JPPIPA 11(5) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of Augmented Reality Based Flip book Learning Media to Improve Learning Outcomes on IPAS of Eating and Eaten Materials

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Received: January 26, 2025
Revised: April 18, 2025
Accepted: May 25, 2025
Published: May 31, 2025

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DOI: 10.29303/jppipa.v11i5.11097

Abstract: This study aims to develop and evaluate the effectiveness of Augmented Reality (AR)-based Flip Book as learning media to improve students' understanding of food chain material in Elementary School Natural and Social Sciences (IPA-SD) subjects for grade V students of SDN 1 Munggu. This research uses a Research and Development (R&D) approach that adapts the Borg and Gall model with eight stages, namely needs analysis, product design, expert validation, product revision, product trials, and field trials, namely with pretest and posttest data. This AR-based flipbook obtained a media validation assessment of 93.75% with a very feasible category and material validation which obtained 88.75% with a very feasible category. Data collection using pre-test and post-test was carried out in two groups, namely large groups (N = 20) and small groups (N = 8). The results showed a significant increase in student learning outcomes, as indicated by statistical analysis that showed a significant difference between pre-test and post-test scores ($p < 0.05$). The N-Gain (Normalized Gain) value criteria for measuring learning effectiveness are generally categorized as low (<0.3), medium ($0.3 \leq$ N-Gain ≤ 0.7), and high (>0.7). In this media development, an N-gain of 0.38 was obtained which is included in the medium criteria, this indicates that the AR-based Flip Book is effective in increasing understanding, but further development is needed to get the optimal impact.

Keywords: Augmented reality; Elementary science; Flip book; Food chain; Interactive learning

Introduction

Regulation of the Minister of Education and Culture number 22 of 2016 concerning process standards for primary and secondary education in chapter I that "Education units organize the learning process in an interactive, inspiring, fun, challenging, and provide sufficient space for initiative, creativity, and independence in accordance with the interests, talents, physical development, psychological development of students, and motivate students to actively participate. Efforts to achieve this learning process can be supported by one of them with tools in the form of learning media as stated in the Minister of Education and Culture Regulation number 22 of 2016 concerning process standards for primary and secondary education chapter III paragraph 2j which states that learning media acts as a tool to convey subject matter in the learning process.

Education is the main pillar in creating quality human resources and being able to compete in the modern world. In the digital era, integrating technology in education is a strategic step to improve the efficiency and effectiveness of learning. Technologies such as Augmented Reality (AR) have great potential to support

How to Cite:
Silmi, S. I., & Bektiningsih, K. (2025). Development of Augmented Reality Based Flip book Learning Media to Improve Learning Outcomes on IPAS of Eating and Eaten Materials. *Jurnal Penelitian Pendidikan IPA*, *11*(5), 935-944. https://doi.org/10.29303/jppipa.v11i5.11097

more dynamic learning. AR works by combining real world and virtual elements in real-time, creating a more engaging and interactive learning experience. With this capability, AR provides an opportunity to make complex learning concepts easier to understand (Hadiapurwa et al., 2021).

In the context of Science subjects in elementary schools, students often have difficulty in understanding abstract concepts such as food chains. Food chains teach the relationship between living things in an ecosystem, which requires in-depth visualization to help students understand it. Conventional learning approaches, which rely on text and static images, are often ineffective in explaining the interrelationships between elements in the ecosystem in detail. This is where innovative technology-based learning media, such as Flip book combined with AR, becomes very important. AR-based flip books not only provide real visualization but also allow direct interaction, thus strengthening students' understanding of the material being taught (Sabitri et al., 2024). AR-based flip books bring renewal in learning by combining visual elements, text, animation, and sound. This media not only bridges the gap in students' understanding of abstract concepts but also increases learning interest and motivation. With Flip book, students can explore the material through creatively designed interactions, helping them connect theoretical information with practical applications in the real world. Flip book's ability to provide an engaging learning experience makes it a relevant tool in technology-based learning in the modern era (Hadiapurwa et al., 2021; Zainuddin et al., 2019).

Flip book is a learning media that presents information in a digital interactive book format, allowing users to turn pages virtually. The integration of Augmented Reality (AR) technology into Flip book allows the presentation of material in three-dimensional form that can be observed from various points of view, making it easier for students to understand the concepts taught. Research shows that the use of AR-based Flip book can increase student motivation and learning outcomes. For example, the development of AR-based Flip book learning media on animal classification material for grade V elementary school students shows that this media is very feasible to use and effective in improving student learning outcomes (Muliyani et al., 2024). Other studies also support the effectiveness of using AR-based Flip book in learning. Research conducted by Gusmania et al. (2018) found that the use of AR-based learning media was effective in improving students' understanding of concepts in vibration, wave, and sound materials. The results showed a significant increase in the average pretest and posttest scores of students after using AR-based learning media, with a tcount> ttable value of 19.482> 2.045 and a significance value of 0.000 (at df 29 and significance 0.05), which means that the use of AR-based learning media is effective for improving students' concept understanding.

Another study by Atut et al. (2023) developed AR-based Flip book media on water cycle material for grade V elementary school students. The results of media expert validation showed a score of 91.6%, material experts 90%, and grade V teachers of 93%, while the results of the trial to students reached 97.59%, so it was included in the "very relevant" category. This shows that AR-based Flip book media meets the criteria for feasibility of use during learning and is effective in helping students understand the scientific material of the water cycle. From these previous studies, the integration of AR into Flip book as an interactive learning media has proven effective in increasing student motivation and learning outcomes. Various studies have shown that the use of AR-based Flip books not only facilitates understanding of the concepts taught, but also increases student involvement in the learning process. The application of this technology in learning is expected to be an innovative solution to improve the quality of education in the digital era.

Based on what has been described above, the urgency of developing innovative learning media is becoming increasingly important along with the challenges of education in the digital era. Elementary school students, especially in Science subjects, often face difficulties in understanding abstract concepts such as food chains. This is reinforced by the results of an interview with the fifth grade teacher of SDN 1 Munggu, Mrs. Siti Fatimah, who stated that most students still have difficulty classifying the roles of producers, consumers and decomposers correctly. Although some students are familiar with the terms, their in-depth understanding of the relationship between living things in the food chain is still limited. This condition is exacerbated by the use of conventional learning media, such as textbooks and static images, which are less attractive to today's students who are more responsive to visual and interactive media. In addition, limited digital facilities such as projectors and internet access, as well as low teacher skills in integrating technology, also become obstacles in creating effective learning. Data on previous learning outcomes also showed that most students scored below the KKM, reflecting a low understanding of the material taught. So, based on pre-research activities through interviews with the fifth grade teacher of SDN 1 Munggu, problems were found in IPAS learning, especially in the material of eating and being eaten. This is evidenced by the IPAS scores obtained, which show that there are 16 students (80%) who scored below the KKM, while students who got a complete score were only 4 students (20%) out of a total

of 20 students. This is because students pay less attention to the teacher during the learning process. In addition, learning is still teacher-centered, there is no variety of models and methods in learning. Teachers have not used media in the implementation of IPAS learning.

Conventional learning methods that rely on text and static images are proven to be less able to convey material effectively, resulting in low student learning outcomes. Therefore, the integration of technology such as Augmented Reality (AR) in learning media is a relevant solution to create a more interactive and interesting learning experience. In this context, this research aims to develop learning media in the form of AR-based Flip book on food chain material for fifth grade students of SDN 1 Munggu. This media is designed to not only improve students' understanding of the material, but also assess its effectiveness in improving learning outcomes and students' responses to its use.

This research is expected to make a significant contribution to efforts to improve the quality of education, especially in science learning in elementary schools. AR-based flip books offer an interactive learning approach and are able to bridge the gap between theory and practice through three-dimensional visualization. In addition to providing better understanding, this media is also designed to increase student learning motivation, thus supporting the achievement of optimal learning objectives. The success of this media development can be a reference for the development of other technology-based learning media that are relevant to the needs of the times. This research not only provides solutions to specific problems in food chain learning, but also provides a foundation for broader educational innovation in the digital era.

The use of information technology (IT)-based learning media is increasingly important in the world of modern education. IT-based media is used to support the learning process by utilizing available technological advances. The presence of this media not only allows teachers to face various challenges in the learning process, but also introduces more innovative and effective teaching methods and techniques. This technology-based media allows for a more interactive transfer of information while creating a learning experience that is relevant to students' needs. The integration of technology in learning media, such as the use of computers, smart phones, e-learning applications, interactive videos, as well as technology-based simulations, provides new opportunities in creating a more dynamic and interesting learning process (Darmawan, 2022).

Information technology has great potential to support the learning process with various benefits. First, technology-based media can improve the quality of learning by focusing on the quality of learning processes and outcomes. Technology integration is designed to improve teaching effectiveness, so that students more easily understand the material being taught. Second, technology can expand access to education by providing equitable learning opportunities without being limited by geographical or economic barriers. With IT-based media, individuals from different backgrounds have equal opportunities to access quality learning resources (Suryani, 2018). Technology also plays a role in reducing the cost of education. By utilizing technology-based media, the provision of learning materials can be done in a more cost-effective manner, thus reducing the financial burden for students and their families. Participation in information technology is also a must in the modern era. The use of technology in education not only aids learning, but also strengthens students' engagement in the digital world, which is an integral part of today's society. Finally, technology-based media helps students develop the necessary IT skills, preparing them for the world of work and everyday life. By using technology in learning, students not only understand the subject matter, but are also skilled in utilizing technological devices productively (Darmawan, 2022; Suryani, 2018). Thus, information technology-based learning media not only serves as a tool in the learning process, but also as a strategic means to improve the quality, accessibility, and efficiency of education. In addition to creating a more relevant and interactive learning experience, this technology also makes an important contribution in preparing students for the challenges of the digital era. The combination of technological innovation and education allows for more inclusive, efficient and meaningful learning.

The use of flip books in learning is known to increase student motivation and interest. With an attractive design, Flip books present a fun learning experience and encourage active student involvement. Research shows that students are more interested in using Flip books than conventional media because Flip books combine visual and interactive elements that match the learning styles of today's students (Juliani et al., 2023). Flip books not only enrich the subject matter but also improve the quality of interaction between students and teachers, thus creating a more conducive learning atmosphere.

From a technical perspective, flip books provide efficiency advantages due to their digital format. Flip books can be accessed through electronic devices such as computers, laptops or smartphones, thus reducing reliance on costly and time-consuming printed materials. Simple navigation features, such as swipe or click, make Flip books easy to use by students from various levels of education (Alfitriani et al., 2021). This flexibility makes Flip books can be used in the classroom

as well as in distance learning, in accordance with the needs of modern education. In its application, Flip book also supports the development of students' visual literacy skills. Visual literacy includes the ability to understand and interpret information conveyed through visual symbols. By using Flip book, students can process information more quickly and deeply because visualization helps them associate abstract concepts with everyday reality. This is proven to increase students' understanding of learning materials, such as in science materials that require in-depth understanding of scientific concepts (Hadiapurwa et al., 2021).

Augmented reality (AR) is a technology that combines virtual elements with the real world in real-time, allowing users to view and interact with virtual objects projected onto the real environment. Unlike Virtual Reality (VR) which creates a completely virtual world, AR aims to enrich the real world by adding relevant virtual elements. This technology uses hardware such as cameras and software such as ARToolKitPlus to detect certain markers or patterns, which are then combined with databases to visualize virtual objects in three-dimensional form (Alfitriani et al., 2021).

The working principle of AR starts with a camera that captures real-world images, which are then processed using a special algorithm to match the marker with the existing database. Once the marker is recognized, the corresponding virtual object is projected onto the real world in real time. This technology has been widely applied in various fields, including education, healthcare, entertainment, and sports. In education AR makes it easier to learn abstract concepts by providing realistic three-dimensional visualizations. In science learning, AR is used to illustrate the structure of the earth, such as mountains, valleys, and plateaus, making it easier for students to understand material that was previously difficult to explain with only two-dimensional images (Alfitriani et al., 2021).

The application of AR in education provides many benefits, especially in improving the quality of learning. This technology provides an interactive and engaging learning experience, which not only strengthens students' understanding of abstract concepts but also increases their learning motivation. By using AR, students can interact directly with virtual objects that appear real, such as simulations of atmospheric layers or the structure of body organs. This ability of AR to present realistic virtual objects helps students develop their reasoning power and imagination. AR becomes one of the effective learning media to improve the quality of teaching-learning process, especially in subjects that require understanding of complex concepts (Özeren et al., 2023).

Method

This research uses the Research and Development (R& D) method to design, refine, and test learning media applied in the science learning process in class V SDN 1 Munggu. The research employs a Research and Development (R&D) approach, adapting the Borg and Gall model with eight stages, including needs analysis, product design, expert validation, product revision, and field testing. This adjustment was made to accommodate the limited time and costs available during the research implementation. The initial step of the research began with a process of observation, interviews, and documentation to identify student needs in science learning. Data was then collected through questionnaires given to teachers and students to get an overview of the specific needs of learning media. Based on this initial data, an initial design of Flip book-based learning media with Augmented Reality (AR) technology was developed. This design is designed in line with the Learning Outcomes (CP) for grade V science material, especially on the topic of food chains, by emphasizing the presentation of interactive and visual material. This study used three data collection techniques. The interview technique was used to obtain data at the needs analysis and development stages. The questionnaire technique was used to collect data on expert validation of the developed product and the level of product practicality. The test technique was used to obtain initial data on students' critical thinking and creative thinking skills and measure the effectiveness of the product through pretest and posttest.

The next stage is design validation by media experts and material experts using a Likert scale-based validation sheet. The assessment includes several aspects, such as material suitability, display quality, language, and pedagogical feasibility. Feedback from this validation was used to revise the initial design to make it more optimal. After revision, the media was tested in two stages. The small-scale trial was conducted on grade V students selected through purposive sampling technique to represent various levels of cognitive ability. The selection of respondents or small-scale trial students was 30% of the total actual respondents. A wide-scale trial was conducted on students to evaluate the effectiveness of the media in improving learning outcomes. Data collection was conducted using qualitative and quantitative methods. Qualitative data was obtained through observation, interviews, and questionnaires, while quantitative data came from student learning outcomes. The research instruments included expert validation sheets, student needs questionnaires, and pretest and posttest questions (Sugiyono, 2019).

After the data was collected, the analysis was carried out using a Likert scale to measure the feasibility of the media based on expert evaluation, and a Guttman scale to assess the practicality of the media. The effectiveness of the learning media was measured using the N-Gain Test, which compares pretest and posttest scores. Based on the N-Gain, the results were classified into low (<0.30), medium (0.30-0.70), and high (>0.70) categories, to determine the level of improvement in student learning outcomes (Jelita et al., 2022).

Result and Discussion

This study produces a product in the form of an AR-based flipbook on the material of eating and eating grade V SD. The results of the development of AR-based flipbooks to answer the problem formulation, namely: characteristics of AR-based flipbook media as learning media for grade V elementary school IPAS learning; feasibility of AR-based flipbook media as learning media for grade V elementary school IPAS learning; the effectiveness of AR-based flipbook media as learning media for grade V elementary school IPAS learning. This is supported by previous research conducted by Anggita et al. (2023) suggesting that teachers should be able to increase students' enthusiasm in learning by connecting learning with real-world experiences because most students consider IPAS as a fun learning experience, while a small number of students consider IPAS boring. One way to make students more enthusiastic in learning is with the existence of learning media. The development of this media can be a solution to make learning more interesting and fun and attract students' attention to be more enthusiastic in learning. In the AR-based flipbook developed by researchers there are supporting materials for media content such as characters, sounds, instructions, competencies, teaching materials, and developer profiles. The following is a display of AR-based flipbooks of eating and eating materials according to the design that has been designed.

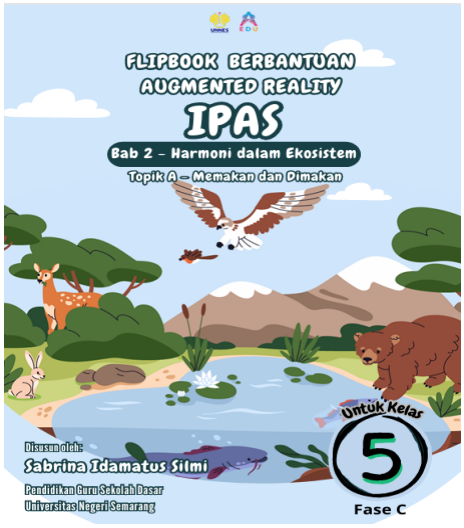

Figure 1. Front cover of flipbook

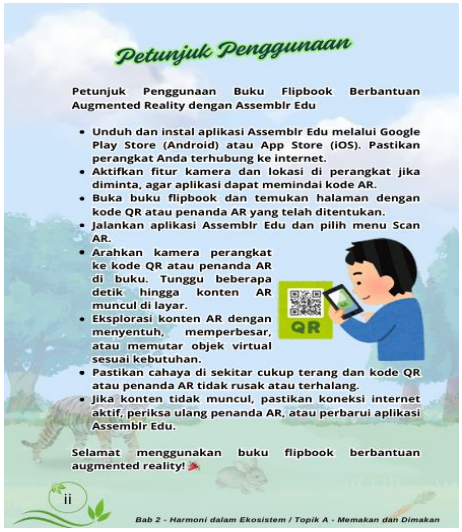

Figure 2. Directions for use

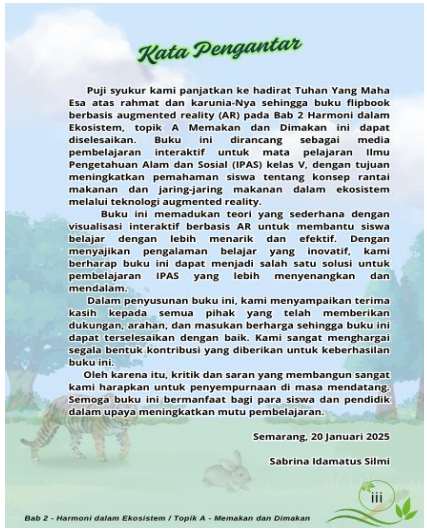

Figure 3. Foreword

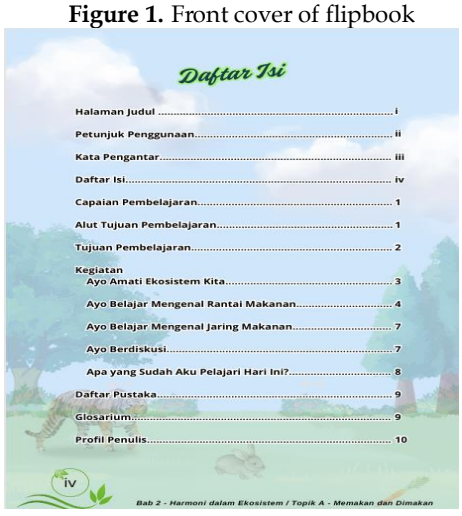

Figure 4. Table of contents

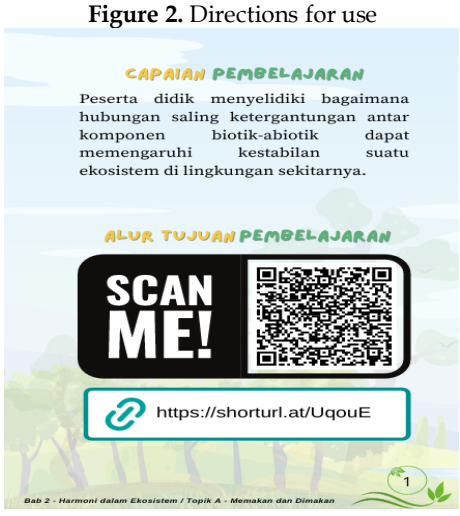

Figure 5. Learning outcomes

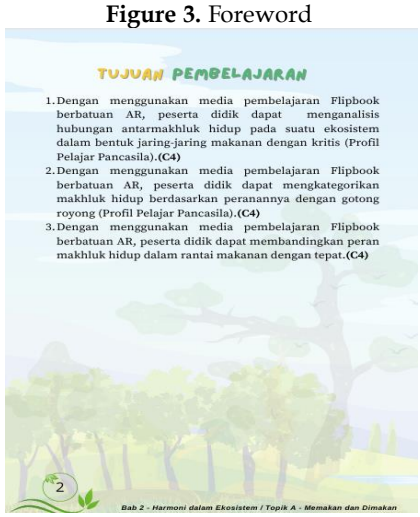

Figure 6. Learning objectives

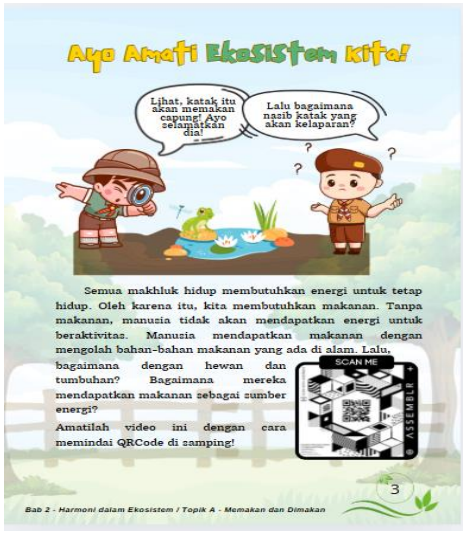

Figure 7. Material 1

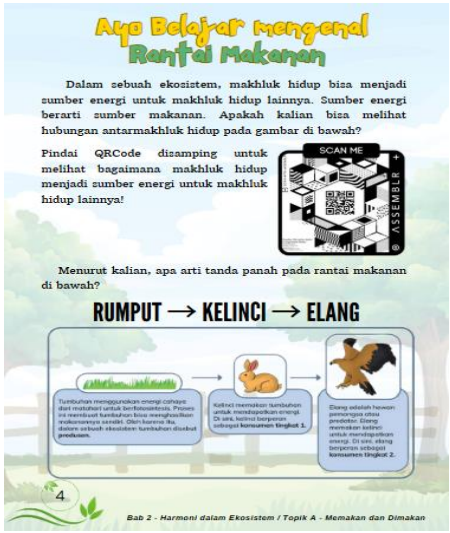

Figure 8. Material 2

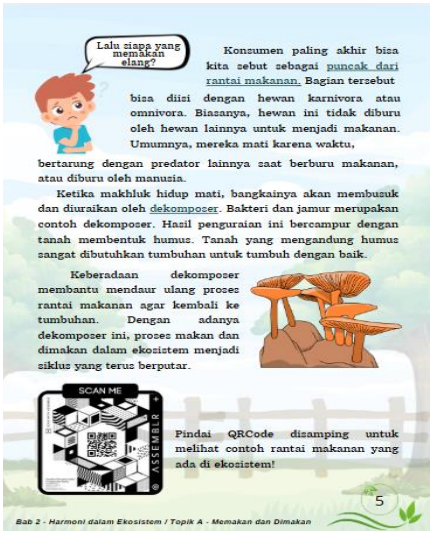

Figure 9. Material 3

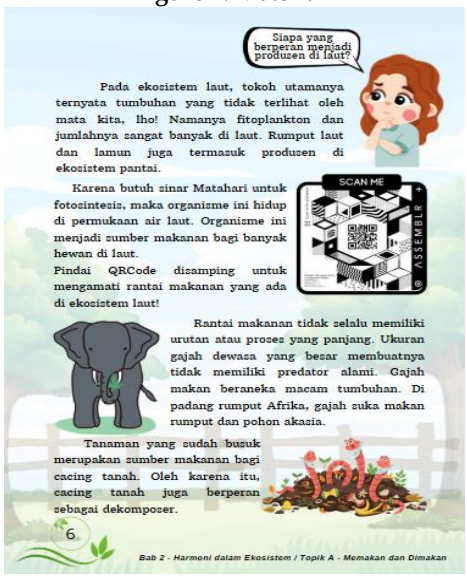

Figure 10. Material 3

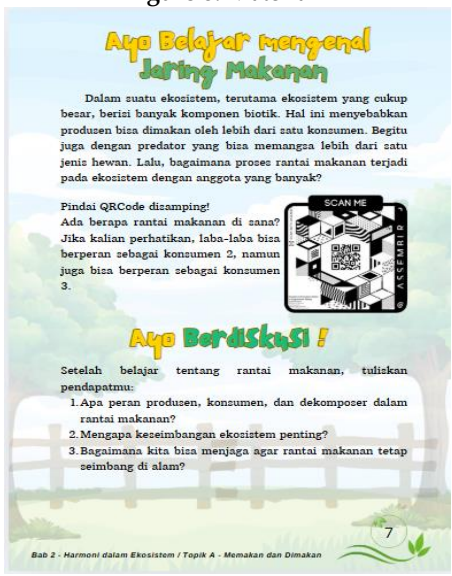

Figure 11. Material 4

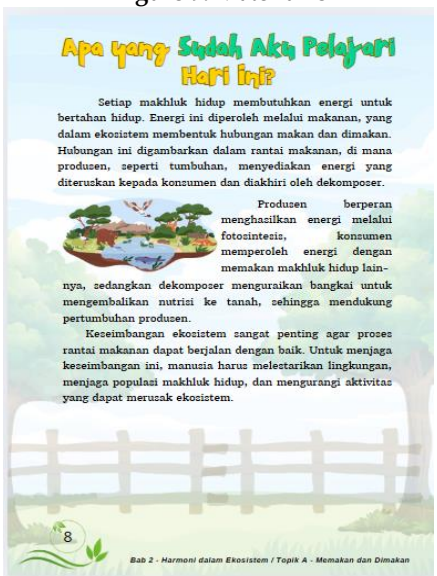

Figure 12. Material 5

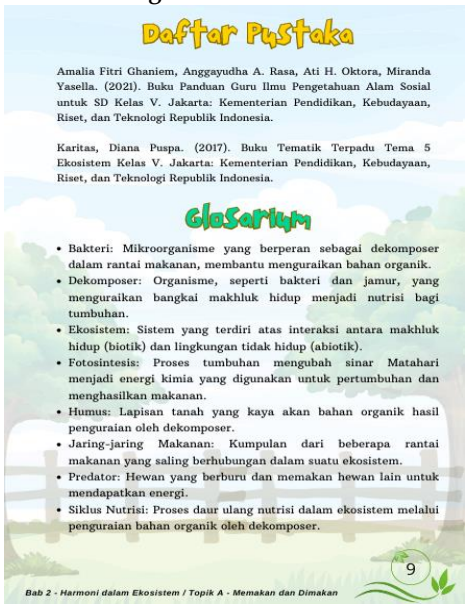

Figure 13. Glossary and bibliography

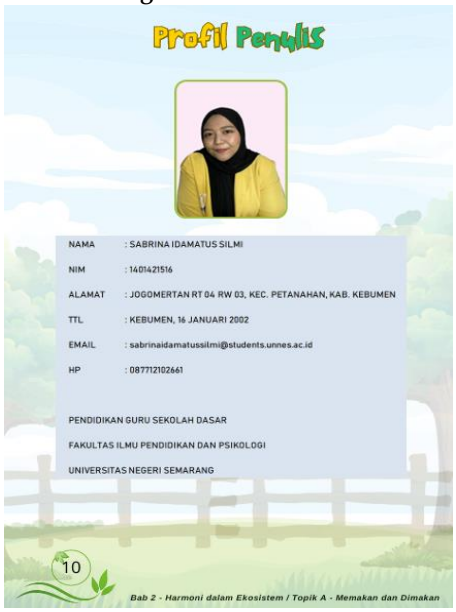

Figure 14. Author

In the validation process, the feasibility of media and media development materials for IPAS learning will be assessed. The developed media materials will then be given input for improvement or revision. Improvements or revisions are made to ensure that the media material is suitable as a learning tool at school.

Table 1. Flipbook Expert Validator Assessment Results

Validation Design	Index Validasi (%)	Description
Material expert	88.75 %	Very valid
Media expert	93.75 %	Very valid

Based on the results of media and material validation, the results of the media developed are feasible and can be a learning media in grade V elementary school, in accordance with the research of Yusuf et al. (2022) with the results of media expert validation showing a percentage value of 97% with valid and feasible criteria based on predetermined criteria. Likewise, data analysis from material experts obtained 95% results with valid criteria and feasible to use in the learning process.

A recapitulation of the data from teacher and the students response questionnaire on AR-based flipbook learning media can be seen in table 2.

Table 2. Recapitulation of Teacher and Students Response Assessment Results

Respondent	Percentage	Description
Teacher	100 %	Very valid
Student	92.53 %	Very valid

The teacher's response results obtained a percentage of 100% with a very feasible category and student responses obtained a percentage of 92.53% with a very feasible category. The table shows that the results of student responses show that the response criteria are "very feasible" indicating that students are interested in the AR-based flipbook development developed. This is in accordance with research from Atmoko et al. (2017) providing media response questionnaires to students and teachers. The results of the student response questionnaire get an average percentage of 94.4% said to be feasible and acceptable to students.

In this study, before conducting the Paired Sample T-Test test, this study first conducted a normality test using the Shapiro-Wilk Test to ensure that the Pre-Test and Post-Test data were normally distributed. The normality test was conducted using the Shapiro-Wilk Test to evaluate whether the Pre-Test and Post-Test data in the large group and small group followed a normal distribution. If the data is normally distributed, parametric statistical tests such as the Paired Sample T-Test can be used, while if it is not normally distributed, it is necessary to use non-parametric methods such as the Wilcoxon Signed-Rank Test. Based on the results of the analysis, the p-value for the Large Group Pre-Test was 0.222, the Large Group Post-Test was 0.213, the Small Group Pre-Test was 0.867, and the Small Group Post-Test was 0.680. All p values are > 0.05, which means that the data is normally distributed.

Table 3. Normality Test Results of Pretest and Posttest Data

Class		Shapiro-Wilk		
		Statistic	df	Sig.
Test Results	Pretest of large group	.938	20	.222
	Posttest of large group	.937	20	.213
	Pretest of small group	.966	8	.867
	Posttest of small group	.947	8	.680

After conducting the normality test, this study continued the analysis with the Paired Sample T-Test to measure the significant difference between Pre-Test and Post-Test in two groups: Large Group and Small Group.

Table 4. Paired T-Test Results of Pretest and Posttest Data

	t	df	Sig. (2-tailed)
Pretest of large group & postest of large group	-10.004	19	.000
Pretest of small group & postest of small group	-6.436	7	.000

The significance value (Sig. 2-tailed) = 0.000 obtained from this test indicates that there is a significant difference between the Pre-Test and Post-Test in both groups, both Large Group (df = 19, t = -10.004) and Small Group (df = 7, t = -6.436). With a p-value = 0.000, this difference is very significant, which means that the increase in learning outcomes after using the Augmented Reality (AR) based Flip Book does not occur by chance, but because of the effectiveness of the learning media itself. These results are in line with the Multimedia Learning theory proposed by Mayer (2014) which explains that the use of visual and interactive-based technology in learning can significantly improve students' understanding of abstract concepts (Mayer, 2009, 2014). In the context of this research, the AR-based Flip Book allows students to see a visual model of the food chain in three dimensions, which helps them in understanding the relationship between living things in the ecosystem better. The combination of visual and interactive elements provided by AR allows students to build experiential understanding, which cannot always be achieved with conventional learning methods based on text or static images.

In addition, the results of this study indicate that the utilization of Augmented Reality in Flip Book can be an innovative solution in improving the effectiveness of learning, especially in IPAS subjects that require an

understanding of scientific concepts. This technology not only functions as a visual aid, but also as an interactive media that can increase students' absorption of complex material. This result is in line with Wu et al. (2013) who state that Augmented Reality can increase student engagement in learning because it provides a more real and contextual experience than traditional learning methods. Therefore, AR-based Flip Book can be used as one of the digital learning strategies that is more interesting, effective, and in accordance with student learning needs.

From a juridical point of view, these results are in line with the mandate of Law Number 20 of 2003 concerning the National Education System, which states that education must be developed dynamically following the development of science and technology. Law No 20 of 2003 on the National Education System, Article 3 emphasizes that national education aims to develop the potential of students to become faithful, pious, knowledgeable, capable and creative human beings. In Permendikbud Number 22 of 2016 concerning Process Standards for Primary and Secondary Education, it is explained that the learning process must be carried out interactively, inspiring, fun, challenging, and motivating students to actively participate. Thus, the development of AR-based Flip Book is in line with national policies that encourage innovation in technology-based teaching and learning processes to improve the overall quality of education.

The results of the N-Gain Score analysis from large groups and small groups show that the use of Augmented Reality (AR)-based Flip Book in learning IPAS material Eating and Being Eaten has succeeded in improving student learning outcomes, although it is still in the medium category.

Table 5. N-Gain Test Results of Pretest and Posttest Data

Descriptive Statistics			
	N	Mean	Std. Deviation
Ngain_score_large group	20	.3909	.178
Ngain_score_persen_ large group	20	39.086	17.858
Valid N (listwise)	20		
Ngain_score_small group	8	.381	.091
Ngain_score_persen_ small group	8	38.112	9.198
Valid N (listwise)	8		

Based on the N-Gain Score division category table according to Melzer in Dzahabiyah et al. (2021), the mean N-Gain Score value for the large group was 0.3909, while for the small group it was 0.3811, both of which were in the range of $0.3 \leq g \leq 0.7$, so it was categorized as a moderate improvement. If converted into a percentage, the mean N-Gain Score value of the large group reached 39.0860%, while the small group reached 38.1126%, which means that there is an increase in learning outcomes after the use of AR-based Flip Book, but it has not reached the optimal level. These findings indicate that AR-based learning is able to have a positive impact on student understanding, although it has not yet reached the maximum level of effectiveness. The not-so-significant difference between the large group and the small group indicates that the AR-based Flip Book can be applied on a wider learning scale without experiencing a decrease in effectiveness.

From a broader perspective, although it has shown a fairly good improvement in learning outcomes, this study also sees that the effectiveness of AR-based Flip Book can still be further improved to reach the high category ($g > 0.7$). One strategy that can be done is to increase the interactivity of the media, such as adding AR-based exercises, more directed instructions, or more complex three-dimensional animations to make students more interested and motivated to explore the material.

Conclusion

Based on the results of the analysis above, it can be concluded that the use of Augmented Reality (AR)-based Flip Book in learning IPAS material Eating and Being Eaten is proven effective in improving student learning outcomes. The results of the analysis show a significant increase in student understanding after using this media, which indicates that the AR-based Flip Book is able to present material in a more interesting, interactive, and easy-to-understand way. Through statistical analysis of the results of media trials in learning involving 20 students as respondents, it is evident that the media developed has a significant impact and is quite effective in supporting efforts to improve student learning outcomes. This is evidenced by the results of the media validation assessment which obtained 93.75% with a very feasible category and material validation which obtained 88.75% with a very feasible category. Data analysis of students' pretest and posttest scores has increased with a significant difference between pretest and posttest scores, namely $p < 0.05$ and N-gain of 0.38 which is included in the medium criteria. This proves that AR-based flipbooks are effective for improving the learning outcomes of fifth grade elementary school students on food and eating material, the increase is at a moderate level. In addition, the results also show that although the effectiveness of this media is quite good, there are still opportunities to further optimize its impact in learning. To achieve maximum results, further development can be done by adding more in-depth interactive features, AR-based

question exercises, and more structured instructions so that students are more active in the learning process.

Acknowledgments
Thank you to my supervisor for all the guidance, direction, and support that has been given during this research process. Thank you to SDN 1 Munggu Kebumen City for giving permission and opportunity to conduct the research, as well as to the principal, teachers, and all school members for their assistance and cooperation. Thank you to Mataram State University for facilitating the production of this article and to the editors who have reviewed and studied this article. Thank you to the respondents who have been willing to take the time and provide the information needed, and also to my family and friends for their prayers, support, and encouragement that always strengthen me. All forms of help and kindness given are very meaningful for the smoothness and completion of this research.

Author Contributions
Sabrina Idamatus Silmi contributed to conducting research, developing products, analyzing research data results, and writing draft articles. Kurniana Bektiningsih as a supervisor in research activities until writing the article, as well as providing critical input on the article manuscript.

Funding
This research is research funded by private funds owned by researchers, not receiving funding from outside parties.

Conflicts of Interest
The authors declare that there is no conflict of interest regarding the publication of this paper.

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