

Research Article

Development of MARASA Learning Media Based on Augmented Reality to Improve Learning Outcomes in Science Subjects among Fifth-Grade Elementary School Students

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Abstract. Learning outcomes are an important aspect of successful science learning. However, learning processes that are still predominantly characterized by one-way delivery of instructional content have resulted in students' understanding of ecosystem concepts remaining suboptimal. This condition indicates the need for interactive learning media that can present learning materials in a more concrete and engaging manner. This study aims to develop a valid, practical, and effective prototype of MARASA learning media based on Augmented Reality (AR) to improve the learning outcomes of fifth-grade elementary school students. This study employed a Research and Development (R&D) approach using the ADDIE development model. Data were collected through

media and material expert validation, observations of learning implementation, teacher and student response questionnaires, and learning outcome tests. The data were analyzed using the Gregory index, percentage analysis, and an Independent Samples t-test. The results showed that: (1) the analysis stage identified a need for the development of technology-based learning media; (2) the design stage produced a prototype of MARASA AR media for ecosystem-related learning materials, equipped with learning objectives, instructional materials, learning videos, evaluation activities, and an Augmented Reality feature with three-dimensional objects; (3) the development stage indicated that the MARASA AR media had a high level of validity based on expert validation results; (4) the implementation stage demonstrated that the media was highly practical, as indicated by teacher responses of 96% and student responses of 94.4%, while the implementation of learning activities reached 88.5% in Meeting I, 94.2% in Meeting II, and 97.1% in Meeting III. The MARASA AR media was also found to be effective based on students' learning outcomes, with the experimental class achieving a score percentage of 86.1%, categorized as very good, which was higher than the control class at 60.8%, categorized as good. Furthermore, the Independent Samples t-test yielded a significance value of $0.001 < 0.05$. (5) The evaluation stage indicated that the media had generally fulfilled the criteria of validity, practicality, and effectiveness. Therefore, MARASA learning media based on Augmented Reality can be used as a science learning medium for ecosystem-related materials and has the potential to support the improvement of fifth-grade elementary school students' learning outcomes.

Keywords: MARASA Learning, Learning Media Based On Augmented Reality, Learning Outcomes, Elementary School

INTRODUCTION

Education from an Islamic perspective is not solely oriented toward the transfer of knowledge but also toward the formation of character, spirituality, and noble moral values. Knowledge is viewed as a means of improving individual quality while simultaneously recognizing the greatness of Allah SWT. One field of knowledge that is closely related to these objectives is Science, as science education encourages students to observe, understand, and scientifically analyze various natural phenomena. Science learning is not merely focused on conceptual mastery but can also serve as a means of developing scientific, critical, and systematic thinking skills while fostering awareness of the order and greatness of Allah SWT's creation. Therefore, science learning needs to be designed in a way that enables students to gain learning experiences that connect knowledge, real-world experiences, and spiritual values.

Learning outcomes are an important indicator for determining the extent to which learning objectives have been achieved. In the context of 21st-century education, learning outcomes are not limited to the mastery of basic knowledge but also encompass higher-order thinking skills, digital literacy, creativity, communication, and the ability to utilize technology. UNESCO (2023) emphasizes that learning outcomes encompass various competencies required by students to face life and subsequent stages of development. In line with technological developments in the era of the Fourth Industrial Revolution (Industry 4.0), learning processes need to be directed toward innovative and contextual learning experiences that utilize digital technology, enabling students to develop competencies in accordance with the demands of the times. Amalida and Halimah (2023) explain that the development of

information and communication technology has brought significant changes to modern human life, including in the field of education.

However, the current condition of science learning in elementary schools indicates that students' learning outcomes still face various challenges. Observations conducted at SD Negeri 004 Sungai Pinang revealed that students' science learning outcomes had not yet optimally met the Learning Objective Achievement Criteria (Kriteria Ketercapaian Tujuan Pembelajaran/KKTP). Among the three classes observed, the percentages of students who had not achieved the KKTP were 60% in Grade IV, 80% in Grade V, and 65% in Grade VI. Specifically, in Grade V, only approximately 20% of students had achieved the KKTP. This condition indicates that most students still experience difficulties in achieving the expected competencies in science learning.

Interviews with the Grade VA teacher revealed that the learning process was still predominantly based on the use of textbooks and lecture-based methods. The use of technology in learning was also limited, resulting in students tending to be passive and relying more on memorizing facts than developing a deeper understanding of concepts. The teacher also explained that the learning media currently used were less effective in attracting students' attention, whereas elementary school students generally require concrete, visual, and interactive learning experiences. These problems indicate that low learning outcomes are not solely related to students' abilities but are also associated with the learning processes and media employed. Mursalin and Muhsam (2021) argue that low learning outcomes can be influenced by a lack of motivation, low levels of student engagement, ineffective group work, and limited use of technology in the learning process.

The use of learning media that is appropriate to students' characteristics is one alternative for addressing these problems. Miftah and Rokhman (2022) explain that the selection of learning media needs to consider students' characteristics, the number of target learners, the learning environment, the type of media, ease of use, and the balance between costs and benefits. Technological developments provide opportunities for teachers to introduce more visual and interactive learning media. One relevant technology is Augmented Reality (AR). Yusup et al. (2023) define AR as a technology that integrates the real and virtual worlds directly or in real time. This technology enables virtual objects, including three-dimensional objects, to be displayed as if they were present in the real environment, allowing abstract learning concepts to be visualized more concretely.

The use of AR in learning has the potential to create more engaging, interactive, and contextual learning experiences. Wahiddiyah et al. (2023) demonstrate that the use of AR in learning can enhance student engagement and understanding. Ilma et al. (2022) also explain that AR technology can optimize the visualization of learning materials for elementary school students who are at the concrete operational stage of cognitive development. Therefore, AR is highly relevant to science learning because science concepts are often associated with objects and phenomena that are difficult to observe directly.

Based on these needs, MARASA based on AR was developed as a science learning medium that integrates concrete learning resources with digital technology.

MARASA is an acronym for *Manarang na Masannang*, a phrase derived from the Mandar language meaning “smart and enjoyable.” The media is designed as an application containing learning objectives, instructional materials, learning videos, evaluation activities, and a marker-scanning feature that displays three-dimensional objects and animations. By scanning marker cards using an Android smartphone, students can observe learning objects in a more realistic and interactive 3D format. This integration is expected to help students understand the concept of harmony within ecosystems, particularly interactions among ecosystem components, food chains, food webs, and ecosystem balance, which require concrete visualization.

Several previous studies have demonstrated that technology-based learning innovations and interactive media can improve students’ learning outcomes. Ekayogi (2023) found that the implementation of Problem-Based Learning assisted by Augmented Reality (AR) could improve students’ learning outcomes and learning independence. Amelia et al. (2025) also found that the use of AR could enhance students’ interest, understanding, and engagement in science learning. Nevertheless, previous studies still have certain limitations. The AR development in Ekayogi’s (2023) study relied on a relatively simple application, while Amelia et al.’s (2025) study did not integrate AR media with concrete learning media. Therefore, further development is needed to provide learning media that not only offers AR visualization but also integrates concrete learning media, instructional materials, videos, animated 3D objects, and evaluations within a single application that can be used more practically.

The novelty of this study lies in the development of MARASA based on AR, which integrates concrete learning media and Augmented Reality technology into a single science learning application. The media not only displays three-dimensional objects and animations through markers but also provides learning objectives, instructional materials, learning videos, and interactive evaluations. In addition, MARASA is designed for offline use, thereby reducing its dependence on an internet connection during learning activities. This integration is expected to provide a more concrete, engaging, and interactive learning experience that is aligned with the characteristics of elementary school students and the demands of digital-era education.

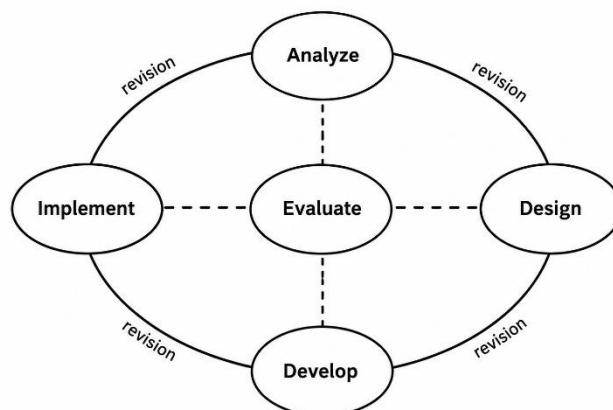
Based on the foregoing discussion, the development of MARASA based on AR is necessary as an innovation to address the problem of low science learning outcomes among students. This media is expected not only to improve students’ understanding of the concept of harmony within ecosystems but also to facilitate more active, meaningful, and enjoyable learning while supporting the use of technology in education. Therefore, this study aims to develop MARASA learning media based on Augmented Reality for teaching the topic of harmony within ecosystems and to determine its validity, practicality, and effectiveness in improving the learning outcomes of fifth-grade elementary school students.

RESEARCH METHODS

This study employed a Research and Development (R&D) approach using the ADDIE development model, which consists of five stages: Analysis, Design,

Development, Implementation, and Evaluation (Branch, 2009). The ADDIE model was selected because it provides a systematic and straightforward development framework and allows continuous evaluation throughout each stage of the development process. The product developed in this study was MARASA learning media based on Augmented Reality (AR) for teaching the topic of harmony within ecosystems to fifth-grade elementary school students.

The study was conducted at SDN 004 Sungai Pinang over a seven-month period, from March to August 2026. The development and expert validation stages were carried out during the first four months, while the subsequent two months were devoted to a small-scale trial and an effectiveness test of the MARASA AR learning media. The subjects of the small-scale trial were 15 fifth-grade students from Class VA, consisting of 5 male and 10 female students. The effectiveness test involved 50 students from Classes VB and VC, divided into an experimental group of 25 students and a control group of 25 students, and involved one teacher. The classes were selected using a non-randomization technique (intact groups), involving pre-existing classes with relatively comparable conditions based on teacher recommendations.



Gambar 1. Desain Model ADDIE
Sumber: Branch (2009)

Analysis Stage

The analysis stage was conducted to identify learning needs as the basis for developing MARASA learning media based on Augmented Reality (AR). The analysis included media needs analysis, content analysis, and student characteristics analysis. Information was collected through observations, interviews, and needs assessment questionnaires. This stage aimed to obtain information regarding the current conditions of science learning, students' characteristics, teachers' and students' needs for learning media, and learning materials that posed difficulties during the learning process. The results of the analysis served as the basis for determining the characteristics and specifications of the media to be developed.

Design Stage

The design stage involved developing the media based on the results of the needs analysis. The activities at this stage included the preparation of a flowchart, storyboard, interface design, learning materials, three-dimensional (3D) objects,

markers, learning videos, and research instruments. MARASA was designed as an AR-based learning medium that integrates text, images, videos, audio, animations, and 3D objects to visualize various ecosystem components, including producers, consumers, decomposers, food chains, and food webs. The technical development of the media involved Adobe Illustrator for designing the user interface and markers, Blender for creating 3D objects, and Unity and Vuforia Engine for integrating AR features into the Android application..

Development Stage

The development stage involved translating the design into a MARASA learning medium based on AR that was ready for use. The product was developed in accordance with the learning objectives and learning outcome indicators. After the product was developed, it was validated by a material expert and a media expert to assess the appropriateness of the content, design, completeness of features, and accuracy of the information presented. Two validators were involved in evaluating the product and providing feedback. The validation results were used as the basis for revising the media before it was subjected to the trial stage. The level of product validity was analyzed using the Gregory Index, with a coefficient of 0.80–1.00 categorized as very valid.

A small-scale trial was subsequently conducted involving 15 fifth-grade students from Class VA to identify potential limitations and assess the ease of use of the media. Feedback obtained from the trial was used as a basis for refining the product before its implementation in the effectiveness test. The practicality of the media was analyzed based on teacher and student responses using a 5-point Likert scale. The media was categorized as highly practical when it obtained a percentage ranging from 81% to 100%.

Implementation Stage

The implementation stage involved applying the MARASA learning media based on AR in Grade V science learning on ecosystem-related content. The effectiveness test employed a quasi-experimental design using a Post-test Only Control Group Design. The experimental group received instruction using the MARASA AR-based learning media, whereas the control group received instruction using conventional learning media. After the learning process was completed, both groups were administered a learning outcomes test consisting of 10 items to measure students' learning achievement following the treatment.

The effectiveness data were analyzed using an Independent Samples t-test after conducting prerequisite tests for normality and homogeneity. The Shapiro–Wilk test was used to assess normality because the sample size was less than 100 students. The media was considered effective if the significance value of the Independent Samples t-test was < 0.05 , indicating a statistically significant difference in learning outcomes between the experimental and control groups. Furthermore, the magnitude of the effect of using the MARASA AR-based learning media was analyzed using Cohen's *d* effect size to determine the strength of the treatment effect.

Evaluation Stage

The evaluation stage was the final stage of the development process and was conducted to assess the overall quality of the MARASA learning media based on Augmented Reality. The evaluation employed both formative and summative approaches. Formative evaluation was conducted at each stage of the development process to ensure that the product was developed in accordance with the predetermined objectives, whereas summative evaluation was conducted after the implementation stage to assess the quality of the media based on the criteria of validity, practicality, and effectiveness. The evaluation results were used as a basis for determining the final feasibility of the MARASA learning media based on Augmented Reality.

Research data were collected using media and material expert validation sheets, teacher response questionnaires, student response questionnaires, and cognitive learning outcome tests. The data were analyzed quantitatively. Media validity data were analyzed using the Gregory Index to determine the level of agreement between validators. The validation assessment employed a four-point Likert scale, while the validity coefficient was interpreted based on the validator agreement criteria proposed by Gregory (2015). Practicality data were analyzed based on teacher and student responses using a five-point Likert scale and converted into percentages to determine the practicality level of the media based on the criteria proposed by Riduwan (2015). The media was categorized as highly practical when it obtained a percentage ranging from 81% to 100%.

Meanwhile, effectiveness data were analyzed using an Independent Samples t-test to determine differences in students' learning outcomes between the experimental and control groups. The analysis was conducted after fulfilling the prerequisite tests of normality and homogeneity. The media was considered effective if the significance value of the Independent Samples t-test was < 0.05 . In addition, an effect size analysis using Cohen's d was conducted to determine the magnitude of the effect of using the MARASA learning media based on Augmented Reality on students' learning outcomes. The MARASA learning media based on Augmented Reality was considered feasible if it met the criteria for validity, practicality, and effectiveness

RESULTS AND DISCUSSI

This study resulted in the development of MARASA learning media based on Augmented Reality for teaching the topic of harmony within ecosystems to fifth-grade elementary school students. The media was developed using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The resulting product integrates instructional materials, videos, evaluations, and an Augmented Reality feature that displays three-dimensional objects, enabling ecosystem concepts to be learned in a more concrete and interactive manner.

Needs Analysis Results

The results of the needs analysis indicated that teachers and students required more innovative and interactive learning media capable of helping them visualize

abstract science concepts. The teacher needs analysis showed that school facilities supporting the use of digital media reached 94.7%, the need for interactive learning media reached 100%, teachers' interest in using Augmented Reality-based media reached 100%, and the perception that AR could create more engaging learning experiences also reached 100%. These findings indicate that the availability of supporting facilities and the high demand for interactive media provide a strong basis for developing MARASA learning media based on AR.

In the content analysis, ecosystem content was selected because it was identified as the topic that required the greatest support from Augmented Reality-based learning media. Concepts such as interactions among ecosystem components, food chains, food webs, and ecosystem balance require concrete visualization to facilitate students' understanding. Therefore, MARASA was developed using three-dimensional objects to help students gain a more tangible understanding of the relationships among ecosystem components.

At the design stage, MARASA was designed by developing a flowchart and storyboard that included the cover page, main menu, learning objectives, instructional materials, learning videos, evaluation activities, and Augmented Reality-based ecosystem cards equipped with three-dimensional visualizations. At this stage, the research instruments were also developed, including expert validation sheets, teacher and student response questionnaires, and cognitive learning outcome test items.

The MARASA prototype was developed by preparing various media assets, including the user interface, three-dimensional objects, images, instructional materials, learning videos, and markers. The user interface and markers were designed using Adobe Illustrator, while the three-dimensional objects were developed using Blender. Subsequently, all media assets were integrated using Unity and Vuforia Engine to develop the Augmented Reality features within the Android application. The media presents various ecosystem components, including producers, consumers, decomposers, food chains, and food webs, through three-dimensional visualizations.

Learning Media Validation Results

Validation was conducted by media and material experts to determine the feasibility of the product before its implementation in the learning process. The validators assessed several aspects, including content, design, feature completeness, alignment with the learning objectives, and the accuracy of the information presented. Content validity was subsequently analyzed using the Gregory Index to determine the level of agreement between the validators.

1. Validation Results of the MARASA Learning Media

Validation Aspect	Persentase	Category
Media Expert	94,38%	Highly Valid
Material Expert	85%	Highly Valid

The analysis using the Gregory Index yielded a value of 1.00, which falls within the range of 0.80–1.00 and is categorized as highly valid. This value indicates a very high level of agreement between the validators regarding the feasibility of the instrument and the developed product. Therefore, the MARASA learning media based on Augmented Reality met the validity criteria and could proceed to the trial and implementation stages.

Learning Media Practicality Results

The practicality of the media was determined based on teacher and student responses after using the MARASA learning media based on Augmented Reality. The teacher response yielded a percentage of 96%, which was categorized as highly practical. This finding indicates that the media was easy to understand and operate, had an appealing interface, and assisted teachers in delivering science learning materials.

Meanwhile, the student responses obtained a total score of 1,180 out of a maximum score of 1,250, corresponding to a percentage of 94.4% and categorized as highly practical. This finding indicates that the media could be used effectively by students, was engaging to use, and facilitated their understanding of the topic of harmony within ecosystems through the visualizations provided

Indicator	Persentase	Category
Teacher Response	96%	Highly Practical
Student Response	94,4%	Highly Practical

Learning Media Effectiveness Results

The effectiveness of the MARASA learning media was analyzed by comparing the posttest results of the experimental and control groups using a Post-test Only Control Group Design. The experimental group received instruction using the MARASA learning media based on Augmented Reality, whereas the control group received instruction using conventional learning media. The normality test results showed that the control group's posttest data had a significance value of 0.432, while the experimental group had a significance value of 0.075, indicating that both datasets were normally distributed. The homogeneity test yielded a significance value of 0.609 > 0.05, indicating that the data from the two groups were homogeneous.

After the prerequisite tests were fulfilled, an Independent Samples t-test was conducted. The analysis yielded $t = 13.000$, $df = 48$, with a significance value of $0.001 < 0.05$. Therefore, H_0 was rejected and H_a was accepted, indicating a statistically significant difference in learning outcomes between the experimental and control groups.

Data	t	df	Sig tailed) (2-	Interpretation
Posttest of Experimental and Control Groups	13,000	48	0,001	< 0,05 = Significant difference

The posttest results showed that the experimental group achieved a learning outcome percentage of 86.1%, whereas the control group achieved 60.8%. This difference indicates that students who learned using the MARASA learning media

based on Augmented Reality achieved higher learning outcomes than students who received instruction using conventional learning media.

Learning Outcomes	Persentase
Control Group	60,8%
Experimental Group	86,1%

In addition to the significance test, the effect size analysis yielded a Cohen's *d* value of 3.677, which falls within the *large* effect category, as it exceeds 0.80. This result indicates that the use of MARASA learning media based on Augmented Reality has a large effect on students' learning outcomes.

Overall, the findings indicate that MARASA learning media based on Augmented Reality meets the criteria of validity, practicality, and effectiveness. The media received highly practical responses from both teachers (96%) and students (94.4%) and resulted in a statistically significant difference in learning outcomes between the experimental and control groups. Therefore, MARASA based on Augmented Reality is considered feasible for use as a science learning medium to support fifth-grade students' understanding of the topic of harmony within ecosystems.

DISCUSSION

The needs analysis revealed that science learning in elementary schools is still predominantly supported by textbooks and simple visual media, which are not yet optimal for helping students understand abstract ecosystem concepts. Interviews indicated that both teachers and students needed more interactive and technology-based learning media. This condition provided the basis for developing MARASA learning media based on Augmented Reality (AR), which can present concepts more concretely through three-dimensional visualization. This finding is consistent with Indrawan et al. (2025), who reported that AR-based media can improve science learning outcomes by presenting engaging and interactive 3D objects. Similarly, Atfaliyah and Imamudin (2024) found that AR can increase student engagement in IPAS learning.

The MARASA prototype was developed through several design stages, including the preparation of a flowchart and storyboard, the creation of 3D objects, and the integration of various media components using Adobe Illustrator, Blender, Unity, Vuforia Engine, and Android APK. The media includes learning objectives, instructional materials, videos, evaluations, and an AR feature that allows students to scan markers to display 3D representations of ecosystem components. The integration of text, images, videos, audio, animations, and 3D objects was designed to provide a more concrete and interactive learning experience. This finding is in line with Puspitasari et al. (2023), who stated that systematic AR media design that considers students' characteristics can improve the quality of learning. Ruiz et al. (2025) similarly explained that AR can integrate virtual objects into real-world environments, thereby creating more interactive learning experiences.

The validation results showed that the MARASA learning media based on AR obtained a highly valid category for both the media and content aspects, with a

Gregory coefficient of 1.00. This result indicates that the media has a very high level of validity and is feasible for use in Grade V science learning. The validity of the media was reflected in the appropriateness of its interface, navigation, AR functionality, visual quality, and alignment of the learning content with the learning objectives. This finding is consistent with Nafis and Fathurrahman (2024), who stated that the validity of AR-based media can be assessed through interface quality, ease of use, and the ability to present learning materials interactively. Similar findings were reported by Asmini et al. (2025), who found that AR-based learning media achieved a highly valid category based on assessments by media and content experts.

The practicality test showed that MARASA received responses of 96% from teachers and 94.4% from students, placing it in the highly practical category. These high percentages indicate that the media is easy to use, has an attractive interface, provides simple navigation, and supports both teachers and students during the learning process. The instructional materials, videos, evaluation activities, and AR features can be accessed easily, thereby providing a more interactive learning experience. This finding is consistent with Wasiyah et al. (2023), who stated that practical learning media should be easy to use, flexible, and capable of supporting the learning process. Meilisa et al. (2025) likewise found that AR-based media achieved a highly practical category based on teacher and student responses.

The effectiveness test showed that the experimental group, which used MARASA learning media based on AR, achieved higher posttest results than the control group, which received conventional instruction. The Independent Samples t-test yielded a significance value of $0.001 < 0.05$, indicating a statistically significant difference in learning outcomes between the two groups. This finding demonstrates that MARASA based on AR is effective in improving science learning outcomes on ecosystem content because it presents concepts through more concrete and interactive 3D visualizations. This result is consistent with Anisyah et al. (2024), who reported that AR-based media can improve learning outcomes by presenting learning materials in an engaging and comprehensible manner. Rachmayani and Setyasto (2025) similarly found that the use of AR has a positive effect on students' learning outcomes by providing more concrete visualizations of learning concepts.

CONCLUSION AND RECOMMENDATIONS

Based on the results of the research and development process, the MARASA learning media based on Augmented Reality for Grade V ecosystem content was found to be valid, practical, and effective. The needs analysis showed teacher responses of 100%, student responses of 93%, and a need for ecosystem-related learning materials of 86.7%. The media was developed as an interactive digital learning medium equipped with instructional materials, videos, evaluations, and AR-based 3D objects that can be displayed through marker scanning. The validity of the media was demonstrated by expert validation, with a Gregory coefficient of 1.00. Its practicality was indicated by teacher responses of 96%, student responses of 94.4%, and learning implementation rates ranging from 88.5% to 97.1%. Its effectiveness was demonstrated by the Independent Samples t-test, which yielded a significance value of $0.001 < 0.05$. The learning outcomes of the experimental group reached 86.1%,

which was higher than the 60.8% achieved by the control group. Therefore, MARASA based on Augmented Reality is considered feasible for use as a science learning medium for ecosystem content.

Based on the limitations of this study, future research is recommended to develop MARASA based on Augmented Reality for other science topics by incorporating more diverse features, 3D objects, and interactive elements. Implementation should also be conducted over a longer period and with a broader scope to obtain more comprehensive evidence of its effectiveness. For teachers, MARASA can serve as an alternative interactive medium for science learning. Schools are also encouraged to support the provision of adequate technological devices and infrastructure to ensure that the media can be utilized optimally.

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