategic component in realizing meaningful learning that is adaptive to the demands of the times.

Science (IPA) as one of the core subjects at the elementary school level requires a concrete, exploratory, and interactive learning approach. The nature of science education, which emphasizes understanding scientific concepts and processes, demands that teachers present the material in a way that is easy to understand and relevant to students' daily lives. Unfortunately, field observations indicate that most teachers still rely on conventional methods such as lectures and textbook-based instruction alone (Ahdar, 2018). This approach results in passive and unmotivated students during science lessons, which in turn leads to low academic achievement and a weak understanding of abstract scientific concepts.

Learning motivation is an internal factor that greatly influences students' success in the learning process. Highly motivated students tend to demonstrate greater enthusiasm for learning, perseverance in completing tasks, and achieve optimal learning outcomes (Putri & Darwan, 2023). Conversely, students with low motivation often struggle to grasp the material and achieve unsatisfactory academic performance (Iskandar, 2021). In the context of science learning, low motivation is often caused by unengaging material presentation and limited use of varied media. Hence, teachers are expected to design learning strategies that are not only informative but also inspirational and psychologically and cognitively motivating for students.

In today's digital transformation era, technology-based learning has become a promising alternative to improve the quality of basic education. One emerging approach is the use of Augmented Reality (AR)-based media, which combines the real world with virtual objects in an interactive manner (Rumajar et al., 2015). AR technology in education enables the visualization of instructional content in three dimensions, allowing abstract scientific concepts to be presented in a more tangible and engaging way. One AR-based application that can be utilized in educational settings is Assemblr Edu, which is designed to facilitate the creation of 3D and interactive learning content without requiring technical programming skills. With its features that support visual, auditory, and kinesthetic learning, Assemblr Edu offers significant opportunities to create immersive learning experiences for students (Ananda & Putri, 2024).

Although AR technology has been widely used across various sectors, its application in the context of elementary science learning remains relatively limited. This is due to several factors, including teachers' limited understanding of new technologies, the lack of training provided, and insufficient infrastructure in schools. Additionally, many teachers are reluctant to try AR-based learning approaches, perceiving them as complex and requiring special devices. In fact, various studies have shown that the use of AR in learning can significantly enhance students' attention, engagement, and learning motivation (Ricardo & Meilani, 2017; Maulia, 2023; Wahiddiyah et al., 2023; Qmarina & Susilo, 2025). Therefore, it is necessary to develop AR-based learning media that are user-friendly, curriculum-relevant, and aligned with the characteristics of elementary school students.

In response to these challenges, the development of Assemblr Edu as a learning medium serves as a strategic solution to meet the demand for interactive, applicable, and contextual media in science education. This application enables teachers to present models, simulations, and illustrations in the form of 3D visualizations that can be accessed via mobile devices (Sutopo, 2022). With attractive displays and interactive barcode features, students can independently and actively explore learning materials. More than just a visual aid, Assemblr Edu also accommodates diverse learning styles and enhances interactivity between teachers and students during the learning process. Therefore, this medium is worthy of development and implementation as part of a strategy to improve the quality of science learning in elementary schools.

Although numerous studies have highlighted the potential of digital learning media in increasing student engagement, there remains a gap between theoretical findings and field practices. Many elementary school teachers are still unable to utilize innovative learning media optimally due to limitations in training, resources, and the availability of media aligned with the national curriculum. Moreover, most of the media currently used remain passive and non-interactive, such as video presentations or PowerPoint slideshows that do not involve students' active participation. The mismatch between learning approaches and the predominantly visual and kinesthetic learning characteristics of elementary students is one of the factors contributing to low motivation and learning outcomes—particularly in science subjects that require understanding of abstract concepts. This fundamental disconnect, where abstract scientific concepts are often taught through passive methods, significantly impedes students' comprehension and engagement, leading to a persistent decline in learning achievement.

Furthermore, the recent implementation of the Kurikulum Merdeka (Independent Curriculum) in Indonesia necessitates a paradigm shift in educational practices, emphasizing student-centered learning, critical thinking, creativity, and the development of essential competencies through project-based and experiential approaches. This curriculum aims to foster students' holistic development and prepare them for future challenges, moving beyond traditional rote learning. In this context, conventional science teaching methods, often characterized by abstract presentations and limited practical engagement, fall short of supporting the transformative goals of Kurikulum Merdeka. Augmented Reality (AR) technology, with its capacity to provide immersive, interactive, and contextualized learning experiences, aligns perfectly with the principles of the Kurikulum Merdeka by enabling students to visualize complex scientific concepts, engage in active exploration, and develop problem-solving skills collaboratively. The integration of AR into science education, therefore, presents a timely and relevant approach to support the successful implementation of the new national curriculum and enhance the learning process in line with its progressive objectives.

On the other hand, the results of observations and preliminary studies indicate that most elementary schools—particularly in urban areas such as Jambi City—already have basic infrastructure such as mobile devices and adequate internet access to support the implementation of AR-based learning media. However, despite this technological readiness and the recognized potential of AR for interactive learning, few media have been specifically developed to address the unique context of elementary science learning. The available media are generally generic and not directly linked to learning outcomes, curriculum structure, or the learning styles of elementary students. This critical lack of tailored, interactive, and curriculum-aligned AR media constitutes a significant research gap that needs to be urgently addressed to optimize science education in elementary schools. This study seeks to address through the development of Assemblr Edu learning media tailored to the concrete needs of science learning at the elementary level.

Novelty and contribution of the study while numerous studies have explored the potential of Augmented Reality (AR) in education, a significant gap remains in its targeted application, particularly within the specific context of elementary science education and its alignment with national curricula. The novelty of this study primarily resides in two key aspects. First, it focuses on the development of AR learning media using the Assemblr Edu platform, which offers an accessible and intuitive environment for creating interactive 3D content, yet its pedagogical application at the elementary level for science learning remains under-explored in the existing literature. Second, this research specifically designs and validates AR media that is directly integrated with the elementary school curriculum, aligning with the learning objectives and characteristics of students in the concrete operational stage. Most existing AR applications for education are often generic or designed for higher educational levels, overlooking the unique cognitive and developmental needs of primary school students. By addressing this specific gap and providing a feasible, practical, and effective AR solution tailored for elementary science education under the current national curriculum framework, this study offers a significant contribution to the body of knowledge in educational technology and provides a practical model for educators seeking to innovate their teaching practices.

Although various studies have highlighted the potential of digital learning media in enhancing student engagement, a gap still exists between theoretical findings and actual classroom practices. Many elementary school teachers are not yet able to fully utilize innovative learning media due to limitations in training, resources, and the availability of media that align with the national curriculum hiepresentations or PowerPoint slideshows, which do not encourage active student participation. The mismatch between learning approaches and the predominantly visual and kinesthetic learning characteristics of elementary students is one of the primary causes of low motivation and learning outcomes—especially in science subjects, which require the understanding of abstract concepts.

On the other hand, the results of observations and preliminary studies indicate that most elementary schools—particularly in urban areas such as Jambi City—already possess basic infrastructure, including mobile devices and sufficient internet access to support the implementation of

AR-based learning media. However, there has been little development of media specifically designed for the context of elementary science learning. The available media are generally generic and not explicitly linked to learning objectives, curriculum structure, or the learning styles of elementary students. This represents a research gap that this study aims to address through the development of Assemblr Edu learning media tailored to the concrete needs of science education at the elementary level.

Previous studies have predominantly focused on the implementation of technology in secondary or higher education, while the application of augmented reality at the elementary level remains very limited. Few AR-based media have been thoroughly evaluated in terms of their validity, practicality, and effectiveness in enhancing the motivation and learning outcomes of elementary students, particularly in science education. This highlights the need for media development studies that consider not only the technological aspects but also emphasize pedagogical and psychological integration within the context of children's learning. Therefore, this research aims to fill that gap by focusing on the development of AR media that is adaptive, contextual, and based on the learning needs of sixth-grade students.

Assemblr Edu was selected as the basis for media development due to its interactive features that support student engagement and its potential to enrich learning experiences through 3D object visualization. The advantages of Assemblr Edu over conventional media include its ease of use without requiring advanced technical skills, flexibility in modeling learning materials, and its integration of visualization, sound, and text to accommodate various student learning styles. Furthermore, the application supports both individual and collaborative learning processes, offering a more immersive and enjoyable learning experience (Resti et al., 2024).

This study not only aims to produce innovative learning media but also seeks to contribute scientifically to the understanding of how digital media influence students' motivational and cognitive aspects. In the context of elementary education, media such as Assemblr Edu can serve as an alternative solution to the common problems in science learning, namely low motivation and difficulties in understanding abstract concepts. By providing empirical evidence through validation, practicality testing, and statistical effectiveness analysis, this research is expected to offer a strong foundation for the broader implementation of AR media in Indonesia's elementary education system.

In the process of developing learning media, success is determined not only by the quality of the technology used but also by how relevant the media are to students' characteristics and the learning context. Science, as a subject that requires critical and analytical thinking skills, demands an approach that can present content in a concrete and easily understandable manner. Interactive, meaningful, and enjoyable learning is essential—especially for elementary students who, according to Piaget, are still in the concrete operational stage. Therefore, the media developed must be capable of providing active learning experiences and facilitating direct exploration of the subject matter, as offered by Augmented Reality technology.

The use of AR-based media through Assemblr Edu in sixth-grade science learning is highly relevant, particularly because topics such as the solar system involve abstract concepts that cannot be directly observed by students. The 3D visualizations offered by this media allow students to explore the structure of the solar system in a tangible way, strengthen conceptual understanding, and foster early interest in science. Furthermore, the interactive features in Assemblr Edu provide opportunities for students to engage in both independent learning and small-group collaboration, ultimately enhancing both learning motivation and academic performance simultaneously.

Based on the aforementioned discussion, there is a clear need for learning media that are not only visually appealing but also pedagogically effective in enhancing the motivation and learning outcomes of elementary school students. Therefore, it is important to develop Assemblr Edu-based learning media specifically designed for science instruction. This development must go through a validation process by experts, a practicality test involving teachers and students, and an effectiveness test using a quantitative approach to produce a product that is feasible for classroom use. This

process also enables researchers to ensure that the developed media align with the actual instructional needs in schools.

Accordingly, this study focuses on four main aspects: (1) designing Assemblr Edu learning media to improve elementary students' motivation and science learning outcomes, (2) testing the validity of the media through expert evaluation, (3) assessing its practicality through the involvement of teachers and students, and (4) examining the effectiveness of the media in enhancing students' motivation and learning outcomes using a statistical testing design. These four aspects are interconnected and form an integrated sequence in the development process of learning media based on real classroom needs.

Therefore, this article aims to present the results of developing Assemblr Edu-based learning media to improve the motivation and science learning outcomes of sixth-grade students at SDN 218/IV Kota Jambi. Through a research and development (R&D) approach using the ADDIE model, this article is expected to offer both theoretical and practical contributions to the development of innovative learning media that are adaptive to technological advancements and the instructional needs of science education in elementary schools. The findings of this study are anticipated to serve as a reference for teachers, media developers, and elementary education researchers in designing more effective and meaningful instruction in today's digital era.

METHODS

This study is a type of research and development (R&D) aimed at producing a product in the form of augmented reality-based learning media using the Assemblr Edu application, as well as testing its feasibility, practicality, and effectiveness in improving students' motivation and learning outcomes in elementary science education. The development process of this study employed the ADDIE model, which consists of five systematic stages: Analyze, Design, Develop, Implement, and Evaluate (Rusdi et al., 2022). This model was chosen because it provides a structured framework for designing and developing instructional media that align with the learning needs of elementary school students (Anggraini & Putra, 2021).

The subjects of this study were 30 sixth-grade students from SDN 218/IV Kota Jambi in the 2024/2025 academic year. In addition to the students, two classroom teachers were also involved in the practicality testing of the developed media. The object of this research was the Assemblr Edu-based learning media, which was specifically designed to present the topic of the solar system in science lessons. This media was developed to enhance the quality of instruction by making it more interactive, enjoyable, and suited to the characteristics of elementary school students.

The data sources in this study consisted of both primary and secondary data. Primary data were obtained directly through observation, interviews, questionnaires, and tests, while secondary data were collected from instructional documents, relevant literature, and other supporting references used in the development and analysis of the media. Data collection techniques varied depending on the research stage and objectives. In the initial phase, observations and interviews were conducted to identify issues and needs in the field related to the science learning process. Subsequently, questionnaires were used to assess the practicality of the media from the perspectives of teachers and students after media implementation, as well as to measure students' learning motivation before and after using the media. Meanwhile, tests were used to measure students' learning outcomes, consisting of pre-tests and post-tests to determine improvements after the use of the media.

All collected data were analyzed using a quantitative approach. Data related to media validity were analyzed descriptively by converting expert evaluation scores into percentages and classifying them into feasibility categories. Practicality data from teachers and students were also analyzed descriptively and categorized based on the level of practicality. To measure the effectiveness of the media on motivation and learning outcomes, inferential statistical analysis was conducted using the Paired Sample t-Test. This test aimed to determine significant differences between pre-test and post-test scores for the two main variables: learning motivation and learning outcomes. The entire analysis

process was carried out carefully and systematically to ensure the validity of the findings and to support conclusions that are accurate and relevant to the research objectives.

RESULTS AND DISCUSSION

This study aimed to develop Assemblr Edu learning media and examine its validity, practicality, and effectiveness in improving the motivation and learning outcomes of sixth-grade students in science subjects at SDN 218/IV Kota Jambi. The development process was conducted systematically using the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation.

1. Analysis

The analysis stage began with determining the appropriate type of media based on the needs of science learning in elementary schools. Based on observations at SDN 218/IV Kota Jambi, science instruction was still conventional and lacked interactive media. The teacher reported that students had difficulty understanding the solar system material due to the absence of concrete media. Therefore, augmented reality (AR)-based media using the Assemblr Edu application was selected, as it allows for interactive three-dimensional visualization. This is in line with Zain & Pratiwi (2021), who emphasize the importance of concrete media in supporting students' comprehension. Competency analysis showed that the solar system topic aligns with the Basic Competencies for Grade VI and requires a visual approach to explain abstract concepts such as planetary rotation and revolution. Through Assemblr Edu, students can rotate and explore 3D objects, supporting enactive and iconic representation processes as proposed by Bruner. Furthermore, student analysis revealed that learners have basic digital skills and a high interest in visual media. According to Piaget's theory of cognitive development, students aged 11–12 are in the concrete operational stage, thus requiring manipulable media. These three types of analysis reinforce that the development of Assemblr Edu media is appropriate in terms of instructional needs, content, and user characteristics.

2. Design

The design stage followed the analysis phase and aimed to systematically plan the Assemblr Edu learning media to match the needs and characteristics of elementary science education. This design process involved several key aspects, including selecting the media development platform, preparing instructional materials, and developing a learning module. The media were designed using the Assemblr Edu platform, which was accessed via a laptop for AR content creation. The content used in the media referred to the Grade VI science textbook based on the *Kurikulum Merdeka*, particularly the topic of the solar system. The material covered the definition of the solar system, its components, and the characteristics of planets orbiting the sun. Additionally, a teaching module was developed as a guide for implementing the media in instruction. The module was structured to direct the learning process systematically, from the introduction to the core and closing activities, and was equipped with assessment instruments to evaluate the effectiveness of the media in achieving the learning objectives. With this comprehensive planning, the media are expected to provide a more contextual, structured, and engaging learning experience for elementary school students.

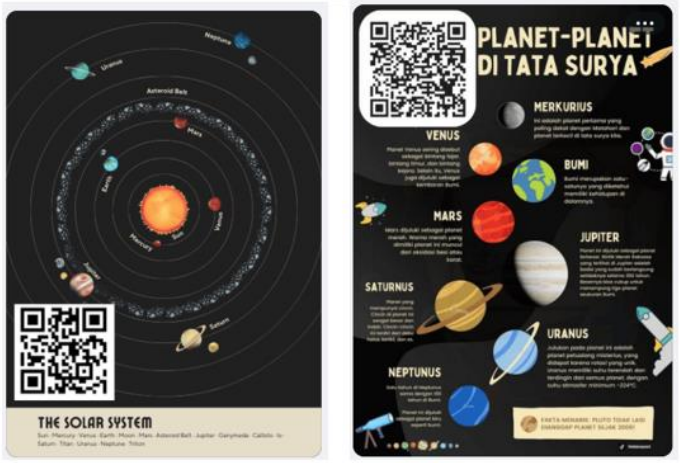
3. Development

The development stage was carried out after the media design phase, with the goal of producing a ready-to-use Assemblr Edu learning media product for science instruction. The development process was conducted through the official Assemblr Edu platform, accessible via laptops or smartphones, and designed in the form of barcodes which, when scanned, display interactive three-dimensional objects of the solar system. The 3D visualizations were designed to be simple yet engaging to help students better understand abstract content. In addition to visual content, explanatory narration and informational labels were also integrated into each object to support concept comprehension.

Once the product was fully developed, a series of validation activities were conducted by a content expert and a media expert to assess the appropriateness of the content and visual presentation. Furthermore, a practicality test was carried out by two classroom teachers and six sixth-

grade students at SDN 218/IV Kota Jambi to evaluate the usability of the media in a real instructional context. These two processes aimed to ensure that the resulting product was feasible and ready for implementation before being applied more broadly in the classroom. The final product of this development process is presented as follows.

Pigure 1. Product Front and Back Cover



Pigure 2. The contents of the Assemblr Edu Media are in the form of cards that have been provided with barcodes and can be scanned.

4. Implementation

The implementation stage is the next phase in the ADDIE model, conducted after the Assemblr Edu media has been fully developed and declared feasible for use. At this stage, the media was directly tested in a real science learning setting with sixth-grade students at SDN 218/IV Kota Jambi, involving all 30 students in a large-group trial. The implementation took place in an authentic classroom environment, where the teacher integrated the Assemblr Edu media into the teaching and learning process on the topic of the solar system.

Students used their own Android devices to scan the provided barcodes and then explored the three-dimensional objects as part of the learning activities. The researcher acted as an observer to closely monitor how the media was utilized, record students' interactions with the content, and assess both the technical and pedagogical effectiveness of the media in the classroom. This implementation served as an important foundation for determining the readiness of the media for full-scale classroom application and formed the basis for the evaluation stage, which aimed to assess the media's impact on students' motivation and learning outcomes in a real educational context.

5. Evaluation

In the final stage of this development process, the researcher conducted data collection, revision, and refinement of the developed learning media through a formative evaluation process. This

evaluation was carried out gradually throughout the development phases. During the analysis stage, data were gathered through interviews and observations, as well as questionnaires distributed to teachers to explore the needs and characteristics of students. In the design stage, evaluations were conducted to ensure the compatibility of the designed media with the available school facilities, such as the use of smartphones or projectors. Final evaluation in the media development process involved revising and improving the product based on feedback from content experts, media experts, and suggestions provided by teachers and students as direct users.

After the Assemblr Edu media was implemented in the science learning process for Grade VI students at SDN 218/IV Kota Jambi, the researcher proceeded with the final phase by collecting quantitative data to assess the quality and effectiveness of the developed media. Assessment was carried out through validity testing by two experts—a content expert and a media expert—to evaluate the appropriateness of the content and visual design. Furthermore, a practicality test was conducted by two teachers and six students as direct users to evaluate the ease of use, attractiveness, and functionality of the media in a classroom setting. In addition, to measure the effectiveness of the media, pre-tests and post-tests were administered to assess both learning motivation and learning outcomes. This measurement aimed to determine the extent to which the use of Assemblr Edu media contributed to enhancing student engagement and understanding of the solar system topic. The results of the validation, practicality, and effectiveness tests are presented in the following section.

Tabel 1. Material Expert Assessment Results

Indicator	Expert 1	Expert 2
1	5	5
2	4	4
3	5	5
4	5	4
5	5	5
6	5	5
7	4	5
8	4	5
9	5	5
10	5	5
Total	47	48
Percentage	94%	96%
Average Percentage Score	95%	

The validation results of the Assemblr Edu learning media by two content experts demonstrated a very high level of feasibility. Based on the evaluation of ten indicators—including content substance, curriculum alignment, language appropriateness, conceptual coherence, and the usefulness of the media in supporting students' understanding—the first expert assigned a total score of 47 and the second expert 48. When converted into percentages, the first expert gave a score of 94% and the second 96%, with an overall average percentage of 95%. This percentage falls into the "very valid" category according to the learning media feasibility criteria by Akbar (2013), indicating that the Assemblr Edu media meets the content eligibility requirements and is suitable for instructional use with minimal or no revision. This assessment confirms that the material presented in the media is not only scientifically accurate but also relevant to the core competencies outlined in the curriculum and easily comprehensible by elementary school students.

The high validity score indicates that the Assemblr Edu media aligns with the principles of effective instructional material development, as suggested by Agwaro (2013), who stated that good instructional content must be well-structured, logical, and aligned with the cognitive development level of learners. The three-dimensional visualizations presented in this media effectively bridge students' understanding of abstract concepts in the solar system by providing concrete visual representations. This is supported by Olympiou et al. (2013), who emphasized that concrete media—such as visual models or simulations—are easier for learners to understand and retain than verbal-

based materials. Therefore, the Assemblr Edu media is considered highly feasible for use in science instruction, particularly for delivering content that requires visualization and active student engagement in the learning process. This content validation provides a strong foundation for proceeding to the practicality and effectiveness testing phases in the field.

Table 2. Results of Media Validation by Content Experts

Indicator	Expert 1	Expert 2
1	5	5
2	5	5
3	5	5
4	5	5
5	4	4
6	5	5
7	4	4
8	5	4
9	4	4
10	5	5
11	5	5
12	5	5
13	4	5
14	4	5
15	5	5
16	4	4
17	5	5
18	5	5
Total	84	85
Percentage	93.34%	94.45%
Average Percentage Score	93.89%	

The validation results of the Assemblr Edu learning media by two media experts indicated a very high level of feasibility in terms of visual design, interactivity, navigation, technological compatibility, and instructional functionality. Based on the assessment of 18 indicators, the first expert assigned a score of 84 and the second expert 85 out of a maximum total of 90. When converted to percentages, the first expert gave a score of 93.34% and the second 94.45%, resulting in an average score of 93.89%. According to the feasibility interpretation criteria for instructional media proposed by Akbar (2013), this score falls into the "very valid" category. This indicates that the media has met the technical and aesthetic standards of a high-quality instructional tool. The media design was rated as responsive, with a visually appealing and consistent interface, and smoothly functioning interactive features. The validators also noted that the media could be easily operated using standard devices commonly available in elementary schools, such as smartphones and projectors.

This validation aligns with the findings of Ali et al. (2024), who emphasized that effective visual design, when combined with verbal and interactive elements, can significantly enhance retention and conceptual understanding in learning. Assemblr Edu media enables the presentation of solar system material in three dimensions, thus allowing students to engage with abstract objects that are otherwise difficult to visualize in real life. In addition, this media complies with the principles of digital ergonomics in learning, which, according to Babiker & Elmagzoub (2015), require instructional tools to be accessible, efficient, and enjoyable for both learners and educators. Therefore, the results of the media expert validation reinforce that Assemblr Edu is not only content-wise feasible but also highly effective in terms of technical and visual aspects for use in elementary science education.

The practicality test of the Assemblr Edu learning media was conducted by two Grade VI teachers at SDN 218/IV Kota Jambi using a structured assessment instrument and interviews. Based on the quantitative evaluation of 18 indicators—including ease of use, clarity of visual display, alignment with instructional objectives, and effectiveness in content delivery—the first teacher assigned a score of 84 and the second teacher 85 out of a maximum of 90 points. The resulting practicality percentages were 93.34% and 94.45%, respectively, with an average of 93.89%. According to the instructional media

feasibility criteria by Akbar (2013), these scores fall under the "very practical" category. These findings indicate that Assemblr Edu is user-friendly for teachers without requiring special training and can be effectively integrated into the teaching and learning process. The teachers did not encounter significant technical difficulties and found the media helpful in explaining abstract concepts, such as the solar system, to their students.

Table 3. Practicality Test Results – Teachers

Indicator	Teacher 1	Teacher 2
1	5	5
2	5	5
3	5	5
4	5	4
5	5	4
6	5	5
7	5	5
8	4	4
9	5	5
10	5	5
Total	49	47
Percentage	98%	94%
Average Percentage Score	96%	

Furthermore, interviews with both teachers reinforced the quantitative results. They stated that the Assemblr Edu media was highly innovative, keeping up with technological advancements and utilizing digital tools that are already familiar to students. One teacher remarked that "the Assemblr Edu learning media is very up-to-date and innovative," while the other noted, "the use of digital technology in this media is excellent and can be further developed for other subject areas." These statements suggest that teachers not only accepted the media with enthusiasm but also recognized its long-term potential as a cross-disciplinary instructional tool. This aligns with the opinion of Pustikayasa et al. (2023), who emphasized that the practicality of instructional media should be assessed based on its ease of integration into the classroom, its functionality, and its flexibility in various learning contexts. Thus, the results of the teacher practicality test confirm that Assemblr Edu significantly supports classroom learning and has the potential to be adapted more broadly across the elementary school curriculum.

Table 4. Small Group Trial Results

Indicator	Students					
	1	2	3	4	5	6
1	5	5	5	5	4	5
2	5	5	5	5	5	4
3	5	5	5	5	4	5
4	5	5	5	5	5	5
5	5	5	5	5	5	5
6	5	5	4	5	4	4
7	5	5	5	5	5	5
Total	35	35	34	35	32	33
Percentage	100 %	100 %	97 %	100 %	91 %	94 %
Average Percentage Score	97%					

The practicality test of the Assemblr Edu media conducted with a small group of students indicated that the media was highly accessible and enthusiastically received by the participants. Based on the evaluation of seven indicators, the average practicality percentage reached 97%, which falls into the "very practical" category. Students reported no difficulty in accessing or operating the media. The learning process through barcode scanning was perceived as simple, fast, and intuitive, aligning well with the digital habits of today's learners. Visually, the three-dimensional solar system objects

presented through Assemblr Edu were considered highly engaging, interactive, and distinctly different from conventional media previously used in class. This high level of practicality reflects not only technical success but also the media's capacity to provide an enjoyable learning experience without imposing cognitive or technological burdens on students.

Student comments reinforced the quantitative findings. Several students expressed that the Assemblr Edu media was "not boring because the images pop out," "learning becomes easier by just scanning a barcode," and "fun because the images move and the planets look real." Other responses such as "this way of learning is really exciting" and "learning is more enjoyable" suggest that the media succeeded in creating a positive and motivating learning atmosphere. This aligns with Moreno et al. (2011), who argue that concrete and visually immersive learning experiences are more easily understood and retained by learners. Furthermore, from an educational psychology perspective, media that can evoke positive emotions and encourage active student engagement is more likely to support improved learning outcomes (Williams et al., 2013). Thus, the results of the small group trial demonstrate that Assemblr Edu is not only practical but also fosters enjoyable, engaging, and meaningful learning experiences for elementary students.

To test the study's hypotheses, a Paired Sample T-Test was employed using SPSS version 16.0. The basis for decision-making was the obtained significance value (p-value). This value was used to determine whether there was a statistically significant difference between the pre- and post-test conditions following the use of the media. The decision criteria were as follows: if the significance value was less than 0.05, a significant difference in students' motivation and science learning outcomes existed before and after the use of Assemblr Edu in the solar system topic.

Thus, if the statistical test results indicated a significance value < 0.05, it can be concluded that the Assemblr Edu media had a significant impact on improving students' motivation and learning outcomes in science at the elementary level. Conversely, if the significance value was greater than 0.05, it would indicate that there was no meaningful difference before and after the use of the media, implying that it did not have a significant effect. The complete results of the hypothesis testing are presented in the following section.

Table 5. Results of the Effectiveness Test on Students' Learning Motivation

	Paired Differences			t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean			
Pair Pretest- Posttest	-1.77000E1	7.84395	1.43210	-12.359	29	.000

Based on the results of the analysis using the Paired Sample t-test on students' learning motivation scores before and after participating in the learning process using Assemblr Edu media, the obtained significance value (Sig. 2-tailed) was 0.000. This value is far below the standard significance threshold of 0.05, which serves as the basis for hypothesis testing. This finding indicates that there is a statistically significant difference between the students' initial and final learning motivation, which can be directly attributed to the use of the augmented reality-based learning media in science instruction, particularly in the topic of the solar system.

Given that the significance value falls below the critical limit ($p < 0.05$), the null hypothesis (H_0), which states that there is no difference in motivation, is rejected, and the alternative hypothesis (H_1) is accepted. This indicates that learning with Assemblr Edu media has a significant impact on increasing students' motivation. This improvement reflects the effectiveness of the media in capturing attention, creating enjoyable learning experiences, and fostering students' interest in the subject matter. This is supported by Keller (1987), who emphasized that learning becomes more effective when it stimulates attention and relevance while also building confidence and satisfaction during the process.

Learning media designed with visual and interactive features through AR technology such as Assemblr Edu has great potential to foster intrinsic motivation among learners. According to Amone et

al. (2011), media that can provide concrete and visually engaging learning experiences will enhance students' readiness to learn and curiosity. In this context, the 3D visualization of the solar system allows students to observe abstract concepts in a tangible manner, making the learning process more active and enjoyable. Therefore, these effectiveness test results affirm that Assemblr Edu functions not only as a visual aid but also as a tool to build a motivational learning environment that fosters deeper emotional engagement from students.

Table 6. Results of the Effectiveness Test on Students' Learning Outcomes

	Paired Differences			t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean			
Pair Pretest- Posttest	-1.96333E1	7.84395	1.99510	-9.841	29	.000

With a significance value far below 0.05, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. This means that there is a statistically significant difference between students' pretest and posttest scores. This finding indicates that the use of Assemblr Edu as a learning medium has a positive impact on improving students' understanding of science concepts that were previously considered difficult. According to Arsyad et al. (2024), learning outcomes are optimized when the instructional process provides appropriate stimuli and helps learners organize information meaningfully. Augmented reality-based media such as Assemblr Edu allow students to visualize abstract concepts in a concrete manner, thereby facilitating the formation of stronger and more memorable cognitive schemas.

The development of the Augmented Reality (AR) learning media leveraging the Assemblr Edu platform involved several technical stages to ensure its functionality and accessibility for elementary school students. Content creation primarily utilized Assemblr Studio, where 3D models of celestial bodies and solar system phenomena were designed or imported. These models were then enriched with interactive elements such as clickable hotspots, information pop-ups, and embedded videos to provide a dynamic learning experience. The media was structured into several scenes, each focusing on a specific concept within the solar system topic, designed to guide students through an exploratory journey. Access to the AR content during classroom implementation was facilitated by providing students with unique QR codes or direct links that, when scanned or clicked via their mobile devices (smartphones or tablets equipped with the Assemblr Edu application), seamlessly activated the AR environment. This allowed students to view and interact with the 3D models superimposed onto their physical surroundings. The intuitive interface of Assemblr Edu enabled students to manipulate the AR objects—rotating, zooming, and interacting with the embedded information—fostering direct engagement with abstract scientific concepts. The technical design prioritized ease of use, ensuring that elementary students could navigate the application independently and experience immersive learning without significant technical barriers.

This finding is also supported by Mayer (2017) in the multimedia learning theory, which states that information presented in both verbal and visual forms simultaneously can enhance students' understanding and retention. Assemblr Edu, with its capability to display three-dimensional objects from various perspectives, enables students to engage in deeper visual exploration-based learning. When students not only read or listen to explanations but also observe, rotate, and understand the relationships between objects directly, the learning process becomes more effective. Therefore, this medium not only enriches students' learning experiences but is also empirically proven to significantly improve learning outcomes.

The effectiveness of Assemblr Edu in enhancing learning outcomes also aligns with the principle of meaningful learning as stated by Ausubel (2012), who asserts that students are more likely to comprehend and retain material when new information is connected to their existing cognitive structures. The interactive visualizations presented through Assemblr Edu enable students to link prior knowledge with new representations in three-dimensional form. Thus, the elaboration process of

information becomes stronger and deeper. This indicates that the integration of technology-based media such as AR is not merely a visual innovation but truly strengthens the learning function itself through a multisensory approach that aligns with the learning styles of elementary school students. Therefore, the effectiveness of this medium in improving learning outcomes can serve as a foundation for developing similar media for other subjects.

Despite the significant findings regarding the feasibility, practicality, and effectiveness of the Assemblr Edu-based learning media, this study is not without limitations that warrant acknowledgment and may influence the generalizability of its findings. First, the research was conducted with a relatively small sample size of 30 sixth-grade students from a single elementary school in Jambi City. While this sample was appropriate for a development study aiming for in-depth evaluation, it may limit the direct generalizability of the effectiveness results to a broader and more diverse student population across different geographical locations or school contexts in Indonesia. Future research could replicate this study with a larger and more varied sample to enhance external validity.

Second, the study focused exclusively on the "Solar System" topic within the science curriculum. While the media demonstrated effectiveness for this specific content, its applicability and impact on other science topics or subjects were not explored. This suggests a need for further development and testing across various curriculum areas to ascertain the versatility of Assemblr Edu as a comprehensive learning tool. Third, while student motivation and learning outcomes were measured, the long-term retention of knowledge and sustained motivational effects were beyond the scope of this short-term intervention study. Longitudinal studies would be beneficial to assess the lasting impact of AR-based learning media. Finally, the study relied on existing technological infrastructure in the school, which might not be universally available in all Indonesian elementary schools, especially in remote areas. This infrastructural dependency highlights a practical constraint for widespread implementation without adequate support.

CONCLUSION

Augmented reality-based learning media using the Assemblr Edu application has proven to be valid, practical, and effective in increasing the motivation and learning outcomes of sixth-grade students at SDN 218/IV Kota Jambi, particularly in the topic of the solar system. The novelty of this study lies in the development of AR media that is directly integrated with the elementary school curriculum and tailored to the characteristics of students in the concrete operational stage, which is still rarely done at the primary education level. The implications of these findings indicate that the integration of visual-interactive technologies such as AR not only strengthens the understanding of abstract concepts but also fosters intrinsic motivation and enjoyable learning experiences, making it highly relevant for 21st-century learning. Therefore, it is recommended that teachers and schools begin to adopt and develop contextual AR-based learning media and organize training programs to enhance teachers' competencies in designing and utilizing innovative learning technologies to support digital education transformation at the primary level. Furthermore, future research is recommended to explore the development and application of Assemblr Edu for a wider range of science topics and other subjects, along with conducting longitudinal studies to assess the long-term impact on student motivation and knowledge retention. Such efforts would provide a more comprehensive understanding of the media's versatility and sustained effectiveness across diverse educational contexts.

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