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Development of E-Learning Materials Assisted by Augmented Reality in the Science Subject of Water Cycle Material for Grade V Elementary Schools

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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 34 fifth-grade students of SDN Dampyak 02 in the 2024/2025 academic year, with a small-scale trial on 12 VA-class students and a large-scale trial on 22 VB-class students. The feasibility of e-learning materials is shown from the results of validation by material, language, and media experts which showed that AR-assisted e-learning materials were declared "feasible" with an average score of 78%. 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 88% from teachers and 88% 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 0.6, 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 science learning for grade V at SD Negeri Dampyak 02.

Keywords: Augmented reality; E-Learning materials; Science; Water cycle

Introduction

In Government Regulation Number 16 of 2022 concerning educational process standards, it states that the implementation of learning is carried out in an interactive, inspiring, fun, challenging learning atmosphere, motivating students to actively participate and the use of technology in the learning process. Learning should provide a fun, interactive experience and motivate students to actively participate. However, in reality, there is still a teacher-centered learning approach that does not actively involve students, which can hinder the learning process of students and the limited learning resources that are less appropriate are also one of the obstacles that make the learning atmosphere less interactive and fun in the learning process so that students become unmotivated and bored because the material presented is not interactive and interesting, which results in low achievement of competencies and learning outcomes (Mawarni & Fitriani, 2019).

The limitations of learning resources are the main obstacle in implementing the independent curriculum because not all schools have supporting, adequate and practical teaching materials to use, so teachers have difficulty accessing and developing these learning materials, which causes many teachers to face difficulties in creating appropriate media for learning and adapting materials to these media. This causes many teachers to not utilize learning media optimally

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(Sihombing et al., 2023). In addition, teachers must also develop materials that suit their students' needs (Anugraheni, 2017). Another problem that often occurs in learning is the lack of utilization of technology that has not been maximized by teachers. Where many teachers have not utilized the technological facilities available in schools 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 (Zayyadi et al., 2017). This is also supported by several previous studies, such as research by Evriyanti et al. (2019) also supports this, with the analysis of interview results the difficulties faced by teachers in using learning media have difficulties in making media, lack of time efficiency in making learning media, creativity in making media that is still low.

Other studies also state that learning is still centered on the teacher, with the methods used being less than optimal and inadequate classroom facilities, resulting in a passive classroom environment and students becoming bored (Cansiz & Cansiz, 2022; Hota, 2023; Tempera & Tinoca, 2022). This shows the lack of teacher creativity and the teacher's willingness to obtain the desired learning resources, which causes boredom or boredom in students due to lack of motivation in learning. To motivate students to learn, it is necessary to use good and correct media, in order to increase students' interest and motivation to learn. From the various obstacles and problems, researchers at SDN 02 Dampyak also found several similar things. From the results of observations and interviews that have been conducted, the lack of use of media and technology in the classroom so that students feel bored during learning. The results of the questionnaire distributed to grade V students of SDN 02 Dampyak provide an overview that there are still many students who are less interested and consider the subject matter of science and natural sciences difficult. From the results of the questionnaire regarding the subjects they like, it is known that 15% of students like mathematics, 44% of students like civics, 41% sports, and 0% of students like science and natural sciences. This means that there is no great interest from students to learn and participate in science and natural sciences learning.

In addition, the existing technology has not been utilized optimally. Facilities such as Wi-Fi, LCD and projectors in schools are underutilized in the learning process because they are only used at certain moments, although teachers sometimes use them in learning so that the use of technology is not maximized in learning. The availability of mobile phones owned by students is also not optimal. From the results of the questionnaire, 94% of students already have their own cellphones, all of which are Android, with 9% of students using them for studying, 38% for YouTube and social media, and 53% of students using them for playing games. This means that 91% of students have not used their cellphones properly for studying, so this has an impact on student learning outcomes in science and natural science subjects at SDN 02 Dampyak, where 62.9% of students have not met the completion standard with a minimum completion score of 75. Based on interviews conducted with teachers in Class V at SD Negeri Dampyak 02, researchers found that teachers still use conventional learning methods such as lectures, discussions and questions and answers. However, sometimes teachers do not optimize the use of technology as a teaching medium, namely by displaying learning videos, which are also rarely used. This makes students easily bored and learning becomes less meaningful, which will later result in a lack of student understanding of the material to be taught because students are less involved in the learning process.

Seeing this problem, the school expects development from several aspects such as variations in teaching materials that utilize interactive media. This step was taken to increase student motivation during learning activities and to encourage collaboration skills. One example of learning media that can be utilized and integrated with technology is E-teaching materials, namely digital teaching materials, the same as teaching materials but in E-teaching materials it is packaged in digital form to address teaching materials that are in accordance with the needs of students. These e-teaching materials are designed for use on devices such as computers, tablets, or smartphones. E-teaching materials utilize several multimedia elements, such as text, images, video, audio, animation, and interactive features to create an interesting and effective learning experience. The advantage of this e-teaching material lies in its ability to present more interesting material (Salfia, 2021), involves varied learning activities, as well as providing a deeper learning experience through visualization and interactivity. In addition, e-teaching materials offer practical use because they can be accessed anywhere and anytime, thus supporting flexible learning and being in accordance with the needs of students in the digital era (Ramadhan et al., 2023).

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 virtual world and the real world in two-dimensional or three-dimensional form in real-time into a real environment, and only uses a smartphone or computer device (Dalimunthe & Simanjuntak, 2023). By integrating virtual objects into the real world and being able to project them, learning becomes more interesting,

fun, and meaningful. In previous studies such as the study entitled "Development of Digital-Based Teaching Materials in English Subjects at SMK Atlantis Plus Depok", it was stated that the use of digital-based teaching materials was considered effective in improving learning and teaching outcomes (Farhana et al., 2021). Furthermore, the research entitled "Development of Interactive Teaching Materials Based on Augmented Reality Assisted by the Assemblr Edu Application on Earth Structure Material for Class 5 at MI Malik Ibrahim Jenggawah" revealed that Augmented Reality (AR) based teaching materials are very feasible and effective to use during learning]. Difficult materials that we cannot see in the surrounding environment can be visualized through Augmented Reality.

The application of Augmented Reality can be one of the most appropriate media to support the learning and teaching process, attract students' attention and increase learning motivation because it can improve students' understanding of the texture and structure of an object and students at elementary school level tend to think directly and concretely, so that difficult-to-understand learning materials must be visualized to make it easier to provide a deeper learning experience so that students can easily understand materials that previously felt abstract. The results of previous research show that AR learning media in this learning attracts the attention and learning motivation of students, and is needed, especially in learning because it can realize the texture, structure, and shape of objects from the virtual world to the real world (Permana et al., 2022). Augmented Reality is a resource that has a series of intrinsic characteristics that supports its inclusion and use in education because it is an interesting, fun, dynamic and versatile teaching tool (Afnan et al., 2021; Cabero Almenara et al., 2020; Moreno-Fernández et al., 2023). The presence of Augmented Reality as part of learning media has been proven to improve students' learning experience in science subjects (Drljević et al., 2024; Khazali et al., 2023) and able to balance student learning outcomes with the learning skills needed in the 21st century (Wen et al., 2023).

Currently, the use of AR for learning can be accessed via handheld devices using an application called Assemblr. This application is an Augmented Reality platform designed to simplify the process of designing 3D content, which can then be displayed in the form of Augmented Reality. This method is carried out in an efficient and profitable way for its users. Both teachers and students can download this application for free via the Google Playstore. The existence of this convenience is an important factor in increasing the effectiveness of teaching materials in the classroom (Ginanjar et al., 2024). The new media that researchers developed is e-teaching material media assisted by Augmented Reality which is packaged in the form of a digital book for grade V elementary school students, which contains water cycle material for grade V elementary school by integrating Augmented Reality technology in certain parts of the material. This aims to facilitate students' understanding of the concept of the water cycle in an interactive and interesting way. This e-teaching material assisted by Augmented Reality is equipped with a QR code which is useful for accessing visualization of the material in 3D form. By scanning the QR code using a smartphone, students can see the material in 3D form which can be enlarged, rotated 360 degrees, and observed in detail. The selection of smartphone use is based on data from filling out the questionnaire on student smartphone use, that 20 out of 22 students (94%) have smartphones and are able to operate them well. Thus, this e-teaching material can be implemented effectively in group learning. This e-teaching material contains grade V science material about the water cycle. This material is often considered abstract by students because they cannot see the process of the water cycle directly.

Through Augmented Reality visualization, students can understand the process of the water cycle in a real and interactive way, making it easier to understand the concepts being taught. Based on these various backgrounds, researchers conducted research on the development of e-learning media assisted by Augmented Reality to improve the learning outcomes of fifth grade students in the subject of science on the water cycle at SDN 02 Dampyak. The purpose of this research and development is to test the feasibility, practicality and effectiveness of the developed product, so that it is hoped that this learning media can make it easier for students to learn the water cycle material in fifth grade at SDN Dampyak 02.

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Method

The type of research used by the researcher is Research and Development (R&D) which will ultimately produce a product of an E-Learning Materials learning media assisted by Augmented Reality in learning science and science materials for grade V of elementary school. In this media research and development, the researcher implemented development in accordance with the procedure developed by Sugiyono which consists of 10 steps, but in this study the researcher only limited it to step 8, namely trial use, due to time and cost constraints. Therefore, the steps in this study consist of: potential and problems; data or information collection; product design; design validation; design revision;

product testing; product revision; trial use. The research scheme can be seen in Figure 1.

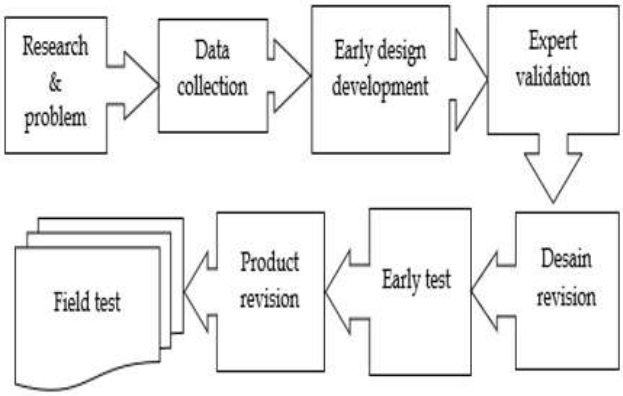

Figure 1. Modified from the Borg & Gall Model

The first stage is the stage of identifying potential and problems to find out the potential and problems that exist in the school by conducting observations, interviews, and documenting data for class V SDN 02 Tambak Aji. The next stage is the data collection stage, in the form of a questionnaire on student needs distributed as a basis for planning products that will be developed in order to overcome the identified problems. The next stage is analyzing the data, the researcher then designs a product with a design that is adjusted to the needs of fifth grade students to be achieved, namely by paying attention to aspects of language, material and media display design. In planning this product, it is adjusted to the Learning Achievements (CP) along with Learning Objectives (TP) in the fifth grade elementary school science subject matter Phase C. The focus of learning includes the definition of the water cycle, the function of the water cycle, the benefits of the water cycle, the process of the stages of the water cycle, the impact caused by humans on water resources and how to maintain water availability.

After the product is designed, the researcher validates the design, the previously designed media will be validated by lecturers at Semarang State University as expert validators who are competent in their fields in this case media experts, material experts, and language experts by filling out the validation assessment sheet that has been prepared by the researcher in the form of a Likert scale of 1-4. The next stage is to revise the product design based on input from expert validators so that the product is ready to be tested. After the revision is complete, the product will be tested on students on a small scale, namely in class VA consisting of 12 students using a purposive sampling technique that takes into account different levels of cognitive ability. At the product testing stage, learning is carried out using the Problem Based Learning (PBL) model and using e-teaching materials supported by Augmented Reality on the water cycle material. After the learning activities are completed, both teachers and students will fill out a questionnaire regarding responses to the use of e-teaching materials assisted by Augmented Reality on the water cycle material, which will then be analyzed to be used as revision material if there are suggestions or input. The final stage is a large-scale product trial, which will be carried out in class VB of Dampyak 02 Elementary School for the 2024/2025 academic year involving 22 students. This stage aims to determine the effectiveness of the product that has been developed based on the Learning Achievements (CP) and Learning Objectives (TP) to be achieved.

The type of data used in the study is primary data obtained directly during the research process, consisting of qualitative and quantitative data. Qualitative data were obtained from observations, teacher interviews, and questionnaire distribution at SDN 02 Dampyak. Quantitative data were obtained from the learning outcomes of fifth grade students at SDN 02 Dampyak on science subject matter about the water cycle as well as the results of pretest and posttest assessments. The research design used by the researcher was a pre-experimental design with a one-group pretest-posttest design model, namely there was a pretest before the treatment was given and a posttest was conducted after the study to find out more precisely the results of the treatment because it could compare conditions before and after the treatment. Data collection techniques used test and non-test techniques. The test technique was in the form of 30 multiple-choice questions that were the same for use in the pretest and posttest. These questions were designed to measure students' understanding of the material taught before and after the implementation of the developed learning media.

Table 1. Recapitulation of Question Item Analysis Results

Analysis Criteria	Analysis Results
Question Validity	All 30 questions are valid with correlation coefficient values > 0.514
Question Reliability	Cronbanch's Alpha Coefficient = 0.86
Difficulty Level	9 Questions: Easy Category
Question Distinction Power	15 Questions: Moderate Category
Conclusion	6 Questions: Difficult Category

While non-test techniques include observation results, interviews, questionnaires, value lists, and documentation. To determine the feasibility of the product in learning is done through data analysis based

on evaluation by expert validator assessments of material, language, and media. The validation process is carried out by lecturers at Semarang State University as validators, in accordance with their fields of competence. This aims to obtain input and assessment of important aspects of the product, such as the suitability of the material, use of language and media presentation. The assessment is carried out using a Likert scale of 1-4.

Assessment of the practicality of the product in learning is carried out through data analysis from student and teacher response questionnaires related to the use of Augmented Reality-assisted e-teaching material products 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. The assessment is carried out using a product using 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 Sharipo-Wilk method through SPSS software to ensure that the data meets the normal distribution. Next is the analysis continued with 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 the pre-study, several problems were found, namely the lack of innovation and use of learning media and the lack of optimization of available learning facilities, in this case related to technology. Based on the results of the questionnaire that had been distributed, it was found that there was no interest from students in the content of science subjects and they considered science lessons difficult. In implementing their learning, students still tended to listen. In addition, in the results of learning the content of science subjects in grade V at SDN 02 Dampyak, it was found that 62.9% of students had not met the graduation standard with a minimum completion score of 75.

Initial Data Collection

The researchers collected initial data by distributing questionnaires to the needs of teachers and students. Based on the results of data collection, it was found that the material contained in the teacher and student books was still not extensive enough. The availability of insufficient material for teaching materials at school also means that teachers must find and compile additional material themselves from other sources to complete it so that students' knowledge of the material remains fulfilled. In learning, teachers are still not optimal in using learning media and utilizing available technology, so that the goal of increasing student learning motivation and providing new learning experiences for students cannot be achieved. Therefore, it is necessary to develop learning media that can attract students' attention by choosing designs, colors, and using images that can increase students' interest in learning. Based on the results of the questionnaire, where 94% of students already have their own cellphones, all of these cellphones are Android-based and 91% of students do not use their cellphones well for learning, this shows that teachers also need technology-based learning media that can be used on cellphones. Thus, students can use their cellphones more for learning. Teachers also provide input to create interactive learning media that can provide new experiences to students so that their understanding of the learning material can last longer. Therefore, the development of E-Learning Materials learning media assisted by Augmented Reality with materials that are appropriate to the student's environment and the use of short and clear language so that the material is easy for students to understand is the answer to all existing problems.

Product Design

The Augmented Reality-assisted E-Learning Material learning media is designed according to the learning achievements and objectives to be achieved in the water cycle material for grade V. This E-Learning Material is packaged with an explanation of the material in the form of writing, images, and integrated with Augmented Reality according to student characteristics so that it is easy to understand and can increase student learning motivation. This Augmented Reality-assisted E-Learning Material is made with the initial step of preparing the material, format and layout that will be used later, followed by creating a product design using several applications. For the design of the E-Learning Material using Canva, while for the objects for Augmented Reality using Assemblr Edu and Sketchfab. The final product of this learning is an application that can be used with the internet to download several assets in the Assemblr Edu application. This Augmented Reality-assisted teaching material consists of a cover, learning achievements, learning objectives, instructions for use, instructions, concept maps, material explanations, summaries, glossaries, bibliographies, author biographies.

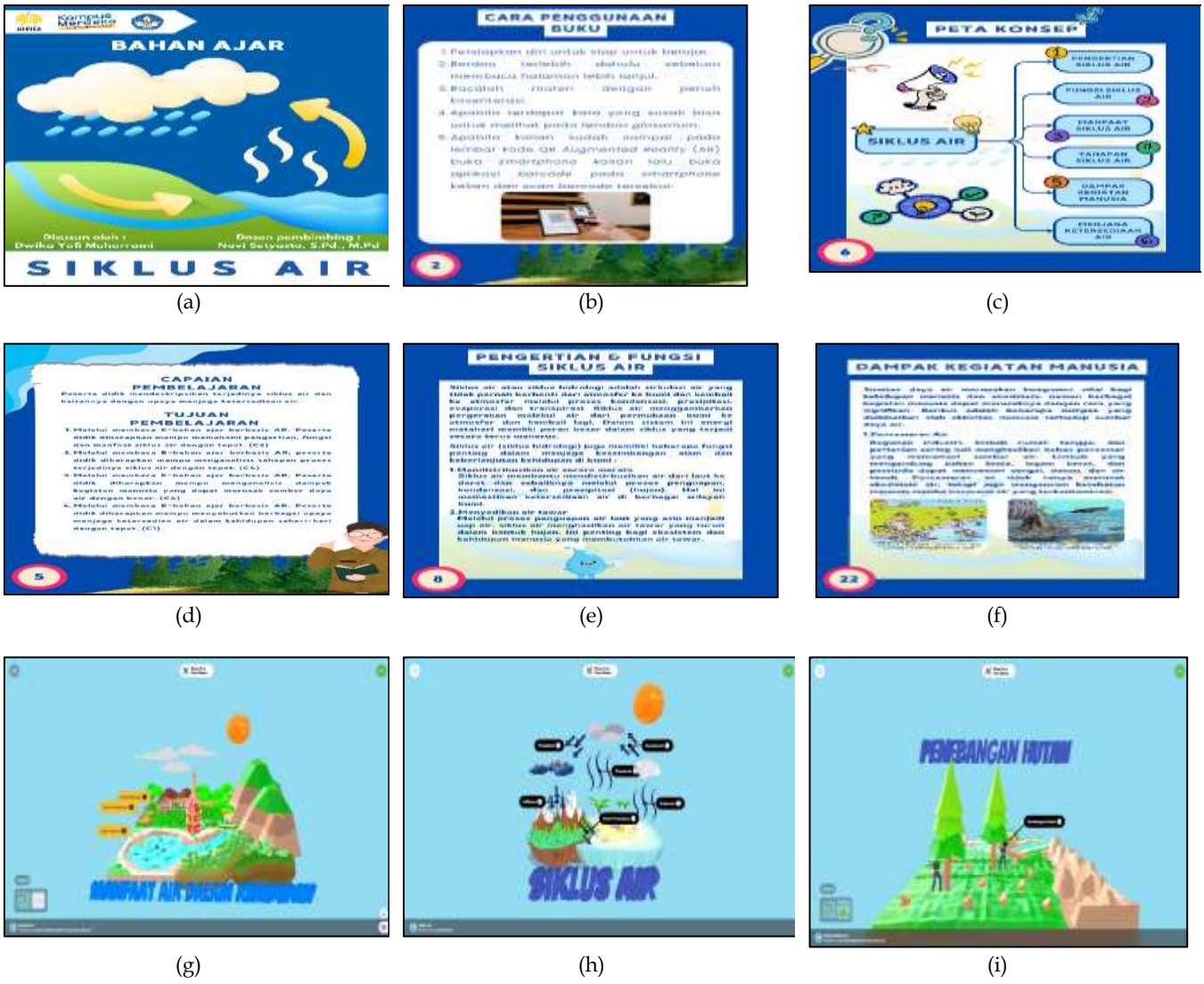

Figure 1. Display of E-Learning Material: (a) Cover Page; (b) Product Usage Instructions Page; (c) Concept Map Page; (d) CP and TP pages; (e) Material Page 1; (f) Material Page 2; (g) Augmented Reality Page 1; (h) Augmented Reality Page 2; and (i) Augmented Reality Page 3

Table 2. Results of Expert Validator Research on Augmented Reality-Assisted E-Learning Materials.

Indicator	Media Validator	Material Validator	Language Validator
Total score	71	55	34
Maximum score	80	68	52
Percentage	88.75%	80.88%	65.38%
Criteria	Very worthy	Very worthy	Worthy

Product Feasibility

At this stage, the researcher will validate competent experts in their fields, including media experts, material experts, and language experts to test the feasibility of the product. After being assessed by the validator, the researcher will revise the product according to the input and suggestions from the expert validators regarding the product developed by the researcher. Learning media will be included in the criteria of very feasible if it gets a score of 76%-100%, feasible if it gets a score of 51%-75%, quite feasible if it gets 26%-50%, and not feasible if it gets 0%-25%. The recapitulation of the validation results for each expert component is presented in Table 2.

Based on the results of the validator assessment presented in table 2, the E-Learning Materials assisted by Augmented Reality are declared valid in terms of overall content or material, appearance or media, and language so that they are ready to be tested in the field.

Design Revision

After validation by expert validators, the researcher made several revisions to the media according to the suggestions and input from expert validators. Media

experts provided a few suggestions from media validators, namely on adjusting the position of page numbers, the initial appearance on the cover page such as class placement for product usage targets, author biography and adjusting the position of text on the closing cover page. Material experts provided suggestions, namely on adjusting learning objectives in adjusting KKO such as changing from understanding to explaining, adjusting videos in teaching materials and improving writing in the material. Language experts provided suggestions, namely on the lack of bibliography, glossary, conclusions and adjustments to standard words that were not in accordance with KBBI.

Figure 2. Display of E-Learning Material: (a) Cover page before revision; (b) Cover page after revision; (c) CP and TP pages before revision; (d) CP and TP pages after revision; (e) Glossary Page; and (f) CP and TP pages after revision

Practicality of Augmented Reality-Assisted Teaching Materials (Product Trial)

The next stage is the product trial stage on a small scale using 12 class VA students of Dampyak State Elementary School in the 2024/2025 academic year who were taken heterogeneously based on the level of student ability, with a division of 4 students with a high level of understanding, 4 students with a medium level

of understanding, 4 students with a low level of understanding. After learning using Augmented Reality-assisted e-teaching materials was completed, teachers and students were given a response questionnaire related to the use of Augmented Reality-assisted e-teaching materials, each questionnaire containing 14 questions. The 14 questions in each questionnaire cover four aspects including material quality, language quality, media quality and learning 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 positive criteria if it gets a score of 82% - 100%, positive criteria if it gets a score of 63% - 81%, sufficient criteria if it gets a score of 44% - 62%, negative criteria if it gets a score of 25% - 43%, and very negative 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	87.50	Very Positive
Students	87.90	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 Augmented Reality-assisted e-learning materials because they get a score above 81%. Augmented Reality-assisted e-learning materials are stated to be practical based on 14 questions on the Likert scale questionnaire 1-4. Thus, Augmented Reality-assisted e-learning materials 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 in a Large-Scale Trial

Respondent	Percentage (%)	Criteria
Teacher	88.60	Very Positive
Students	89.20	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 14 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 small-scale trial has been conducted on class VA students of Dampyak 02 Elementary School in the 2024/2025 academic year with a total of 12 students using Augmented Reality-assisted e-teaching materials in the Science subject on the water cycle material to determine the effectiveness of the product developed by researchers based on student learning outcomes. The research design used is a pre-experimental design with a one-group pretest-posttest design model, namely there is a pretest before being given treatment and a posttest after being given treatment.

Table 5. Results of the Pretest and Posttest of Students in the Trial of Use in the Small-Scale Trial.

Test Types	Average (%)	Average Difference (%)
Pretest	59	25
Posttest	84	

Based on the data in table 5, it is known that there was an average increase in student learning outcomes of 24% in small-scale product trials. The data shows that there is a difference in student learning outcomes before and after using Augmented Reality-assisted e-teaching materials in the Science subject on the water cycle in class VA at SD Negeri Dampyak 02. Thus, Augmented Reality-assisted e-teaching materials can be used practically in learning activities on a large scale. Furthermore, at this stage a large-scale trial has been conducted on class VB students of SD Negeri Dampyak 02 in the 2024/2025 academic year with a total of 22 students using Augmented Reality-assisted e-teaching materials in the Science subject on the water cycle to determine the effectiveness of the product developed by researchers based on student learning outcomes. The research design used is a pre-experimental design with a one-group pretest-posttest design model, namely there is a pretest before treatment is given and a posttest after treatment is given as shown in Table 6.

Table 6. Results of the Pretest and Posttest of Students in the Trial of Use in the Large-Scale Trial.

Test Types	Average (%)	Average Difference (%)
Pretest	64.23	21
Posttest	85.23	

Based on the data in table 5, it is known that there is an average increase in student learning outcomes of 21% in large-scale product trials. The data shows that there is a difference in student learning outcomes before and after using Augmented Reality-assisted e-teaching materials in the Science subject on the water cycle in class VB at SD Negeri Dampyak 02. The next data

analysis is a normality test to evaluate changes in Science learning outcomes before the main analysis, a normality test is carried out to assess whether the data is 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 7.

Table 7. Data Normality Test Results

Test	Shapiro-Wilk		
	Statistics	Df	Sig.
Pretest Score	0.89	22	0.062
Posttest Score	0.93	22	0.149

Based on the analysis results in table 7, 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-making for this t-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 in science and technology between the pretest and posttest scores; if the significance value is > 0.05, then there is no significant difference in the average learning outcomes of grade V students in science and technology between the pretest and posttest scores. The results of the Paired Sample Test analysis are shown in table 8.

Table 8. Paired Sample Test Results (T-Test)

Paired Sample Test	T-statistic	Degree of Freedom	Sig. (2-tails)
Pretest Score Posttest Score	-8.681	21	0.000

Based on the analysis results in table 8, 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 9.

Table 9. N-Gain Test Results

Average Difference (%)	N-Gain	Group
21	0.6	Currently

Based on table 9 of the results of the N-gain analysis, it is known that the average difference in large-scale product trials is 21 and the N-gain value is 0.6. This shows that the learning outcomes of grade V students of Dampyak 02 Elementary School have increased by an average of 0.6 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 water cycle material in grade V of Dampyak 02 Elementary School are quite effective in improving student learning outcomes. The results of the data analysis show that e-teaching materials assisted by Augmented Reality are suitable for use in learning Science and water cycle material. This is supported by several supporting factors.

First, the use of e-teaching materials assisted by Augmented Reality contributes to increasing student motivation to learn technology as part of 21st century learning while creating an interesting, interactive, and adaptive learning atmosphere, this technology is able to help create an effective and efficient learning atmosphere (Faraniza, 2021; Kabudi et al., 2021). Through this digital media, it can help teachers in creating a more effective, efficient, and interactive learning environment that is packaged in attractive visuals, which plays an important role in strengthening their understanding of science material. Therefore, the use of attractive teaching materials can improve student understanding (Fitri et al., 2023; Siswanti, 2019). So, the teaching materials that are developed can improve student learning outcomes because the teaching materials developed are in accordance with the needs and characteristics of students (Syarifah et al., 2023; (Yusrina et al., 2021).

Second, e-teaching materials assisted by Augmented Reality are an innovation in the use of learning media because they can be used anytime, anywhere so they are practical to use (Khoirunisa & Floriasti, 2023). In addition, indirectly Augmented Reality (AR) provides flexibility that allows students to learn independently which involves students to be actively involved which is not limited to the classroom (Hernández-Rodríguez & Guillén-Yparrea, 2023; Zulfi & Suleman, 2024). Third, the use of e-teaching materials assisted by Augmented Reality can also help students to visualize abstract things so that students become interested in learning (Al-Ansi et al., 2023; Herman et al., 2023; Radu et al., 2023). In addition, the use of Augmented Reality (AR) technology has a positive impact on students' enthusiasm and understanding (Alkhabra et al., 2023; Prasetya et al., 2024) and can improve critical thinking skills (Dutta et al., 2023; Hidayat et al., 2024). The Assemblr Edu application used successfully visualized material interactively through three-dimensional objects, making it easier to understand concepts that previously felt abstract, and creating an interesting and enjoyable learning experience for students.

Augmented Reality can also stimulate students' mindsets in thinking critically about problems and events that exist in everyday life, because Augmented Reality can visualize abstract concepts for understanding and the structure of an object model, thus allowing Augmented Reality as a more effective medium in accordance with the objectives of the learning media (Arifin et al., 2021; Yusa et al., 2023). Finally, e-learning materials assisted by Augmented Reality are flexible so that they are very easy to access anywhere, and anytime (Saputra & Octavia, 2024; Yanti, 2022). The results of the study showed that e-learning materials assisted by Augmented Reality can be used as a learning aid by teachers and students to improve learning outcomes. Looking at the results of previous studies, conditions, and problems in the field, researchers have succeeded in developing e-teaching materials assisted by Augmented Reality for science learning for fifth grade elementary school students. Based on the results of the research and analysis that have been carried out, this e-teaching material assisted by Augmented Reality has proven to be feasible, practical, and effective for use in science learning for fifth grade elementary school students.

Conclusion

Based on the research results, e-teaching materials assisted by Augmented Reality in the subject of Science on the water cycle material have been proven to improve the learning outcomes of grade V students of Dampyak 02 Elementary School. This is proven by the results of validation by material, language, and media experts which show that e-teaching materials assisted by Augmented Reality are declared "feasible" with an average score of 78%. The results of the questionnaire responses of teachers and students to the use of e-teaching materials assisted by Augmented Reality showed a "very positive" level of satisfaction, with a score of 88% from teachers and 88% 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 0.6, which is included in the "moderate" category. This shows that e-teaching materials assisted by Augmented Reality meet the criteria of feasibility, practicality, and effectiveness to improve the learning outcomes of grade V students of elementary school in the subject of Science on the water cycle material.

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