

Development of Assemblr Edu-Assisted Augmented Reality Learning Media on Ecosystem Material for Fifth Grade Elementary Students

Lutfiah Azizah ^{1*}, Zaka Hadikusuma Ramadan ¹

¹ Universitas Islam Riau, Pekanbaru, Indonesia

lutfiahazizah@student.uir.ac.id, zakahadikusuma@edu.uir.ac.id

corresponding author: lutfiahazizah@student.uir.ac.id

ABSTRACT

The present study discusses the limited use of technology-based learning media in Natural and Social Sciences (IPAS) instruction at SDN 17 Pekanbaru, where the abstract concept of ecosystems was difficult for fifth-grade students to understand through conventional methods. This research aims to develop and assess the validity and user responses to augmented reality (AR) learning media supported by Assemblr Edu within the materials ecosystem for fifth-grade students. The study employs a research and development (R&D) approach using the ADDIE model, focusing on the Analysis, Design, and Development stages. Data were collected through interviews and questionnaires and analyzed using a percentage formula based on a five-point Likert scale. Validation involves media, material, and language experts, while practicality is assessed through teacher and student responses ($n = 7$). The results reveal that the media obtained average validity scores of 93.75% (media), 91.76% (material), and 89.44% (language), all in the very valid category, with an overall validity of 91.65%. The teacher response reached 85.33% (very practical), and the average student response reached 83.67% (very interesting). These findings indicate that the developed AR media is valid and practical for supporting ecosystem learning in elementary school and can serve as an alternative technology-based medium for teachers. The novelty of this study lies in developing Assemblr Edu-assisted AR specifically for ecosystem (food-chain) material at the fifth-grade level, an emphasis rarely addressed in prior AR studies that mostly targeted other science topics or focused only on motivation; the study thus contributes a validated, ready-to-use AR medium as a reference for developing technology-based science learning.

Keywords: *augmented reality, educational technology, fifth-grade elementary students, learning media, science education*

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INTRODUCTION

Education holds a vital place in human life because it enables a person to acquire knowledge, experience, and skills that are useful in daily life. In the classroom, students are expected not merely to listen to the teacher's explanation but also to recognize their surroundings and actively participate throughout the learning process. Hence, learning activities need to be designed to be more engaging so that students do not become bored quickly and remain enthusiastic about the lesson. Moreover, the rapid advancement of technology has had a major influence on education, requiring teachers to design creative learning experiences by selecting appropriate methods and media to avoid a monotonous learning environment (Zhao et al., 2023).

Engaging learning media can encourage students to be more focused, more active, and better able to understand the material. One subject that requires such media is Natural and Social Sciences (IPAS). This subject is not confined to a single discipline but integrates several interrelated fields. From the elementary level, students are introduced to IPAS to understand their environment and various natural phenomena (Parisu & Sisi, 2025). The goal of IPAS learning is not to memorize material but to involve students actively in learning, such as exploring and discovering concepts, testing them, and drawing conclusions based on the findings (Parisu & Sisi, 2025). In this regard, the teacher plays a central role, not only delivering material but also aligning the teaching approach with students' abilities and characteristics.

The use of learning media plays a major role in improving learning outcomes and fostering students' motivation, because media can support and enrich understanding throughout the learning process (Dayanti et al., 2023). Media can take various forms, ranging from images, videos, and audio to other visual displays.

However, observations and interviews conducted at SD Negeri 17 Pekanbaru on 12 December 2025 with the homeroom teacher of class V A reveal several problems. According to the teacher, students' understanding of ecosystem material in IPAS learning remains low. In teaching IPAS, the teacher generally uses only limited media, such as YouTube videos or simple self-made media. Even so, the available media still have numerous shortcomings and have not enabled all students to understand the material thoroughly, while students' reactions also vary; some are enthusiastic, while others are less interested and quickly lose concentration.

This situation reveals a gap between the learning that takes place in the field and the ideal conditions that should be achieved. Ideally, science instruction in elementary school uses interactive, engaging technology and adapts to students' learning styles. In reality, however, the media are still simple and lack variety, leading to a decline in learning motivation, easy boredom, and uneven understanding of the material. The entry of digital technology has brought significant changes to science learning, including teaching methods, the material delivered, and supporting facilities (Al-Ansi et al., 2023); therefore, the accuracy of selecting and using media is a key to an effective learning process.

To address this problem, more engaging, interactive, and technology-based learning media are needed, and one promising alternative is augmented reality (AR) media. AR is a technology that combines real and virtual objects in the real environment, allowing direct interaction (Arena, Collotta, Pau, & Termine, 2022). With this technology, users can see a blend of the real and digital worlds simultaneously on certain devices, resulting in a more engaging and easier-to-understand display. AR holds great potential for application in education to create a learning experience that is more engaging, interactive, and feels real for students (Kamińska et al., 2023; Verdiatmoko & Pinandita, 2025). With this medium, students can view material in three dimensions, making it appear more authentic and easier to understand, which is highly suitable for elementary students who still require visual aids to grasp abstract concepts (Syawaludin et al., 2019).

One application for developing AR-based media is Assemblr Edu. This application is used to create three-dimensional (3D) and AR-based media with an interactive display. With the various features and objects provided, Assemblr Edu can be used by both teachers and students to produce media that are more engaging, creative, and easy to operate, and the media can be accessed via tablets or smartphones to display 3D objects (Nengsih et al., 2023). Several previous studies have shown that Assemblr Edu use has a positive impact on student learning. Rahmawati, Noperman, & Kurniawati (2024) reported that this application influenced the improvement of science learning outcomes among fifth-grade students, while Jahi, Irfan, Rahman, & Hermuttaqien (2024) found that AR assisted by Assemblr Edu was able to improve science learning outcomes with an average percentage of 84.64%, which falls into the high category.

Nevertheless, studies specifically examining the application of Assemblr Edu-assisted AR in fifth-grade IPAS learning on ecosystem materials remain limited. Existing studies tend to focus on media development in general or on learning motivation, and few have addressed the context of SD Negeri 17 Pekanbaru, with its distinctive student characteristics and learning conditions. Building on this gap, this study focuses on developing Assemblr Edu-assisted AR learning media for ecosystem materials, designed for fifth-grade students. Accordingly, this study aims to describe the media development process, determine its validity through expert assessment, and measure user responses (teachers and students) to the developed media as an indicator of its practicality. This focus sets the present study apart from earlier work in a specific way. Previous research on Assemblr Edu-assisted AR has largely been directed at general science achievement (Jahi et al., 2024; Rahmawati et al., 2024) or at other topics such as spatial geometry and the solar system (Verdiatmoko and Pinandita, 2025), while the studies did take up ecosystems either stopped at the needs-analysis stage (Qorimah et al., 2022) or are built on a different platform (Nengsih et al., 2023). International reviews and meta-analyses report consistently positive effects of AR on science learning and motivation, but they also stress that the size of these effects varies with topic, instructional design, and grade level; a medium still has to be developed for the context in which it will be used as such (Faria & Miranda, 2024; Ibáñez & Delgado-Kloos, 2018; Law & Heintz, 2021). What this study contributes, therefore, is an AR medium for fifth-grade ecosystem learning, developed for a specific classroom and tested for both validity and practicality.

LITERATURE REVIEW

Learning Media

Learning media are essentially tools for conveying messages and organizing learning resources, enabling learning to take place more effectively and efficiently. Well-designed visual media, such as images, videos, animations, and attractive color compositions, can make learning more lively and help students understand the material more easily, because the teacher's delivery no longer relies solely on verbal explanation (Yunita et al., 2022). At the elementary level, media that present concepts concretely become increasingly crucial, considering that students at this age generally still think at the concrete operational stage. The decisive factor, however, is not the technology but the way it is designed. Digital and interactive media raise engagement and deepen conceptual understanding when their features are matched to the learning task rather than added for novelty (Al-Ansi et al., 2023; Algerafi et al., 2023; Lampropoulos & Evangelidis, 2025). Immersive-learning theory explains why: a sense of presence and the opportunity to act on the material reduce extraneous cognitive load, leaving more working memory for generative processing (Makransky & Petersen, 2021), the indistinguishable mechanism that underlies the motivational gains observed when media incorporate game-based elements (Lampropoulos et al., 2022). Studies in Indonesian elementary schools point in the same direction, reporting improved science learning outcomes with interactive, technology-based media (Dayanti et al., 2023; Maharani et al., 2023), while also revealing that classroom use remains uneven because teachers differ in device access and in their readiness to operate such media (Nursidiq & Batubara, 2022; Panjaitan, 2017).

Augmented Reality

Augmented reality is a technology that displays digital objects, whether two- or three-dimensional, into the real environment and presents them directly; hence, users can see and interact with these objects through devices such as smartphones, tablets, or special AR glasses (Arena et al., 2022; Kamińska et al., 2023). In education, AR is regarded as capable of helping students understand abstract concepts that are difficult to explain through conventional methods, and several previous studies indicate that AR can improve students' cognitive learning outcomes (Syawaludin et al., 2019; Omurtak & Zeybek, 2022). The size of this benefit, however, is not uniform. Meta-analytic and systematic reviews converge on positive effects for achievement, motivation, and the grasp of abstract concepts, yet reveal that these effects widen or narrow according to instructional design, the structure of the task, and the length of the intervention (Faria & Miranda, 2024; Syskowski & Wilfinger, 2024; Zhang et al., 2024). They are most consistent in biology, where much of the content is spatial and process-based (Stanic & Špernjak, 2025), a pattern also evident in classroom studies of primary science achievement (Zhao et al., 2023), of inquiry-based science learning (Wen et al., 2023), and of biology achievement and motivation (Chuang et al., 2023), as well as in work reporting that mobile AR strengthens learners' self-efficacy alongside their motivation (Aldeeb et al., 2024). Running through this literature is a practical qualification: the benefits materialize only when the application is easy to use, and its instructions are clear enough for learners to work independently (Ibáñez & Delgado-Kloos, 2018; Law & Heintz, 2021).

Assemblr Edu

Assemblr Edu is a 3D and AR-based platform that lets users create more interactive, dynamic learning content, accessible via a web link or an application. Several studies report that learning assisted by Assemblr Edu can improve students' learning outcomes and support more varied technology-based learning (Jahi et al., 2024; Rahmawati et al., 2024). These findings provide a theoretical and empirical basis for developing Assemblr Edu-assisted AR media for ecosystem materials in elementary schools. This accessibility makes the platform well-suited for elementary science: teachers can create 3D content without programming expertise, and students can access it on an ordinary smartphone. Studies in IPAS and related subjects report that AR content built in this way supports comprehension while sustaining students' motivation and engagement

(Fauziyyah, 2019; Hamisah et al., 2022; Nengsih et al., 2023), which is consistent with the wider shift towards digital platforms as learning innovations in the upper primary grades, where attention and interest are strongly shaped by how material is presented (Asmar et al., 2019; Purnamaningsih, 2022; Sinaga et al., 2022).

Read together, these strands of evidence leave one gap unaddressed. The available studies concentrate on anatomy, physics, the solar system, and biology in general, whereas the ecosystem and food-chain topic at the elementary level has received comparatively little attention; the studies that do address it either stop at the needs-analysis stage (Qorimah et al., 2022) or build the media on a different platform (Nengsih et al., 2023). Since the effects of AR have repeatedly been shown to depend on topic, instructional design, and grade level (Faria & Miranda, 2024; Law & Heintz, 2021), a medium developed for one setting cannot simply be transferred to another; it has to be built and validated for the context in which it will be used. The present study responds to that requirement by developing and validating Assemblr Edu-assisted AR media for fifth-grade ecosystem learning at SD Negeri 17 Pekanbaru.

METHODS

The present study employs a research and development (R&D) approach, specifically a systematic, directionally designed method for producing products or practical solutions through tested and accountable stages (Waruwu, 2024). The development model was ADDIE, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected for its flexibility, ease of adaptation to field conditions, and the room it provides for evaluation and improvement at each development stage (Branch, 2009). In this study, the development process was limited to the first three stages (Analysis, Design, and Development) because the focus was on producing a valid and practical product rather than measuring its effectiveness on learning outcomes. Limiting the ADDIE model to the Analysis, Design, and Development stages is a common and defensible strategy in development research when the aim is to produce a product that is proven valid and practical rather than to test its effectiveness on learning outcomes, because the Implementation and Evaluation stages require a larger sample and an experimental design that lie beyond the scope of this study (Branch, 2009; Waruwu, 2024). Consequently, the media's effectiveness on learning outcomes was not measured, which constitutes a limitation of this study that is revisited in the discussion and conclusion.

The study was conducted at SD Negeri 17 Pekanbaru, located on Pasir Putih street No. 10, Simpang Tiga, Bukit Raya District, Pekanbaru, with fifth-grade students as the context. In the analysis stage, the researcher examines the curriculum (the Merdeka Curriculum used in class V), the teacher's condition, and the students' characteristics through observation and interviews with the fifth-grade homeroom teacher. In the design stage, the researcher arranges the material according to the learning objectives and designs the media display (including the interface, color selection, text, and presentation flow) along with three-dimensional objects relevant to the ecosystem material. In addition, during the development stage, the design is realized as an AR product using Assemblr Edu, which can be accessed by scanning a barcode/QR code; the product is subsequently validated by experts and tested to gather user responses.

The research subjects include validators and users. The validators consist of three lecturers serving as media, material, and language experts, accompanied by a practitioner teacher, while the users comprise the fifth-grade teacher and seven fifth-grade students. Data were collected through interviews and questionnaires. Interviews are used to gather in-depth information about learning needs during the analysis stage, while questionnaires are used to assess the validity of the media (by experts) and its practicality (through teacher and student responses). Each questionnaire item is scored on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Each instrument is developed based on a number of aspects and their indicators. The blueprints for the validation instruments (media, materials, and language) are presented in Table 1, and those for the user response instruments (teachers and students) are presented in Table 2.

Table 1. Blueprint of the Validation Instruments

Instruments	Aspects	Indicators
Media Validation	Media display	Visual design, color suitability, and text readability
	AR media quality	Clarity of 3D objects, suitability of objects to the material, and interactivity
	Ease of use	Ease of access, ease of navigation, clarity of usage instructions
	Technical quality	Application stability, responsiveness, compatibility
	Suitability for learning	Suitability with learning objectives, support for comprehension
Material Validation	Media practicality	Efficiency of use, ease of integration
	Suitability with the Merdeka Curriculum	Suitability with learning outcomes (CP/TP) and learning objectives
	Material correctness	Conceptual accuracy, factual accuracy
	Material completeness	Material coverage, material depth
	Suitability with student characteristics	Difficulty level, language clarity
	Material presentation	Systematic presentation, material coherence
Language Validation	Linkage with AR media	Suitability of material with AR visuals, clarity of information in AR
	Material usefulness	Improving comprehension, attracting learning interest
	Language suitability	Suitability with students' developmental level, language simplicity
	Language clarity	Clarity of information, ease of understanding
	Linguistic accuracy	Spelling usage, sentence structure
	Readability	Text size and shape, term consistency
	Language attractiveness	Language style, appeal of delivery
	Suitability with AR media	Synchronization of text with visuals, clarity of instructions

Source: Adapted from Akbar (2013)

Table 2. Blueprint of the User Response Instruments

Instruments	Aspects	Indicators
Teacher Response	Learning suitability	Suitability with objectives, suitability with the curriculum
	Media quality	Attractive display, object clarity
	Ease of use	Ease of use, clarity of instructions
	Learning effectiveness	Supporting comprehension, increasing learning interest
	Practicality	Time efficiency, ease of integration
Student Response	Media attractiveness	Attractive display, not boring
	Ease of use	Easy to use, clear instructions
	Material comprehension	Supporting learning, easing learning
	Interactivity	Student engagement, learning experience
	Learning motivation	Learning enthusiasm, curiosity

Source: Adapted from Akbar (2013)

The collected data were analyzed using both qualitative and quantitative techniques. The qualitative data, in the form of validators' comments and suggestions, are examined descriptively and used to inform revisions to the product. Meanwhile, the quantitative data, in the form of scores from validators and users, were calculated using the following percentage formula, where P is the percentage score, Σx is the total score obtained, and n is the maximum score (Fernando & Sarkity, 2022).

$$P = (\Sigma x / n) \times 100\%$$

The resulting percentages are subsequently converted into categories. Media validity is evaluated against the criteria in Table 3, while practicality, based on teacher and student responses, is evaluated against the criteria in Table 4. A medium is considered fit for use if it reached at least the valid category for validity and the good criterion for response.

Table 3. Media Validity Criteria

Percentages (%)	Categories
81% – 100%	Very Valid
61% – 80%	Valid
41% – 60%	Fairly Valid
21% – 40%	Invalid
0% – 20%	Very Invalid

Source: Hidayatullah & Aripin (2026)

Table 4. User Response Questionnaire Criteria

Percentage (%)	Criterion
80% – 100%	Very Good
70% – 79%	Good
60% – 69%	Fair
50% – 59%	Poor
0% – 49%	Very Poor

Source: A'yun & Murtini (2025)

RESULTS AND DISCUSSION

This study produced Assemblr Edu-assisted augmented reality (AR) learning media on ecosystem material for fifth-grade students of SD Negeri 17 Pekanbaru. The product was developed through the three stages of the ADDIE model (Analysis, Design, and Development) and subsequently evaluated for validity and practicality. In summary, the recapitulation of the validity and user response percentages for the developed media is presented in Figure 1, while the outcomes of each stage are described afterward.

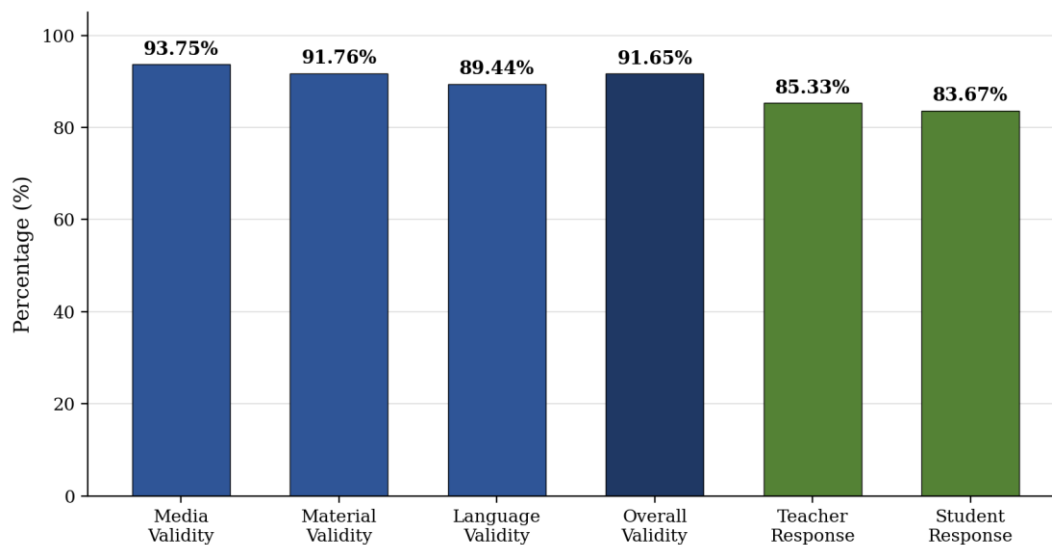


Figure 1. The Percentage Recapitulation of Validity and User Response Results

In the analysis stage, three aspects were examined: the curriculum, the teacher, and the students. The curriculum analysis reveals that class V at SD Negeri 17 Pekanbaru implemented the Merdeka Curriculum; hence, the media development had to align with its learning outcomes. The teacher analysis, conducted through an interview with the homeroom teacher of class V A, demonstrates that students still found it difficult to understand ecosystem material, partly due to low concentration during learning and the limited media used, such as pictures, YouTube videos, and PowerPoint presentations. Meanwhile, the student analysis reveals a need for more interactive and visual media to support the understanding of abstract concepts. These findings underscore the significance of developing technology-based media that can present ecosystem concepts more concretely.

In the design stage, based on the identified problems, the researcher selected AR media via the Assemblr Edu application as an appropriate solution to improve students' understanding of abstract material.

The researcher, furthermore, organized the ecosystem material with an emphasis on the food chain and the relationships among living things, while designing the media display (including the interface, color selection, text, and presentation flow) to make it easy for students to follow. The components prepared at this stage consisted of three-dimensional (3D) objects, animations, images, and text that appear when a barcode or QR code is scanned. When the code is scanned, the 3D object appears on the screen and can be manipulated (e.g., rotated or enlarged); thus, direct interaction is possible, and learning becomes more engaging.

In the development stage, the design was realized as an actual product. The researcher built the AR media in Assemblr Edu, using a barcode as the access point. This began with determining the material based on the learning objectives, followed by arranging the display and creating relevant 3D objects to help visualize abstract concepts. All these components were thereafter integrated into a single complete medium that can be accessed by scanning a barcode using a smartphone or tablet. The product of this stage is an initial prototype that was subsequently validated by experts to assess its feasibility before being used by students, and was revised based on the validators' suggestions.

The final product is AR learning media for ecosystem material, particularly the food chain and the relationships among living things, which displays three-dimensional objects that can be manipulated when the barcode is scanned. Through this medium, students can observe ecosystem components and the flow of the food chain from various angles, rather than merely imagining them from book illustrations. The decision to present the material in three-dimensional form was based on the idea that three-dimensional media have a concrete form that could be observed from all sides, allowing students to witness a process directly and understand it more easily (Nengsih et al., 2023). Thus, this medium is designed not to replace the teacher's role but to enrich the teacher's explanation and provide a more concrete representation of abstract concepts. To provide visual documentation of the developed product, the AR media display and an example of its use during learning are shown in Figures 2 and 3, respectively.

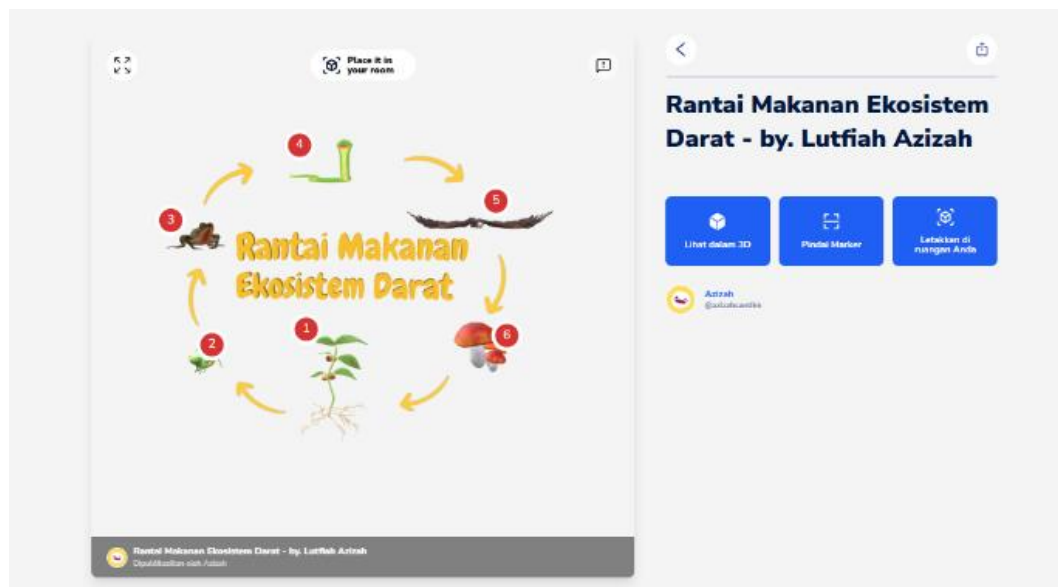


Figure 2. Display of the Assemblr Edu-Assisted AR Media on Ecosystem Material

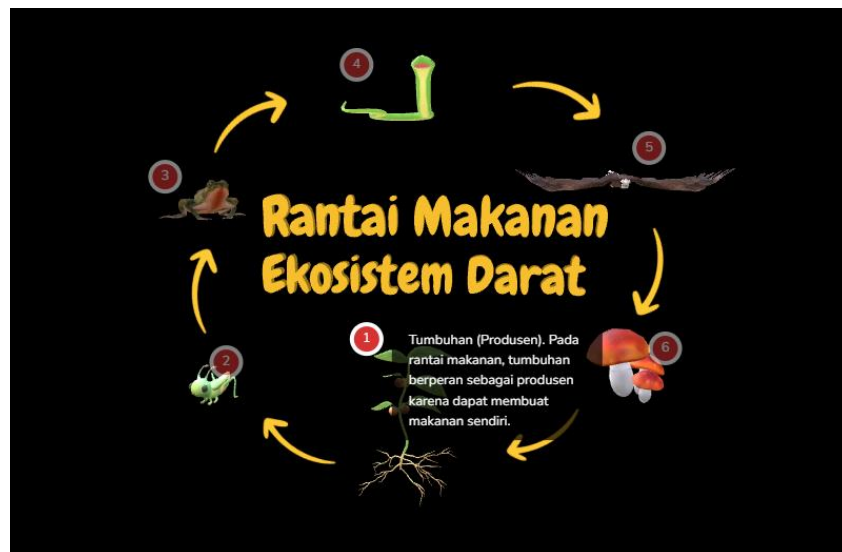


Figure 3. Example of the AR Media During the Learning Process

After the media were developed, a validity test was conducted using expert judgment, involving media, material, and language experts, with each aspect assessed by one expert lecturer and one practitioner teacher. This validation aims to assess the product's feasibility before it is applied in learning.

Table 5. Recapitulation of Expert Validation Results

No	Validation Aspects	Validators	Scores (%)	Categories
1	Media	Media expert lecturer	93.75	Very Valid
		Practitioner teacher	93.75	Very Valid
		Average	93.75	Very Valid
2	Material	Material expert lecturer	83.53	Very Valid
		Practitioner teacher	100.00	Very Valid
		Average	91.76	Very Valid
3	Language	Language expert lecturer	85.56	Very Valid
		Practitioner teacher	93.33	Very Valid
		Average	89.44	Very Valid
	Overall Validity		91.65	Very Valid

Source: Processed research data (2026)

Referring to Table 5, the media aspect achieves an average of 93.75%, the material aspect 91.76%, and the language aspect 89.44%, resulting in an overall validity of 91.65%. All these scores fall into the very valid category according to the criteria in Table 3. The high score on the media aspect indicates that the display, design, and ease of operation of the AR media are well received, while the score on the material aspect confirms the suitability of the content with the learning objectives and the Merdeka Curriculum. The language aspect, albeit the lowest among the three, still falls into a very valid category. The language expert's input primarily focuses on simplifying several terms to better suit the comprehension level of fifth-grade students, and this input is used to improve the product.

This validity result is consistent with the notion that a learning medium must first be declared valid by experts before use, as the validation process serves as a quality assurance mechanism that examines the medium's content, display, and language (Fernando & Sarkity, 2022). A very valid category is, in addition, in line with the findings of Verdiatmoko and Pinandita (2025), who developed AR-based media with a very high feasibility level for elementary schools, and with Hidayatullah and Aripin (2026), who reported that technology-based interactive media met the very valid criterion. The agreement between the expert lecturers' and the practitioner teacher's assessments further strengthens the conclusion that the developed media has met feasibility standards, both theoretically and practically.

It is worth noting that these validity scores are not obtained immediately but rather through a revision process informed by the validators' qualitative input. The media expert suggested improvements to the display's consistency and clarity of the usage instructions; the material expert encouraged aligning the content with the learning outcomes of the Merdeka Curriculum; and the language expert recommended simplifying several terms to match the readability level of fifth-grade students. After completing the revisions, the product reached a high level in all three aspects. This process underscores that qualitative and quantitative data complement each other: the scores indicate the level of feasibility, while the validators' comments provide direction for improvement, which is a hallmark of development research (Waruwu, 2024).

After being declared valid, the practicality of the media was measured through user responses, namely those of the fifth-grade teacher and seven fifth-grade students who directly used the media in learning. The teacher's response focused on the suitability of the media for the learning process, ease of use, and usefulness, while the students' responses focused on the media's attractiveness, ease of operation, and its contribution to understanding the material. The recapitulation of user responses is presented in Table 6.

Table 6. Recapitulation of Teacher and Student Responses

No	Respondents	Scores (%)	Categories
1	Class V teacher	85.33	Very Good
2	Student 1	82.86	Very Good
3	Student 2	81.43	Very Good
4	Student 3	85.71	Very Good
5	Student 4	80.00	Very Good
6	Student 5	87.14	Very Good
7	Student 6	84.29	Very Good
8	Student 7	84.29	Very Good
Average student response		83.67	Very Good

Source: Processed research data (2026)

Table 6 visualizes that the teacher's response reaches 85.33%, which falls into the very good criterion and can be interpreted as very practical. 7 students' responses range from 80.00% to 87.14%, with an average of 83.67%, which falls within the very good criterion and can be interpreted as very interesting. Even the lowest individual score (80.00%) still meets the highest criterion, indicating that all students responded positively to the media. This achievement indicates that AR media is not only visually appealing but also easy to use and helpful for students in understanding ecosystem material.

The high practicality score can be explained by the characteristics of AR media, which present material in a concrete, interactive way. By simply scanning a barcode, students can directly observe 3D models of ecosystem components and the food chain, rather than merely imagining them, making the learning experience more meaningful. This finding underscores the view that visual media make learning more engaging and reduce boredom, as the material is no longer delivered solely through verbal explanation (Makransky & Petersen, 2021). It is, in addition, in line with the results of Nengsih et al. (2023) and

Rahmawati et al. (2024), who found that learning assisted by Assemblr Edu received positive responses and supported improvements in student learning, as well as with Jahi et al. (2024), who reported that AR assisted by Assemblr Edu was practical and effective in science learning at the elementary level.

The students' positive responses are also closely related to their developmental stage. Fifth-grade students are generally at the concrete operational phase; hence, they more easily grasp concepts when these are presented through real, observable representations rather than merely verbal or symbolic explanations. AR media address this need by transforming abstract concepts, such as the flow of energy in a food chain, into visual and interactive objects that can be explored. This is consistent with the view that AR offers significant opportunities to enrich the learning experience and increase user engagement, despite the fact that its use still requires adequate facilities and teacher readiness (Al-Ansi et al., 2023). In this study, the consistently high responses across the seven students indicate that the media can accommodate each student's interaction with the material.

Based on a practical standpoint, these findings have several implications for learning. For teachers, this medium provides an alternative that reduces dependence on the lecture method and conventional media such as printed pictures and presentation slides, while being easy to integrate into learning because it can be accessed through devices already familiar to students. For students, this medium opens up the opportunity to study ecosystem material in a more active and enjoyable way, thereby potentially fostering motivation and attention during learning. These implications are relevant to broader efforts to improve the quality of elementary education through the appropriate use of technology-based digital learning media (Maharani et al., 2023; Yunita et al., 2022).

Overall, the validity results (an overall average of 91.65% in the very valid category) and the practicality results (a teacher response of 85.33% and an average student response of 83.67%, both in the very good criterion) reveal that the developed AR media have met the feasibility standards for use in learning. The agreement between expert assessment and user response strengthens the conclusion that the media is fit to support ecosystem learning in class V. This finding aligns with previous research showing that AR technology can serve as an innovative learning medium that helps students understand abstract concepts and increases their engagement in learning (Faria & Miranda, 2024; Kamińska et al., 2023; Stanic & Špernjak, 2025). Thus, the Assemblr Edu-assisted AR media developed in this study can serve as an alternative technology-based IPAS learning medium, particularly for ecosystem materials, tailored to the characteristics and needs of fifth-grade students at SD Negeri 17 Pekanbaru.

The effectiveness of AR for the ecosystem topic can be explained on both theoretical and practical grounds. Ecosystem concepts such as food chains, energy flow, and the interdependence of biotic and abiotic components are dynamic and spatial, and are difficult to grasp from static two-dimensional illustrations alone. By overlaying manipulable three-dimensional objects onto the real environment, AR produces these otherwise invisible relationships observable and interactive, which addresses the macroscopic, submicroscopic, and symbolic representation demands of science learning and accords with immersive-learning theory, in which sensory-rich, interactive representations lower extraneous cognitive load and promote generative processing (Makransky & Petersen, 2021). This interpretation is consistent with international evidence that AR improves the learning of environmental and biological concepts and raises motivation (Faria & Miranda, 2024; Omurtak & Zeybek, 2022; Wen et al., 2023), and with the specific need previously identified for AR media on food-chain material (Qorimah et al., 2022). Theoretically, therefore, the study underscores the view that AR is particularly suited to abstract, process-based science content; practically, it offers teachers a validated, low-cost medium that runs on students' own devices, thereby lowering the barrier to integrating technology into IPAS instruction. At the same time, these benefits depend on adequate device availability and teacher readiness, which schools should consider when adopting AR (Aldeeb et al., 2024; Law & Heintz, 2021).

CONCLUSIONS AND RECOMENDATION

Based on the research results, the Assemblr Edu-assisted augmented reality learning media for ecosystem materials was successfully developed through the Analysis, Design, and Development stages of the

ADDIE model and was found to be valid and practical for use in fifth-grade learning at SD Negeri 17 Pekanbaru. The media validity obtained an overall average of 91.65%, derived from the media aspect (93.75%), the material aspect (91.76%), and the language aspect (89.44%), all in the very valid category, while practicality based on user responses reached 85.33% for the teacher (very practical) and an average of 83.67% for students (very interesting). These results indicate that the developed media is well-suited as an alternative technology-based learning medium that can help teachers present abstract ecosystem concepts more concretely while fostering students' interest and engagement, thereby contributing to the development of innovative learning media in primary education. This study is limited to the first three stages of the ADDIE model and to expert validation, as well as the responses of a teacher and a small number of students (7), without directly measuring the media's effectiveness on learning outcomes, and its scope is confined to the ecosystem topic with a food-chain focus for fifth grade. Therefore, future research is recommended to continue this development through the implementation and evaluation stages, using a larger, more diverse sample to test the media's effectiveness in improving students' learning outcomes. Beyond confirming the product's feasibility, the study produces three contributions. Theoretically, it furnishes evidence that Assemblr Edu-assisted AR is a valid and practical medium for abstract, process-based science content at the elementary level; practically, it provides teachers with a ready-to-use, device-friendly medium for ecosystem learning, and it offers a validated instrument blueprint that other researchers can adapt when assessing similar media.

Limitation

This study has several limitations that should be acknowledged. First, the development process is limited to the first three stages of the ADDIE model (Analysis, Design, and Development); hence, the Implementation and Evaluation stages are not carried out, and the media's effectiveness on learning outcomes is not tested. Second, the practicality test involves only 1 teacher and 7 fifth-grade students at a single school; thus, the findings cannot yet be generalized to other schools with different characteristics and facilities. Third, the material scope is confined to the ecosystem topic, with an emphasis on food chains, and the use of media depends on the availability of smartphones or tablets and on teacher readiness to operate augmented reality technology.

Credit Authorship Contribution Statement

First Author (Lutfiah Azizah): Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing of the original draft. Second Author (Zaka Hadikusuma Ramadan): Supervision, Validation, Methodology, Review, and editing.

Declaration of Competing Interest

The authors declare that they have no financial conflict of interest or personal relationships that could have influenced the results reported in this study.

Ethical Declaration

All participants provide their consent before taking part in this study. The school granted permission for the research, and the teacher and students were informed of the study's purpose, the procedures involved, and their right to withdraw at any time without consequences. The data obtained were used solely for academic purposes, and participants' identities were kept confidential.

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REFERENCES

- Al-Ansi, A. M., Jaboob, M., Garad, A., & Al-Ansi, A. (2023). Analyzing augmented reality (AR) and virtual reality (VR) recent development in education. *Social Sciences & Humanities Open*, 8(1), 100532. <https://doi.org/10.1016/j.ssaho.2023.100532>
- Aldeeb, F. H., Sallabi, O. M., Elaish, M. M., & Hwang, G. J. (2024). Enhancing students' learning achievements, self-efficacy, and motivation using mobile augmented reality. *Journal of Computer Assisted Learning*, 40(4), 1823–1837. <https://doi.org/10.1111/jcal.12989>
- Algerafi, M. A. M., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the potential: A comprehensive evaluation of augmented reality and virtual reality in education. *Electronics*, 12(18), 3953. <https://doi.org/10.3390/electronics12183953>
- Arena, F., Collotta, M., Pau, G., & Termine, F. (2022). An overview of augmented reality. *Computers*, 11(2), 28. <https://doi.org/10.3390/computers11020028>
- Asmar, R. S., Kurniaman, O., & Hermita, N. (2019). Analisis motivasi intrinsik belajar siswa kelas V sekolah dasar se-Gugus 1 Kecamatan Payung Sekaki Kota Pekanbaru. *Jurnal PAJAR (Pendidikan dan Pengajaran)*, 3(1), 93. <https://doi.org/10.33578/pjr.v3i1.6327>
- Branch, R. M. (2009). *Instructional design: The ADDIE approach*. Springer. <https://doi.org/10.1007/978-0-387-09506-6>
- Chuang, C. H., Lo, J. H., & Wu, Y. K. (2023). Integrating chatbot and augmented reality technology into biology learning during COVID-19. *Electronics*, 12(1), 222. <https://doi.org/10.3390/electronics12010222>
- Dayanti, S., Alpusari, M., & Witri, G. (2023). Development of interactive learning media on human respiratory system learning material at grade V elementary school. *Primary: Jurnal Pendidikan Guru Sekolah Dasar*, 12(1), 134–145. <https://doi.org/10.33578/jpkip.v12i1.8974>
- Faria, A., & Miranda, G. L. (2024). Augmented reality in natural sciences and biology teaching: Systematic literature review and meta-analysis. *Emerging Science Journal*, 8(4), 1666–1685. <https://doi.org/10.28991/esj-2024-08-04-025>
- Fauziyyah, N. (2019). The potential of augmented reality to transform education into smart education: Sebuah review. *Jurnal PAJAR (Pendidikan dan Pengajaran)*, 3(4), 966–973. <https://doi.org/10.33578/pjr.v3i4.7433>
- Fernando, A., & Sarkity, D. (2022). Pengembangan instrumen uji validitas dan praktikalitas media pembelajaran IPA. *Pedagogi Hayati*, 6(2), 67–77. <https://doi.org/10.31629/ph.v6i2.5212>
- Hamisah, S., Caska, C., & Kartikowati, S. (2022). Pengembangan bahan ajar multimedia interaktif berbantu Anyflip dan Quizizz untuk meningkatkan motivasi belajar siswa. *Jurnal PAJAR (Pendidikan dan Pengajaran)*, 6(6), 1950–1963. <https://doi.org/10.33578/pjr.v6i6.8880>
- Hidayatullah, M., & Aripin, I. (2026). Pengembangan media pembelajaran aplikasi interaktif berbasis Genially untuk meningkatkan hasil belajar IPAS materi sistem tata surya pada siswa SD. *Jurnal Pendidikan MIPA*, 16(2), 323–333. <https://doi.org/10.37630/jpm.v16i2.4188>
- Ibáñez, M. B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. *Computers & Education*, 123, 109–123. <https://doi.org/10.1016/j.compedu.2018.05.002>
- Jahi, M., Irfan, M., Rahman, A., & Hermuttaqien, B. P. F. (2024). Pengaruh penggunaan media augmented reality berbantuan Assemblr Edu terhadap hasil belajar ilmu pengetahuan alam. *Kognisi: Jurnal Penelitian Pendidikan Sekolah Dasar*, 4(1), 24–31. <https://doi.org/10.56393/kognisi.v4i1.2115>
- Kamińska, D., Zwoliński, G., Laska-Leśniewicz, A., Raposo, R., Vairinhos, M., Pereira, E., ... Anbarjafari, G. (2023). Augmented reality: Current and new trends in education. *Electronics*, 12(16), 3531. <https://doi.org/10.3390/electronics12163531>

- Lampropoulos, G., & Evangelidis, G. (2025). Learning analytics and educational data mining in augmented reality, virtual reality, and the metaverse: A systematic literature review, content analysis, and bibliometric analysis. *Applied Sciences*, 15(2), 971. <https://doi.org/10.3390/app15020971>
- Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2022). Augmented reality and gamification in education: A systematic literature review of research, applications, and empirical studies. *Applied Sciences*, 12(13), 6809. <https://doi.org/10.3390/app12136809>
- Law, E. L.-C., & Heintz, M. (2021). Augmented reality applications for K-12 education: A systematic review from the usability and user experience perspective. *International Journal of Child-Computer Interaction*, 30, 100321. <https://doi.org/10.1016/j.ijcci.2021.100321>
- Maharani, D. T., Alpusari, M., & Hermita, N. (2023). Development of interactive multimedia materials on animal classification based on food category. *Primary: Jurnal Pendidikan Guru Sekolah Dasar*, 12(2), 448–457.
- Makransky, G., & Petersen, G. B. (2021). The cognitive affective model of immersive learning (CAMIL): A theoretical research-based model of learning in immersive virtual reality. *Educational Psychology Review*, 33(3), 937–958. <https://doi.org/10.1007/s10648-020-09586-2>
- Nengsih, N., Eka, A. E. S., & Sunandar, A. (2023). Development of augmented reality learning media based on Assemblr Studio web in ecosystem material. *JINoP (Jurnal Inovasi Pembelajaran)*, 9(2), 277–291. <https://doi.org/10.22219/jinop.v9i2.25251>
- Nursidiq, A. P., & Batubara, H. H. (2022). Pengalaman guru sekolah dasar dalam menggunakan media pembelajaran. *Primary: Jurnal Pendidikan Guru Sekolah Dasar*, 11(5), 1319–1334. <https://doi.org/10.33578/jpfkip.v11i5.9017>
- Omurtak, E., & Zeybek, G. (2022). The effect of augmented reality applications in biology lesson on academic achievement and motivation. *Journal of Education in Science, Environment and Health*, 8(1), 55–74. <https://doi.org/10.21891/jeseh.1059283>
- Panjaitan, S. (2017). Meningkatkan hasil belajar IPA melalui media gambar pada siswa kelas IIA SDN 78 Pekanbaru. *Primary: Jurnal Pendidikan Guru Sekolah Dasar*, 6(1), 252–262. <https://doi.org/10.33578/jpfkip.v6i1.4105>
- Parisu, C. Z. L., & Sisi, L. (2025). Analisis mata pelajaran IPAS dalam Kurikulum Merdeka di sekolah dasar: Tantangan dan peluang. *Journal Sultra Elementary School*, 6(1), 1133–1143. <https://doi.org/10.64690/jses.v6i1.465>
- Purnamaningsih, I. R. (2022). Penggunaan aplikasi TikTok sebagai inovasi pembelajaran bahasa Inggris di masa pandemi COVID-19. *Jurnal PAJAR (Pendidikan dan Pengajaran)*, 6(3), 861–868. <https://doi.org/10.33578/pjr.v6i3.8753>
- Qorimah, E. N., Laksono, W. C., Hidayati, Y. M., & Desstya, A. (2022). Kebutuhan pengembangan media pembelajaran berbasis augmented reality (AR) pada materi rantai makanan. *Jurnal Pedagogi dan Pembelajaran*, 5(1), 57–63.
- Rahmawati, M. I. A., Noperman, F., & Kurniawati, I. (2024). Pengaruh penggunaan aplikasi Assemblr Edu terhadap hasil belajar IPA SDN Gugus III Kota Bengkulu. *Juridikdas: Jurnal Riset Pendidikan Dasar*, 7(2), 297–304. <https://doi.org/10.33369/juridikdas.v7i2.33709>
- Sinaga, A., Gaol, R. L., HS, D. W. S., & Silaban, P. J. (2022). Pengaruh pengguna handphone terhadap motivasi belajar siswa kelas V sekolah dasar. *Jurnal PAJAR (Pendidikan dan Pengajaran)*, 6(3), 692–705. <https://doi.org/10.33578/pjr.v6i3.8672>
- Stanic, K., & Špernjak, A. (2025). Augmented reality in biology education: A literature review. *Multimodal Technologies and Interaction*, 9(12), 117. <https://doi.org/10.3390/mti9120117>
- Syawaludin, A., Gunarhadi, & Rintayati, P. (2019). Enhancing elementary school students' abstract reasoning in science learning through augmented reality-based interactive multimedia. *Jurnal Pendidikan IPA Indonesia*, 8(2), 289–298. <https://doi.org/10.15294/jpii.v8i2.19249>
- Syskowski, S., & Wilfinger, S. (2024). Impact and classification of augmented reality in science experiments in teaching: A review. *Education Sciences*, 14(7), 760. <https://doi.org/10.3390/educsci14070760>
-

- Verdiatmoko, A. C., & Pinandita, T. (2025). Pengembangan media pembelajaran berbasis augmented reality pada materi pengenalan bangun ruang di SD Negeri 1 Purbalingga Wetan. *Jurnal Informatika Teknologi dan Sains (JINTEKS)*, 7(1), 91–100. <https://doi.org/10.51401/jinteks.v7i1.5382>
- Waruwu, M. (2024). Metode penelitian dan pengembangan (R&D): Konsep, jenis, tahapan dan kelebihan. *Jurnal Ilmiah Profesi Pendidikan*, 9(2), 1220–1230. <https://doi.org/10.29303/jipp.v9i2.2141>
- Wen, Y., Wu, L., He, S., Ng, N. H. E., Teo, B. C., Looi, C. K., & Cai, Y. (2023). Integrating augmented reality into inquiry-based learning approach in primary science classrooms. *Educational Technology Research and Development*, 71(4), 1631–1651. <https://doi.org/10.1007/s11423-023-10235-y>
- Yunita, V., Alpusari, M., & Noviana, E. (2022). Pengembangan media pembelajaran berbasis Android materi sistem tata surya untuk siswa sekolah dasar. *Primary: Jurnal Pendidikan Guru Sekolah Dasar*, 11(6), 1670–1679. <https://doi.org/10.33578/jpkip.v11i6.8705>
- Zhang, Y., Feijoo-Garcia, M. A., Gu, Y., Popescu, V., Benes, B., & Magana, A. J. (2024). Virtual and augmented reality in science, technology, engineering, and mathematics (STEM) education: An umbrella review. *Information*, 15(9), 515. <https://doi.org/10.3390/info15090515>
- Zhao, X., Ren, Y., & Cheah, K. S. L. (2023). Leading virtual reality (VR) and augmented reality (AR) in education: Bibliometric and content analysis from the Web of Science (2018–2022). *SAGE Open*, 13(3), 1–17. <https://doi.org/10.1177/21582440231190821>