DEVELOPMENT OF AUGMENTED REALITY-BASED LEARNING MEDIA FOR GEOGRAPHY SUBJECT ON ANDROID USING THE ADDIE MODEL

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ABSTRACT
In the field of education, several issues have been identified, such as decreased student interest and the lack of new learning media that support interactive and collaborative teaching methods. This problem arises because teachers not only teach but also have other responsibilities that reduce the time available for developing new learning media. This study aims to create an Android application using Augmented Reality (AR) technology as a teaching aid for geography lessons on the lithosphere for class X-4 at SMA Negeri 1 Sokaraja, and to evaluate the improvement in student understanding after the media's implementation. The development method used in this research is ADDIE. The application was tested using Black Box Testing to ensure all features function correctly. The content expert evaluation showed a validity score of 80%. The evaluation of the media's effectiveness in improving student understanding showed an n-gain value of 63.29%, indicating it was moderately effective. It can be concluded that the developed learning media is both suitable and effective for teaching geography on the lithosphere.
Keywords: Augmented reality, learning media, ADDIE model

A. Introduction

Education plays a crucial role in the current era of globalization, particularly in sustainable development, as it determines the direction of a nation's progress. According to data from the World Population Review in 2021 regarding global education system rankings, Indonesia ranks 54th out of 78 countries. In Southeast Asia, Indonesia ranks 4th, but compared to other countries in the region such as Singapore (ranked 21st), Malaysia (ranked 38th), and Thailand (ranked 46th), Indonesia's position remains far from the top, with a significant gap between Southeast Asian nations (Yulianingsih, 2022). Through quality education, a generation of future leaders with broad knowledge and noble character will emerge, contributing to the development and progress of the nation (Fortuna et al., 2022).

The importance of education for the advancement of Indonesia can be seen in the continuous improvement of educational standards by educational institutions to keep pace with the times. This is evidenced by the introduction of a new learning curriculum called the "Kurikulum Merdeka" (Independent Curriculum), which is now being implemented simultaneously across elementary, junior high, and senior high schools. Under the Kurikulum Merdeka, the learning model is project-based, aimed at developing students' soft skills, character, and competencies (Festiyed Festiyed et al., 2022).

SMA Negeri 1 Sokaraja is a high school in Banyumas Regency that has implemented the Kurikulum Merdeka for tenth-grade students. Based on interviews with geography teachers, several issues were identified, such as a decline in student interest in learning and the suboptimal development of new learning media to support the implementation of interactive and collaborative teaching methods. This is partly because, in addition to teaching, teachers also have many other responsibilities at school, leaving little time to develop new

learning media. According to the interviews, there is also a need for the development of more varied learning media to motivate students and help them better understand the lessons.

Students' difficulty in understanding learning material is influenced by the lack of media used as learning resources (Gulo and Harefa, 2022). Rapid development has pushed technology to be utilized across various fields, including education, which has seen significant technological growth in recent years. One example of this is the use of Augmented Reality (AR) technology in learning, through the creation of mobile learning media based on Android. Augmented Reality (AR) itself is a technology developed to integrate the real-world environment with virtual objects, visualized through projections and displayed in real-time using equipment such as webcams, computers, and smartphones. This is similar to virtual reality, which adds to or enhances reality, rather than completely replacing it (Kanti et al., 2022). The use of AR in learning media can stimulate students' thinking abilities, as it allows them to see and directly engage with the learning process in a more tangible way (Mahfudh et al., 2022).

One of the subjects that still lack of sufficient learning media is geography. The lithosphere is one of the topics in geography that explains various aspects of the Earth's layers. In the learning process, this topic tends to be abstract and lacks clear visual representation, as it cannot be directly observed. Therefore, there is a need to develop learning media that can enhance students' understanding by applying AR technology, which can provide a clear visual representation through projections.

Based on this background, the purpose of this research is to develop an application-based learning media that incorporates AR technology to support the teaching of the lithosphere topic in geography for 10th-grade students at SMA Negeri 1 Sokaraja. The study will also conduct testing to determine the extent of improvement in student understanding after using the learning media during the teaching process. This application is expected to increase students' interest and make it easier for them to understand the geography lesson on the lithosphere.

The outcome of this research is the development of an effective and engaging AR-based learning media application for teaching. Additionally, the results of this study are expected to contribute to the development of more interactive and innovative teaching methods.

B. Literature Review
Learning Media

Learning media is a tool used to facilitate the learning process, where communication occurs between the students, the teacher, and the learning materials (Sugianto, 2018). According to Kamiana et all. (2019), learning media is the medium used during instruction, which includes tools that assist the teacher in teaching and also serve as a channel for delivering messages from the instructor to the learners.

Augmented Reality

Augmented Reality (AR) is a technology that combines virtual objects, both two-dimensional and three-dimensional, with the real world, presented through projections and displayed in real-time using equipment such as webcams, computers, and smartphones. This is not virtual reality that completely replaces reality, but rather enhances or complements it (Kanti et all. 2022).

Lithosphere

The lithosphere is the outermost layer of the Earth's surface, composed of various rocks and minerals. Its shape follows the curved surface of the Earth (Afdal et all., 2018).

C. Research Method

In this study, the object used is an Android-based learning media application that applies AR technology to support the teaching of Geography, specifically the Lithosphere topic. The subjects of this research are 36 students from class X-4 who are studying the Lithosphere at SMA Negeri 1 Sokaraja, located at JL. RAYA SOKARAJA TIMUR, Sokaraja Wetan, Sokaraja District, Banyumas Regency, Central Java Province.

The method used for the development of learning media in this research is ADDIE, which is an adaptation of the Research and Development (R&D) method. This method is suitable for developing learning media because it follows a systematic process and ensures that the resulting product meets the specific needs (Fridayanti, Irhasyuarna, and Putri, 2022). The stages of the ADDIE method can be seen in Figure 1.
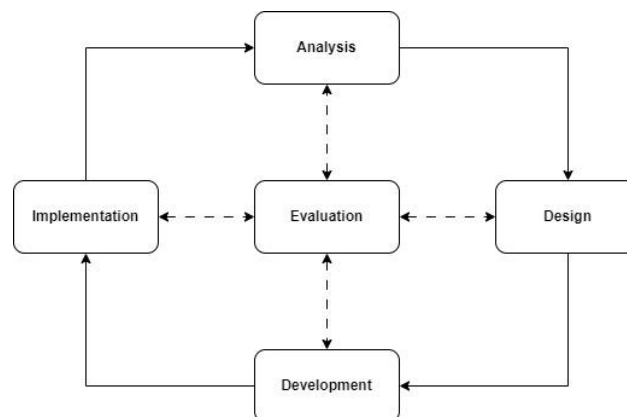

Figure 1. ADDIE method stages

In the Analysis stage, a series of interviews were conducted with the geography teachers. The purpose of these interviews was to collect data related to the needs analysis for the development of learning media. The results of the interviews revealed that the material that could be developed into learning media in line with the current curriculum is the phenomenon of the lithosphere. Therefore, the learning media to be developed will cover the lithosphere topic, including the structure of the Earth and various types of earthquakes, while incorporating Augmented Reality (AR) technology. Furthermore, based on the interview results regarding the policies at SMA Negeri 1 Sokaraja, students are allowed to bring and store their personal smartphones at school, with the restriction that they cannot use them during class time unless they are related to the learning process itself. This condition allows the use of smartphones to support the learning process. Therefore, the learning media to be developed will take the form of an Android application.

In the Design stage, a series of designs were created for the application to be developed based on the results of the analysis. The design will be tailored to meet the needs of the users, which is why it is necessary to create a use case diagram and wireframe designs. This is done to ensure that, during the development of the learning media, the concepts planned from the outset are accurately realized.
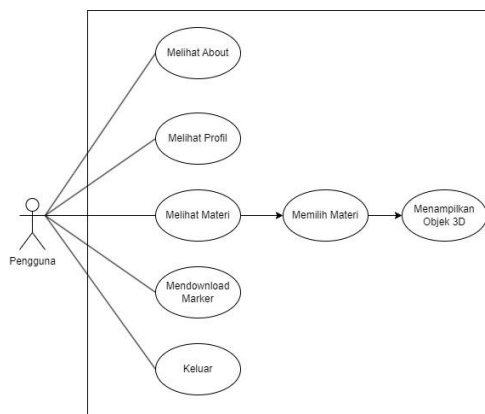
Figure 2. Use Case Diagram

The use case diagram in this study can be seen in Figure 2. This diagram is used to illustrate the interaction between the actors and the system in the developed learning media. Several menu features that will be available in the learning media, which can be accessed by the actors (users), include the "About" menu, profile menu, marker download menu, exit menu, and the content menu. Within the content menu, there will be subtopics, and within these subtopics, there will be an AR menu to display three-dimensional objects.

Figure 3. Wireframe Halaman *Loading Screen*, Halaman Awal dan Halaman Utama

A wireframe is a simple visual representation of the learning media to be created. The wireframe helps ensure the layout, content structure and navigation are appropriate without including graphic design elements, colors, or detailed design features.

In the Development stage, the realization of the application design that was previously created is carried out. The development includes creating three-dimensional objects, markers, audio, user interface design, and the learning media application itself. Once the application is complete, it will undergo testing using the Black Box Testing method and content expert testing. The purpose of these tests is to determine whether the application functions correctly and aligns with the intended learning objectives to be tested.

To obtain the value from the expert content testing, the following equation can be used (Herniawan and Vivianti, 2022).

$$Persentase = \frac{\sum x}{\sum x\,i} \times 100\%$$

Description:

$\sum x$: total number of answers

$\sum x\,i$: total all questionaires item x higesht score

The following is a table of validation criteria percentages to measure the value of the content expert test.

Table 1. Validation Percentage Criteria

No.	Percentage	Category
1.	20% - 36%	Highly Unqualified

2.	37% - 52%	Unqualified
3.	53% - 68%	Somewhat Unqalified
4.	69% - 84%	Qualified
5.	85% - 100%	Highly Qualified

In the Implementation stage, the developed application will be tested for use during an ongoing learning process. This field test will be conducted in class X-4, consisting of 36 students at SMA Negeri 1 Sokaraja.

In the final stage, Evaluation, data collection will take place during the implementation phase. The evaluation will focus on assessing the impact of using the learning media on student learning outcomes, using the gain test method. The testing will involve giving a pretest to the students, which consists of a set of questions related to the material before the lesson is delivered using the learning media. Afterward, a posttest will be conducted with the same set of questions related to the material, but this time after the students have experienced the lesson using the learning media. The impact of the learning media on student learning outcomes can be measured by calculating the N-Gain score.

To obtain the N-Gain score, the following equation can be used (Rosidah et al., 2022).

$$N - Gain = \frac{Skor\ Post\ Test - Skor\ Pre\ Test}{Skor\ Ideal - Skor\ Pre\ Test}$$

Table 2. Category of N-Gain Score

Nilai	Category
g > 0,7	High
0,3 ≤ g ≤ 0,7	Sedang
0 < g < 0,3	Rendah

Table 3. Criteria of efektifitas N-Gain

Prosentase	Criteria
<40	Innefective
40 - 55	Less effective
56 - 75	Quite effective
>75	Effective

D. Discussion

In the previous stages, the implementation process involved design and development, which resulted in the creation of an Android-based learning media application. The results of this process can be seen in Figures 4 to 5 below. This was done to ensure that the application functions properly and aligns with the design that was planned earlier.

Figure 4. Page of Loading Screen, Halaman Awal dan Halaman Utama

Figure 4 shows the loading screen when opening the application, followed by the home page and the main page, which consists of five buttons. The "About" button is used to access the about page, which provides a brief explanation about the learning media

application. The "Profile" button leads to the profile page, which provides information about the app developers. The "Materi" (Content) button takes the user to the main content page, where they can access various subtopics, such as the materials on types of earthquakes, the structure of the Earth, and the AR camera page to scan markers and display 3D objects. The main menu also includes a "Download Marker" button and an "Exit" button.

Figure 5. Page of Menu Materi Utama, Halaman Materi Macam-Macam Gempa Bumi and Struktur Bumi

Figure 5 shows the display of the main content menu page, which includes the materials on types of earthquakes and the structure of the Earth. On the main content menu page, there are three sections, with two buttons to access the subtopic pages and an "X" button to return to the previous page, which is the main page. On the Types of Earthquakes page, there are six buttons: four for different material sections, one to open the AR page, and an "X" button to return to the main content page. On the Structure of the Earth page, there are eight buttons: six for different material sections, one to open the AR page, and an "X" button to return to the main content page.

Figure 6. Page of AR Kamera

Figure 6 shows the display of the AR camera page, where users can scan a marker to display 3D objects. The total number of 3D objects is ten, corresponding to the topics covered in the Types of Earthquakes and Structure of the Earth sections. The AR camera page includes five buttons: the "X" button to return to the previous page, the audio button to play an explanation related to the 3D object in audio form, and three interactive buttons: the rotation button to rotate the displayed object, the zoom-out button to enlarge the 3D object, and the zoom-in button to shrink the size of the 3D object.

After the application is completed, it will undergo testing using the Black Box Testing method and content expert testing to determine whether the application functions correctly and aligns with the intended learning objectives to be assessed.

Table 4. Scenario for Black Box Testing

No.	Scenario Testing	Result
1.	Membuka Aplikasi	Berhasil/Success
2.	Sentuh Tombol About	Berhasil/Success
3.	Sentuh Tombol Profil	Berhasil/Success
4.	Sentuh Tombol Download Marker	Berhasil/Success
5.	Sentuh Tombol Materi	Berhasil/Success
6.	Sentuh Tombol Macam-Macam Gempa Bumi	Berhasil/Success
7.	Sentuh Tombol Seteruktur Bumi	Berhasil/Success
8.	Sentuh Tombol Kamera	Berhasil/Success
9.	Sentuh Tombol Rotasi	Berhasil/Success
10.	Sentuh Tombol Zoom Out	Berhasil/Success

| 11. | Sentuh Tombol Zoom In | Berhasil/Success |
| 12. | Sentuh Tombol Audio | Berhasil/Success |

Based on the Black Box Testing conducted, as shown in Table 4, it can be concluded that the developed application has successfully passed all testing scenarios with results as expected. This indicates that the application is feasible for use and meets the expected quality and reliability standards.

Table 5. Expert Testing

NO.	Aspect	Total Item	Maximum Score	Total Score	Percentage
1.	Material	2	10	7	70%
2.	Learning Process	3	15	13	86%
	Overall Score	5	25	20	80%

Based on the content expert testing conducted, as shown in Table 5, it can be concluded that the developed application is deemed feasible. The material aspect received a score of 70%, while the learning aspect received a score of 86%. The overall average score across all aspects is 80%, which falls into the "feasible" category.

Table 6. Calculation of N-Gain Score

No.	N-Gain Score	N Gain Score (%)
1.	0,7	71,4
2.	1,0	100,0
3.	0,7	66,7
4.	1,0	100,0
5.	0,5	50,0
6.	1,0	100,0
7.	0,5	50,5
8.	0,7	71,4
9.	0,7	66,7
10.	0,4	42,9
11.	1,0	100,0
12.	0,7	66,7
13.	0,8	75,0
14.	0,7	66,7
15.	0,2	20,0
No.	N-Gain Score	N Gain Score (%)
16.	0,8	75,0
17.	0,8	80,0
18.	0,5	50,0
19.	0,7	66,7
20.	0,6	60,0
21.	0,7	66,7
22.	0,7	71,4
23.	0,8	80,0
24.	0,3	33,3
25.	0,5	50,0
26.	0,7	66,7
27.	1,0	100,0
28.	0,6	57,1

29.	0,3	33,3
30.	0,3	33,3
31.	0,8	83,3
32.	0,9	87,5
33.	0,2	16,7
34.	1,0	100,0
35.	0,0	0,0
36.	0,2	20,0
mean	0,63	63,29

In the final stage of Evaluation, data was collected regarding the impact of using the learning media on student learning outcomes, using the gain test method. The obtained n-gain score was 0.63, which falls within the range of $0.3 \leq g \leq 0.7$, placing it in the "medium" category. This category is outlined in the n-gain score criteria table in Table 2. The effectiveness percentage of the n-gain score is 63.29%, which falls into the "moderately effective" category. This category is shown in the n-gain effectiveness percentage table in Table 3.

E. Conclusion

Based on the results of the research conducted on the development of learning media for the geography subject, specifically the lithosphere topic, this learning media utilizes Augmented Reality technology and is equipped with several features, such as an AR page that displays 3D objects, including volcanic earthquake landscapes, tectonic earthquakes, collapse earthquakes, collision earthquakes, and six 3D objects explaining the structure of the Earth. From the system testing of the learning media using Black Box Testing, it was found that all features functioned properly as intended. The results of the content expert evaluation indicated that the developed learning media is feasible, with a score of 80%. The effectiveness of the media was deemed sufficiently adequate, with an n-gain score of 63.29%. Therefore, it can be concluded that this application is suitable to be used as a learning media for the Geography subject on the Lithosphere topic for 10th-grade students (Class X-4) at SMA Negeri 1 Sokaraja.

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