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Development of Smart *Book-Based Augmented Reality* Learning Media to Improve Student Learning Outcomes of Human Respiratory System Materials

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ABSTRACT

The limited availability of learning media capable of concretely visualizing objects has resulted in low student learning outcomes regarding the human respiratory system. This study aims to describe the design and development, test the feasibility, and evaluate the effectiveness of smart book-based augmented reality learning media to improve the learning outcomes of fifth-grade students at SDN Wonolopo 02 in Semarang. This is an R&D study using the ADDIE model, which includes analysis, design, development, implementation, and evaluation. The research subjects consisted of 28 fifth-grade students. Non-test data collection techniques included observation, interviews, and documentation, as well as questionnaires and tests, such as pre-tests and post-tests. Data analysis utilized normality tests, paired-sample t-tests, and N-Gain tests. The results showed that the media was developed using *Assembler Edu* which was integrated with *a smart book* to display 3D interactively and equipped with a learning stimulus. The feasibility of the media was shown by the validation of the material experts of 93.75%, the media experts 93% of the very feasible category and the teacher's response of 96.66%, the response of 93.45% of the students in the very feasible category. The effectiveness of the media was shown by an increase in learning outcomes of 20.32%, the significance value of the paired sample t-test was 0.000 (<0.05), and the average value of N-Gain was 0.5206 in the medium category. In conclusion, *smart book-based augmented reality learning media* has been successfully developed, very feasible and effective in improving the learning outcomes of grade V students of SDN Wonolopo 02.

Keywords: *Augmented Reality*; Learning Outcomes; *Smart Book*; Human Respiratory System

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INTRODUCTION

Education is a planned process for developing students' potential in terms of knowledge, skills, and attitudes. This is in line with Government Regulation No. 4 of 2022 on National Education Standards, which states that education aims to enlighten the nation and foster a dignified character and civilization. Education not only focuses on academic achievements but also on the development of character and life skills in students. Internalization of character values needs to be done through integration and example in learning in order to develop optimally Improving the quality of education is realized through learning in accordance with national standards (Hidayat et al., 2022). Therefore, learning needs to be systematically designed according to the needs and characteristics of students in order to provide a meaningful learning experience and support the development of student competencies (Rosmiati, 2025). The achievement of quality education depends on how learning is planned and implemented, so that each learning process is able to provide a meaningful learning experience and support student development.

Learning plays a crucial role in imparting knowledge, skills, and attitudes to students. Its success is influenced by various factors, including the instructional media used. (Octavia, 2020) states that learning is an activity designed by teachers to enable students to achieve the expected competencies. Furthermore, the use of appropriate instructional media can significantly improve learning outcomes (Fadhil Musyaffa & Isdaryanti, 2024). One subject that requires appropriate media is science, as it involves concepts, processes, and phenomena that are abstract and difficult for students to observe directly. Therefore, there is a need for innovative, technology-assisted learning media that can present abstract concepts in a more tangible, interactive, and easily understandable way for students.

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Science learning aims to develop students' science literacy through understanding scientific process concepts and skills. Pursuant to Decision No. 046/H/KR/2025 of the Head of BSKAP, Ministry of Primary and Secondary Education, regarding Learning Outcomes in Early Childhood Education, Primary Education, and Secondary Education, science learning in class V emphasizes understanding of concepts and process skills such as observing, collecting information, analyzing, and communicating results. Understanding science plays a role in building science literacy and the ability to solve problems scientificallyn (Lestari et al., 2023). Meanwhile, process skills can be developed through practicum activities that allow students to gain active learning experience (Syahrin et al., 2024). According to Piaget's theory of cognitive development, fifth-grade elementary school students are in the concrete operational stage, a stage in which students find it easier to understand concepts through objects that can be directly observed and manipulated (Rahanubun et al., 2026). Furthermore, Bruner's learning theory explains that during the iconic stage, students gain understanding through visual representations such as pictures, models, and illustrations (Aulia Safira et al., 2025). Therefore, in Phase C of fifth grade—when students begin to study more complex natural phenomena—instructional media are needed that can visualize abstract concepts in a more concrete and easily understandable way. In phase C of class V, students begin to learn more complex natural phenomena so that learning media that is able to visualize abstract concepts in a more concrete and easy to understand manner is needed.

The scope of science phase C class V includes various materials, one of which is the human organ system. The material of the human respiratory system includes the structure and function of the respiratory organs, the mechanism of breathing, gas exchange, disturbances in the respiratory system, and efforts to maintain the health of the respiratory organs (Ghaniem et al., 2021). This material is important to study because it is related to the body's vital processes in obtaining oxygen and excreting carbon dioxide as metabolic residue (Mufidah & Habibi, 2022). Therefore, a good understanding of the respiratory system is necessary so that students can understand the function of the respiratory organs and the importance of maintaining a healthy body.

Science education is greatly influenced by the media teachers use to convey material to students. (Qorimah et al., 2022) state that the use of instructional media is one way to achieve learning objectives. Media serve as tools that help make the delivery of material more effective, while also increasing students' interest and motivation to learn (Kurniawan et al., 2024). In addition, the use of technology in learning makes it easier for students to understand the material, especially in science learning which contains many abstract concepts. This is important because students are at a concrete operational stage so they need media that is able to visualize abstract concepts to be more real and easy to understand.

Technology-assisted concrete learning media aims to provide a more real and easy-to-understand learning experience for elementary school students. In order for learning objectives to be achieved optimally, media needs to be equipped with structured components, such as instructions for use, activity instructions, and learning materials that support contextual learning experiences. (Darmawan et al., 2024) stated that technology-assisted learning media must be designed to support the achievement of Learning Outcomes (CP) and Learning Goal Flows (ATP) as well as developing high-level thinking skills (HOTS). Therefore, the media needs to be designed systematically and integrated to be able to support active student involvement and help achieve learning objectives effectively (Pernama et al., 2024).

Based on the results of preliminary research conducted through observation, interviews, questionnaires, and documentation of the learning outcomes of fifth-grade students at SDN Wonolopo 02, it was found that the use of technology-assisted concrete learning media has not been optimal. Teachers still use audiovisual media such as PowerPoint presentations and educational videos, as well as visual media such as images. However, the PowerPoint presentations used are dominated by text, while the videos and images are obtained from online sources without further adaptation. These conditions result in learning that tends to be monotonous, teacher-centered, and fails to actively engage students, thereby leading to boredom in the learning process. (Utomo, 2023) states that engaging learning media play a crucial role in enhancing student engagement. Furthermore, a variety of learning media can help create a more enjoyable learning atmosphere and facilitate understanding of the material (Nuryani & Abadi, 2021). Consequently, the underutilization of learning media also impacts students' conceptual understanding and learning outcomes.

The results of a summative assessment of 28 fifth-grade students at SDN Wonolopo 02—comprising 16 boys and 12 girls—show that their academic achievement remains relatively low. As many as 57% of students

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have not reached the KKTP, while 43% have reached the set KKTP, which is 80. This condition shows that some students still have difficulty in understanding the material thoroughly. One of the factors that affect low learning outcomes is the use of learning media that is not optimal in supporting the delivery of material effectively and technology-based. (Sani et al., 2021) stating that the lack of use of supportive learning media can hinder the understanding of concepts and have an impact on learning outcomes. In addition, media that does not match the characteristics of the material can cause difficulties in understanding and remembering the material being studied (Mulyati et al., 2024). Therefore, technology-assisted learning media is needed that is able to visualize concepts more concretely so that the material is easier for students to understand.

Students have difficulty understanding the material on the human respiratory system, particularly in distinguishing terms related to respiratory organs, analyzing the structure and function of organs such as the trachea, bronchi, bronchioles, and alveoli, and understanding the mechanisms of respiration, disorders, diseases, and ways to maintain respiratory health. These difficulties were identified through observation, interviews with fifth-grade teachers, and documentation of students' summative test results, and are attributed to the abstract nature of the material and a lack of adequate visual aids. (Utomo, 2023) stating that technology-based visual media can help students build scientific concepts in a more concrete way. In addition, technology-assisted concrete learning media is able to improve concept understanding through clear visualization and getting closer to the actual object (Angraini et al., 2025). Therefore, a media is needed that can display the structure and process of the respiratory system more clearly so that it is easier for students to understand the material.

Technological developments encourage the birth of various learning innovations that aim to increase student engagement and understanding. One of these innovations is a technology-assisted concrete learning media that is able to present material in a more attractive and easy-to-understand manner. (Meilina & Afriyah, 2025) stating that technology-based digital media can help turn abstract concepts into more real. In addition, concrete media assisted by technology is also able to improve students' critical thinking skills and learning outcomes (Junitasari et al., 2024). In science learning, the use of media can be a solution to overcome difficulties in understanding the material and low learning outcomes. One of the concrete technology-assisted learning media that can be used is *smart books*.

Smart books are learning media in the form of printed books combined with *augmented reality* technology, allowing students to access interactive visual content through digital devices. (Wardah & Andriani, 2025) stated that *augmented reality-based books* are effective in improving conceptual understanding because they present material through text, images, and 3D models. In this study, *smart books* were designed using *Canva* which provides various visual features to produce an attractive and easy-to-understand media display (Safa'at et al., 2024). This media is equipped with instructions for use, learning outcomes and objectives, materials, scannable images to display 3D objects, summaries, glossaries, practice questions, and *augmented reality markers*. The presence of three-dimensional visualization allows students to observe objects more realistically, thus helping to understand abstract concepts. In addition, augmented reality-based learning media has been proven to be valid, practical, and able to improve science learning outcomes in elementary schools (Juli Lestari et al., 2025). Therefore, the use *of smart* book-based *augmented reality* can be an alternative to create more meaningful and interactive learning.

One of the technologies that can be used in educational media is augmented reality. (Kurniawan et al., 2024) stated that AR is able to combine virtual objects with the real world so that students can see three-dimensional objects directly through digital devices. This technology provides a more engaging and interactive learning experience because it is equipped with visualizations and animations that support material understanding. In addition, the use of AR has been proven to be able to improve learning outcomes in the cognitive realm through the presentation of more concrete objects. Clear visualization and proximity to the actual object also help students understand the material more easily (Purwanti et al., 2024). Therefore, augmented reality has the potential to be an effective technology for supporting science education.

In the material on the human respiratory system, media is needed that is able to visualize abstract concepts in a more concrete way and is easy for students to understand. One relevant alternative is a *smart* book-based *augmented reality* learning media developed using *the Assembler Edu* application. *Smart books* contain human respiratory system materials equipped with markers to display three-dimensional objects of respiratory organs through gadgets. The visualization allows students to observe the structure and function of the respiratory organs

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more realistically, helping to improve understanding of concepts. (Yusa et al., 2023) stated that AR-based learning media is valid, practical, and able to improve students' understanding of science concepts. In addition, the use of AR can also develop abstract, creative, and critical thinking skills (Zufahmi et al., 2025). Therefore, the integration of *smart books* and *Assembler Edu* can create more interactive, meaningful, and supportive learning outcomes for students at SDN Wonolopo 02 Semarang City.

The results of the previous research conducted entitled (Armia & Andriani, 2025) *"Development of the Augmented Reality Book to Improve Learning Outcomes of Photosynthesis Material in IPASLearning"* stated that the *Augmented Reality book* of photosynthesis material developed using the Assembler EDU application and Canva has been proven to be feasible and effective to use, as shown by the validation results of 92.5% of material experts and 89% of media experts as well as positive responses from teachers and students.

Based on the problem identification outlined above, a solution is needed to address low learning outcomes and the limited use of technology-assisted concrete learning media through the development of engaging, effective, and user-friendly media. Therefore, the researcher developed a smart-book-based augmented reality learning medium that integrates printed books with three-dimensional (3D) object visualizations using the Assembler Edu application for material on the human respiratory system. The development of this medium is expected to help students understand concepts more concretely and improve learning outcomes. This study aims to develop a smart-book-based augmented reality learning medium integrated with Assembler Edu-based augmented reality technology for the human respiratory system curriculum, test the feasibility of the medium, and evaluate its effectiveness in improving the learning outcomes of fifth-grade students at SDN Wonolopo 02 in Semarang.

METHODS

Research and development (R&D) is a method used to create a product and test its effectiveness (Sugiyono, 2024) therefore, in this study, the R&D method was used to develop a smart-book-based augmented reality learning medium and to test its feasibility and effectiveness in improving students' learning outcomes on the topic of the human respiratory system. In the development of *augmented reality* based on *Samrt Book* , the researcher used the ADDIE development model. The ADDIE model features systematic, structured, and flexible stages that make it easier for researchers to develop and revise learning products in stages—from needs analysis through evaluation—thereby producing products that meet user needs and are both feasible and effective for use in learning.

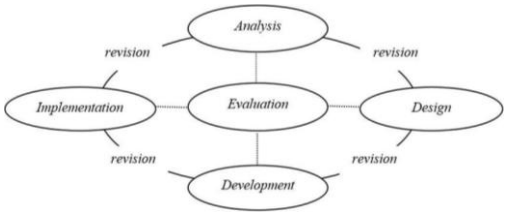

Figure 1. ADDIE Development Stage (Sugiyono, 2024)

Figure 1 illustrates the stages of research and development (R&D) using the ADDIE model. (Sugiyono, 2024) noted that, according to the ADDIE development model, it consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The Analysis stage is conducted to identify needs, problems, and characteristics that serve as the foundation for product development. The Design stage focuses on preparing product designs, ranging from content and appearance to the components to be developed. The Development stage involves creating the product and implementing validation and revisions based on feedback from validation experts. The Implementation stage involves using the developed product, and the final Evaluation stage aims to assess the product's quality, feasibility, and effectiveness to determine the success rate of the developed product.

The research subjects were 28 fifth-grade students. The product testing was conducted in two phases: a small-group pilot test involving 6 students categorized by high, moderate, and low cognitive ability, and a large-group pilot test involving 22 students. Subjects were selected using purposive sampling, a technique for determining a sample based on specific considerations aligned with the research objectives (Sugiyono, 2024). Data collection was conducted through non-test and test methods. The test methods consisted of pre-tests and

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post-tests to measure student learning outcomes, while the non-test methods included observation, interviews, questionnaires, and documentation (Marithasari et al., 2023). The data obtained were analyzed using descriptive percentage analysis to determine the media's suitability, a normality test to assess the data distribution, and a paired-sample t-test to determine differences in learning outcomes before and after the use of the media. The descriptive percentage analysis, normality test, and paired-sample t-test were conducted using IBM SPSS 25 software. Furthermore, improvements in student learning outcomes were analyzed using the N-Gain test, referring to the interpretation categories according to Hake (1999), namely: a value of $g > 0.70$ falls into the high category, $0.30 \leq g \leq 0.70$ falls into the moderate category, and $g < 0.30$ falls into the low category.

RESULTS AND DISCUSSION

Smart Book-based Augmented Reality *Media Development Design*

The development *of smart book-based augmented reality* learning media uses the ADDIE model which consists of five stages, namely Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was chosen because it has systematic development steps so that it can produce products that suit learning needs.

The first stage is Analysis. This stage aims to identify the gap between the learning conditions that occur and the expected ideal conditions, so that solutions can be formulated in the form of appropriate learning products (Rinawan et al., 2024). At this stage, the researcher conducts observations, interviews, questionnaires, and documentation studies of student learning outcomes to identify learning problems and needs. The results of the analysis show that teachers are not optimal in utilizing concrete learning media assisted by technology. In addition, students have difficulty understanding the material of the human respiratory system, especially the structure and function of respiratory organs, respiratory mechanisms, and disorders in the respiratory system. Based on the results of a summative assessment of 28 students in class V, it is known that the KKTP set is 85. A total of 16 students (57%) have not achieved KKTP, while 12 students (43%) have achieved KKTP. The data shows that student learning outcomes are still relatively low and the understanding of the material of the human respiratory system is not optimal. Based on the results of the analysis of the needs of teachers and students, a concrete learning media assisted by technology is needed that is able to visualize abstract concepts to be more real, interesting, and easy to understand.

The second stage is Design. This stage aims to formulate learning specifications systematically as the basis for product development, including the determination of learning objectives, material structure, presentation strategies, media used, and the form of evaluation to be applied (Rinawan et al., 2024). At this stage, the researcher prepares a learning media design based on the results of the analysis of the needs of teachers and students. The product developed is in the form of *smart* book-based *augmented reality* media designed to help students understand the material of the human respiratory system in a more concrete way. *Smart books* are developed in the form of printed learning books that contain materials, learning activities, student worksheets, summaries, glossaries, practice questions, and *augmented reality markers* that are integrated with digital technology.

The process of designing *a smart book* is done using *the Canva application*. This application is used to design media displays to be more attractive, systematic, and in accordance with the characteristics of elementary school students (Hafidh & Sri Lena, 2023). Through *Canva*, the researcher compiled various media components including covers, introductions, instructions for use, table of contents, learning outcomes, learning objectives, human respiratory system materials, student activities, practice questions, bibliography, and developer profiles. Using *Canva* makes it easier for researchers to set layouts, colors, illustrations, and typography to produce informative and easy-to-understand media.

Figure 2. Smart *Book Design*

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Figure 2 shows a *smart book* design developed using *Canva* on human respiratory system material. *The smart book* contains material on respiratory organs, such as the nose, pharynx, larynx, trachea, bronchi, bronchi, alveolis, lungs, inspiration and expiratory mechanisms, disorders that exist in the respiratory organs, and how to maintain the health of the human respiratory organs. Each page is designed with an attractive combination of text, images, and illustrations and features markers connected to *augmented reality* technology. Through scanning markers using the *Assembler Edu application*, students can display three-dimensional (3D) objects of the respiratory organs interactively so that learning becomes more concrete and easy to understand (Evanjeli et al., 2024).

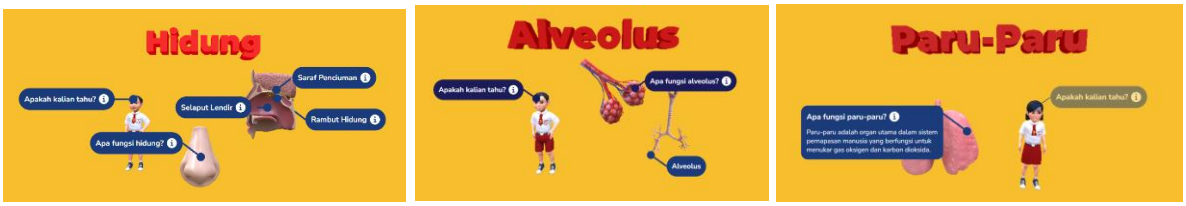

Figure 3. Augmented *Reality Design*

Figure 3 shows an *augmented reality* design developed using the *Assembler Edu app*. The AR content is designed to display a three-dimensional visualization of the organs of the human respiratory system connected by markers on *a smart book*. In addition to 3D objects, the media is also equipped with brief information about the structure and function of organs as well as animations that support students' understanding of the material. Through scanning markers using gadgets, virtual objects can appear interactively so that students can observe the respiratory organs from various perspectives. In its use, students use a camera on a gadget and then scan the QR code available on the *smart book* page. Once the QR code is scanned, the *augmented reality display* will open and display the 3D object along with supporting information that can be observed directly. This process allows students to interact with the visualization of the respiratory organs in a more realistic way so that the learning experience becomes more interesting and meaningful.

Smart *book design* that is integrated with *augmented reality* is supported by Jean Piaget's theory of cognitive development and Jerome Bruner's theory of learning. According to Piaget, students aged 7–11 years are in the concrete operational stage, which is the stage when children more easily understand concepts through objects that can be observed and manipulated directly (Rahanubun et al., 2026). Meanwhile, Bruner explained that in the iconic stage, students gain understanding through visual representations such as pictures, models, and illustrations (Aulia Safira et al., 2025). The application of these two theories is realized through the visualization of the organs of the human respiratory system in the form of three-dimensional objects that can be observed interactively through *augmented reality*. This, the media developed is able to help students understand abstract concepts to be more concrete and provide a more meaningful learning experience.

The development process is the transformation of the media design created during the design phase into a product ready for use in teaching activities (Rinawan et al., 2024). In this phase, an augmented reality learning tool based on a smart book containing material on the human respiratory system was developed for fifth-grade students at SDN Wonolopo 02 in Semarang City. After the product was fully developed, it underwent validation by subject matter experts and media experts to determine its suitability. Content expert validation aims to assess the alignment of the content with learning outcomes, the accuracy of concepts, the depth of the material, and the systematic presentation of the content within the media (Macalikod & Simpal, 2025). The assessment was conducted by expert validators with expertise in elementary school science (IPA) content. Based on the subject matter expert validation results, the product achieved a 93.75% suitability rating in the "highly suitable" category. Meanwhile, the instructional media expert validation was conducted to assess the appearance, design, ease of use, visual quality, and integration of the components of the instructional media that had been created. The results of the instructional media expert validation showed a 93% rating in the "highly suitable" category.

Input and suggestions from material experts and media experts are used as the basis for product improvement before being implemented in learning. Revisions based on the input of subject matter experts are carried out on the linguistic aspect, namely correcting the writing of foreign terms or names in italic format according to the applicable writing rules. Meanwhile, the revision based on the input of media experts includes improving the logo layout to make it more proportional and adjusting the writing of foreign terms or names in

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italic format. After being revised according to the suggestions of the two validators, *the smart* book-based *augmented reality* learning media was declared suitable for use in learning human respiratory system materials.

The implement stage is the stage of implementing learning media that have been developed and deemed feasible based on the validation results of content experts and media experts. This stage aims to apply the developed learning products in real learning situations to test the effectiveness, implementation, and user acceptance of the media before final improvements are made (Rinawan et al., 2024). Prior to implementation, the researcher first developed a learning outcome assessment instrument consisting of 40 questions in the form of multiple-choice items, which were tested to ensure their suitability for use in the study (Devega et al., 2022). The results of this instrument development were then analyzed through validity, reliability, difficulty, and differentiation tests. Based on the analysis results, 18 questions were deemed valid and 22 were deemed invalid. Furthermore, the 18 valid questions were also found to be reliable, making them suitable for use as research instruments. The 18 valid questions are then used as pre-test and post-test instruments to measure students' initial and final abilities, thereby allowing for the assessment of the improvement in learning outcomes after the use of the developed learning media (Kusna Aura Dewi et al., 2025).

The evaluation phase is the final stage in the ADDIE model, aimed at assessing the effectiveness of the instructional media that has been developed (Rinawan et al., 2024). The evaluation is conducted after the media has been validated and implemented in the classroom. In this stage, the researcher performs a normality test, a paired sample t-test, and an N-Gain test to determine the data distribution, the difference between pre-test and post-test results, and the level of improvement in student learning outcomes after using the developed instructional media.

Smart Book-based Augmented Realty *Media Eligibility*

The feasibility of *smart* book-based *augmented reality learning media* on human respiratory system materials is determined through validation by material experts and media experts as well as teacher responses and student responses related to *the developed smart* book-based *augmented reality* media.

Table 1. Validation of Material Experts and Media Experts

Yes	Validator	Percentage	Criteria
1	Material Expert	93,75%	Highly Worth It
2	Media Member	93%	Highly Worth It

In Table 1, it can be seen that the *smart* book-based *augmented reality learning media* developed obtained the validation results of material experts of 93.75% and the validation of media experts of 93%, both of which are included in the very feasible category. In the validation of material experts, the aspect of media accuracy with learning objectives received the highest assessment because the material presented was in accordance with the learning outcomes and objectives. This is in line with (Yuliani et al., 2023) stating that the suitability of the material with the learning objectives is an important indicator in determining the quality of learning media. In addition, the high assessment of this aspect is also supported by its strategic role in the learning process, because it can help teachers deliver material in a more targeted manner and facilitate students in achieving the expected competencies (Ningrum & Dharin, 2026). However, there are several indicators that obtain a score of 3 related to the linguistic aspect, so the validator suggests improving the writing of foreign terms or names using *italics*.

Media expert validation, technical aspects and display received the highest rating because media design is considered attractive, easy to use, and able to present concrete material visualization through *augmented reality technology*. This is in line with (Khasanah et al., 2025) the statement that augmented reality-based learning media has the advantage of presenting more real visualizations so as to improve the quality of the display and the attractiveness of learning. In addition, the high assessment of technical and display aspects shows that the developed media has met the principles of ease of use, clarity of display, and good visual quality. This condition is in accordance with (Vlasenko et al., 2023) the opinion that good technical quality and visual design are important factors in supporting the effectiveness of the use of learning media. Some indicators still get a score of 3 regarding the layout of design elements, so validators suggest improving the position of the logo to be more proportional. All suggestions from the two validators have been followed up through revisions to the linguistic aspects and design layout so that the developed media meets the material, display, and technical feasibility aspects to be used in learning.

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Table 2. Results of Teacher and Student Responses

Yes	Respoden	Percentage	Criteria
1	Teacher	96,66%	Highly Worth It
2	Students	93,45%	Highly Worth It

Table 2 shows that the teacher's response obtained a percentage of 96.66% with the very feasible criterion, while the response of 28 students obtained a percentage of 93.45% with the very feasible criterion. These results show that smart *book-based augmented reality learning media* received a very positive response from teachers and students. Students assessed that the developed media was interesting, easy to use, and helped understand the material of the human respiratory system through interactive three-dimensional visualization (Evanjeli et al., 2024). In addition, teachers consider that the media is able to support the delivery of material and increase student involvement in learning. Thus, *smart book-based augmented reality* learning media is stated to be very feasible for use in learning human respiratory system material.

The high response of teachers and students also shows that the use of *smart* book-based *augmented reality* media is able to encourage active student involvement during the learning process. Through scanning markers on *smart books*, students can observe and explore 3D models of the respiratory system organs directly. The 3D visualization presented is close to real forms so that it helps students understand concepts that were previously abstract to become more concrete (Mansour et al., 2025). Active involvement in observing, exploring, and interacting with these virtual objects makes the learning process more interesting, increases curiosity, and helps students build a deeper understanding of the material of the human respiratory system.

The Effectiveness of *Smart* Book-based *Augmented Reality Media*

The effectiveness of *smart* book-based *augmented reality learning media* was reviewed from the improvement of learning outcomes of grade V students at SDN Wonolopo 02, Semarang City. Effectiveness measurement was carried out through a comparison of pretest and posttest scores obtained by students before and after using the media. The learning outcome data was then analyzed using the normality test, the paired sample t-test, and the N-Gain test to determine the effectiveness of the media in improving student learning outcomes (Saat et al., 2024).

Table 3. Normality Test Results

	Shapiro-Wilk		
	Statistic	df	Sig.
Pre-test	0,944	22	0,244
Post-test	0,921	22	0,079

Table 3 shows that for the normality test, the researcher used the Shapiro-Wilk method because the sample size in the study class was less than 50 students, so this method was deemed more appropriate for testing the research data. Based on the results of the normality test above, the pre-test significance value was 0.244 and the post-test significance value was 0.079. The pre-test significance value of 0.244 > 0.05 indicates that the pre-test data is normally distributed. Additionally, the post-test significance value of 0.079 > 0.05 also indicates that the post-test data is normally distributed. Thus, it can be concluded that the pre-test and post-test data meet the normality assumption because both significance values are greater than 0.05.

Table 4. T-test results

Respoden	N	Red	T	Correlation	Sig, (2-tailed)
Pre-test	22	61,18	-13,080	0,837	0,000
Post-test	22	81,50			

Table 4 shows that, based on the results of the Paired Samples Test above, the mean pre-test score was 61.18, while the mean post-test score was 81.50. These results indicate an increase of 20.32 following the use of smart-book-based augmented reality learning media. The Paired Samples Correlations table shows a correlation coefficient of 0.837, indicating a very strong positive relationship between the pre-test and post-test scores. Furthermore, the p-value was 0.000—less than 0.05—so the relationship between the two sets of data is considered statistically significant. The results of the Paired Samples Test also showed a significance value (2-tailed) of 0.000.

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Since this significance value is less than 0.05, H_0 is rejected and H_1 is accepted. Thus, it can be concluded that there is a significant difference between the pre- and post-test scores following the use of the smart book-based augmented reality learning medium. The magnitude of the effect of using this medium is indicated by an Eta Squared (η^2) value of 0.891, which falls into the "large effect" category; thus, the developed medium has a strong influence on improving student learning outcomes.

Table 5. N-Gain Test Results

	Aspects	Average (N-Gain)	Criteria
Pre-test	61,18	0,5206	Medium
Post-test	81,50		

In Table 5, the N-Gain test results show an average value of 0.5206, which falls into the moderate category. These results indicate that smart-book-based augmented reality learning media can improve student learning outcomes to a moderate degree. This improvement aligns with Piaget's theory, which states that elementary school students are in the concrete operational stage and thus find it easier to understand concepts through tangible visualizations (Rahanubun et al., 2026). Furthermore, Bruner's theory emphasizes the importance of visual representations in learning; thus, 3D visualizations help students transform the abstract concept of the human respiratory system into a more concrete understanding (Aulia Safira et al., 2025). Consequently, the use of smart-book-based augmented reality media facilitates the cognitive development of elementary school students, thereby leading to improved learning outcomes. A comparison of the average pretest and posttest scores can be seen in Diagram 1.

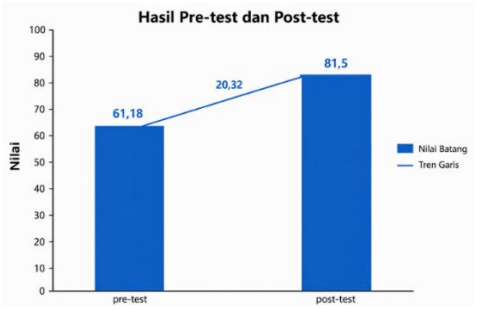

Diagram 1. Average Pre-test and Post-test Results

Based on Diagram 1, it can be seen that the average student learning outcomes have increased after the use of *smart book-based augmented reality* learning media. The average pretest score of 61.18% increased to 81.50% in the posttest. The increase of 20.32% shows that the media developed is able to help students understand learning materials better. These results are supported by an N-Gain value of 0.5206 which is included in the medium category, so thatsmart *book-based augmented reality learning media* is declared effective in improving student learning outcomes.

The N-Gain value of 0.5206 is included in the medium category because the increase in learning outcomes obtained has not reached the high category. This can be influenced by differences in learning styles and characteristics of students. *Smart book-based augmented reality* media favors students with visual learning styles through the presentation of concrete and interactive 3D objects, while some students find it easier to learn through verbal explanations or discussions. In addition, students' readiness to learn also affects the results obtained. Students' initial knowledge plays an important role in helping to connect new information with previously understood concepts to facilitate the learning process. This is in line with (Hattan et al., 2023) the statement that initial knowledge helps students in integrating new information with existing. In addition to initial knowledge, high learning motivation encourages students to be more active in learning, explore media, and try to understand the material being studied (Costa & Reis, 2025). In addition, the ability to use technology affects the ease of students in operating *augmented reality* media so that they can optimally utilize the available features to support concept understanding (Arifitama & Rahman, 2024). Thus, smart-book-based augmented reality learning media has demonstrated the ability to improve student learning outcomes to a moderate degree and has the potential to serve as an alternative learning medium to support the understanding of concepts related to the human respiratory system.

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CONCLUSION

Based on the results of research and data analysis that has been conducted, it can be concluded that smart *book-based augmented reality* learning media was developed using *Canva* as an application to design *smart books* and *Assembler Edu* to integrate *augmented reality* technology which displays three-dimensional (3D) objects in a concrete and interactive manner. The developed media contains instructions for use, learning materials, images, and visualizations of 3D objects that can be observed through mobile devices. The results of validation by material experts and media experts, as well as the responses of teachers and students show that the developed media is in the category of being very feasible to be used in learning. The effectiveness of the media was shown by an increase in the average score from 61.18% in the pretest to 81.50% in the posttest, resulting in an increase of 20.32%. These results were strengthened by the paired sample t-test which showed a significant difference between learning outcomes before and after media use, as well as the N-Gain test result of 0.5206 which was included in the medium category. Thus, *the smart* book-based augmented reality *learning media* developed was declared feasible and effective to improve student learning outcomes of human respiratory system materials in the class of SDN Wonolopo 02 Semarang City.

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