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Development of Augmented Reality-Based Learning Media in Science Learning on Plant Body Parts Material for Grade IV of Lasoani State Elementary School

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A B S T R A C T

This research aims to develop Augmented Reality (AR)-based learning media for the IPAS subject, focusing on the Plant Body Parts material for fourth-grade students at Lasoani State Elementary School. The background highlights the challenges students face in understanding abstract concepts like plant anatomy using conventional 2D media within the Merdeka Curriculum framework. To address this, the study employed a Research and Development (R&D) approach with the ADDIE model, covering the phases of analysis, design, development, implementation, and evaluation. Data were collected through interviews, observations, expert validations, and user response questionnaires. The developed AR media was validated by media and material experts, achieving high feasibility scores of 86.66% and 83.15%, respectively. Student responses indicated an attractiveness score of 85.60%, while teacher responses showed a practicality score of 94%, both categorized as very valid. These results demonstrate that the AR-based media effectively transforms abstract content into interactive visualizations, increases student engagement, and supports meaningful learning. In conclusion, the developed AR learning media is a valid and practical innovation that can enhance students' understanding of plant body parts and has the potential for broader application in other abstract topics within the IPAS subject.

1. Introduction

The landscape of education in Indonesia has been undergoing a substantial transformation with the implementation of the Merdeka Curriculum, which seeks to shift learning from rote memorization to a more holistic and integrated approach. One significant change is the integration of subjects that were previously taught separately, resulting in the formation of IPAS, a unified subject combining natural sciences (IPA) and social sciences (IPS). This pedagogical shift aims to help students connect scientific and social phenomena, develop critical thinking, and

apply knowledge in real life. However, while the Merdeka Curriculum introduces numerous benefits, it also presents new challenges for both teachers and students. Many fundamental concepts in IPAS, especially those rooted in natural sciences, remain abstract and difficult for students to grasp. This abstractness often results in students struggling to visualize processes and structures, leading to disengagement and superficial understanding (Alfatonah et al., 2023).

One example of such challenging material is plant body parts and their functions, taught to fourth-grade students in the first semester. This foundational topic includes roots, stems, leaves, flowers, and fruits, all of which play vital roles in plant survival and reproduction (Andi & Rismayanti, 2021). Understanding these parts helps students appreciate plants' significance in ecosystems and daily life while fostering their observational skills. Ideally, students should be able to relate these concepts to tangible examples in their surroundings. Yet, in reality, internal plant processes and microscopic structures are not easily observed directly, making it harder for students to develop a comprehensive understanding. Textbooks and static 2D diagrams have long been used to explain such topics, but they often fail to convey the depth and dynamics needed for students to fully comprehend them. As a result, students may memorize the names and functions of plant parts without truly visualizing how they work, which undermines the Merdeka Curriculum's goal of promoting meaningful and student-centered learning.

Addressing this challenge requires educators to adopt more engaging and innovative learning resources that help bridge the gap between abstract theory and concrete understanding. Learning media is a tool that teachers can use to deliver material more effectively and create a stimulating classroom environment. According to Kusmaini (2017), various learning media, from physical models to digital tools, are instrumental in enhancing student interest and helping them grasp complex ideas. Asmayanti et al. (2023) emphasizes that media should not only present information but also actively involve students in the learning process, making abstract material more accessible. In line with these recommendations, the integration of modern technology in learning media has become increasingly relevant. One promising technological tool is AR, which overlays virtual 3D objects onto the real world, enabling students to interact with and manipulate these objects in real time (Widyawati & Sukadari, 2023).

AR technology offers unique advantages for visualizing abstract scientific concepts, particularly for topics like plant anatomy. By presenting three-dimensional models that students can rotate, enlarge, and examine from different angles, AR can help students develop a more accurate mental image of plant structures (Irawan & Yatri., 2022). Unlike static textbook images, AR provides an immersive learning experience, turning students from passive recipients of information into active explorers. Such interactive visualizations have the potential to deepen understanding, increase retention, and stimulate curiosity, which aligns with the Merdeka Curriculum's emphasis on fostering creativity and problem-solving skills.

Fitriani et al. (2020) despite its potential, the use of innovative media such as AR in Indonesian classrooms remains limited. Observations and interviews conducted with teachers and students at Lasoani State Elementary School reveal that IPAS lessons still rely heavily on conventional methods, with textbooks and chalkboard explanations dominating instruction. Teachers frequently instruct students to read and memorize from books, supported by static 2D images that do not adequately illustrate the complexities of plant body parts. This approach often leaves students disinterested and less motivated to engage with the material. Similar findings were reported Pradana (2020), who noted that many schools continue to apply traditional teacher-centered learning with minimal use of technology. Further highlighted that the lack of interactive and realistic teaching aids contributes to students' struggles in understanding plant structures. Waruwu (2024) also found that providing real-life examples of all plant parts is not always feasible, making abstract material even more challenging to convey effectively.

Recognizing these gaps, it becomes clear that there is a pressing need for more effective, interactive, and technology-based learning media to support the teaching of abstract IPAS concepts. One practical solution is to develop AR-based learning media tailored to the topic of plant body parts. Assemblr EDU, a dedicated AR platform, offers accessible tools for educators to create and present interactive 3D models. This platform allows teachers to design content without extensive programming skills and supports a variety of media formats, including animations and audio, which can enrich the learning experience. Students can scan barcodes or markers with their devices to access 3D plant models, view them in real time within their environment, and interact with each structure by rotating, zooming, or moving the models. This interactive process not only clarifies how each plant part functions but also makes the learning experience more enjoyable and memorable. Assemblr EDU's collaborative features further enable teachers and students to work together in a virtual space, fostering an engaging and student-centered learning atmosphere.

By leveraging AR technology, educators can overcome the limitations of traditional teaching aids and create a learning environment that aligns with the goals of the Merdeka Curriculum. Students gain opportunities to observe and explore plant anatomy in detail, bridging the gap between abstract concepts and concrete understanding. The use of AR can also motivate students to participate more actively in the learning process, enhancing both comprehension and retention. Moreover, the platform's flexibility allows content to be used online and offline, ensuring accessibility even in schools with limited internet connectivity, provided initial setup and downloads are completed beforehand.

In conclusion, the persistent difficulties faced by students in grasping abstract concepts within IPAS, especially in understanding plant body parts, highlight the necessity of adopting innovative, technology-enhanced learning media. The development of AR-based learning media through Assemblr EDU represents a promising step toward addressing this challenge. By providing immersive and interactive experiences, AR can transform passive learning into an active exploration, making abstract material more tangible and comprehensible. The purpose of this research is to develop AR-based learning media in IPAS for Plant

Body Parts material to help teachers deliver effective instruction and improve students' understanding of abstract concepts. The results are expected to contribute valuable insights and practical resources for educators, helping them realize the Merdeka Curriculum's vision of fostering student-centered, meaningful, and future-ready learning.

2. Methodology

This research adopts a Research and Development (R&D) approach, which is a systematic method used to develop and validate a new product or improve an existing one (Sari & Ratu, 2021). The main goal is to develop an AR-based learning media for the IPAS subject, focusing on the Plant Body Parts material for fourth-grade students. This method is appropriate because it enables the creation of an innovative educational product to solve specific learning problems. As Waruwu (2024) states, development research addresses research questions through the design, testing, and refinement of products or models. Products are created based on a needs analysis and undergo validation and evaluation to ensure effectiveness. In this study, the R&D method supports the systematic design, development, and initial assessment of AR-based learning media to enhance student understanding and engagement.

The development procedure follows the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Andi Rustandi & Rismayanti, 2021). Due to time constraints, this research focused up to the Development stage.

Research Design and Procedure

The research design is structured around the ADDIE model, ensuring a systematic and iterative development process. Each phase is detailed as follows:

Analysis Phase
This first phase involved identifying the main problems teachers and students face when learning the Plant Body Parts material in fourth-grade IPAS. The analysis included:

1) Performance Analysis: Conducted through structured interviews with the IPAS teacher and eight fourth-grade students to identify challenges in understanding abstract concepts.
2) Needs Analysis: A literature review and field observations were used to identify limitations of conventional media like textbooks and static images and to assess AR's potential to help visualize plant structures.
3) Curriculum Analysis: The Merdeka Curriculum was reviewed to ensure the developed AR media aligns with the content and competency standard (KD 3.2) for fourth-grade IPAS.

Design Phase
This phase focused on planning the AR-based learning media:

1) Media Interface Design: Visual aspects such as colors, clear fonts, and simple animations were designed to be suitable for elementary students.
2) Content Structuring: The material was organized logically according to KD 3.2, covering definitions and functions of each plant part. Interactive features like numbered buttons on 3D models were added to display relevant information.

Development Phase

This phase involved developing the AR-based learning media and validating it:

1) Media Realization: The 3D AR models and interactive content were created using the Assemblr EDU platform, including instructions and an About section.
2) Expert Validation: Material and media experts from FKIP Tadulako University validated technical aspects and content accuracy.
3) User Validation: The IPAS teacher evaluated the media's relevance, alignment with the curriculum, and ease of use, and suggestions were used for improvements.

Implementation Phase

A small-scale trial was conducted with 22 fourth-grade students at Lasoani State Elementary School from June 19 to June 28, 2025. The purpose was to test the media's usability, clarity, and attractiveness. Questionnaires were given to both students and the teacher to gather feedback.

Evaluation Phase

A full evaluation stage was not completed due to time limitations. However, expert validation and trial feedback provided important data for assessing the product's feasibility and practicality, supporting necessary revisions.

Subjects, Time, and Location of Research

The subjects were 22 fourth-grade students at Lasoani State Elementary School, Palu City, Central Sulawesi. The research was conducted during the odd semester of the 2024/2025 academic year.

Instruments and Data Analysis Techniques

Instruments used included structured interviews, observations, validation sheets, and response questionnaires. Data were analyzed using descriptive quantitative and qualitative methods to determine the validity and practicality of the AR-based learning media.

3. Results and Discussion

This section presents the findings derived from the systematic development and initial implementation of the AR-based learning media for IPAS on plant body parts. The results are structured according to the ADDIE model phases, while the discussion explains the significance of the findings, focusing on the why and how aspects as well as the practical implications.

Results of Development

Analysis Phase Outcomes

The initial analysis phase revealed significant obstacles in teaching abstract IPAS concepts with conventional media. Interviews with the teacher and students at Lasoani state elementary school confirmed that the use of textbooks and static images often led to disengagement and poor comprehension. Field observations and literature reviews reinforced the need for innovative, technology-supported learning tools.

Design Phase Outcomes

Based on the needs analysis, the media was designed using Assemblr EDU to deliver interactive 3D content. The design included a clear home page, interactive 3D plant models, and concise explanatory text suitable for fourth-grade students.

Development Phase Outcome

a. Media Realization: The AR-based learning media contains four main features:

1. Home Page with clear instructions,
2. Content Page with interactive 3D plant models,
3. Pop-up Material Displays,
4. About Media section.

The media displays are presented, as shown in Figures 1, 2, 3, and 4 below:

Figure 1. Home Page of the AR Learning Media

Figure 2. Illustrates the interactive content page displaying the 3D plant model, where numbered buttons direct students to detailed information

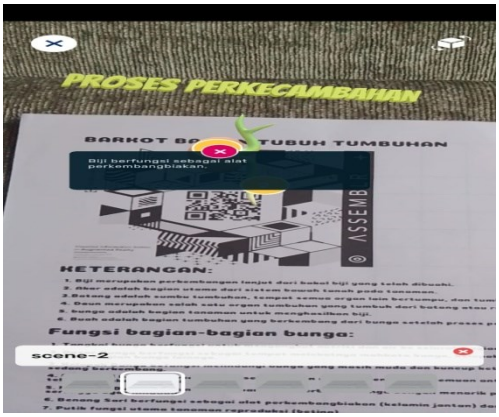

Figure 3 presents an example of the pop-up material display that appears when students tap on a specific plant part

Figure 4. About Media Section

b. Expert Validation

The media was validated by media and material experts to assess feasibility. Table 1 shows the results of the media expert validation, including the scores for each indicator, percentage, and category:

Table 1. Media Expert Validation Results

No	Indicator	Score	Percentage	Criteria
1	Media Design	25	83.33%	Very Valid
2	Layout	13	86.66%	Very Valid
3	Attractiveness	9	90%	Very Valid
4	Programming	18	90%	Very Valid
Total		**65**	**86.66%**	**Very Valid**

Table 2 presents the material expert validation results, highlighting aspects such as accuracy, language, and relevance:

Table 2. Material Expert Validation Results

No	Indicator	Score	Percentage	Criteria
1	Material Accuracy	25	83.33%	Very Valid
2	Currency	12	80%	Valid
3	Language use	12	80%	Valid
4	Language Rules	8	80%	Valid
5	Conciseness	8	80%	Valid
6	AR Media Use	14	93.33%	Very Valid
Total		**79**	**83.15%**	**Very Valid**

The high percentage scores confirm the media's technical feasibility and pedagogical accuracy.

c. User Validation (Teacher)

A user validation was conducted by the IPAS teacher at Lasoani state elementary school. Table 3 summarizes the teacher's user validation results, indicating the practical feasibility of the AR media:

Table 3. User Validation Results (Teacher)

No	Aspect	Score	Percentage	Criteria
1	Learning	10	100%	Very Valid
2	Curriculum	13	86.66%	Very Valid
3	Content	18	90%	Very Valid
4	Language Use	18	90%	Very Valid
5	Screen Display	9	90%	Very Valid
6	Design	12	80%	Valid
7	Implementation	9	90%	Very Valid
Total		**89**	**89%**	**Very Valid**

d. Implementation Phase Outcomes (Small-Scale Trial)

A small-scale trial was conducted with 22 students. Table 4 shows the student response results during the small-scale trial, covering content, design, and usability aspects:

Table 4. Small-Scale Trial Results (Student Response)

No	Aspect	Score	Percentage	Criteria
1	Content	563	85.30%	Very Valid
2	Media Design	376	85.45%	Very Valid
3	Usage	756	85.90%	Very Valid
Average		**1695**	**85.60%**	**Very Valid**

Discussion

The results demonstrate that the AR-based learning media is highly feasible, valid, and engaging for fourth-grade students. Validation by media and material experts confirmed the media's technical soundness and pedagogical relevance. The consistently high ratings underscore the media's alignment with the Merdeka Curriculum's objectives of fostering critical thinking and student-centered learning. The teacher's user validation further highlights the practicality of using AR technology in the classroom, while the positive student responses validate the media's ability to make abstract concepts more concrete and interesting. The improvements made during the revision phase also show that iterative refinement based on feedback is crucial for developing effective educational media.

The developed AR-based learning media offers significant advantages in supporting students to understand abstract IPAS concepts, such as plant anatomy. Through interactive 3D visualization, students can manipulate and observe each plant part from various angles, helping them build a concrete mental image. This is in line with Pasande et al. (2025), who stated that teknologi AR mampu menghadirkan objek tiga dimensi secara interaktif dan real-time di lingkungan nyata siswa, sehingga lebih menarik dan memberikan pengalaman belajar yang imersif serta mendalam yang sulit dicapai melalui metode konvensional. This immersive aspect helps bridge the gap between abstract theory and concrete understanding, which conventional 2D media cannot easily achieve.

Moreover, Amalia (2021) emphasized that media pembelajaran berbasis AR dapat menciptakan suasana belajar yang lebih dinamis dan menyenangkan, sehingga siswa lebih termotivasi untuk belajar dan menjelajahi materi dengan lebih mendalam. This shows that AR-based media can foster a more dynamic and enjoyable learning atmosphere, encouraging students to engage more deeply with the material. Furthermore, this innovation aligns with the transition from K13 to the Merdeka Curriculum, which requires creative learning media to help students visualize abstract topics and make learning more meaningful (Kusumaningpuri, 2024). This flexibility allows teachers to replicate and adapt AR media for other IPAS topics with minimal technical barriers, fostering technology integration in schools and increasing students' motivation and engagement.

In addition, the interactive features of AR not only help students visualize abstract biological structures but also encourage higher-order thinking skills by prompting students to explore, manipulate, and analyze 3D models in real-time. This active learning aligns with Bloom's Taxonomy, where students move beyond remembering facts to applying and analyzing knowledge critically. The success of this media indicates its broader potential for replication in other topics within IPAS or similar abstract subjects. By leveraging an accessible platform like Assemblr EDU, teachers can develop their own AR-based resources with minimal technical barriers, promoting a culture of innovation and collaboration among educators. This can significantly enhance learning outcomes, especially in schools with limited physical learning aids.

4. Conclusion

Based on the comprehensive research conducted, it can be concluded that the development of AR-based learning media has a significant positive impact on the learning experience of fourth-grade students. This innovative media successfully transforms abstract concepts, particularly in the IPAS subject on plant body parts, into concrete and interactive visual representations. The media's high validity, as confirmed by expert evaluations, underscores its robust design and accurate content, ensuring its suitability for educational purposes. Furthermore, the overwhelmingly positive responses from both students and teachers affirm the media's attractiveness and practicality in a classroom setting. Students demonstrated heightened enthusiasm and engagement, leading to improved comprehension and a more dynamic learning environment compared to conventional methods. Teachers also found the media to be a valuable and effective tool, aligning well with pedagogical objectives and facilitating the delivery of complex material. This research successfully developed a viable and engaging AR-based learning media, demonstrating its potential to enhance student motivation and understanding. Future work could explore the long-term impact of this media on student retention and academic performance, as well as its applicability across a wider range of subjects and grade levels, potentially integrating more advanced interactive features or personalized learning paths.

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