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Development of E-Learning Materials Assisted by Augmented Reality on Human Digestive System Material to Improve Elementary School Students' Learning Outcomes

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Abstract: This study aims to develop, test the feasibility, effectiveness, and practicality of Augmented Reality (AR)-assisted e-learning materials to improve student learning outcomes. This study is a Development Research (R&D) using the Borg and Gall model. This study involved 42 fifth grade students of Kedungmundu State Elementary School (SDN) in the 2024/2025 academic year, with a small-scale trial on 15 VA class students and a large-scale trial on 27 VB class students. Data collection techniques used test techniques (pretest - posttest) and non-test in the form of interview results, questionnaires, observations, score lists, and documentation. The results of validation by material, language, and media experts which showed that AR-assisted e-learning materials were declared "very feasible" with an average score of 89%. The practicality of e-teaching materials is shown from the results of the questionnaire responses of teachers and students to the use of e-teaching materials assisted by AR showing a "very positive" level of satisfaction, with a score of 97% from teachers and 86% from students. The effectiveness of e-teaching materials assisted by AR is proven through the results of the t-test with a significance value of 0.000 (<0.05) and an N-gain of 0.67, which is included in the "moderate" category. The results of the study indicate that e-teaching materials assisted by AR meet the criteria of being feasible, practical, and effective in improving learning outcomes in class V science learning at SDN Kedungmundu.

Keywords: Augmented reality; E-teaching materials; IPAS; Learning outcomes

Introduction

Ideal education is inclusive, relevant, and learner-centered. Ideal education ensures equal access for all learners, encourages active participation of learners, and supports their social, emotional, and moral development. In addition, ideal education utilizes 21st-century technology and skills to create a safe and comfortable learning environment for learners. This statement is in line with Permendikbudristek No. 16 of 2022 concerning Process Standards, which states the importance of learner-focused learning to optimize learner potential, as well as the use of technology in learning to increase the accessibility and effectiveness of education. However, in reality, to achieve an ideal education, it is often faced with various problems for both teachers and learners. Among them, one of the causes of the low achievement of competencies and learning outcomes of learners is a teacher-centered learning approach that does not actively involve learners. This approach makes learners tend to be

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passive, less motivated, and easily bored, thus hindering their learning experience (Cansiz & Cansiz, 2022).

The limited learning resources available in schools are also one of the main obstacles in implementing the Independent Curriculum, especially in providing adequate textbooks for students. Not all schools have adequate and practical teaching materials, so teachers have difficulty accessing and developing innovative learning materials that are appropriate to the needs of students (Fauzi, 2023; Hazmar et al., 2022). In addition, many teachers face difficulties in finding the right media for learning and adapting materials to these media. This has caused many teachers to not utilize learning media optimally, sometimes even this media is ignored in the teaching and learning process (Adam, 2023; Utami et al., 2021). Another problem that often occurs in learning is the use of technology that has not been fully optimized by teachers. Where many teachers have not optimized the technology facilities available in schools, especially in using them as learning resources that are in accordance with the characteristics of students, so that it can hinder the teaching and learning process from being less than optimal (Dewi & Suniasih, 2023; Wiguna et al., 2022).

From the various obstacles and problems found, researchers also found similar obstacles at the Kedungmundu State Elementary School (SDN). Based on the results of interviews, questionnaires, observations, grade lists, and also documentation of class V of SDN Kedungmundu, several problems were found in the learning process. The results of the questionnaire filled out by 27 class V students showed that the science subject was less popular. As many as 4 students (15%) liked mathematics, 3 students (11%) liked science, 15 students (56%) liked physical education, and 5 students (19%) liked other subjects. Especially in the human digestive system material, as many as 48% of students stated that they did not like this material because it was difficult to understand (33%), too much theory or memorization (22%), not interesting (30%), and other reasons (8%). Based on the results of the questionnaire obtained, it can be concluded that students' interest in learning and following science lessons, especially in the human digestive system material, is still low.

The availability of teaching materials used in learning is often not in accordance with the needs of students. On the other hand, teachers tend to rely on government-published books, such as teacher books and student books, as the main source. In addition, teachers also sometimes use materials from YouTube without any modifications that are adjusted to the needs and characteristics of students. This indicates the need to develop relevant and contextual teaching materials to improve the effectiveness of learning. This is reinforced by the results of a questionnaire of grade V students at SDN Kedungmundu which showed that 74% of the learning resources used were still dominated by textbooks. This finding is in line with interviews with grade V teachers, which revealed that grade V science learning still largely relies on government-published textbooks, with occasional use of materials from YouTube. Although teacher books and student books include illustrations, the number is limited and not all materials, such as the human digestive system, can be visualized properly. This is because the internal organs of the human digestive system cannot be observed directly. In addition, teachers tend not to utilize the available technological facilities optimally. Although each class has been equipped with a Wi-Fi network, teachers sometimes still rely on learning videos from YouTube without any modifications that are adjusted to the needs and characteristics of students.

Problems were also found in the application of learning methods, where teachers tend to predominantly use the lecture method in learning, resulting in boredom and minimal student involvement. This is reinforced by the results of the questionnaire filled out by students, which showed that the use of learning media in science learning by teachers is included in the category of "sometimes" (56%). These results are in line with the results of teacher interviews which stated that in science learning, learning media is not applied in every lesson, teachers will first look at the material whether it requires learning media in the learning process or with teaching materials that have been prepared previously. In addition, student participation and motivation are also not optimal. This is reinforced by the results of the questionnaire which showed that students' enthusiasm in working on questions was inconsistent with the category of "sometimes" (59%). Active student involvement in class is also quite low, as seen from the results of the questionnaire which showed that students only occasionally asked questions (63%) or answered questions (52%). This condition shows that learning methods, media use, and active involvement of students still need to be improved to support the achievement of maximum learning outcomes.

Problems with the use of technology, especially smartphones, in learning are still often encountered. Based on the results of the student questionnaire, 26 out of 27 (96%) grade V students at SDN Kedungmundu already have smartphones that can access the internet. However, many of them have not used it optimally to support learning. As many as 13 students (48%) use smartphones to play games, 11 students (41%) to play social media, and 3 students (11%) to watch YouTube for

entertainment. In fact, 18 out of 27 students (67%) were reported to spend more than 4 hours per day using smartphones for these activities. This shows that all students (100%) have not utilized smartphones optimally for learning. The results of the student questionnaire data show that all students 27 out of 27 (100%) have a high interest in using smartphones as a learning aid. In addition, support also came from the guardians. Where 28 out of 35 guardians (80%) who had filled out the approval questionnaire regarding the use of smartphones at school, agreed to the use of smartphones at school with teacher supervision. However, the data also shows that so far the use of smartphones among students is still limited to communication and entertainment purposes.

On the other hand, the great potential to integrate smartphones in learning has not been fully optimized by teachers. Based on the data obtained, 25 out of 27 students (93%) stated that smartphones helped them understand the subject matter. In addition, 18 out of 27 students (67%) admitted that they preferred learning about the human digestive system using technology, while 20 out of 27 students (74%) were more interested in learning media in the form of images or videos. Furthermore, 14 out of 27 students (52%) stated that technology really helped them learn about the human digestive system. These data indicate the need for strategic steps to utilize the potential of smartphones as an effective learning medium in schools. Problems related to the learning outcomes of grade V students at SDN Kedungmundu were also found. Based on the document data on the learning outcomes of grade VB students in the 2023/2024 academic year, it can be seen that the learning outcomes of social sciences, especially in the material on the human digestive system, are still quite low. Of the 27 students, 19 students (70%) have not reached the KKTP, while 8 students (30%) have met the KKTP, with the KKTP used being 75. This condition shows that learning has not been effective in helping most students achieve the expected competencies.

From these various problems, innovation is needed to improve learning outcomes, in the form of developing digital teaching materials that are integrated with technology. Digital teaching materials are easy for teachers to use, present more interesting and interactive materials, and provide different learning experiences for students, so that they can improve their learning outcomes. The subject of science is one of the subjects that requires the development of digital teaching materials to support the learning process. This is due to obstacles in understanding abstract concepts that often appear in learning materials. Digital teaching materials, or often called e-teaching materials, are teaching materials that are presented in digital format and designed for use on devices such as computers, tablets, or smartphones. E-teaching materials utilize multimedia elements, such as text, images, video, audio, animation, and interactive features, to create a more engaging and effective learning experience (Fernando et al., 2022). The advantages of e-teaching materials lie in their ability to present more interesting materials, involve varied learning activities (Alzahrani, 2020; Buragohain et al., 2023) and provide a richer learning experience through visualization and interactivity. In addition, e-teaching materials offer practicality of use because they can be accessed anytime and anywhere, thus supporting flexible learning and in accordance with the needs of students in the digital era (Alenezi et al., 2023; Müller et al., 2023).

Science learning supported by technology, especially through the use of visual elements, has been proven to be more effective than conventional methods. This approach is able to increase students' interest in learning science while facilitating their understanding of abstract and concrete concepts (Abdulrahaman et al., 2020; Toli & Kallery, 2021). In line with this, one of the efforts to realize digital teaching materials that are in accordance with the characteristics of students is to integrate them using Augmented Reality technology. Augmented Reality is a technology that combines the real world with the virtual world in two-dimensional or three-dimensional form in real time into a real environment, and can only be accessed via a smartphone or computer camera (Kamińska et al., 2023), By integrating virtual objects into the real world and projecting them, learning becomes more fun, clear, and meaningful. Thus, materials that are difficult and cannot be seen in the surrounding environment can be visualized through Augmented Reality. Through the visualization of this learning material, students' abstract reasoning abilities can be improved.

The application of Augmented Reality in learning the human digestive system for elementary school students is an innovation in the field of education that has the potential to improve the quality of learning. Augmented Reality technology allows elementary school students to explore and understand the human digestive organs interactively through interesting 3D visualizations (Salmiyanti et al., 2023). E-learning materials assisted by Augmented Reality make it easier for students to understand science material in more depth (Mansour et al., 2024). In addition to increasing interest in learning, the use of Augmented Reality also contributes to improving student learning outcomes (Refmidawati, 2023). This learning media provides a fun learning experience, so that it can motivate students to be more active and collaborative in the learning process. In addition, Augmented Reality has a significant effect

on the development of critical thinking skills, creativity and visual-spatial skills of students (Guntur et al., 2020). This Augmented Reality-assisted e-learning material is practical to use and can be accessed by anyone, making the learning process easier (Yulian et al., 2022).

The new media developed by researchers is e-teaching materials assisted by Augmented Reality in the form of digital books for fifth grade elementary school students, which contain material on the human digestive system by integrating Augmented Reality technology in certain parts of the material. This aims to facilitate students' understanding of the concept of the human digestive system in an interactive and interesting way. This e-teaching material assisted by Augmented Reality is equipped with a QR code to access visualization of the material in 3D. By scanning the QR code using a smartphone, students can see the sequence of human digestive system organs and their functions in 3D that can be enlarged, rotated 360 degrees, and observed in detail. The selection of smartphone use is based on data from the questionnaire on student smartphone use, that 26 out of 27 students (96%) have smartphones and are able to operate them well.

In addition, based on the results of the questionnaire on the approval of parents regarding the use of smartphones at school, it shows that 28 out of 35 (80%) parents agree to the use of smartphones with teacher supervision, and the school also has a supporting Wi-Fi network. Thus, this e-teaching material can be implemented effectively in group learning. This e-teaching material contains grade V science material on the human digestive system. This material is often considered abstract by students because they cannot directly see the digestive organs in the body. Through Augmented Reality visualization, students can understand the form and function of the digestive organs in a concrete and interactive way, making it easier to understand the concepts being taught. Based on this background, the researcher conducted a researchs on the development of learning media in the form of Augmented Reality-based e-teaching materials to improve the learning outcomes of grade V students in the science subject with the human digestive system material at SDN Kedungmundu. The purpose of this study was to test the feasibility, practicality, and effectiveness of the product developed. It is hoped that this learning media can make it easier for students to understand the human digestive system material, so that it can support the learning of grade V students at SDN Kedungmundu.

Method

This study uses the Research and Development (R&D) method which aims to develop learning products and test their effectiveness (Sugiyono, 2019). The focus of the study is the development of Augmented Reality-based e-teaching materials for the subject of science on the human digestive system in grade V of elementary school. The development model applied is the Borg and Gall model, which consists of 10 steps. However, this study was limited to the 8th step due to time and cost constraints. The steps taken include: potential and problems, data collection, product design, design validation, design revision, product trial, product revision, and usage trial (Sugiyono, 2019). An overview of this research scheme can be seen in Figure 1.

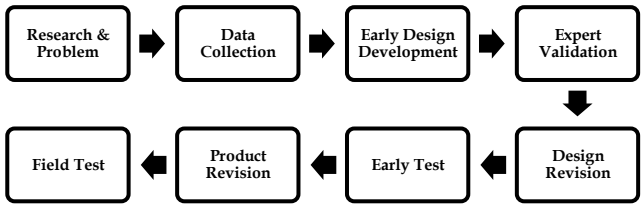

Figure 1. Modified from the Borg and Gall model

In the first stage, namely the stage of identifying potential and problems in the research school, by conducting observations, interviews, and documenting data in the form of learning outcomes of grade V students of SDN Kedungmundu. Furthermore, at the data collection stage, a questionnaire on student needs was distributed as a basis for planning a product that would be developed to overcome the problems that had been identified. At the product design stage, the researcher designed the product based on the analysis of student needs questionnaire data, by paying attention to aspects of material, language, and media display design. This product planning is adjusted to the Learning Outcomes (CP) and Learning Objectives (TP) on the human digestive system material in the subject of science for grade V SD Phase C. The focus of learning includes the function of the digestive organs, the digestion process, nutrition in food, and digestive disorders and how to prevent them. After the product design is complete, the next stage is the design validation stage. The previously designed media was validated by lecturers at Semarang State University as validators, consisting of material, language, and media experts according to their fields of competence. Expert validators filled out the validation assessment sheet prepared by the researcher in the Likert Scale 1-4 format.

The next stage is the design revision stage, by revising the product based on input from expert validators so that the product is ready to be tested. The

next stage is the trial stage, at this stage the first trial was carried out on a small scale on 15 class VA students of SDN Kedungmundu in the 2024/2025 academic year. The selection of students used the purposive sampling method based on variations in their cognitive ability levels. At the product trial stage, learning was carried out using the Problem Based Learning (PBL) model, and using Augmented Reality-assisted e-teaching materials on the human digestive system. After the learning was completed, teachers and students were asked to fill out a questionnaire to provide responses to the use of Augmented Reality-assisted e-teaching materials on the human digestive system. Data from the teacher and student response questionnaires were analyzed using descriptive statistical methods, and the results were used as a basis for revising the product that had been tested.

The last stage is the large-scale trial stage, involving 27 class VB students of SDN Kedungmundu in the 2024/2025 academic year. This stage aims to determine the effectiveness of the product developed based on the Learning Outcomes (CP) and Learning Objectives (TP) to be achieved. The type of data in this study is primary data obtained directly during the research process. The data consists of qualitative and quantitative data. Qualitative data were obtained through observation, interviews with teachers, and distributing questionnaires to students at SDN Kedungmundu. Meanwhile, quantitative data comes from the learning outcomes of grade V students in the science subject of the human digestive system, as well as from the results of the pretest and posttest assessments. This study used a pre-experimental design with a one-group pretest-posttest design model, where the pretest was conducted before the treatment was given, and the posttest was conducted afterward. This design aims to increase the accuracy of the results by comparing the conditions of participants before and after treatment.

Data collection in this study was carried out through test and non-test techniques. The test technique involved 30 multiple-choice questions, which were used in the pretest and posttest. These questions were designed to measure the level of students' understanding of the material before and after the application of the developed learning media. The narratives of the pretest and posttest questions were differentiated to ensure that students understood the material being taught, not just remembering questions that had been worked on previously. All questions have gone through a validity test process carried out using the content validity and empirical validity methods, and were analyzed with the help of SPSS statistical software. A summary of the results of the item analysis is presented in Table 1.

While non-test techniques include the results of interviews, questionnaires, observations, value lists, and documentation. Assessment of product feasibility in learning is carried out through data analysis based on evaluations by material, language, and media experts. The validation process is carried out by lecturers at Semarang State University as validators, consisting of material, language, and media experts according to their fields of competence. This aims to obtain input and assessment of important aspects of the product, such as material suitability, language use, and media presentation. The assessment is carried out using a questionnaire with a Likert scale of 1-4. Assessment of the practicality of the product in learning is carried out through data analysis from teacher and student response questionnaires related to the use of e-teaching material products assisted by Augmented Reality during the learning process. This assessment aims to identify the level of acceptance and response of teachers and students to the practicality of the product in supporting learning.

Table 1. Summary of Item Analysis Results

Analysis Criteria	Analysis Results
Validity of Questions	All 30 questions are valid with a correlation coefficient value > 0.51
Question Reliability	Cronbach's Alpha coefficient = 0.97
Difficulty Level	28 questions: Medium Category2 questions: Difficult Category
Differential Power of Questions	Questions: Very Good Category; 6 questions: Good Category; 3 questions: Fair Category (with minor improvements)
Conclusion	The pretest and posttest questions were declared to meet the criteria of validity, reliability, level of difficulty, and discriminatory power that were suitable for use in research.

The assessment is carried out using a questionnaire with a Likert scale of 1-4. Assessment of the effectiveness of the product in learning is carried out through data analysis from the results of the pretest and posttest. The analysis process begins with a data normality test using the Shapiro-Wilk method through SPSS software to ensure that the data meets a normal distribution. Furthermore, the analysis is continued with the Paired Samples Test (t-test) to test whether there is a significant difference between the pretest and posttest results. Finally, the N-Gain test is used to measure the level of score increase from pretest to posttest, which aims to evaluate the effectiveness of the product based on changes in student scores at the large-scale trial stage.

Result and Discussion

Potential and problems

Based on the results of a preliminary study at SDN Kedungmundu, several problems were found, including that student were less interested in the science subject and considered the science subject of the human digestive system to be difficult. The available learning resources are not fully in accordance with the needs of students. Teachers tend to rely on government-published books, such as teacher's books and student books, as the main source, and occasionally use materials from YouTube without any modifications that are adjusted to the needs and characteristics of students. In addition, teachers tend not to utilize the available technological facilities optimally, even though each class has been equipped with a Wi-Fi network. Teachers sometimes still rely on learning videos from YouTube without any modifications that are adjusted to the needs and characteristics of students. In implementing learning, students tend to show a passive attitude, this is reflected in the dominant use of the lecture method by teachers and the low participation of students in asking or answering questions. In addition, the learning outcomes of the science subject of the human digestive system material for grade V at SDN Kedungmundu in the 2023/2024 academic year were found that out of 27 students, 8 students (30%) had met the learning objective achievement criteria (KKTP). Meanwhile, 19 students (70%) have not met the learning objective achievement criteria (KKTP) with a minimum completion score of 75.

Data Collection

Initial data collection was carried out through interviews with class teachers and distributing questionnaires to students to identify their needs for learning resources. Based on the results of initial data collection, it is known that the available learning resources are not fully in accordance with the needs of students. Teachers tend to rely on government-published books, such as teacher books and student books as the main source, and occasionally use material from YouTube without any modifications that are adjusted to the needs and characteristics of students. Although teacher and student books provide illustrations, the number is limited, so it is not enough to visualize complex science material, such as the human digestive system. This is an obstacle because the organs in the digestive system cannot be observed directly. In addition, in learning, teachers tend not to optimize the use of learning media and the use of technology available in schools, so that the goal of increasing student learning motivation and providing new learning experiences for students has not been achieved. Conventional teaching materials have several weaknesses, such as being easily damaged, materials that tend to be monotonous, requiring space to carry, and being less interesting for students. This condition makes teaching materials an important issue that needs to be studied further.

On the other hand, the great potential for integrating smartphones in learning has not been fully optimized by teachers. Based on the results of the questionnaire, as many as 26 out of 27 (96%) grade V students at SDN Kedungmundu have their own smartphones that can be used to access the internet. However, as many as 27 students (100%) only use their cellphones for playing games and entertainment. The results of the questionnaire data show that all students (100%) have a high interest in using smartphones as a learning aid, with 27 out of 27 students stating that they like to learn using smartphones. In addition, support for the use of smartphones in learning also comes from parents, where 28 out of 35 (80%) parents agree to the use of smartphones on condition that they are under the supervision of a teacher. Based on the data obtained, 25 out of 27 students (93%) stated that smartphones help them understand the learning material. In addition, 18 out of 27 students (67%) admitted that they preferred learning about the human digestive system using technology, while 20 out of 27 students (74%) were more interested in learning media in the form of images or videos. These data indicate the need for strategic steps to utilize the potential of smartphones as effective learning media in schools. Therefore, the development of digital teaching materials integrated with technology is needed as a solution to overcome these shortcomings. Digital teaching materials allow teachers to access them easily, present more interesting materials, and provide different learning experiences for students.

Product Design

The Augmented Reality-assisted e-learning material is designed in accordance with the Learning Outcomes (CP) and Learning Objectives (TP) to be achieved in the human digestive system material. This Augmented Reality-assisted e-learning material is designed based on adjustments to the characteristics of students so that it is easy to understand and can increase the learning motivation of elementary school students with a concept consisting of images, animations, videos, writing, and 3D objects. This Augmented Reality-assisted e-learning material is created with the initial step of preparing the material, design, and layout to be used. After the initial steps are completed, it is continued with the product design creation stage using several applications. For the design of the e-learning material, the CorelDraw 2018 application is used, while the objects

for Augmented Reality are created using the Assemblr Edu application. The final stage is to combine e-teaching materials with Augmented Reality exported in the form of a QR code, perfecting the design using the CorelDraw 2018 application. The final product of this learning media is a digital book in flipbook format that can be accessed online, and can be scanned using the Asseblr Edu application or website, Google Lens, or the default scanner application from a smartphone. The parts of this Augmented Reality-assisted e-teaching material consist of the following components:

Figure 2. Front Cover

Figure 3. Product Use Instructions

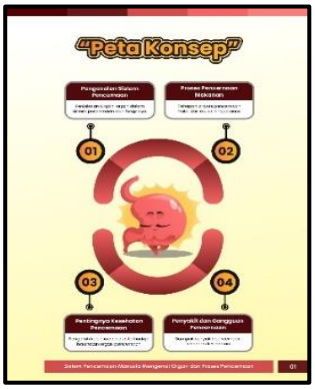

Figure 4. Concept Map of All Material

Figure 5. CP and TP

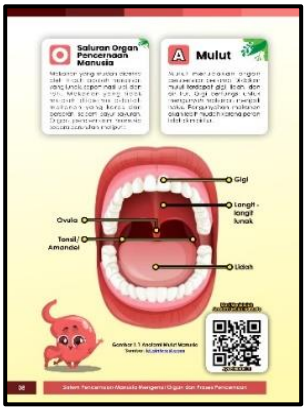

Figure 6. Material Page 1

Figure 7. Material Page 2

Figure 8. Augmented Reality Human Mouth Anatomy

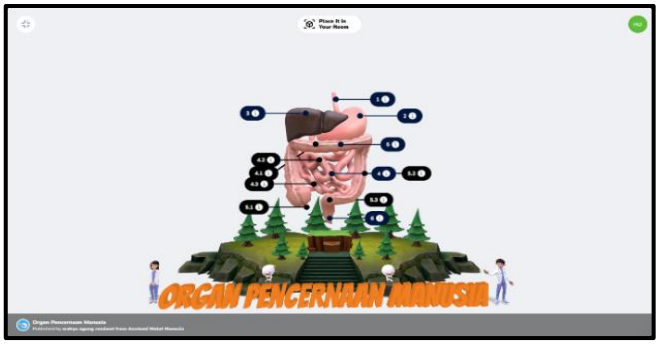

Figure 9. Augmented Reality Anatomy of Human Digestive Organs

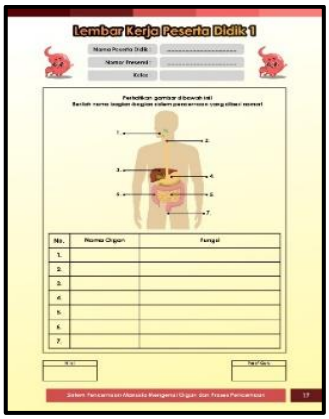

Figure 10. LKPD

Figure 11. Back Cover

The product design stages include: preparation of materials; making 3D images using Assemblr edu; and making e-teaching materials and implementing Augmented Reality QR codes on e-teaching materials.

Validation of Augmented Reality-Assisted E-Teaching Material Product Design

At this stage, the researcher validates the product developed with expert validators in terms of material, language, and media to test the suitability of the product to the needs. After the product is assessed by the expert validator, the researcher revises the product according to the suggestions and input given by the expert validator. Learning media will be included in the very feasible criteria if it gets a score of 82% - 100%, the feasible criteria if it gets a score of 63% - 81%, the fairly

feasible criteria if it gets a score of 44% - 62%, the less feasible criteria if it gets a score of 25% - 43%, and the very unfeasible criteria if it gets a score of less than 25%. The recapitulation of the product validation results for each expert validator is presented in table 2.

Based on the results of the expert validator assessment presented in table 2, the Augmented Reality-assisted e-learning materials are declared valid overall in terms of content or material, language, and display or media. The assessment of the feasibility of the material by the material expert obtained a score of 94% which is included in the "very feasible" category. Furthermore, the assessment of the feasibility of the language by the linguist obtained a score of 80% which is included in the "feasible" category. And the assessment of the feasibility of the media by the media expert obtained a score of 94% which is included in the "very feasible" category. Based on the feasibility value obtained from the expert validator, it can be concluded that the Augmented Reality-assisted e-learning materials are declared feasible overall in terms of material, language, and display or media. And the Augmented Reality-assisted e-learning materials are feasible and ready to be tested.

Table 2. Results of Expert Validator Assessment of Augmented Reality-Assisted E-Teaching Materials

Indicator	Material Validator	Language Validator	Media Validator
Total Score	94	80	94
Maximum Score	100	100	100
Percentage	94%	80%	94%
Criteria	Very Feasible	Feasible	Very Feasible

Design revision

Figure 12. CP and TP sheets before revision

Figure 13. CP and TP sheets after revision

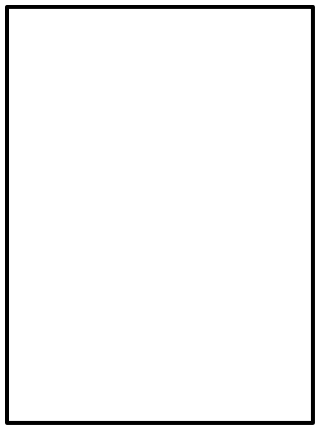

Figure 14. There is no discussion sheet on the digestive tract and glands yet.

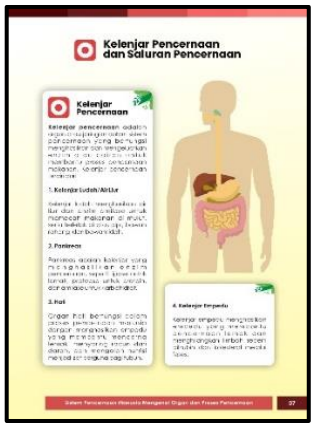

Figure 15. Digestive tract and glands discussion sheet

Figure 16. Food nutrition material before revision

Figure 17. Food nutrition material after revision

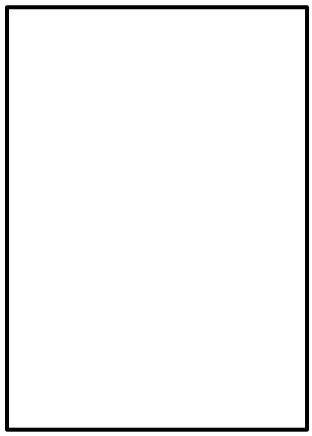

Figure 18. There is no discussion sheet for the 10 balanced nutrition messages yet

Figure 19. Discussion sheet for 10 balanced nutrition messages

Figure 20. Ways to prevent digestive disorders are still in each digestive disorder

Figure 21. Ways to prevent digestive disorders are combined into one general method.

The researcher revised the product design according to the suggestions and input from the material expert validators, language experts, and media experts. Suggestions and input from the material expert validators include adjusting the learning objectives, adjusting the sequence of learning materials in Learning Objective 3 and Learning Objective 4, and adding discussion of materials related to the digestive glands. Suggestions and input from the language expert validator include avoiding the use of double quotation marks in each title, improving the writing in the material explanation section, rechecking the conformity of the writing with KBBI/PUEBI, and adjusting the writing of the bibliography to the American Psychological Association (APA) writing style. There are no suggestions and input from the media expert validator because according to the media expert, this Augmented Reality-assisted e-teaching material is good and complete.

Practicality of Augmented Reality-Assisted E-Learning Materials (Product Trial)

The next stage is the small-scale product trial stage involving 15 class VA students of SDN Kedungmundu in the 2024/2025 academic year. Students were selected heterogeneously based on their ability level, consisting of 5 students with a high level of understanding, 5 students with a medium level of understanding, and 5 students with a low level of understanding. After learning using Augmented Reality-assisted e-learning materials was completed, teachers and students were given a response questionnaire related to the use of Augmented Reality-assisted e-learning materials, each questionnaire containing 20 questions. The 20 questions in each questionnaire cover three aspects, namely material quality, language quality, and media quality. This questionnaire uses a Likert scale of 1-4 which must be filled in by teachers and students based on their experience when using the product that the researcher has developed. This response questionnaire will be included in the very feasible criteria if it gets a score of 82% - 100%, feasible criteria if it gets a score of 63% - 81%, quite feasible criteria if it gets a score of 44% - 62%, less feasible criteria if it gets a score of 25% - 43%, and very unfeasible criteria if it gets a score of less than 25%.

Table 3. Results of the Teacher and Student Response Questionnaire on the Use of E-Learning Materials Assisted by Augmented Reality Small-Scale Trial

Respondent	Percentage (%)	Criteria
Teacher	95	Very Positive
Students	84	Very Positive

From the data shown in table 3, it shows that the responses of teachers and students in small-scale classes are very positive towards the use of e-learning materials assisted by Augmented Reality because they obtained a score above 81%. E-learning materials assisted by Augmented Reality are stated to be practical based on 20 questions on the Likert scale questionnaire 1-4. Thus, e-learning materials assisted by Augmented Reality can be used practically in learning activities.

Table 4. Results of the Teacher and Student Response Questionnaire on the Use of E-Learning Materials Assisted by Augmented Reality Large-Scale Trial.

Respondent	Percentage (%)	Criteria
Teacher	97	Very positive
Students	86	Very Positive

From the data shown in table 4, it shows that the responses of teachers and students in large-scale classes are very positive towards the use of Augmented Reality-assisted e-teaching materials because they get a score above 81%. Augmented Reality-assisted e-teaching materials are stated to be practical based on 20 questions on a Likert scale questionnaire 1-4. Thus, Augmented Reality-assisted e-teaching materials can be used practically in learning activities.

Effectiveness of Augmented Reality-Assisted E-Teaching Materials

At this stage, a large-scale trial has been conducted on grade VB students of SDN Kedungmundu in the 2024/2025 academic year with a total of 27 students using Augmented Reality-assisted e-teaching materials in the Science subject on the human digestive system to determine the effectiveness of the product developed by researchers based on student learning outcomes. This study uses a pre-experimental design with a one-group pretest-posttest design model, where the pretest is

carried out before the treatment is given, and the posttest is carried out afterwards.

Table 5. Results of the Pretest and Posttest of Students in the Usage Trial.

Test Type	Average	Average Difference
Pretest	39.15	40
Posttest	79.15	

Based on the data in table 5, it is known that there is an average increase in student learning outcomes of 40 in large-scale product trials. The data shows that there is a difference in student learning outcomes before and after using e-teaching materials assisted by Augmented Reality in the subject of science on the human digestive system in grade V at SDN Kedungmundu. The next data analysis is the normality test to evaluate changes in science learning outcomes. Before the main analysis, a normality test was conducted to assess whether the data was normally distributed. Decisions are based on significance values: if the significance value <0.05, the data is not normally distributed; If the significance value> 0.05, the data is normally distributed. The results of this normality test are summarized in table 6.

Table 6. Data Normality Test Results

Normality test			
			Shapiro-Wilk
	Statistics	Df	Sig.
Pretest Score	.94	27	.117
Posttest Value	.95	27	.167

Based on the analysis results in table 6, the data shows a normal distribution because the significance value is > 0.05. The next test conducted is the Paired Sample T-test. The decision in this test is based on the significance value (2-tailed). If the significance value is <0.05, there is a significant difference in the average learning outcomes of grade V students between the pretest and posttest. Conversely, if the significance value is > 0.05, then there is no significant difference in the average learning outcomes. The results of the Paired Sample Test analysis are shown in table 7.

Table 7. Paired Sample Test Results (T-Test)

Paired Sample Test			
Pretest Score – Posttest Value	T-statistic	Degree of freedom	Sign. (2-chord)
	32.21	27	.000

Based on the analysis results in table 7, the data shows a significance value (2-tailed) of 0.000 <0.05, so it can be concluded that there is a significant difference between the pretest and posttest scores with the use of Augmented Reality-assisted e-learning materials. In addition, this is also proven through the average increase test (N-gain) by comparing the increase in pretest and posttest results calculated using the N-gain index analysis in table 8.

Table 8. N-Gain Test Results

Average Difference	N-Gain	Group
40	0.67	Moderate

Based on table 8 from the results of the N-gain analysis, it is known that the average difference in large-scale product trials is 40 and the N-gain value is 0.67. This shows that the learning outcomes of grade V students at SDN Kedungmundu have increased by an average of 0.67 and are included in the "moderate" criteria. The increase in average learning outcomes shows that e-teaching materials assisted by Augmented Reality in the subject of science on the human digestive system in grade V SDN Kedungmundu are effective in improving student learning outcomes. The results of the data analysis show that e-teaching materials assisted by Augmented Reality meet the criteria of feasibility, practicality, and effectiveness in improving the learning outcomes of grade V SD students in science learning on the human digestive system. This is supported by several supporting factors.

First, the use of e-learning materials assisted by Augmented Reality provides a significant contribution in increasing students' motivation to learn technology as part of 21st century learning while creating an interesting and enjoyable learning atmosphere, thus supporting students' active involvement in the learning process. This media creates an interactive and enjoyable learning experience while encouraging students' interest in reading through interesting visualizations which plays an important role in facilitating understanding (Haleem et al., 2022), strengthening memory of the material presented by the teacher, and supporting the achievement of learning objectives. Second, e-learning materials assisted by Augmented Reality are innovative and practical learning media used to support the learning process in the classroom (Pamorti et al., 2024; Sakr & Abdullah, 2024; Supriyanto et al., 2023).

In addition to helping students during classroom learning, this media also allows students to learn independently, thus indirectly empowering students who tend to be slow to understand the material in school (Irawan, 2020; Zhai et al., 2024). In addition, the Augmented Reality feature also helps students who have learning difficulties by presenting interactive and easy-to-understand visualizations (Dendodi et al., 2024; Hermawan & Hadi, 2024). Third, the use of Augmented Reality-assisted e-learning materials helps students understand the basic concepts of the material taught by

the teacher while stimulating their curiosity (Liang et al., 2023; Radu et al., 2023; Zaid et al., 2022). Augmented Reality-assisted e-learning materials as learning media are designed with attractive designs and equipped with images and short videos that clarify the material, so that they can increase students' interest in the learning process (Mu'afiqoh & Wachidah, 2024; Resti et al., 2024). Thus, the use of this media as a whole contributes to improving student learning outcomes (Tempera & Tinoca, 2022). Fourth, Augmented Reality is an innovative technology that is easy to use and is able to stimulate formative learning scenarios that motivate and support collaborative work, thus indirectly increasing student engagement during the learning process (Hernanda & Aji, 2024). In addition, the use of this technology has a significant influence in developing critical thinking skills (Jannah & Atmojo, 2022) and improving students' visual-spatial skills in elementary schools (Lokollo et al., 2024; Lowrie & Logan, 2023). Finally, e-learning materials assisted by Augmented Reality are very easy to carry and use anywhere, anytime (Amirahma & Setyasto, 2024; Hafizhah & Setyasto, 2024). The results of the study indicate that e-learning materials assisted by Augmented Reality can be utilized by teachers and students as a learning aid to improve learning outcomes. Based on conditions, problems in the field, and previous research studies, researchers have succeeded in developing e-learning materials assisted by Augmented Reality for science learning for grade V elementary school students. The analysis and results of the study prove that this e-learning material is feasible, practical, and effective for use in science learning in grade V elementary school.

Conclusion

The results of the study indicate that e-teaching materials assisted by Augmented Reality in the subject of science on the human digestive system material have been proven to improve the learning outcomes of grade V students at SDN Kedungmundu. This is indicated by the results of the feasibility test based on the results of the validation of material, language, and media experts which show that e-teaching materials assisted by Augmented Reality are declared "very feasible" with an average score of 89%. The practicality of e-teaching materials is indicated by the results of the questionnaire responses of teachers and students to the use of e-teaching materials assisted by Augmented Reality showing a "very positive" level of satisfaction, with a score of 97% from teachers and 86% from students. The effectiveness of e-teaching materials assisted by Augmented Reality is proven through the results of the t-test with a significance value of 0.000 (<0.05) and an N-gain of 0.67, which is included in the "moderate" category. These results indicate that e-teaching materials assisted by Augmented Reality meet the criteria of feasibility, practicality, and effectiveness to improve the learning outcomes of grade V elementary school students in the science subject of the human digestive system.

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M. W. A. R contributed to research, product development, data analysis, and article writing. N. S as a supervisor in research activities until article writing.

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Conflicts of Interest

The author declares that he has no conflict of interest.

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