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Research Article

Development of digital learning media based on augmented reality to improve student learning outcomes of elementary school

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Abstract: Based on observations that have been made at SDN Agungmulyo, there are problems with student learning outcomes, one of which is monotonous learning. The purpose of this study was to develop and see the effect of using Augmented Reality media on student learning outcomes. The type of research in this study is Research and Development (RnD) research that uses the ADDIE research model with the stages of analysis, design, development, implementation, evaluation. The development of Augmented Reality digital-based learning media products in IPAS subjects is considered valid with an average value from experts of 88%. The results showed an increase in student learning outcomes in grade V IPAS subjects there was an increase of 0.8000 with High criteria on a small scale, and an average increase of 0.5384 with Moderate criteria on a large scale, by the N Gain Test which shows an increase in the average before and after implementing learning, then digital Augmented Reality-based learning media can improve student learning outcomes in IPAS Class V subjects at SDN Agungmulyo Pati. Researchers suggest that education in Indonesia is increasingly able to develop application-based learning media for the advancement of education.

Keywords: augmented reality; digital learning media; student learning

1. Introduction

Education has a big role in advancing a country. Through education, the quality of human resources can be improved so that they are able to participate in building the nation and state, and are ready to compete globally (Indrawati, 2021). The implementation of education to achieve the national goals of education is supported by the National Education Standards. The National Education Standards as the minimum criteria for the education system in Indonesia are described in Government Regulation No. 32 of 2013 and are used as a reference in curriculum development. A curriculum that is relevant and integrated with students' real-life experiences can improve their motivation and learning outcomes. The curriculum should be designed to facilitate critical thinking and problem-solving skills (Labaree, 2022). Curricula designed to reduce academic stress, by providing emotional support and supporting active student engagement, can improve learning outcomes and student well-being (Jenifer et al., 2023).

The government of the Republic of Indonesia has provided opportunities for all Indonesian citizens to obtain quality education, as a major step towards improving the lives of citizens. While Indonesia's education policy aims to improve the quality of education, the gap between policy and practice on the ground often leads to uneven results across the country. A more data-driven and participatory approach can help improve policy implementation (Simonofski et al., 2021). Efforts that can be made in the learning process today are one of them by utilizing the media. As regulated in Government Regulation No. 22 of 2016 concerning Process Standards for Primary and Secondary Education in Chapter I point 13, namely the use of information and

communication technology to improve the efficiency and effectiveness of learning. The quality of teaching in Indonesia remains mixed, with significant challenges related to teacher training and professionalism. Improving the quality of education requires investment in ongoing teacher training and support for professional development (Sholeh, 2020). Fun learning can increase students' motivation to learn, one of which is with a variety of learning media, one of which is by utilizing technological developments. Indonesia's education system faces a range of challenges, including resource inequality, teaching quality and access to education in remote areas. However, there are also opportunities for more inclusive and technology-based reforms to improve the overall quality of education (Pratiwi & Waluyo, 2023).

Natural and Social Sciences (NSP) is a subject that examines a set of events, facts, concepts, and generalizations related to natural phenomena and social issues. An integrative and project-based teaching approach in IPAS can enhance students' understanding by connecting scientific and social concepts in a real-world context. (Unaizahroya et al., 2022). This method encourages students to think critically and creatively. IPAS is a subject that is close to human life and its activities with the surrounding nature because it is integrated from several materials of geology, geography, history, sociology, living things. “Innovative pedagogical approaches, such as problem-based learning and digital technology, can enhance student engagement in IPAS. Technology can facilitate more interactive and contextualized learning (Bedenlier et al., 2020).

Educational technology is a field in facilitating human learning through the systematic identification, development, organization and utilization of all learning resources and through the management of the process of all of them (Granić, 2022). Technology should be designed with students' resilience and adaptability to change in mind (Shay & Pohan, 2021). Technology that supports adaptive learning can help students face challenges and innovate (Muñoz et al., 2022). The rapid development of technology can be utilized as an effective learning tool, improving the quality of information delivery, and expanding the reach for students. The integration of multimedia technology in learning, when applied with appropriate design principles, can improve students' understanding and retention of information. Multimedia used in an evidence-based way can make learning more effective (Mayer, 2022).

Learning Media is any object that can be used as a tool for teaching can be used to convey information from the learner to the person who will receive it, or vice versa (Rosmandi et al., 2021). An engaging learning media is one that utilizes multimedia elements effectively to increase student engagement (Mayer, 2022). Gamification in learning media can increase student motivation and engagement through game elements such as points, levels, and challenges (Panlilio et al., 2022).

In reality, the media often used by teachers are simple pictures. The use of learning media that is less varied has an impact on student interest in following the subject, student understanding of the material presented, and student learning outcomes (Harefa et al., 2023). This causes problems for students, because the use of still images available in textbooks makes students tend to be passive and less interactive in learning, especially in materials that require media other than images to convey their messages, because image media are unable to provide reciprocal responses, less real and less interesting.

Augmented Reality (AR) is a technology that combines digital objects with the real world in real-time, providing an interactive experience that combines virtual elements with the physical environment (Arena et al., 2022). AR has three main characteristics: (1) integration of virtual objects with the real world, (2) real-time interaction, and (3) the ability to enhance real-world experiences. AR can be used as a tool to develop 21st century skills such as problem solving, critical thinking, and collaboration (Sari & Wardhani, 2020). This technology provides an immersive and interactive learning experience that supports the development of essential skills in the digital age (Kunkera et al., 2024). AR

can increase student engagement and motivation by creating an engaging and fun learning experience. However, the successful implementation of AR depends on the design of relevant content and adequate technical support.

The novelty of this research lies in the material used in learning media, namely natural resource material. Augmented Reality media is designed with as many as four QR codes. On QR code one describes and explains the general understanding of natural resources and their origin. Then, the second QR code describes and explains about renewable natural resources and their examples. The third QR code explains about non-renewable natural resources and their applications. Then the fourth QR code explains the impact of excessive use of natural resources and efforts to preserve them. Augmented Reality media is designed and made to adjust the image of the material, then arranged so that when clicked will appear a more complete explanation of the image. IPAS learning by using Augmented Reality media is more attractive to students with various images and explanations provided. It is expected that students are happier to learn IPAS, so as to improve their learning outcomes.

2. Materials and Methods

2.1 Types of research

The type of research used by researchers is Research and Development (RnD). Research and Development (R & D) is a method or step to create new products or develop and improve existing products and is used to test the effectiveness of these products (Saptono et al., 2021). Several methods are used when conducting R&D, namely methods: descriptive, evaluative and experimental (Rennane et al., 2021). The purpose of this research is to produce products that will be used in education through a scientific process that ends with a validation stage. This development research uses the ADDIE model. The ADDIE model consists of five stages including Analyze, Design, Development, Implementation and Evaluation.

In this study, researchers will use a quantitative research approach, which is research that emphasizes its analysis on numerical data (numbers) processed by statistical methods. The results of the quantitative approach are in the form of numbers and statistics in the collection and analysis of measurable data (Mohajan, 2020). With the quantitative approach method, the significance of group differences or the significance of the relationship between the variables studied will be obtained. This research develops augmented reality-based digital learning media to improve student learning outcomes in Natural and Social Sciences subjects at SDN Agungmulyo Pati. The feasibility of the resulting product was tested by material expert validators, media experts in the field of education and users (teachers) at SDN Agungmulyo Pati.

2.2 Research Subjects and Objects

The subjects of this study were several school parties related to research information. Respondents of interviews and questionnaires are Class V teachers, test subjects of questions to VI grade students of SDN Agungmulyo as many as 31 students. Then the subject in the development of augmented reality-based digital learning media that has been developed will be tested on grade V students of SD Negeri Agungmulyo Pati. Small-scale trials by selecting 5 students from 20 grade V students of SDN Agungmulyo Pati, and large-scale trials by selecting 15 out of 20 grade V students of SDN Agungmulyo Pati.

2.3 Data Types and Sources

The types of data in this research are descriptive qualitative and descriptive quantitative data. Qualitative data sources used in this study were obtained from the results of product validation by material experts, media experts, and linguists, as well as comments and input from teachers. Quantitative data is obtained from the results of

validation questionnaires on augmented reality-based digital learning media and teacher response questionnaires and student responses.

2.4 Data collection technique

Data collection techniques in this study are test and non-test techniques. The test technique is used by researchers by making initial test questions (pretest) and final test (posttest) with the aim of knowing student learning outcomes. Pretest is used to determine the initial knowledge of students before being given treatment or treatment. Posttests are used by researchers to both groups to determine student learning outcomes after being given treatment or treatment. Pretest and posttest are presented in the form of multiple choice which contains related to basic competency indicators. Non-test techniques used by researchers are observation techniques and questionnaires or questionnaires. In this study, the observation technique carried out by researchers was structured observation which was used to collect data on student learning activities with an instrument in the form of an observation sheet. In this study, researchers used several questionnaires to find out information. Among them are expert validation questionnaires, teacher and student needs questionnaires, and teacher and student response questionnaires. The experts' validation questionnaire is addressed to media expert validators and material expert validators, while the media needs questionnaire and media responses are addressed to teachers and fifth grade students of SD Negeri Agungmulyo before and after being treated.

2.5 Data Analysis Techniques Data Analysis Techniques

The data obtained were then analyzed. Initial data analysis in this study used a normality test using the SPSS program to determine whether the data was normally distributed. The final data analysis in this study used normality test, T-test, and N Gain (average) test.

3. Results

3.1 Results of Augmented Reality Technology Learning Media

Augmented Reality media functions to convey information between the receiver and the sender or educator with students, can clarify the delivery of information provided by educators and students in the learning process, can provide stimulation, motivation and interest in learning (Midak et al., 2020). Augmented Reality media in this study has the theme of natural resources. The design is by dividing into 5 sub-materials including the definition of natural resources, renewable natural resources, non-renewable natural resources, the impact of excessive use along with conservation efforts, and concrete examples of natural resources found around students. The design is packaged concisely on the QR code, so there are as many as five QR codes. The following researchers present Figure 1 and Figure 2 which are design images of the cover and some of the material content of the Augmented Reality media. In Figure 1 there are various cover designs viewed from a top perspective that can show the topic of each QR code. In Figure 2 shows the design when viewed from the front side which shows various examples of the application of images from the material. In each image there is an "i" icon if clicked then the details of the material in each image appear, such as examples, applications, explanations of the natural resource images.

Figure 1. The Upside of Natural Resources Augmented Reality

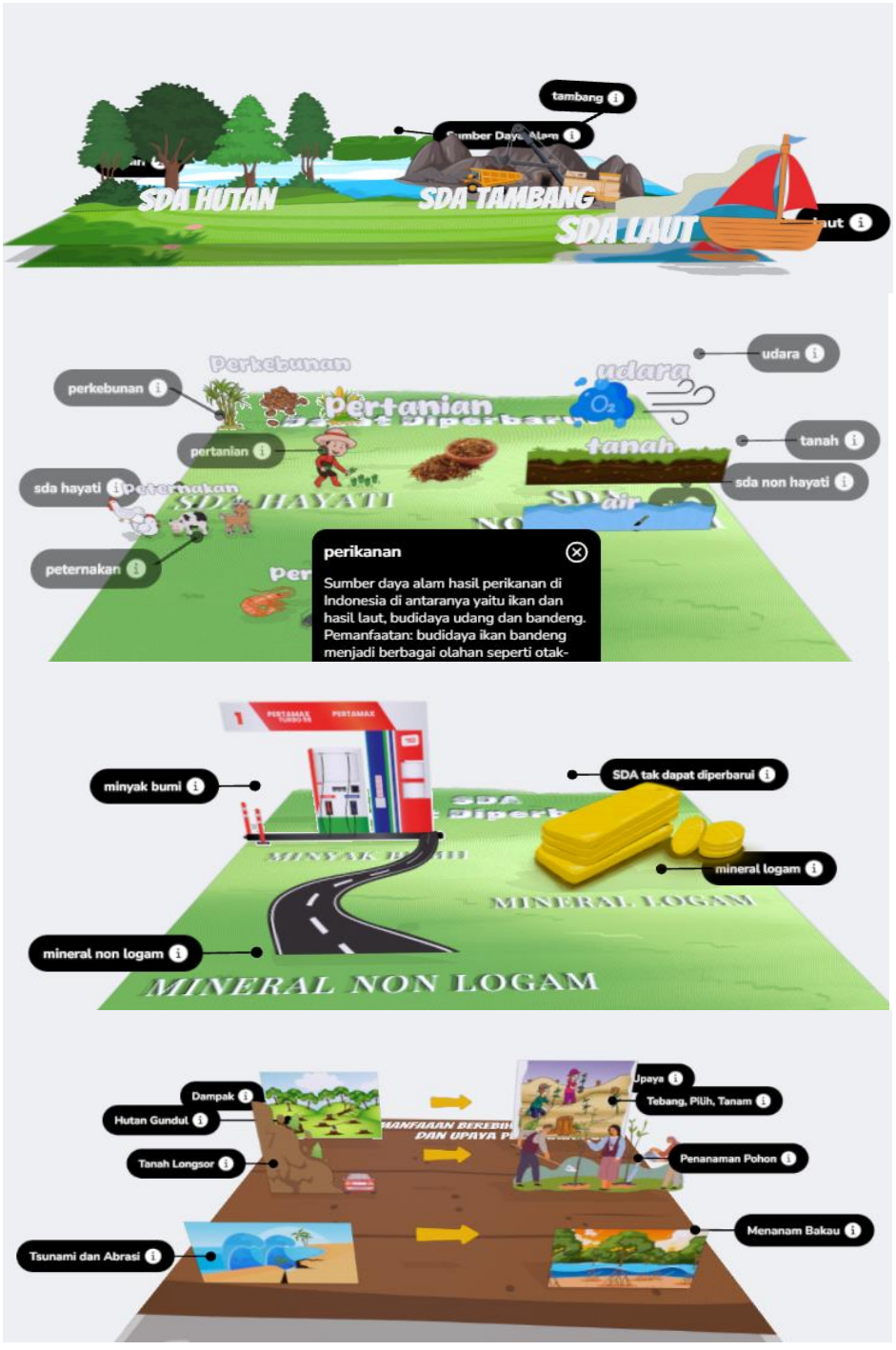

Figure 2. Front Side of Natural Resources Augmented Reality

3.2 Feasibility of Learning Media Based on Augmented Reality Technology

The feasibility results of augmented reality-based digital media in IPAS subjects are obtained from the assessment of media expert validators, material experts, student responses and teacher responses. The following aspects of the assessment of the material experts have been arranged according to Table 1.

Table 1. Assessment Results from Material Expert Validators

No.	Assessment Aspect	Score Earned	Maximum Score	Feasibility (%)	Validity Level
1.	Content Feasibility	17	20	85	Valid
2.	Language Feasibility	34	40	85	Valid
3.	Technical Feasibility	36	40	90	Valid
	Average percentage			87	Valid

Based on all aspects of the assessment in table 1, the percentage of content feasibility is 85%, the percentage of language feasibility is 85%, and the percentage of presentation feasibility is 90%. Then an average of 87% is obtained, which shows that the material from the media is proven to be valid and feasible to use in accordance with the revision.

Based on all aspects of the assessment from media experts in Table 2, it is stated that the image/illustration of the media gets a feasibility value of 95%, based on the appearance, the feasibility value is 82%, based on the use of the media, the feasibility value is 95%, and based on the convenience of the media, the feasibility value is 80%. The average result obtained a feasibility value of 88%, so the media is declared valid and feasible to use in accordance with revisions from media expert validators.

Table 2. Media feasibility assessment results

No.	Assessment Aspect	Score Earned	Maximum Score	Feasibility (%)	Validity Level
1.	Picture/illustration	19	20	95	Valid
2.	Display	29	35	82	Valid
3.	Media Usage	19	20	95	Valid
4.	Media Convenience	12	15	80	Valid
	Average percentage			88	Valid

After the media is declared feasible, a small-scale trial is carried out first to find out the reactions and responses after being given treatment to fifth grade students of SDN Agungmulyo Pati. Small group trials can be conducted with 4-20 respondents. Researchers chose a sample of 5 students or 20% of the total number of fifth grade students of SDN Agungmulyo. Researchers also provided a questionnaire for teacher and student responses about digital augmented reality learning media on natural resources material.

The implementation of small-scale product trials begins with working on pre-test questions about natural resources that have been tested before. Then proceed with learning activities with the application of augmented reality-based digital learning media in IPAS class V natural resource material in accordance with the instructions and directions of the teacher. After being given the material students work on a post-test to measure the results after students are given treatment. Students were also given a response questionnaire about digital augmented reality-based learning media. The results of student responses show an average score of 83% they need the media and the media is categorized as feasible. So, it can be concluded that augmented reality media is feasible to use for research without revision.

Next is a large-scale product trial by taking 15 fifth grade students of SDN Agungmulyo. Small group test subjects were carried out on 4-14 respondents and for large groups between 15-50 respondents. Large-scale product trials have the same stages as small-scale product trials. The first step students are given a pre-test question to do as a measure when before being treated. Then continued learning natural resource material with the application of Augmented Reality (AR) based digital learning media. After being given the treatment students were again given a post-test question to measure the difference after the students were given the treatment. In the final stage students and teachers were given a response questionnaire to determine the feasibility of the media, the results showed a feasibility percentage of 90% with a very feasible category. It can be concluded that digital learning media based on Augmented Reality technology is feasible to use.

3.3 Effectiveness of Learning Media Based on Augmented Reality Technology

The effectiveness of augmented reality technology-based learning media is obtained from the results of pre-test and post-test scores to small groups and large groups before being treated and after being treated. In small-scale product trials there are differences between before and after using Augmented Reality (AR) learning media. In the small group pre-test, the average learning outcomes were 82%, then in the small group post-test, the average learning outcomes were 96%. This shows an increase in student learning outcomes between before and after being treated in small groups. In the large group pre-test, the average learning outcome was 55%, then in the large group post-test, the average learning outcome was 80%. This shows an increase in student learning outcomes between before and after being treated.

Furthermore, to find out whether the data is normally distributed or not, a normality test is carried out. Data is said to be normally distributed if the significant value> 0.05 then Ho is accepted. In this study, the calculation with the help of SPSS version 29.0.2.0 (20), the results of the pretest and posttest normality test were obtained in Table 3.

Table 3. Small Scale Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Small_Pretest	.473	5	<.001	.552	5	.327
Small_Posttest	.367	5	.026	.684	5	.437

a. Lilliefors Significance Correction

Based on Table 3, it can be seen that the results of the normality test calculation using SPSS software version 29.0.2.0 (20) show a significant value in the Shapiro-Wilk column (for samples under 50) obtained a pretest value of 0.327 and a posttest value of 0.437. These results indicate that the pretest and posttest scores of the small group in this study were normally distributed.

Based on Table 4, it can be seen that the results of the normality test calculation using SPSS software version 29.0.2.0 (20) show a significant value in the Shapiro-Wilk column for the pretest value of 0.142 and for the posttest value of 0.326. These results indicate that the pretest and posttest scores in the large group of this study are normally distributed

Table 4. Large Scale Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Large_Pretest	.166	15	.200*	.907	15	.142
Large_Posttest	.143	15	.200*	.932	15	.326

a. Lilliefors Significance Correction

After conducting a normality test, the researcher measures the T test to determine whether the hypothesis is accepted or rejected. The criteria for testing the average difference are if t-count < t-table Ha is accepted and if t-count > t-table then Ho is accepted. If calculated based on significance, if sig> 0.05 then Ho is accepted and if sig < 0.05 then Ha is accepted. The following are the results of the T-test using SPSS software version 29.0.2.0 (20).

Based on the results of the pretest and posttest mean difference test using the SPSS version 29.0.2.0 (20) application, the significance value is 0.005 (Table 5). After comparison, the significance value of 0.005 <0.05, therefore it can be decided that Ha is accepted and Ho is rejected. So, it can be seen that there is a significant difference in student learning outcomes in the small-scale test between before and after using digital augmented reality-based learning media.

Table 5. Small Scale T-test Results

	Paired Differences					T	df	Significance	
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				One-Sided p	Two-Sided p
				Lower	Upper				
Pair 1 before treatment — after treatment	-14.00000	5.47723	2.44949	-20.80087	-7.19913	-5.715	4	.002	.005

Based on the results of the pretest and posttest mean difference test using the SPSS version 29.0.2.0 (20) application, the significance value is <0.001 (Table 6). After comparison, the significance value < 0.001 < 0.05, therefore it can be decided that Ha is accepted and Ho is rejected. So, it can be seen that there is a significant difference in student learning outcomes in the large-scale test between before and after using digital augmented reality-based learning media. Therefore, it can be concluded that the development of augmented reality digital-based learning media is effectively used in Natural and Social Science lessons.

Table 6. Large Scale T-test Results

	Paired Differences					t	df	Significance	
	Mean	Std. Deviation	Std. Mean Error	95% Confidence Interval of the Difference				One-Sided p	Two-Sided p
				Lower	Upper				
Pair 1 before treatment — after treatment	-24.28571	13.42460	3.58787	-32.03685	-16.53458	-6.769	13	<.001	<.001

Furthermore, researchers conducted the N Gain Test to determine the average increase in student pre-test and post-test learning outcomes on a small scale and large scale. According to Lestari and Yudhanegara (2017) if the N-Gain result ≥ 0.70 then the category is high, if the result is 0.30 < N-Gain < 0.70 then the category is medium, if the N-Gain result ≤ 0.30 then the category is low.

Based on Table 7 shows the results of the pretest and posttest average difference test using the SPSS version 29.0.2.0 (20) application, showing the results that grade V students of SDN Agungmulyo in the small-scale test experienced an average increase of 0.8000 with High criteria.

Table 7. Small Scale N-Gain Test Results

	N	Minimum	Maximum	Mean	Std. Deviation
NGain	5	.50	1.00	.8000	.27386
Valid N (listwise)	5				

Based on the results of the pretest and posttest average difference test using the SPSS version 29.0.2.0 (20) application, it shows that the fifth-grade students of SDN Agungmulyo on a large scale experienced an average increase of 0.5384 with moderate criteria (Table 8).

Table 8. Large Scale N-Gain Test Results

	N	Minimum	Maximum	Mean	Std. Deviation
NGain	15	.00	1.00	.5384	.26717
Valid N (listwise)	15				

4. Discussion

Observations have been made at Agungmulyo Elementary School to observe various problems and efforts to overcome them. Some of the problems found are that the material in the Merdeka curriculum, especially IPAS, is still minimal, providing material is still limited to teacher books and student books provided by the government (Hasna, 2023). Then the learning media used, especially in IPAS learning, are still in the form of writing and pictures, so students tend to feel bored and have an impact on student learning outcomes (Noviyanti, 2023). Another problem found is the unavailability of application technology-based learning media on student learning outcomes when viewed from what is implemented, namely natural resource material. The Merdeka Curriculum emphasizes interactive learning media, but in the implementation of learning, most of them still use lectures between teachers and students instead of students and students (Hasna, 2023).

So, the researcher limits the problem to the lack of varied learning by using technology-based learning media according to the demands of the Merdeka curriculum. Especially in IPAS learning which still uses limited learning media and low utilization of technology so that it has an impact on the lack of student interest in learning so that it has an impact on student learning outcomes (Noviyanti, 2023). For this reason, researchers want to develop innovative technology-based learning media in accordance with the demands of the curriculum, namely developing Augmented Reality digital learning media in Grade V IPAS learning using the Research and Development (RnD) research type at SDN Agungmulyo Pati.

After the research was conducted, there were differences in student responses when learning was monotonous with learning by utilizing Augmented Reality technology, students became more enthusiastic, enthusiastic, so they paid more attention. This also has an impact on student learning outcomes between before treatment and after treatment. So, Augmented Reality technology-based learning media is declared successful to improve student learning outcomes

5. Conclusion

Based on the results of the study, digital learning media based on augmented reality technology proved to be feasible and effective in improving student learning outcomes. The media is feasible to use in research because it has received scores from experts with an average of 88% feasibility with a very feasible category. The results of teacher and student responses show a percentage Then the results obtained between students before being treated and after being treated there is a difference that shows increased learning outcomes. After the research, three tests were carried out, namely the normality test, T test, and N-Gain Test. In the normality test, the small-scale pre-test value showed a significant number of 0.327 and at the posttest value of 0.437, on the large-scale pre-test

obtained a significant result of 0.142 and at the posttest value of 0.326. These results indicate that the pretest and posttest scores on a small scale and large scale of this study are normally distributed. In the small-scale T test, the significance value is 0.005 <0.05, therefore it can be decided that Ha is accepted and Ho is rejected, in the large-scale T test the significance value is <0.001 <0.05, therefore it can be decided that Ha is accepted and Ho is rejected. So, it can be seen that there is a significant difference in student learning outcomes in the large-scale test between before and after using digital augmented reality-based learning media. In the N-Gain Test, the small-scale test experienced an average increase of 0.8000 with high criteria, on a large scale it experienced an average increase of 0.5384 with moderate criteria. Therefore, it can be concluded that the development of augmented reality digital-based learning media is effectively used in Natural and Social Science lessons. In the results of this study, augmented reality media succeeded in attracting student interest in learning, interactive, increasing student involvement participation, able to improve student learning outcomes.

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