

Development of Augmented Reality-Based BUCARA Flipbook Media to Improve Students' IPAS Learning Outcomes

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Abstract: The role of visual learning media is crucial in enhancing the education experience, helping students engage with the material, understand abstract science concepts, and improve learning achievements, especially in the topic of Plant Body Parts in science learning. However, the integration of interactive and technology-based media in classroom learning remains limited. This study aimed to develop a valid, practical, and effective Augmented Reality (AR)-based BUCARA Flipbook for fourth-grade students. The novelty of this study lies in integrating AR technology with an interactive flipbook designed to support elementary science learning through visual and contextual experiences. This research employed a Research and Development (R&D) approach using the ADDIE model and involved 29 fourth-grade students at SD Negeri Gunungpati 02 Semarang. Data were collected through observation, interviews, questionnaires, and pretest-posttest assessments, then analyzed using quantitative and qualitative methods. The results showed that the AR-based BUCARA Flipbook was categorized as very feasible with a validation score of 95% and received highly positive responses from teachers and students. The paired-sample t-test indicated a significant difference between pretest and posttest scores (Sig. 2-tailed = 0.000 < 0.05). In addition, the N-Gain score of 0.7374 indicated a great improvement in students' learning outcomes. In conclusion, the AR-based BUCARA Flipbook is an innovative and effective learning medium for improving elementary students' IPAS learning outcomes.

Keywords: ADDIE Model; Augmented Reality; Elementary Education; Flipbook BUCARA

Introduction

Education is a deliberate and systematically designed endeavor aimed at helping individuals acquire knowledge and develop their potential through a variety of planned learning experiences. Fundamentally, education is achieved through active, creative, and innovative learning processes that enable students' potential to develop optimally. Education is not merely concerned with the transmission of knowledge, but also plays a crucial role in shaping the abilities and skills required in the 21st century (Oktaviani, 2023). In line with this perspective, Zubaidah (2022) emphasizes that education in the era of globalization is expected to equip students to navigate technological advancements while

simultaneously cultivating 21st-century skills, including critical thinking, collaboration, communication, and creativity. One school subject that can foster these 21st-century skills is Integrated Science and Social Studies (IPAS). Integrated Science and Social Studies (IPAS) is a combination of two disciplines, namely Natural Sciences (IPA) and Social Studies (IPS), within the Merdeka Curriculum at the elementary school level, and is designed to be relevant in supporting 21st-century learning (Zakarina et al., 2024). This view is consistent with the assertion that IPAS learning aims to enable students to apply their knowledge to explore and investigate their surrounding environment, as well as to develop scientific attitudes such as critical thinking and problem-solving skills.

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Through IPAS instruction, students are guided to understand the interrelationships between natural and social phenomena, so that learning does not merely emphasize theoretical understanding but also emphasizes the discovery of concepts, facts, and meaningful learning experiences (Andriani & Sari, 2024). Nevertheless, the implementation of IPAS learning continues to face challenges, particularly in the use of technology (Rahmani et al., 2025). Many elementary schools still rely on conventional, less interactive instructional media, which have not been able to accommodate students' diverse learning needs. In IPAS learning at the elementary level, especially in Grade IV, several topics are abstract and often complex for students to comprehend. Consequently, the limited availability of interactive learning media is a significant obstacle to achieving optimal learning outcomes. This condition is reflected in studies reporting low levels of student engagement and interest in learning when instructional media are not supported by contextually relevant and visually appealing presentations (Arisinta et al., 2025).

Along with the advancement of educational technology in the era of Society 5.0, Augmented Reality (AR) has emerged as an innovative approach that enables the integration of three-dimensional (3D) visual objects into real learning contexts, *thereby supporting students' conceptual understanding and engagement in science learning* (Ibáñez & Delgado-Kloos, 2018). The use of AR-based flipbook media in education, particularly through the Assemblr Edu application, can enhance students' interactive learning experiences by presenting 3D visualizations (Gutama & Winanto, 2025; Ibáñez & Delgado-Kloos, 2018). This application combines AR technology with learning experiences that allow students to explore information according to the instructional content. The application of AR technology is highly relevant to IPAS learning in elementary schools, especially in Grade IV, where abstract concepts are frequently encountered and often pose comprehension difficulties for students, making the lack of interactive media a significant barrier to optimal learning outcomes (Akçayir & Akçayir, 2017; Cheng & Tsai, 2013; Garzón et al., 2019). However, the integration of AR technology into flipbook-based learning media has not yet been systematically implemented at SD Negeri Gunungpati 02, indicating a research gap that warrants further investigation (Radianti et al., 2020). The urgency of this study is reinforced by field observations showing that the school still faces limitations in developing instructional media that are not only valid but also capable of making a tangible contribution to improving students' learning outcomes in IPAS.

Based on classroom observations conducted with the Grade IV teacher at SD Negeri Gunungpati 02,

Semarang City, on 12 November 2024, several issues related to IPAS instruction were identified. The first primary concern is the teacher's limited ability to utilize interactive electronic learning media based on Augmented Reality (AR), which has contributed to students' low interest and limited understanding of IPAS learning. Instruction still relies predominantly on conventional, context-based media that lack interactivity, resulting in insufficient student comprehension of the subject matter. The teacher has not yet optimized the use of innovative learning media; instead, they primarily employ images, posters, PowerPoint presentations, and videos. Moreover, these media are rarely used due to limited facilities, as the school has only three projectors, none of which are permanently installed in each classroom.

Second, the learning outcomes of Grade IV students remain low. This is evident from the End-of-Semester Summative Assessment (SAS) data, which indicates that the Minimum Learning Achievement Criteria (Kriteria Ketercapaian Tujuan Pembelajaran/KKTP) for IPAS is set at 70. The data show that only 10 out of 29 students (34.5%) achieved scores above the KKTP, while 19 students (65.5%) scored below the established criterion. These results are attributed to students' limited understanding of abstract concepts in the Plant Body Parts topic and to the teacher's suboptimal use of interactive AR-based learning media.

Third, the material in Chapter 1, Topic A: Plant Body Parts, is inherently abstract, contains numerous unfamiliar scientific terms, and lacks adequate instructional visualizations. These limitations reduce students' motivation to engage actively in IPAS learning activities. The instructional problems in IPAS at SD Negeri Gunungpati 02 require immediate attention, as they significantly affect students' mastery of the content and learning outcomes, ultimately hindering the achievement of the intended learning objectives.

Based on the identified problems in IPAS learning at SD Negeri Gunungpati 02, it is evident that students require new variations in the learning process to make it more effective, less monotonous, and better at providing the information needed to understand abstract concepts. Innovative and interactive learning media are therefore necessary instructional tools that can support teachers in delivering classroom material (Garzón et al., 2019; Xu et al., 2022). The presence of learning media plays a crucial role in ensuring that the learning process runs more effectively and efficiently (Silmi & Bektiningsih, 2025). According to Wulandari et al. (2023), learning media are tools teachers use to facilitate students' understanding of learning materials, making the content more straightforward to comprehend. Furthermore, (Nuryani & Abadi, 2021) state that learning media aim to attract students' interest, motivation, and willingness to learn,

thereby encouraging greater enthusiasm for participating in learning activities.

If teachers are unable to foster students' motivation and interest in learning, the learning process will be challenging to achieve optimally (Schindler et al., 2017; Sung et al., 2016). This aligns with Munajar et al. (2025), who emphasize that students' learning interests significantly influence learning outcomes and therefore must receive serious attention from teachers. Consequently, teachers need to employ innovative, interactive learning media to create enjoyable, meaningful learning experiences. One effort to address these challenges is the development of innovative learning media that actively engage students by providing new learning experiences. One such medium that enables students to learn through play is the Augmented Reality-based Flipbook BUCARA learning media.

According to Rahmawati et al. (2023), a flipbook is an interactive digital learning medium in the form of an electronic book that integrates supplementary materials such as 3D images, text, animated videos, links, barcodes, and audio in a virtual format based on digital technology, particularly Augmented Reality (AR). This medium is developed to present learning content through systematically and interactively designed materials, incorporating colorful visual elements to enhance students' learning experiences. Flipbook BUCARA is a learning medium developed as a virtual book based on Augmented Reality technology. The term BUCARA is an acronym for (*bantu cinta alam sekitar*). This flipbook is designed to foster critical thinking skills, stimulate curiosity, and develop students' intellectual abilities through a learning-by-playing approach.

The Flipbook BUCARA consists of several components, including a cover page, table of contents, usage instructions, learning outcomes, learning objectives, apperception activities (such as singing, observing, and identifying), and interactive learning materials packaged with barcodes that can be scanned using smartphones. One of the barcodes provides detailed explanations of the learning content supported by the Assemblr Edu application, which presents 3D visualizations that students can view in 3D and manipulate 360 degrees in all directions.

In addition, Flipbook BUCARA includes instructional videos, educational games, student worksheets (LKPD), evaluation questions, summaries, references, author profiles, and supervisor profiles. This digital flipbook also includes links and barcodes that can be accessed or scanned via smartphones, laptops, and computers, and is compatible with Android- and iOS-based digital devices. Based on Piaget's theory of cognitive development, students at the concrete operational stage begin to think logically with the

support of physical objects or concrete representations (Babullah, 2022; Hwang et al., 2016; Parong & Mayer, 2018). According to Piaget's theory of cognitive development, at the concrete operational stage, students begin to think logically using concrete objects (Babullah, 2022).

Based on this theory, fourth-grade students at Gunungpati 02 Elementary School are classified as being in the concrete operational stage, as they are between 7 and 11 years old. The AR-based BUCARA Flipbook is designed to bridge previously abstract concepts into easier-to-understand solutions to learning challenges. Concept visualization is implemented through the presentation of three-dimensional (3D) images and audiovisual-based instructional videos designed to help students concretely visualize the structure of Plant Body Parts. The Flipbook BUCARA learning media is designed to provide stimuli that encourage active student interaction by offering detailed explanations and interactive educational games that facilitate direct two-way interaction (Makransky et al., 2019; Parong & Mayer, 2018). Moreover, Flipbook BUCARA is accompanied by background songs that function as motivational stimuli to enhance students' enthusiasm and engagement in understanding the learning material.

Numerous previous studies have examined the effectiveness of Flipbook media integrated with Augmented Reality (AR) technology. The study conducted by Arisinta et al. (2025) shows that students' responses to Augmented Reality-based Flipbook media are in the very good category, thereby validating the effectiveness of AR-based Flipbook media. Furthermore, the t-test showed a significant difference between the pretest and posttest scores. Apart from that, the n-gain test results of previous research were included in the high category (Cahya & Bektiningsih, 2024). This aligns that Augmented Reality-based flipbook media has proven feasible and effective for science learning. However, no one has yet integrated it into the AR-based acronym SPEAK.

Based on the reviewed studies, the novelty of the present research lies in the AR-based application employed (Garzón et al., 2019; Radianti et al., 2020). Unlike previous studies, this research uses Assemblr Edu as a supporting application in developing the BUCARA Flipbook. Another aspect of novelty is the development of the AR-based BUCARA Flipbook specifically for IPAS Grade IV, Chapter 1 *Plants as a Source of Life on Earth*, Topic A *Plant Body Parts*, at SD Negeri Gunungpati 02, Semarang City, which has implemented the Merdeka Curriculum. This study also introduces innovative learning strategies, such as grouping students by ability and learning style. This approach not only facilitates deeper conceptual understanding but also fosters collaborative skills that

have not been adequately addressed in previous research.

This research is significant in providing deeper insights into the potential of AR-based BUCARA Flipbook media in learning, particularly in supporting more innovative and engaging mastery of subject matter for students (Cheng et al., 2020; Kusumawati & Prastiwi, 2025). Through the development and evaluation of the AR-based BUCARA Flipbook, this study is expected to offer an innovative solution to challenges encountered in IPAS learning and to improve students' learning outcomes.

Based on the aforementioned background, this study aims to describe the development design, examine the feasibility, and measure the effectiveness of the AR-based BUCARA Flipbook media in improving IPAS learning outcomes among fourth-grade students at SD Negeri Gunungpati 02, Semarang City.

Method

This study employed a Research and Development (R&D) approach to develop an Augmented Reality-based Flipbook BUCARA learning medium to improve IPAS learning outcomes for fourth-grade students at SD Negeri Gunungpati 02, Semarang. The research procedure adopted the ADDIE development model proposed by Dick and Carey, which consists of five main stages: Analysis, Design, Development, Implementation, and Evaluation (Mtodana-Zide, 2024; Spatioti et al., 2022; Sugiyono, 2021). The R&D research framework is illustrated in Figure 1.

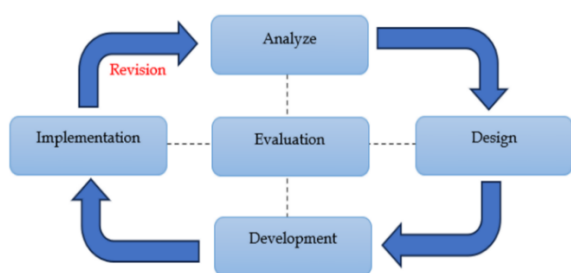


Figure 1. ADDIE Development Model Chart

The analysis stage examined the curriculum, student characteristics, available school technology, existing learning conditions, student responses, and students' ability to understand the material. This stage involved classroom observations, interviews, distribution of needs-assessment questionnaires to teachers and students, and documentation of fourth-grade students' learning outcomes at SD Negeri Gunungpati 02.

The next stage was product design, which began with developing the design and framework of the

learning media and documenting the production process at each stage. This was followed by the development stage, which involved integrating the collected learning materials into the designed learning media while incorporating innovative elements into the product. At this stage, the design will be validated by qualified validators, namely media experts and subject-matter experts. The results of expert validation are used to revise the product before entering the implementation stage.

The subsequent stage was implementation, during which the developed product was tested in a small-group trial involving six fourth-grade students selected through purposive sampling. During the learning sessions, both teachers and students were asked to complete response questionnaires regarding the use of the Augmented Reality-based Flipbook BUCARA learning media. Following this, a large-group trial was conducted involving 29 fourth-grade students in the 2024/2025 academic year. The effectiveness of the developed product was determined based on students' learning outcomes. The final step is evaluation. This stage aims to evaluate the entire development process, including the effectiveness of the media and the improvements needed for mass production.

The research was conducted during the even semester of the 2025 academic year at SD Negeri Gunungpati 02, Gunungpati District, Semarang City, Central Java. The research subjects included all 29 fourth-grade students of SD Negeri Gunungpati 02, as well as the fourth-grade classroom teacher. The study focused on the AR-based Flipbook BUCARA learning media for the Plant Parts unit in the IPAS subject. Data were collected through observation, interviews, document analysis, questionnaires, and tests. The collected data were subsequently analyzed using both quantitative and qualitative methods.

Quantitative data were obtained from students' pretest and posttest scores, the results of student and teacher response questionnaires, and validation questionnaires completed by media and subject-matter experts. These quantitative data were analyzed using normality tests, homogeneity tests, hypothesis testing (paired sample *t*-test), and N-gain analysis, with SPSS version 26 employed for statistical processing. Qualitative data were derived from observations, interviews, documentation, and feedback and suggestions from teachers, students, and media and content experts. The qualitative data were analyzed using descriptive qualitative methods and presented in narrative form to provide evaluative input for improving and refining the AR-based Flipbook BUCARA learning media.

Result and Discussion

The product resulting from this development research is an Augmented Reality (AR)-based Flipbook BUCARA learning medium that has been empirically validated for feasibility, practicality, and effectiveness. The AR-based Flipbook BUCARA is expected to enhance IPAS learning outcomes among fourth-grade students at SD Negeri Gunungpati 02, Semarang City. Developed using the ADDIE instructional design model, the product underwent a systematic process encompassing the analysis, design, development, implementation, and evaluation stages.

Analyze

Based on the preliminary study results, several key problems were identified. First, teachers have not yet optimized the use of innovative learning media or integrated augmented reality-based technology into classroom instruction. Second, learning activities still rely heavily on conventional, less interactive context-based media, resulting in limited student understanding. Third, the learning outcomes of fourth-grade students remain low, as many students have not achieved the Minimum Learning Achievement Criteria (Kriteria Ketercapaian Tujuan Pembelajaran/KKTP) for IPAS, which is set at 70. Of 29 students, only 10 (34.5%) met the KKTP, while the remaining 19 (65.5%) failed to meet the expected standard.

Initial data collection through interviews with the fourth-grade teacher indicated that the school has implemented the Merdeka Curriculum. Further needs analysis was conducted using questionnaires distributed to both teachers and students to identify the required learning media. The findings revealed a strong need for innovative Augmented Reality-based learning media to support teachers in fostering students' interest, enhancing learning motivation, and improving learning outcomes. Consequently, teachers require supportive instructional media to broaden students' understanding of Plant Body Parts.

The learning media should be developed as an interactive Flipbook, incorporating engaging elements such as colors, 3D images, songs, and animated videos relevant to the learning content to support improved student learning outcomes (Widyatama & Wulandari, 2025). Teachers expect an AR-based Flipbook that aligns with students' characteristics and employs concise, clear, and easily comprehensible language. Therefore, the most appropriate learning media for IPAS Topic A, *Plant Body Parts*, is an Augmented Reality-based Flipbook. The Flipbook BUCARA not only offers interactive learning experiences but also creates an enjoyable learning atmosphere that can enhance students' motivation and learning achievement.

Design

During the design stage, the researcher developed a structured plan to produce a prototype or initial product that would be realized in the development phase. This design stage can be described as follows. (1) Mapping learning outcomes and learning objectives as the basis for determining the content of the AR-based BUCARA Flipbook. The selected subject was IPAS for Grade IV, Chapter 1, Plants as Sources of Life on Earth, Topic A, *Plant Body Parts*. The expected learning outcomes require students to analyze plant parts and their functions, and to relate these functions to plants' needs for growth, self-protection, and reproduction. (2) Designing the framework of the AR-based BUCARA Flipbook, which includes planning the flipbook layout using the Canva application, developing interactive 3D images with the support of Assemblr Edu, creating educational games and evaluation questions using Wordwall, and generating barcodes.

The AR-based BUCARA Flipbook was systematically designed to address students' learning needs, expected learning outcomes, and IPAS's learning objectives on Plant Body Parts. This learning media uses a barcode system accessible on smartphones, laptops, computers, and Chromebooks. The content of the BUCARA Flipbook consists of: (a) front cover, (b) table of contents, (c) user guide, (d) learning outcomes, (e) learning objectives, (f) observation and identification activities, (g) instructional material accompanied by interactive 3D images, (h) educational games, (i) student worksheets (LKPD) and usage instructions, (j) evaluation questions, (k) songs about plant functions, (l) conclusion, (m) references, (n) author profile, and (o) supervisor profile.

The instructional materials, interactive 3D illustrations, songs, and animated videos were designed to support conceptual understanding in ways that align with students' characteristics. Media development involved preparing learning materials and designing the visual layout in Canva, while Assemblr Edu was used to support augmented reality (AR) features. The book cover includes the title, subject, material, topic, target grade level, barcode, and the developer's name.

Development

At this stage, the AR-based BUCARA Flipbook was developed using the Assemblr Edu application and subsequently refined and finalized in Canva. The finalization process included layout arrangement, color tone selection, the addition of visual elements and images, and the integration of supplementary instructional media, such as barcodes linking to learning videos, educational games, student worksheets (LKPD), and evaluation questions. Once completed, the product was uploaded to the Anyflip.com platform and

distributed to students via barcodes and hyperlinks that require internet access. The AR-based BUCARA

Flipbook consists of several main components, as illustrated in Figure 2.



Figure 2. Media display: (a) BUCARA Flipbook Cover; (b) Table of Contents and User Guide; (c) Learning Outcomes and Objectives; (d) Learning Stimulus; (e) Learning Video and 3D Interactive Materials; (f) Educational Games and Student Worksheets; (g) Evaluation Questions and Song Lyrics; and (h) Conclusion and References

Following the design and development phase, the next stage involved media and content validation. This stage aimed to assess the feasibility and appropriateness of the AR-based BUCARA Flipbook as an instructional medium. The validation process was conducted under the guidance of media and subject-matter experts from the Elementary School Teacher Education Program, Universitas Negeri Semarang.

Media Expert Validation

Media expert validation was conducted to evaluate the feasibility of the AR-based Flipbook BUCARA learning media that had been developed. The assessment was carried out using Formula 1.

$$P = \frac{f}{N} \times 100\% \quad (1)$$

Descriptions:

P = Percentage Score

F = Obtained Score

N = Maximum Score

The results of the media expert evaluation are presented in Table 1.

Table 1. Media Expert Evaluation Results

Aspects	Score	Percentage	Criteria
Presentation	37	95%	Very Decent
Linguistic	26		
Practicality	30		
Competency	30		
Feasibility	29		

Based on the content expert evaluation, the score is 152 out of a maximum score of 160. From the score results, a feasibility percentage of 95% was obtained. This result indicates that the AR-based Flipbook BUCARA learning media falls within the "very decent" category, as it meets the criteria range of 84–100%. According to the media expert's calculations, the AR-based Flipbook BUCARA learning media is valid and highly feasible for use in learning activities.

Content Expert Validation

Content expert validation was conducted to assess the feasibility of the AR-based Flipbook BUCARA learning media that had been developed, using the Formula 2

$$P = \frac{f}{N} \times 100\% \quad (2)$$

Descriptions:

P = Percentage Score

F = Obtained Score

N = Maximum Score

The results of the content expert evaluation are presented in Table 2.

Table 2. Content Expert Evaluation Results

Aspects	Score	Percentage	Criteria
Presentation	36	95%	Very Decent
Linguistic	26		
Practicality	38		
Competency	27		
Feasibility	26		

Based on the content expert evaluation, the score is 153 out of a maximum score of 160. From the score results, a feasibility percentage of 95% was obtained. This finding indicates that the AR-based Flipbook BUCARA learning media is highly feasible, meeting the 84–100% feasibility criteria. The results of the calculations demonstrate that the AR-based Flipbook BUCARA learning media is valid and highly feasible for implementation in learning activities. The results of both the media expert and content expert validations yielded the same average score of 95%, indicating that the media is valid and very suitable for application in learning activities.

The validation process produced both quantitative and qualitative data. Quantitative data were obtained from validation questionnaire scores on a 1-4 scale. In contrast, qualitative data were derived from suggestions and feedback from media and content experts who served as validators. Based on these findings, it can be concluded that the AR-based Flipbook BUCARA learning media is valid and appropriate for use as a learning medium to support the IPAS learning process on Plant Body Parts for fourth-grade students at SD Negeri Gunungpati 02 Semarang.

Implementation

The implementation stage was conducted on 24 February 2025 at SD Negeri Gunungpati 02 using the AR-based Flipbook BUCARA learning media. This media was applied through small-group trials and large-group trials – the product trial stage aimed to determine the practicality and effectiveness of the developed media. The learning process began with a preliminary activity, followed by the introduction and implementation of the AR-based Flipbook BUCARA media. At the end of the learning session, the researcher distributed test instruments and response questionnaires to both students and the teacher for completion.

Practicality Trial Results of the Learning Media

Small-Group Trial

The small-group trial involved 6 students of SD Negeri Gunungpati 02 with diverse academic abilities.

The participants consisted of two low-achieving students, two moderate-achieving students, and two high-achieving students. This trial aimed to examine the extent to which students with varying levels of academic competence could optimally utilize the learning media. The results of the small-group trial are presented in Table 3.

Table 3. Small-Group Trial Result

Assessment Aspects	Score	Percentage	Criteria
Motivation	47	97%	Very
Linguistic	70		Practical
Visual Appeal	93		
Practicality	94		
Relevance	48		

Based on the small-group trial results, the average student questionnaire score was 97%, placing it in the "Very Practical" category. During the small-group trial, no aspects of the media required revision. Therefore, the learning media were deemed suitable to proceed to the large-group trial stage.

Large-Group Trial

In the large-group trial, students who had participated in the small-group trial were not allowed to become respondents. Consequently, the large-group trial involved 23 students. The results of the large-group trial are presented in Table 4.

Table 4. Large-Group Trial Result

Assessment Aspects	Score	Percentage	Criteria
Motivation	184	99%	Very
Linguistic	276		Practical
Visual Appeal	361		
Practicality	368		
Relevance	185		

The findings from the large-group trial indicate that the average percentage score of the student questionnaire was 99%, classified as "very practical", with no revisions required. Students responded very positively to the media and expressed enjoyment while learning through the AR-based Flipbook BUCARA.

Teacher Response

The teacher response questionnaire was administered to the fourth-grade teacher of SD Negeri Gunungpati 02 Semarang. The questionnaire was completed based on the teacher's role as an observer during the researcher's classroom implementation of the Flipbook BUCARA media. The results of the teacher response assessment are presented in Table 5.

Table 5. Teacher Response

Assessment Aspects	Score	Percentage	Criteria
Motivation	12	98%	Very
Linguistic	10		Practical
Visual Appeal	12		
Practicality	15		
Relevance	10		

Based on the teacher response questionnaire, a 98% score was obtained, placing it in the "Very Practical" category. Considering the results from the small-group trial, the large-group trial, and the teacher's response, the learning media is categorized as very practical, as all percentage scores fall within the 84–100% range.

According to the results of the practicality trials, the AR-based Flipbook learning media demonstrates advantages that strongly support the implementation of IPAS learning (Dewi & Setyasto, 2024). This media is considered practical because it effectively attracts students' interest and learning motivation through interactive features and integrated educational games. In addition, the content within the Flipbook media can be further developed for various topics and is not limited to a single subject matter. The use of this media also encourages students to become more active in the learning process and can be easily accessed on smartphones or Chromebooks anytime, anywhere with internet connectivity.

These advantages position the AR-based Flipbook BUCARA as a practical learning tool that helps teachers deliver the Plant Body Parts topic. The results of both small-group and large-group trials show that students participated in learning activities enthusiastically and with high motivation. Therefore, the AR-based Flipbook BUCARA media can be concluded to be highly practical for enhancing students' interest and learning motivation in fourth-grade IPAS learning at SD Negeri Gunungpati 02 Semarang.

Results of the Media Effectiveness Trial

To measure the effectiveness of the learning media, students' learning outcomes were collected through pretests and posttests administered before and after students used the Augmented Reality-based Flipbook BUCARA. The learning outcome data were subsequently analyzed using four types of statistical tests: a normality test, a homogeneity test to ensure population data uniformity, a hypothesis test using a paired sample t-test to compare learning outcomes before and after the treatment, and an N-gain test to determine the average improvement in students' learning outcomes following the use of the learning media.

After the media trial was implemented, students were given an individual test. The test instrument

consisted of 20 multiple-choice questions. The students' learning outcomes are presented in Table 6.

Table 6. Pretest and Posttest Results

Data	Pretest	Posttest
Highest Score	70	100
Lowest Score	25	85
Mean	53	92.5
Total	29	29

Based on the pretest and posttest data for the topic Plant Body Parts involving a sample of 29 students, the pretest results showed a highest score of 70 and a lowest score of 25, with an average score of 53. Meanwhile, the posttest results indicated a highest score of 100 and a lowest score of 85, with an average score of 92.5. These data were further analyzed using SPSS.

A normality test was conducted to determine the appropriate statistical formula for data analysis. The results of the normality test are presented in Table 7.

Table 7. Normality Test Results

Learning Outcomes	df	Sig.	Description
Pretest	6	0.104	Normal
Posttest	6	0.415	Normal

Based on the Shapiro-Wilk normality test, the pretest data yielded a p-value of 0.104, while the posttest data yielded a p-value of 0.415. Since both significance values exceeded the 5% threshold (> 0.05), the null hypothesis (H_0) was accepted, indicating that the data were normally distributed.

After meeting the normality assumption, a parametric hypothesis test was conducted. The paired-samples t-test was used to compare pretest and posttest scores and to determine whether there was a significant difference in students' learning outcomes before and after the intervention (Soeprajogo & Ratnaningsih, 2020). In this study, the null hypothesis (H_0) stated that there was no significant difference between the pretest and posttest results. In contrast, the alternative hypothesis (H_a) stated that a significant difference existed. The level of significance was set at 5%, with H_0 accepted if the significance value was greater than 0.05 and H_a accepted if the significance value was less than 0.05. The results of the paired-samples t-test are shown in Table 8.

Table 8. Paired Sample T-test Results

Data	Pretest-Posttest
Mean	-17.93103
Std. Deviation	5.90358
t	-16.356
df	28
Sig. (2-tailed)	0.000

The Paired Samples T-Test analysis shown in Table 8 has a significant level of 0.000, which is less than 0.05, indicating that the t-value is statistically significant ($0.000 < 0.05$). Thus, H_0 was rejected, and H_a was accepted. This finding demonstrates a significant difference in students' learning outcomes before and after using the AR-based Flipbook BUCARA. Therefore, it can be concluded that there is a significant difference in the average learning outcomes between the pretest and posttest. This indicates a positive impact of the Flipbook BUCARA learning media based on Augmented Reality on enhancing IPAS learning outcomes, particularly for the Plant Body Parts material among fourth-grade students at SDN Gunungpati 02. In addition, a gain test was conducted to measure the average increase in student learning outcomes. The pretest and posttest scores were calculated using the following n-gain formula. The N-gain calculation results are presented in Table 9.

$$\text{N-Gain} = \frac{\text{Posttest score} - \text{Pretest score}}{\text{maximal score} - \text{Pretest score}} \quad (3)$$

Table 9. N-Gain Test Results

Data	Mean	Std. Deviation
N-Gain	0.7374	0.21440

The interpretation criteria are shown in Table 10.

Table 10. N-Gain Index Interpretation

N-Gain value	Criteria
$\text{N-Gain} \geq 0.70$	High
$0.30 < \text{N-Gain} < 0.70$	Medium
$\text{N-Gain} \leq 0.30$	Low

The N-gain analysis indicated an improvement score of 0.7374, which falls into the high category, as the N-gain value is greater than or equal to 0.70. This result reflects a substantial improvement in learning outcomes among the 29 fourth-grade students of SD Negeri Gunungpati 02.

In conclusion, based on the overall analysis, the AR-based Flipbook BUCARA learning media is efficacious in improving fourth-grade students' learning outcomes in the IPAS subject, particularly in the Plant Body Part topic, at SD Negeri Gunungpati 02 Semarang. This effectiveness is evidenced by the significant increase in students' pretest and posttest scores. The average pretest score of 53 increased to 92.5 after students learned using the AR-based Flipbook BUCARA, indicating a significant difference in learning outcomes.

Evaluation

Evaluation in this study was conducted throughout the development and implementation stages of the product in accordance with the applied development

model. During the development phase, evaluation was conducted by media and subject-matter experts, who served as validators and provided feedback and suggestions on the developed learning media. The results of the media expert validation indicated that the AR-based Flipbook BUCARA learning media was valid and highly feasible, with only minor revisions required based on the suggestions. Meanwhile, the material validation yielded feedback primarily in the form of suggestions to present the content on the functions of flower parts in a more detailed, in-depth manner to support students' optimal understanding better.

During the implementation phase, evaluation data were obtained from student and teacher response questionnaires administered after the use of the AR-based Flipbook BUCARA learning media. The questionnaire results showed that the media were effective for IPAS learning on Plant Body Parts. No critical feedback emerged from the student response questionnaires; instead, students demonstrated high enthusiasm, favorable responses, and a desire to reuse the media in future IPAS lessons. Teachers, on the other hand, provided feedback in the form of suggestions to adjust the font size to make the material presentation more straightforward. Overall, both students and teachers concluded that the AR-based Flipbook BUCARA learning media is efficient and effective for implementation in IPAS learning and can enhance students' interest, motivation, engagement, and learning outcomes.

Conclusion

The Augmented Reality-based BUCARA Flipbook was successfully developed using the ADDIE model as an innovative visual learning for supporting IPAS learning on Plant Body Parts for fourth-grade elementary students. The integration of Augmented Reality technology with an interactive flipbook provided visual and contextual learning experiences that helped students understand abstract concepts effectively. The results showed that the media were categorized as highly feasible and practical for classroom implementation, based on expert validation and positive responses from teachers and students. In addition, the media proved effective in improving students' learning outcomes, as indicated by an increase in the average score from 53 in the pretest to 92.5 in the posttest. The paired-sample t-test showed a significant difference between students' learning outcomes before and after using the media (Sig. 2-tailed = 0.000 < 0.05), while the N-Gain score of 0.7374 was categorized as high. Therefore, the AR-based BUCARA Flipbook can be concluded as an innovative and effective learning

medium for improving elementary students' IPAS learning outcomes. Future research is recommended to implement this learning media across broader subjects and educational levels, and to develop more interactive AR features further to enhance students' learning experiences.

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Author Contributions

This research article was published through the collaboration between the first author, L.A., and the second author, I.R. The first author, L.A., was responsible for conducting the research, collecting data, developing the learning media, designing the research instruments, testing and analyzing the data, and preparing the manuscript. The second author, I.R., contributed by providing supervision and guidance, reviewing the manuscript, validating the research instruments, and approving the final version of the article.

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Conflicts of Interest

Authors declare no conflict of interest.

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