

Designing Material Learning for 4th Grade Elementary School Using Augmented Reality for Understanding Science Concepts

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Abstract. This study aims to produce teaching materials based on augmented reality and determine the feasibility and effectiveness of these materials. This teaching material was created in the form of modules to help elementary school students understand the Science concept of Plants, the Source of Life on Earth. Research and development in the field of education uses the ADDIE method. Data analysis techniques were carried out quantitatively and qualitatively. Data collection instruments in the form of tests and non-tests. Nontes were conducted by distributing questionnaires and conducting semi-structured interviews. According to the assessment of material experts, media, and practitioners, teaching materials based on augmented reality are feasible to use. The use of teaching materials based on augmented reality is effective for increasing understanding of the science concept of plants as the source of life on earth.

Keywords: augmented reality, teaching materials, understanding science concepts

1 Introduction

Online learning creates new habits for students, namely the excessive use of gadgets [1-4]. Even though it is not yet appropriate for elementary school-age children to have their own gadget, they still have to be under strict parental guidance in using it [5][6]. Technology cannot be separated from student life. Efforts to facilitate children's intellectual development are made by encouraging children to like reading and introducing them to technology products related to informatics[7]. In addition, teachers must be able to utilize technology to support learning activities. Thus, teachers are expected to be able to create technology-based teaching materials and adapt them to the needs of students in class.

Teachers are expected to be able to compile teaching materials based on augmented reality in order to provide a real picture that can strengthen students' understanding of the science concept. As stated by Piaget [8], elementary school students in the 7–11 year range are in the concrete thinking stage, not yet able to think abstractly. Students solve problems using logic. The ability of augmented reality, which is able to present an interactive real picture of the material provided in teaching materials, is very effective in making understanding of difficult subject matter concepts easier and easier to master by students [9-13]. Many ebook-based teaching materials have been made, but conventional teaching materials are still used

physically in elementary schools. Teachers need to modify books by incorporating augmented reality technology into them to reinforce students' conceptual understanding.

According to Altinpulluk, Hakan, and Mehmet Kesim^[14], augmented reality (AR) is a technological approach that allows the real and virtual to become one seen from the same place by supporting the real world with 3D virtual objects and enhancing user perception. Meanwhile, augmented reality, as defined by Ziden et al [15], is the projection of virtual reality elements such as images, text, video, and sound on a screen to enhance the visual experience. Thus, augmented reality is a tool used to combine the real and virtual worlds at the same time by presenting existing objects to provide real experiences to users. This technology allows students to interact with virtual objects and information in ways that are not possible with traditional teaching methods.

Augmented reality technology is not only used as a learning medium; this technology is also used in teaching materials designed by teachers. According to Annafi et al [16], augmented reality can help students independently and add to their own experiences even with limited facilities and teaching material designs. Technology has developed, but printed book teaching materials have not been abandoned; instead, they have been developed by incorporating digital elements such as augmented reality systems [14]. Augmented reality encourages students to learn not only through text, but also through 3-dimensional images, animation, sound, and video [17]. AR technology can provide access to learning materials that may be difficult or impossible to access; for example, teachers may have difficulty explaining the process of photosynthesis and can use it as material to explain things that cannot be captured by the eye.

The augmented reality system can be used by teachers to improve students' understanding of concepts. Conceptual understanding is a person's ability to understand a concept and be able to interpret it without changing its true meaning [18]. Meanwhile, according to Aen [19], understanding the concept is a higher level than knowledge obtained, so an introduction or knowledge to understand is required. Nahdi et al. also stated that understanding a concept is an individual's ability to understand a particular concept [20]. Thus, understanding the concept is a person's ability to understand a concept so that he is able to apply it, so that the concept he has can be useful for his life. This study aims to produce teaching materials based on augmented reality and determine the feasibility and effectiveness of these materials.

2 Methode

Method of research is called development research. The development model used is ADDIE from Branch [21]. The step of ADDIE model is analysis, design, development, implementation, evaluation. The research subjects were 30 grade IV students at SDN 1 Grendeng as the experimental class and 34 grade IV students at SDN 1 Sumampir as the control class. Instruments of this research is test and nontest. Test result data were processed to determine the product's effectiveness in strengthening elementary school students' understanding of the science concept obtained from written tests for the experimental and control classes. Nontest result data by material expert validation questionnaires, media expert validation, teacher responses, and student responses were all used by the researchers. The questionnaire used is a closed questionnaire; respondents can choose from predetermined answers. But in the instrument, respondents have the right to provide comments and suggestions on the teaching materials being developed. Researchers will conduct semi-structured interviews with teachers and students to obtain more open answers.

Data analysis carried out in this research and development are quantitative and qualitative. Qualitative analysis in this research is the teacher conducts interviews by asking questions regarding the level of understanding and the best concepts they understand. The teacher can determine how confident students are in their understanding [22]. Researchers analyzed the results of interviews qualitatively in the form of sentences. Quantitative Analysis in this research is the normality test data, homogeneity, and hypotheses is carried out. The Two Group Post-test Only Design was used to create the research design. The design can be described as follows [23]:

Table 1. Two Group Post-test Only Design

Class	Treatment	Posttest
E	X	○
K	-	○

Information:

- E = Experimental class using teaching materials based on augmented reality
- K = Control class using available student books
- X = Treatment uses teaching materials based on augmented reality.
- = Posttest experimental class and control class

The data that has been collected on the validation sheet will be converted into quantitative data according to the weight of the score with the following formula [24]:

$$P = \frac{\text{g.ain score}}{\text{max score}} \times 100\% \quad (1)$$

Based on the class intervals obtained, the decision to validate the teaching material design uses the following table criteria [25]:

Table 2. Validator Analysis Criteria

Presentage	Validation criteria	Information
51-100	Valid	Can be used
0 - 50	Invalid	Unable to use and still requires consultation

3 Discussion

The process of research and development of teaching materials based on augmented reality will be described by researchers based on the stages of research and development of the ADDIE method, namely: The initial activity carried out was to analyze the need for the development of augmented reality-based teaching materials based on the problems found in learning. Researchers distributed questionnaires to teachers and parents as well as conducted interviews with students to find out the problems they faced. Teachers really need to develop science teaching materials.

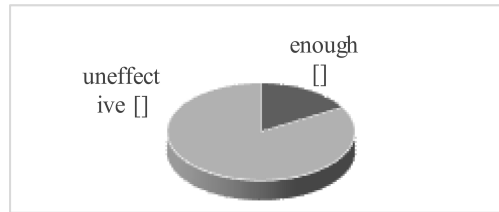


Fig 1. Effective Use of Available Books

All respondents, namely grade IV teachers in Korwilcam Purwokerto Utara, agreed that the teacher's book and student books for science were not enough as the only source of learning for students. Teachers must develop more effective teaching materials. Teachers still have to make other supporting teaching materials to meet the different needs of each educational unit, realizing that the main books provided by the government are compiled based on minimum learning outcomes nationally.

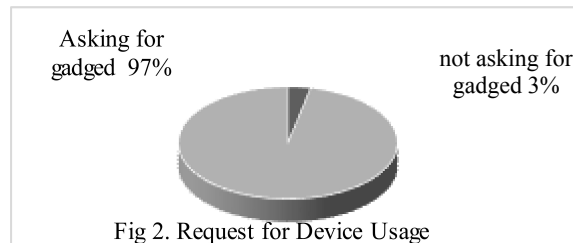


Fig 2. Request for Device Usage

Based on the distribution of a questionnaire conducted by researchers to 120 parents or guardians of elementary school students in North Purwokerto Regional Office, most students asked to use their gadgets as soon as they arrived home after school. Students do not only use applications that support learning activities, but based on the results of interviews, applications that students often use include YouTube, TikTok, Free Fire, Roblox, video snacks, Mobile Legends, Mine Craft, and Instagram. In fact, many of them are faster than their parents at surfing in various applications. In addition, 50% of student respondents have their own gadgets, and the rest use their parents'.

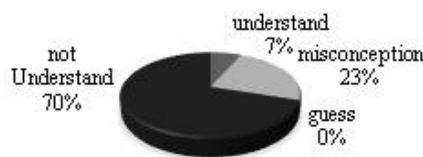


Fig 3. Understanding the IPAS concept for class IV students SDN 1 Grendeng

The material in the teacher's and student's book on page 11 of the chapter Plants, the Source of Life on Earth states that plants photosynthesize with the help of sunlight. In addition, the material in the book also explains that chlorophyll is used in the process of photosynthesis to make leaves green. After the researcher asked several questions to diagnose students' understanding of the Science-Science concept through questions related to the material above, it showed that most students experienced the wrong concept and did not understand the true concept of Science-Science, such as that leaves that are not green do not have chlorophyll for

the photosynthesis process. In fact, leaves that have other color pigments such as red, purple, yellow, and so on still have chlorophyll.

From the findings, it can be said that the problems encountered in learning in elementary schools include: (1) technology cannot be separated from students' lives; (2) the Science Student Book is not sufficient as the only source of learning for students; and (3) students need materials to complete IPAs. The effort to overcome this problem is to provide a selection of teaching materials based on augmented reality that present a real and interactive picture so as to facilitate mastery of the science concept.

The design of this teaching material is still conceptual, which will form the basis for the next development process. The following are some of the activities carried out in this stage:

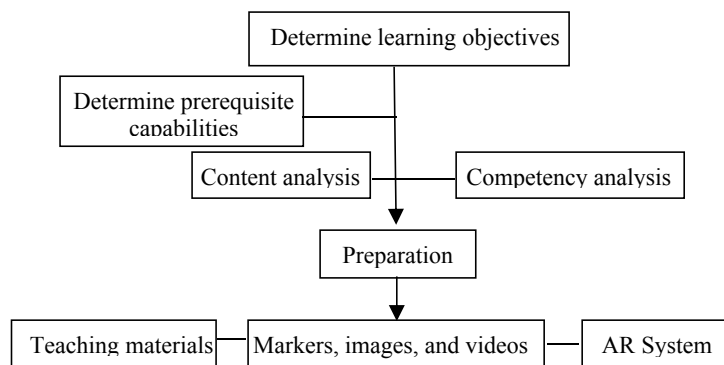


Fig 4. Augmented reality-based teaching material design stage

The researcher determines the learning experiences that students need to have while using teaching materials in order to master the science concepts according to their needs. Teaching materials are made based on module-type teaching material components. Researchers arrange learning materials according to the learning objectives in predetermined chapters. The material is obtained from various sources that are scientifically proven, so that the science concepts given are able to strengthen students' understanding. Researchers sort any material that requires a real picture in order to strengthen the conceptual understanding of the IPAS material. Researchers provide 2-dimensional and 3-dimensional images and videos that are relevant to the material in teaching materials. Researchers provide 16 marker images, or markers, that are used to access augmented reality images. Without a marker, the image cannot be accessed. The researcher divided 14 pictures and 2 videos into 16 projects as a real picture of the material that students would later access through markers or markers printed on teaching materials.

The draft of teaching materials based on augmented reality that have been developed are assessed by material experts, media experts, and practitioners. The validity of these experts and practitioners focuses on the components of material quality, language, exercises and questions, usefulness, ease of access, and quality of augmented reality images as material for further development.

Table 3. Recapitulation of Material Validation

No.	Aspects	Percentage each component	Criteria for each component
1.	Material Quality	96	Valid
2.	Language	96	Valid
3.	Questions and Student Exercises	97	Valid
	Amount	289	Valid
	Percentage	96,1	Valid

The assessment of material experts and practitioners shows the results of the validation performed by material experts, indicating that it is very valid and practicable. This shows that the material in teaching materials is in accordance with learning objectives, depth coverage, consistency, clarity of material, use of language, exercises, and questions. Based on the results of interviews with practitioners or users, it is stated that this augmented reality-based teaching material has material that is in accordance with the current needs of students and the technological needs of students. The existing material content provides a correct conceptual understanding of the science and technology material that teachers should provide in the midst of developments in science and technology. The choice of words and the arrangement of sentences are effective according to the needs of fourth-grade students in an elementary school. The teaching materials that researchers have developed are very useful and can be used as relevant and very scientific learning resources to be taught to students; only researchers need to pay attention to the typing of each word used again.

The media expert's assessment is shown in the aspects of technology and informatics. Media experts assess the quality of 3-dimensional images and videos, the ease of access, and their usefulness in strengthening elementary school students' understanding of the science concept.

Table 4. Media Expert Validation Recapitulation

No	Aspects	Percentage each component	Criteria for each component
1.	Component quality	89	valid
2.	Ease of access	90	valid
3.	Usefulness	93	valid
	Percentage	91	Valid

The results of the validation carried out by media experts and practitioners obtained a very valid category, so that the media attached to augmented reality-based teaching materials is feasible to be used to strengthen elementary school students' conceptual understanding. The results of the validation of media experts contain comments or suggestions that must be considered for revision, namely that 3-dimensional images (augmented reality images) should be more specific in their presentation, namely directly on the image you want to present so that students' attention is directly on the intended image.

Based on the results of interviews with practitioners, it was stated that teaching materials based on augmented reality were something new and there were no teachers presenting this learning in North Purwokerto Korwilcam. The ability of augmented reality in books to support understanding of the science concepts presented in these teaching materials Students were also very excited to participate in the learning that occurred; they explored 3-dimensional images by freely turning right, left, up, and down to gain an understanding of the science concept as well as possible using their gadgets.

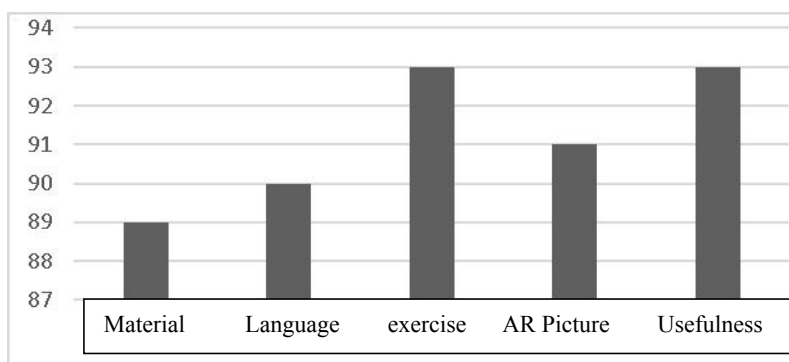


Fig 5. Results of Student Responses to Teaching Materials Based on Augmented Reality

Based on the questionnaire distributed, 30 students gave a positive response to the teaching materials they used. The calculation of material aspects (including material, language, and exercises) and media (including augmented reality images and usefulness) obtained a final percentage of 91 with valid criteria and suitable for use in learning activities.

The data at this trial stage included a teacher and student response questionnaire and a rubric for assessing the understanding of the science of science concept. To find out the effectiveness of this teaching material, the researcher conducted normality, homogeneity, and hypothesis tests, along with the following explanations:

Table 5. Shows the Normality Test results for the Experimental and Control classes

Tests of Normality			
Kolmogorov-Smirnov ^a			
	Statistic	Df	Sig.
Kontrol Class	.109	30	.200*
Eksperiment Class	.140	30	.136

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The significance value of the experimental class in the Kolmogorov-Smirnov test is $0.136 > 0.05$, so H_0 is accepted, meaning that the sample data is normally distributed, while the control class has a significance value of $0.200 > 0.05$, so H_0 is accepted, which means the sample is normally distributed.

Table 6. Homogeneity Test Results for Experimental Class and Control Class

		Test of Homogeneity of Variances			
		Levene Statistic	df1	df2	Sig.
XY	Based on Mean	2.769	1	62	.101
	Based on Median	2.690	1	62	.106
	Based on Median and with adjusted df	2.690	1	53.706	.107
	Based on trimmed mean	2.797	1	62	.100

The results of the homogeneity of the experimental class and control class using SPSS showed a significance value of $0.101 > 0.05$, so H_0 was accepted, meaning that there was no difference in variance between the experimental class and the control class (homogeneous).

Table 7. Independent Samples Test Results for Experiment Class and Control Class

		Independent Samples Test				
		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	T	df	Sig. (2-tailed)
XY	Equal variances assumed	2.769	.101	9.390	62	.000
	Equal variances not assumed			9.606	58.703	.000

Based on the results of the independent sample test output, it is known that the sign value (2-tailed) is $0.00 < 0.05$, so as in the independent sample t-test basis of decision making, it can be concluded that H_0 is rejected and H_a is accepted, meaning that there is a significant difference between the average understanding of the IPAS concept between the experimental class and control class. It can be concluded that teaching materials based on augmented reality about plants, the source of life on Earth, are effective for strengthening students' understanding of the science concept. Students not only learn two-dimensional text and images but can access three-dimensional images and videos through markers attached to teaching materials. As stated by Piaget that elementary school students are at the stage of "concrete thinking, three-dimensional images and videos in an augmented reality system provide a real picture of the concept material provided [26].

4 Conclusion

The stages of making teaching materials based on augmented reality are determining learning objectives, determining prerequisite skills, analyzing content and competencies, preparing teaching materials, preparing markers, images, animations, and videos, and preparing augmented reality projects. These steps have been validated and declared valid. Based on the assessment of material experts, media, and practitioners, teaching materials based on augmented reality are appropriate for use in learning activities. Augmented reality-

based teaching materials are effective for improving elementary school students' understanding of the Science concept of Plants, the Source of Life on Earth. Augmented reality teaching materials can not only be used in research subjects but can also be used as a source of learning and a reference for other educational units to strengthen the understanding of the science concept of plants, the source of life on Earth. Teaching materials based on augmented reality present material that is in accordance with scientific technological developments. Teachers can present engineering with learning that makes positive use of devices in the world of education through the use of augmented reality systems. The use of augmented reality-based teaching materials motivates teachers to utilize technology in the world of education in order to achieve an understanding of the science concept in other materials to the maximum according to learning objectives.

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