Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

# Development of the Augmented Reality Book to Improve Learning Outcomes of Photosynthesis Material in *IPAS* Learning

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Received: May 22, 2025. Accepted: June 16, 2025. Published: June 30, 2025

**Abstract:** Teachers have not been optimal in using technology-based teaching materials, causing the learning outcomes of fourth-grade students of Purwoyoso 04 State Elementary School in Semarang City on *IPAS* subjects, especially photosynthesis material, to be low. This study aims to describe the development design, test the feasibility, and effectiveness of the Augmented Reality Book to improve student learning outcomes. This type of research is Research and Development (R&D) with the Borg and Gall model. Data were collected through tests (pre-test and post-test) and non-tests (observation, interview, and questionnaire), then analyzed using a normality test, t-test, and N-gain. The results showed that the development design using Assemblr Edu and Canva applications produced an interactive and innovative Augmented Reality Book with components of instructions for use, CP and TP, concept maps, Problem-Based Learning-based materials, 3D content, interactive learning videos, student worksheets, and quizzes. The feasibility of the product from material experts is 92.5% and material experts are 89% very feasible criteria, supported by the results of the analysis of teacher and student response questionnaires of 100% very feasible criteria. The effectiveness of the product is shown by an increase in pre-test and post-test by 22%, supported by a t-test showing the value of Sig. (2-tailed)=0.001< 0.05, which means there is a significant difference between learning outcomes before and after using the product, as well as an N-gain score of 0.64 in the medium category. The conclusion of this study shows that the Augmented Reality Book was successfully developed, feasible and effective in improving learning outcomes of photosynthesis material in *IPAS* learning class IV SD Negeri Purwoyoso 04 Semarang City.

**Keywords:** Augmented Reality Book; *IPAS*;Learning Outcomes; Photosynthesis.

## Introduction

Education plays an important role in developing abilities, shaping the character, and civilization of the nation. The government guarantees the quality of education through the National Education Standards [1] which reads "National education functions to develop abilities and shape the character and civilization of a dignified nation in order to educate the nation's life, aims to develop the potential of students to become human beings who are faithful and devoted to God Almighty, noble, healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizens". The goal is to develop students' potential to become people of faith, piety, noble character, healthy, knowledgeable, independent, creative, democratic and responsible. *IPAS* (Natural and Social Sciences) learning acts as a strategic tool in realizing these educational goals by fostering curiosity, critical thinking skills, and social and environmental awareness in students.

*IPAS* is a subject that aims to build science literacy. IPAS subjects include the study of living things, inanimate objects in the universe, and the interaction between the two [2]. *IPAS* aims to strengthen the understanding of social-science and environmental science psychomotor skills through active learning, such as experiments and simulations. Learning is done in a real way by linking branches of science and everyday experiences, so that students understand the relevance of science in a broad context [3].

The scope of *IPAS* in basic education includes the development of scientific knowledge, skills, and attitudes to build students' understanding of nature and their lives [4]. The material taught focuses on essential concepts, such as living things, energy, the earth, and the environment. This is referred to in the revised edition of the Kemendikbudristek Teacher's Book 2023 [5]. One example is photosynthesis material in grade IV, which teaches students to understand the process of plants producing oxygen and glucose by utilizing light, water, and carbon dioxide. This is supported by the use of technology-based teaching materials, which make abstract concepts in the photosynthesis process more concrete and easy to understand.

Teaching modules are learning tools that are systematically arranged based on the curriculum used, with the aim of supporting the achievement of established competency standards [6]. E-Module is one of the digital-based non-print teaching material products that is independently designed to be studied by students [7]. Teachers can utilize digital technology in teaching *IPAS* by incorporating various types of materials learning, such as audio, video, text, images, and animations, which can be accessed through electronic devices such as smartphones, laptops, and others.

**How to Cite:**
N. I. Armia and A. E. Andriani, "Development of Augmented Reality Book to Improve IPAS Learning Outcomes", *J. Pijar.MIPA*, vol. 20, no. 4, pp. 700–709, Jun. 2025. https://doi.org/10.29303/jpm.v20i4.9116

E-Modules at least contain learning objectives, learning steps (which include learning media to be used), assessments, information, and other learning references that can assist teachers in carrying out learning [8]. The components in E-Modules must be compiled completely in the learning process, because this is one of the determining factors for the success of learning and provides great benefits for teachers in delivering material and developing E-Modules effectively. E-Module development aims to provide teaching tools that guide teachers in learning and are tailored to student characteristics [9]. The efforts made by researchers are to develop E-Modules that are inserted with Augmented Reality using the Assemblr Edu and Canva applications, which are then referred to as Augmented Reality Books.

Augmented Reality book-based learning with the help of the Assemblr Edu application makes student perception clearer through 3D objects and Augmented Reality [7]. Augmented Reality Book can also encourage students' active involvement, develop creativity, and strengthen their memory through direct interaction with digital elements such as animations, 3D models, or videos relevant to the learning content. This is in line with the purpose of this development, to assist students in understanding learning materials and visualizing abstract concepts [10].

Based on the results of pre-research conducted on teachers and fourth-grade students of Purwoyoso 04 State Elementary School in Semarang City on September 18, 2024, several problems were found related to *IPAS* learning. The problems found by teachers are not optimal in using technology-based teaching materials. Implementation of learning in class IV SD Negeri Purwoyoso 04, photosynthesis material, teachers stated that in learning activities, teaching materials used were such as textbooks sourced from the Ministry of Education and Culture, and not technology-based. Although teachers have used textbooks from the Ministry of Education and Culture and learning videos from YouTube, the material taught, such as photosynthesis, still relies on conventional teaching materials. This is supported by a statement from [11] that teachers are required to design the learning process as well as possible, if in the learning process the teacher does not have ideas for developing interactive teaching materials and is not innovative during the learning process, it can have an impact on learning outcomes.

In the textbook held by the teacher, there is already photosynthesis material equipped with Problem-Based Learning (PBL) syntax. In its application, the teacher has not been able to maximize the Problem-Based Learning learning model. So, the problem found is that students are less able to design concepts on photosynthesis material, and the lack of varied teaching materials results in low learning outcomes on photosynthesis material. This is in line with the results of other studies, which state that the Problem-Based Learning model can effectively improve student learning outcomes [12].

The level of cognitive learning achievement of fourth-grade students is still relatively low, as indicated by the results of the diagnostic assessment on *IPAS* learning material on photosynthesis, where 75% of students scored below the Minimum Passing Criteria (KKTP) of 78. It can be concluded that *IPAS* learning on the photosynthesis material has not run optimally. This is supported by the statement [13] that digitizing learning tools can be a solution to overcome low interest in learning, which has an impact on student scores that have not met *KKTP*, one of which is in a simple way that teachers can do, namely, increasing students' digital literacy skills through the use of digital teaching materials.

The low learning outcomes were influenced by the students' limitations in constructing an understanding of abstract material. One of them is triggered by the teacher's dependence on teaching materials from the government without any new innovations, resulting in an incorrect understanding of the subjects taught [14]. Students experience obstacles in understanding the concept of photosynthesis because there are foreign terms that they do not encounter in everyday life. In addition, the process of photosynthesis is abstract because it takes place in the plastid organelles found in the leaves, making it difficult for students to imagine without the help of adequate visualization.

The combination of E-Modules and Augmented Reality increases students' learning motivation because they are active in the learning process through thorough observation and visualization of objects [15]. This study focuses on presenting material that integrates 3D content with Problem-Based Learning syntax presented systematically. Concept visualization is achieved through the use of images and educational videos designed by the researcher, thereby facilitating students' understanding of abstract material. Additionally, the developed product is designed to provide stimuli that encourage active student engagement, present comprehensive material explanations, and include engaging quizzes.

Research that supports this problem is research conducted by [16] shows that Augmented Reality Book-based media in science subjects can be declared valid and practical. Research [17], shows that AR Book Math is very effectively used in learning mathematics on the material Volume Buildings Space in elementary school. Meanwhile, research [18] that the product is very feasible and effective to use in learning.

Referring to previous research studies, the innovation of this research focuses on the development of Augmented Reality Books for fourth-grade students, with application to photosynthesis material at Purwoyoso 04 Elementary School. This research presents visual material in the form of 3D content that provides real visualization to help understand abstract concepts. In addition, innovation is also seen in the learning syntax, such as group division based on student ability and organizing discussions, which support material understanding and build students' collaborative skills. Previous research has not specifically developed an Augmented Reality Book aimed at learning photosynthesis in grade IV SD. In addition, the Problem-Based Learning model, which is tailored to students' abilities, is also still rarely applied. Therefore, this research presents an innovation in the form of an Augmented Reality Book with 3D content and Problem-Based Learning syntax to improve understanding of abstract concepts.

The development of this Augmented Reality Book is expected to be an innovative solution in overcoming *IPAS* learning problems while improving overall student learning outcomes. Based on the background described above, the

purpose of this study is to describe the development design, test the feasibility, and evaluate the effectiveness of the Augmented Reality Book in improving *IPAS* learning outcomes on photosynthesis material for fourth-grade students at SD Negeri Purwoyoso 04 in Semarang City.

## Research Methods

This research uses the type of Research and Development (R&D) with the development model of Borg and Gall. The sequence of research and development stages is described as follows [19]:

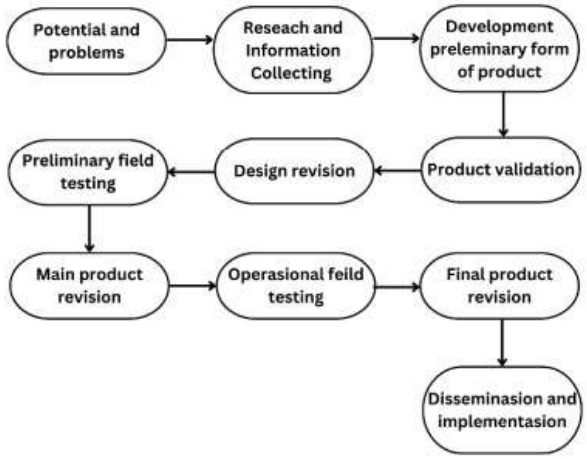


**Figure 1.** Stages of R&D Research Using the Borg and Gall Model.

Researchers carried out 10 stages as follows: potential and problems; data collection; product design; design validation; design revision; product trial; product revision; usage trial; final product revision; and mass production and implementation. This research was conducted up to the mass production and implementation stage. The deployment of the Augmented Reality Book was carried out in a limited manner [20], namely in the elementary school used as a research site, namely SD Negeri Purwoyoso 04, Semarang City, in class IV. The research subjects consisted of 24 fourth-grade students of SD Negeri Purwoyoso 04, Semarang City, consisting of 11 male students and 13 female students. This study involved two types of groups, namely small groups and large groups. The small group consisted of six students who were selected proportionally based on academic achievement, namely two high achievers, two medium achievers, and two low achievers out of a total of 24 students. Meanwhile, the large group consisted of 18 other students. The data collection technique used tests, namely pre-tests and post-tests, consisting of 20 multiple-choice questions with levels of difficulty ranging from easy, medium, and difficult, as well as non-tests, namely observation, interviews, questionnaires, and documentation. This instrument sheet is the result of the adaptation of instruments that have been developed by previous researchers [46]. Data analysis techniques were carried out through normality tests, t-tests to measure effectiveness [21] and N-gain tests to determine the improvement of student learning outcomes [22].

## Results and Discussion

The results of the Augmented Reality Book development research aim to describe the development design, test the feasibility and effectiveness to improve the learning outcomes of *IPAS* fourth-grade students of Purwoyoso 04 State Elementary School, Semarang City.

### Augmented Reality Book Development Design

Based on the Borg and Gall development model, researchers designed and compiled the Augmented Reality Book development design through predetermined stages.

The first stage is Potential and Problems. At this stage, what needs to be done is to conduct a field study by visiting a place that will later be used as a research location [20]. This stage aims to understand the needs and problems that exist, which is an important first step as a basis for product development. At this stage, researchers identified learning problems at SD Negeri Purwoyoso 04 by conducting interviews with teachers, observing teaching and learning activities, and reviewing related documents. A number of main problems were found, such as the less than optimal use of technology-based teaching materials by teachers, the application of Problem-Based Learning has not been optimal, the low cognitive outcomes of students, and the lack of visualization on abstract material. On the other hand, a potential analysis was conducted to assess the utilization of devices such as mobile phones, as well as the availability of supporting facilities such as wifi and LCD. In its implementation, students are allowed to bring cell phones to school with an agreement and permission from the school and their parents.

The second stage is Data Collection. This stage includes collecting various information related to teaching materials or supporting media [23]. Researchers distributed questionnaires analysing the needs of teachers and students. The data from the questionnaires was then compiled and used as the basis for designing products aimed at addressing the problems identified. Based on the results of the needs analysis questionnaire, it is known that teachers and students need Augmented Reality Book as an additional teaching material to increase students' knowledge and understanding of *IPAS* material, especially photosynthesis material that is abstract because it takes place in the plastid organelles contained in the leaves, making it difficult to imagine by students without the help of adequate visualization. The expected Augmented Reality Book must be visually appealing in order to facilitate students ' understanding of the material and significantly improve learning outcomes. The teacher also said that the Augmented Reality Book must pay attention to the harmony of the layout, contain images, video, and clear sound, as well as use simple language that is easily understood by students.

The third stage is Product Design. Researchers designed the Augmented Reality Book, which began with prototyping. The purpose of this stage is to design products that suit the needs of teachers and students [20]. In this stage, researchers design learning tools that will be used during the learning process [24]. The applications used to design the product are Assemblr Edu and Canva. Assemblr Edu is an Augmented Reality (AR) technology-based learning application that allows teachers to create, access, and display

interactive 3D content. The augmented reality platform used specifically for educational purposes with 3D and AR technology, facilitates the learning process by creating interactive learning media [25]. According to [26] Canva is an online design platform that offers a wide range of features, such as creating presentations, resumes, posters, flyers, brochures, graphics, infographics, banners, bookmarks, newsletters, and various other design needs available in the application. The use of Assemblr Edu and Canva applications facilitates the process of making an Augmented Reality Book, so that the display becomes more practical and easily accessible to students. This also helps in improving students' understanding of learning materials. After the design is completed through the two applications, the file is downloaded in PDF format and converted into a flipbook so that it can be used as an Augmented Reality Book, which is then shared with students via a link.

The novelty of this research lies in the presentation of material that utilizes 3D content to visualize abstract concepts, thus helping the teaching process to be more interactive and improving student understanding [27]. The Augmented Reality Book that was developed also integrates interactive elements in the form of images, videos, audio, and interactive quizzes to reinforce understanding of the concept of photosynthesis in a more tangible way. In addition, innovation is also evident in the application of learning syntax, such as grouping students based on ability and managing discussions, which not only helps students master the material but also develops their collaborative skills. The results of the product development are shown in Figure 2.


**Figure 2.** Achievement Indicators and Concept Map

This page contains the Learning Outcomes (CP) and Learning Objectives (TP). The CP emphasizes students' understanding of the preservation of natural resources and mitigation of environmental change, while the TP covers two topics: the process of photosynthesis and its impact. In addition, there is also a concept map page that serves to help students understand the overall picture and relationship between concepts in the material to be learned, thus facilitating the learning process in a structured and comprehensive manner.

**Figure 3.** Syntax 1

The innovation of this development is reflected in the implementation of the learning syntax, starting from the stimulus variation in the first syntax. In the first and second lessons, students were presented with visualizations in the form of images and interactive videos made directly by the researcher. The audiovisual display aims to facilitate understanding of the material and help students in mastering abstract concepts more realistically [28].

**Figure 4.** Syntax 2 and 3

In the second syntax, students were grouped based on their level of understanding. In addition, the steps of working on the LKPD were also arranged. Furthermore, in the third syntax, the material is delivered with the help of images, 3D content, and interactive learning videos that encourage discussion between students.

**Figure 5.** Syntax 4 and 5

The fourth syntax includes activities to present student work in front of the class. Meanwhile, in the fifth

syntax, students are invited to draw conclusions from the material that has been learned. In addition, there is an interactive quiz designed to stimulate critical thinking skills, as well as a glossary that helps students understand the scientific terms used in learning.

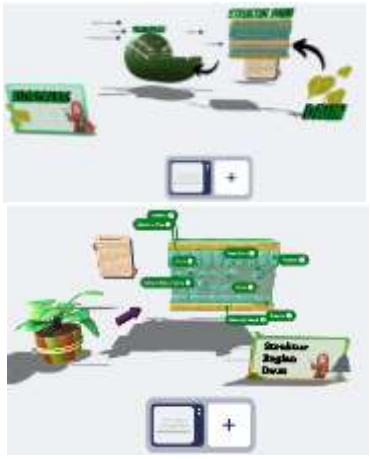

**Figure 6.** Augmented Reality

In the first lesson, the chloroplast and leaf material are presented with the help of augmented reality. Augmented reality aims to help students understand abstract concepts in a more real way. In the augmented reality display, new vocabulary is also provided, which makes it easier for students to understand the material. In addition, each part of the chloroplast is accompanied by an explanation of its function.

**Figure 7.** Augmented Reality

In the second lesson, the photosynthesis process is presented through augmented reality-based dioramas. This diorama allows students to see visually and interactively how the photosynthesis process takes place, starting from the absorption of sunlight to the formation of glucose. This augmented reality helps students understand the complex process flow in a more real and fun way. In the display, new vocabulary related to photosynthesis is also available to enrich students' knowledge.

The fourth stage is Design Validation. At this stage, the researcher validated that the product design has been designed [29]. The design validation stage aims to assess the feasibility of the material and media content of the developed product and see whether it meets the predetermined criteria or not [20]. At this stage, material experts evaluate the learning content, such as the topic of photosynthesis, by considering the clarity of concepts, relevance to the curriculum, and suitability for student needs. Meanwhile, media experts focus their assessment on visual, technical, and interactive aspects, including appearance, interface design, and ease of use. If there are any shortcomings, validators will provide feedback or recommendations for improvement to enhance product quality in line with the expected learning objectives.

The fifth stage is Design Revision. The activities carried out at this stage are to revise the Augmented Reality Book in accordance with the suggestions and input obtained from the validator during the validation test [30]. Researchers made revisions based on input from subject matter experts regarding the learning syntax in order to improve the clarity and structure of the material. Revisions were made to the QR Code display. Previously, there was one QR Code that did not include the instruction “scan here.” After the revision, all QR Codes now include this instruction to make it easier for students to access the interactive content available.

The sixth stage is the Product Trial stage. Product trials aim to collect data used as a basis for determining the level of effectiveness of the products produced [31]. At this stage, the research continued with the implementation of small-scale trials involving teachers and six fourth-grade students of Purwoyoso 04 State Elementary School in Semarang City. The six students were selected proportionally based on academic achievement, consisting of two high-achieving students, two students with medium achievement, and two students with low achievement from a total of 24 students. After the learning process using the Augmented Reality Book that has been developed, researchers distributed response questionnaires to teachers and students. The results of this questionnaire are used as a basis for making product improvements before entering the large-scale use test stage [20].

The seventh stage is Product Revision. The activities carried out at the product revision stage of development are to make improvements to the Augmented Reality Book in accordance with the suggestions of the test subjects, namely fourth-grade students of Purwoyoso 04 State Elementary School [32]. Based on responses from teachers and students on small-scale product trials, a positive response to the use of the Augmented Reality Book was obtained. This shows that the learning product is considered feasible and ready to proceed to the use test stage (large scale).

The eighth stage is the Usage Trial. The product was tested on a large scale in class IV of Purwoyoso 04 State Elementary School, involving 18 students. This trial aims to measure the effectiveness of using an Augmented Reality Book in the learning process. Testing is done through pre-test and post-test to assess the level of understanding and achievement of student learning before and after using the Augmented Reality Book [33]. In addition, responses from students are also collected to evaluate the quality of the products developed. The results of this stage are used to validate that the Augmented Reality Book is feasible and effective to use as teaching materials at the elementary school level.

The ninth stage is the final product revision stage. The data obtained from the usage test is used as a basis for making final stage revisions to the effectiveness of the

developed product [34]. The analysis of the results of the usage trial shows a very high level of effectiveness in helping students learn.

The tenth or final stage is the dissemination stage. The purpose of this stage is to introduce the product so that it can be accepted by users, both individually and in groups. The dissemination of the Augmented Reality Book is carried out on a limited basis, namely only in elementary schools that are the location of the implementation of research, namely SD Negeri Purwoyoso 04, Semarang City, in class IV [35].

**Feasibility of Augmented Reality Book**

Feasibility is carried out through product validation by material validators and media validators [36], which aims to evaluate the quality and suitability of the products developed. The assessment process is carried out by filling out validation instruments that have been prepared in advance by each validator. The results of the validation process show that:

**Table 1.** Validator's Assessment of Feasibility Aspects

| Validator | Total Score | Percentage% | Assessment Category |
|---|---|---|---|
| Material Expert | 74 | 92.5% | Very Eligible |
| Media Expert | 57 | 89% | Very Eligible |

Based on Table 2, the aspects of assessment given by material expert evaluators include (1) accuracy with learning objectives; (2) in accordance with the level of thinking of students; (3) support for the content of augmented reality books; (4) stimulus can help understand the material: (5) appropriate to support the content of lessons that are facts, concepts, principles, or generalizations. These aspects obtained a percentage assessment of 92.5% with a very feasible category. The assessment given by the media validator includes (1) aspects of content quality and objectives, (2) instructional technical/appearance aspects, (3) with an assessment percentage of 89% and also in the very feasible category. If the overall percentage score from the assessment of material validators and media validators shows that the product is declared very feasible, the next step is to carry out evaluation and revision, then proceed with product trials [37]. The material expert's response includes adjusting the leaf structure material, light and dark reactions, adjusting syntax 2 and 3 in the teaching module correctly, and adding the direction "scan here" for the QR Code displayed. This revision is to improve the clarity, suitability, and integration of content with the level of student development and to strengthen the effectiveness of the learning process. The responses from the media experts included adjusting the visual design to the characteristics of the learners in order to increase student engagement and attention.

In addition, teachers and students filled out questionnaires to evaluate the suitability of the content and presentation. The data obtained from the questionnaires was used to assess the suitability and effectiveness of the products developed in supporting the learning process.

**Table 2.** Results of Teacher and Student Responses

| Respon | Total Score | Percentage% | Assessment Category |
|---|---|---|---|
| Teacher | 80 | 100% | Very Eligible |
| Students | 1440 | 100% | Very Eligible |

Based on Table 3, the results of the questionnaire responses filled out by teachers and students show a very high level of feasibility. The teacher's assessment includes aspects of material suitability and presentation design, while the student's assessment includes similar aspects, namely the suitability of material content and presentation appearance. The results show that both teachers and students gave an assessment percentage of 100%, which is included in the very feasible category. Positive responses from teachers and students indicate that the material delivered through the Augmented Reality Book is in accordance with the learning objectives and needs of students, so as to facilitate understanding of abstract concepts [38]. In addition, the attractive and interactive design, with the incorporation of image elements, 3D content, videos, and quizzes, contributes to clarifying the delivery of material and increasing student involvement in the learning process.

**Effectiveness of Augmented Reality Book**

The effectiveness of using Augmented Reality Books is reflected in the increase in scores between the pre-test and post-test [39]. In this study, the effectiveness of Augmented Reality Books was analyzed through several statistical tests, including normality tests, t-tests, and N-Gain tests. The results of the analysis showed that the average pre-test score of 66 increased to 88 in the post-test, resulting in an average increase of 22.

**Table 3.** Pre-test and Post-test Normality Test Results

| Test | Statistic | df | Sig. | Category |
|---|---|---|---|---|
| Pretest | .934 | 18 | 0.229 | Normal |
| Posttest | .929 | 18 | 0.187 | Normal |

Based on Table 4, the pre-test and post-test data obtained by the researchers were analyzed using the normality test. The purpose of this analysis is to determine whether the data has a normal distribution. Data is said to be normally distributed if the data values are symmetrically distributed around the mean value and form a bell curve [40]. The distribution of the data is symmetrical to the center value or mean, so that most of the data values are close to the mean, and the amount of data will be less if it moves away from the mean to the right or left. The criteria used in decision making are: if the significance value (sig) exceeds 0.05, the data is considered to be normally distributed; conversely, if the significance value is below 0.05, the data is not normally distributed. In the pre-test and post-test data, the significance value (Sig.) is above 0.05, so it can be concluded that the data is normally distributed. After the data was declared normally distributed based on the normality test results, the next step was to conduct a t-test. This test uses parametric statistical techniques to measure the difference in average scores between the pre-test and post-test.

Table 5 shows that the Sig. (2-tailed) is 0.001. The paired t-test criteria are if Sig. (2-titled) < 0.05 then $H_0$ isrejected an $H_a$ is accepted or there is a significant

difference between the pretest and posttest data, ut if Sig (2-tailed) > 0.05, then $H_0$ is accepted and $H_a$ is rejected, or there is no significant difference between the students' pretest and posttest data [41]. So, it can be concluded that there is a significant difference between the pretest and posttest scores of students before and after using the Augmented Reality Book.

**Table 4.** Pre-test and Post-test t-test

| Action | Mean | Sig. (2-tailed) |
|---|---|---|
| Pre-test | -21.66 | 0.001 |
| Post-test | | |

The final test in this study was the N-Gain test, which was used to determine and measure the level of improvement in students' cognitive learning outcomes [42]. The average increase in learning outcomes was analyzed using the N-Gain test to assess the effectiveness of the development product in supporting the learning process.

**Table 5.** N-Gain Test of Pre-test and Post-test

| Action | Mean | Different | N-Gain | Category |
|---|---|---|---|---|
| Pre-test | 66 | 22 | 0.64 | Moderate |
| Post-test | 88 | | | |

Based on Table 6, it is known that there is an average increase (N-Gain) between the pre-test and post-test results of 0.64, which is classified in the moderate category, with an increase in student learning outcomes score of 22. This increase indicates that the learning products developed are able to have a positive impact on student learning outcomes [43]. In addition, the Augmented Reality Book product received a very worthy assessment from material and media experts and obtained positive responses from teachers and students.

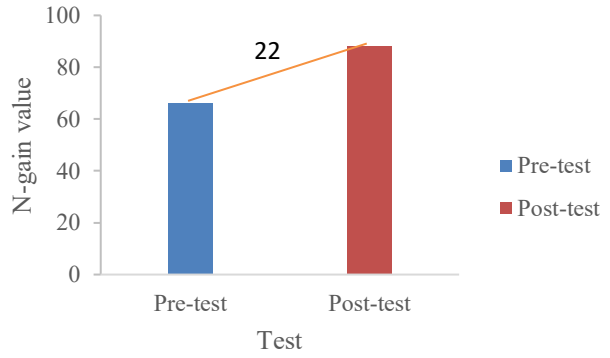


**Figure 10:** Average Results of Pre-test and Post-test of Fourth-Grade Students of Purwoyoso 04 Elementary School, Semarang City

Category Medium at Results N-Gain results were influenced by several factors, including students' readiness for the technology used and learning style. Students who have good digital literacy will find it easier to access and utilize interactive features, such as images, 3D content, and videos, which can help them understand the material [12]. In addition, the use of an Augmented Reality Book requires adaptation time, especially for students who are less familiar with technology. In addition, other readiness factors that influence the main problem are the unstable internet access at school due to the high number of users, so that the process of accessing the Augmented Reality Book becomes slower and has an impact on increasing the duration of learning time. Differences in learning styles also contribute to variations in the achievement of learning outcomes.

This is in line with previous research [44] The Water Cycle material developed for Grade IV MI students proved effective in improving learning outcomes, as also shown in the development of AR books on photosynthesis material in this study. Other supporting research conducted by [45] Those who developed learning media for Class III students showed that augmented reality-based SADAR media obtained a percentage score (PSP) in the range of 75% ≤ PSP ≤ 100%, thus meeting the criteria of very good effectiveness. Thus, it can be concluded that SADAR learning media based on augmented reality is effectively used in the learning process in elementary schools. Other supporting research conducted by [20] which develops material, Exploring Outer Space Class VI, shows that Augmented Reality (AR) based textbooks can significantly improve student learning outcomes, so that it is very effective to use during learning.

## Conclusion

Based on the results of the analysis and discussion. The Augmented Reality Book of photosynthesis material developed using Assemblr Edu and Canva applications is proven to be interactive, feasible, and effective to use, as indicated by the validation results from material experts and media experts, as well as positive responses from teachers and students. Augmented Reality Book is effective for improving learning outcomes of photosynthesis material in *IPAS* learning for fourth-grade students of SD Negeri Purwoyoso 04, Semarang City, with a significant increase in learning scores. In addition, the Augmented Reality Book is considered very feasible as a learning resource because it is able to facilitate students in understanding the concept of photosynthesis, which is abstract, through the presentation of interesting and contextual three-dimensional visuals. Future research is recommended to use other 3D applications or develop an Augmented Reality Book on different learning materials to expand its application and impact in learning.

### Author's Contribution

Naja Izza Armia: contributed to the conceptualization of the study, development of the Augmented Reality (AR) book, design of the research instruments, and preparation of the manuscript. Aldina Eka Andriani: contributed to the revision and final editing of the manuscript.

### Acknowledgement

The authors would like to express their deepest gratitude to Universitas Negeri Semarang (UNNES) for the facilities provided throughout the research process. The authors also sincerely thank SD Negeri Purwoyoso 04, Semarang City, for their cooperation and participation in the implementation of the study.

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