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RESEARCH ARTICLE

Development of Physics Learning Media Based on Augmented Reality

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Abstract

The purpose of this research is to determine whether it is feasible to develop augmented reality-based physics learning materials and to certain how instructors and students react to such materials when they are based on magnetic field material. The ADDIE paradigm, which stands for Analysis, Design, Develop, and Evaluate, is used in this study. Experts, educators, and MIPA class XI students at SMAN 8 Selayar served as the study's subjects. After demonstrating the use of augmented reality media, teachers and students were given the opportunity to respond to a questionnaire or voice their opinions on the program. This allowed researchers to collect data for their study. The Gregory method is the method used for data analysis. The analysis's findings showed that the Gregory internal consistency coefficient was either 1 or 100%, and the replies from physics instructors and students fell between 80% and 100% of the total. This demonstrates that learning physics with augmented reality media is feasible.

Keywords

augmented reality, ADDIE, learning media, physics, magnetic field

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State of the literature

- Augmented Reality is technology that can display 3-dimensional images in real time.
- Overall, few learning media to introduce the magnetic field material in physics just using pics on the books and 'right-hand' rule
- The Development of learning media based on Augmented Reality is inexpensive and available for android user.
- Using the 3-D Blender, Vuforia, and Unity to build the application

Contribution of this paper to the literature

- Using Augmented Reality can improve contextual and authentic learning for student.
- Teaching principles of magnetic field with Augmented Reality enables students to visualize abstract concepts.
- Facilitate independent learning with Augmented Reality.
- Increasing student engagement in class and spatial understanding of magnetic field.

Introduction

Physics is one of the sciences that studies natural phenomena that can be visualized simply so that they are easy to understand (Yovan, 2021). However, facts in the field show that learning physics is still considered difficult. Research conducted by (Hafi and Supardiyono, 2018; Anugrah et al, 2015) stated that 78.2% of students find it difficult to understand physics concepts because learning is only delivered with textbooks and doing problems that contain formulas only, some physics require mathematics visualization because not all physical symptoms can be observed directly. For high school students, it is difficult to learn concepts in physics when the topic is theoretical and cannot be seen directly (Sırakaya & Kılıç Cakmak, 2018).

Technological developments have great potential. In changing the learning system and teachers have the opportunity to develop learning media that are in accordance with learning objectives. The development of augmented reality (AR) technology, one of the learning media based on 3-dimensional animation. AR mixes virtual items that are either two or three dimensions and projects them in real time (James R. Valino, 1998; Mustaqim, 2016). The learning process can be greatly aided by augmented reality, which can also help turn abstract ideas into useful notions.

Background

In the sphere of education, augmented reality is utilized to facilitate understanding of a subject. According to Ibáñez et al. (2014), physics, chemistry, biology, and mathematics subjects can all be understood with the application of augmented reality technology. According to Harun et al. (2020), visualizations with three-dimensional pictures are displayed using augmented reality to enhance perceptions of the surrounding world. This explanation leads to the conclusion that augmented reality technology has the potential to improve students' comprehension of physics' complex ideas.

There are two categories of augmented reality: *image-based* and *position-based*. Position-based augmented reality, according to Majgaard et al. (2017: 97), depends on compass measurement coordinates and presents text models, graphics, sound, video, and three-dimensional animation in addition to actual location. In the meantime, picture-based augmented reality displays a three-

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dimensional animation overlaid on top of an image by using a smartphone's camera to scan a Quick Response (QR) code. Through the scanning of two-dimensional photographs, an image-based augmented reality will be built in this study. Students studying physics, particularly when studying the subject of magnetic field, need visual aids that may help them observe directly and that can depict the formation of three-dimensional magnetic field force lines or magnetic field directions due to a rod magnet, a straight wire, a solenoid, a coiled (ring) wire, and a toroid (see **Figures 1-5**).

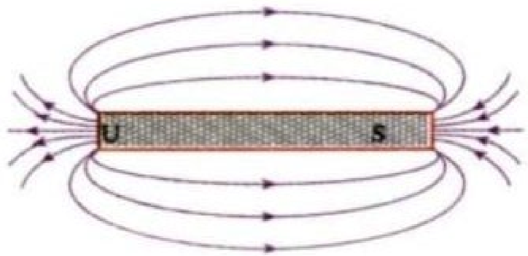


Figure 1. Magnetic field by bar magnet (Arifudin, 2007)

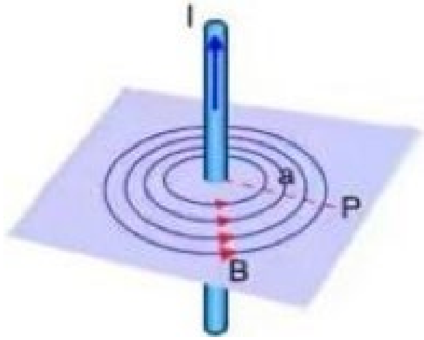


Figure 2. Magnetic field by long straight wire (Sitanggang, 2019)

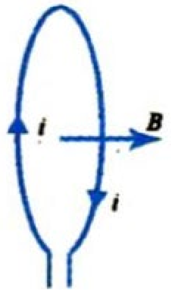


Figure 3. Magnetic field by coiled wire (Kamajaya, 2007)

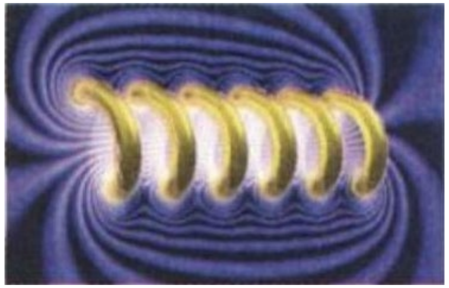


Figure 4. Magnetic field by solenoid (Arifudin, 2007)

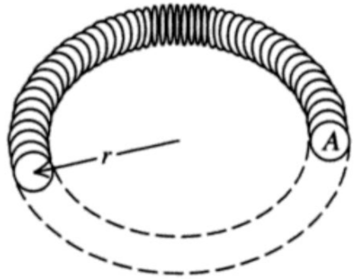


Figure 5. Magnetic field by toroid (Young & Freed, 2003)

Methods

Research Type

This type of research is *Research and Development (R&D)* by adopting the *ADDIE model* (*Analysis, Design, Development, Implementation and Evaluation)* (see **Figures 6**).

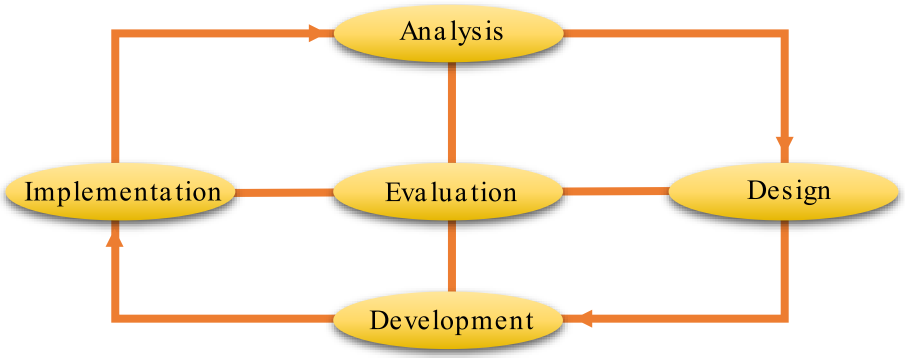


Figure 6. ADDIE model stages

Analysis

The analysis carried out in this study is *content analysis*, *student needs analysis* and *software requirements analysis*.

a. Content analysis

Content analysis was carried out by conducting interviews with teachers and students at SMA Negeri 8 Selayar located in Baruia, Selayar Islands, South Sulawesi Province. Based on the results of interviews that have been conducted with teachers and students of class XI MIA, it was found that the physics learning process that took place was still dominated by teachers in explaining learning materials (teacher-center). Because the teaching method is still traditional, students are typically less motivated to participate in physics classes. Physics topics are hard for students to understand, especially when they are abstract or cannot be seen immediately.

To help students comprehend the direction of the magnetic field, augmented reality media must be developed. To enhance the capacity to conduct additional analysis, particularly in KD 3.3 regarding evaluating magnetic fields, one must have a better grasp of the direction of the magnetic field. During the start of learning activities, augmented reality media is used to visualize the direction of the magnetic field. This helps students grasp the concept at first, especially during perceptual tasks.

b. Analysis of student learning needed

Learners using augmented reality must be able to see abstract ideas and take independent learning assignments. Physics lessons on the material magnetic field, which depict the formation of magnetic field force lines or directions in three dimensions, are currently being taught to students. Students must have an Android device running Android specs version 7.0 (Nougat) or version 13 (Tiramisu) in order to use augmented reality apps. In order for students to scan and bring up three-dimensional items, they must additionally print picture markers that have been supplied by augmented reality.

c. Software requirements analysis

Software and hardware that are compatible with augmented reality are needed to create educational materials. The following software is used to create augmented reality-based learning materials: Blender, Unity 3D, Microsoft Word, Figma, Canva, and Vuforia.

Design

The first step in this media design process is gathering media content, in this case, magnetic field content from M.C.O.F.W.D. After that, a simple framework (wireframe) was developed using the Figma app, an image-marker design was created using Canva, and Blender was used to create three-dimensional (3D) objects. The following illustrates the design steps: design of wireframe application, design of image marker, and 3D object creation (see **Table 1**).

The layout of barcodes or markers that will be scanned in augmented reality applications is known as the image marker design. The websites Canva and Vuforia are used to create markers. The marker design's outcomes are shown in **Table 2**.

The creation of 3D objects that will appear in the augmented reality application is made using Blender 3.4 software. The results of 3D objects that have been designed are shown in **Table 3**.

The 3D object that has been designed is followed by animation in the *edit scene*. The animation and color of the object are adjusted to the playback time of the 3D object animation. After that, the 3D object is exported in a file with the *type.fbx* so that it can be identified as a 3D object in *Unity 3D*.

Table 1. Design of the wireframe application

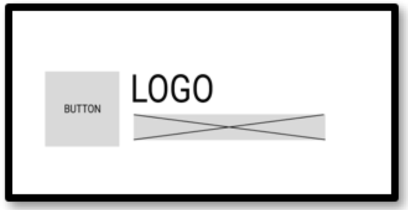
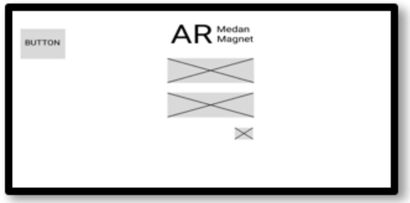
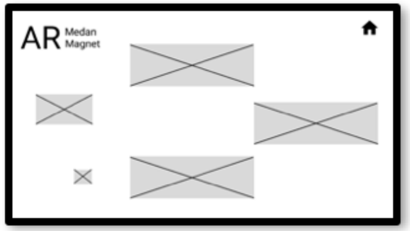
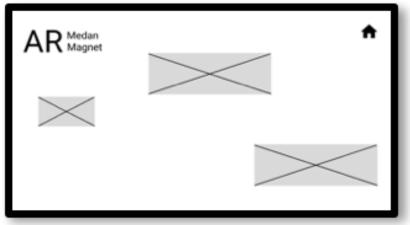
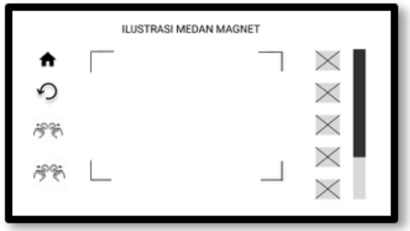
Design	Name
	Application start page
	Main page of the application
	Material selection page
	Camera selection page
	Camera page in use

Table 2. Design of augmented reality marker

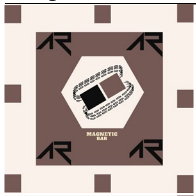
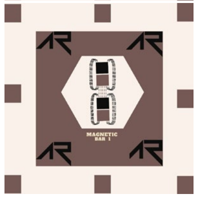
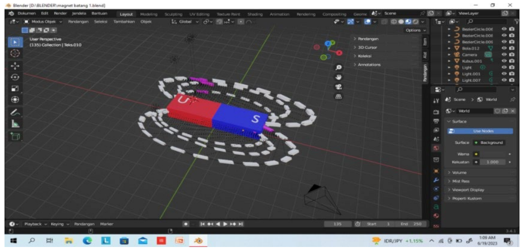
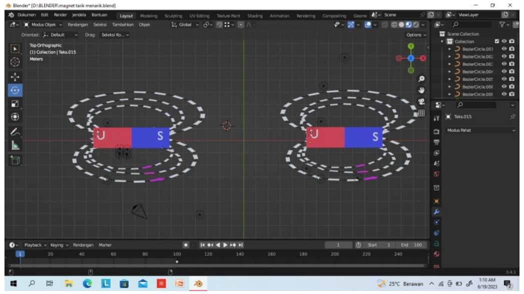
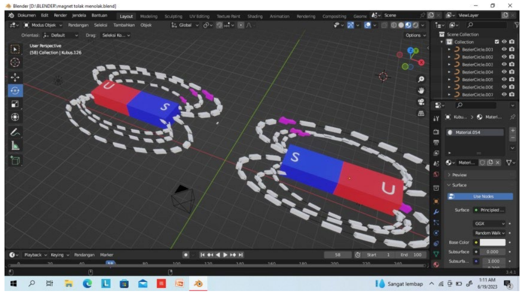
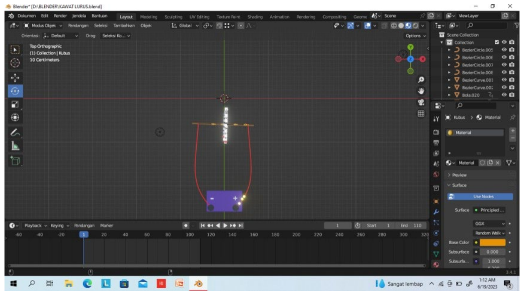
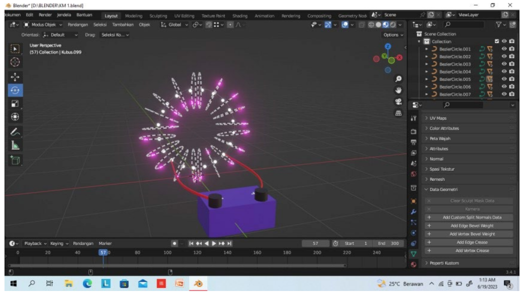
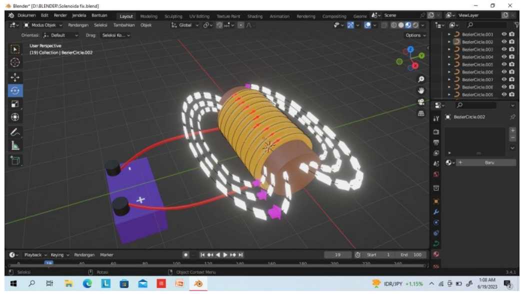
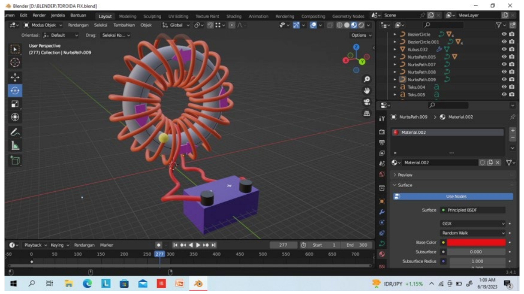
Design	Name
	Magnetic bar
 	Interaction between north and south pole of magnetic bar
	Straight wire
	Ring wire
	Solenoid
	Toroid

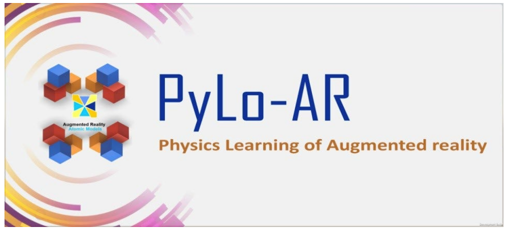
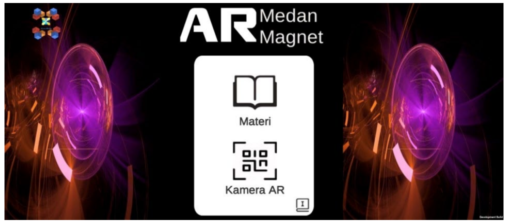
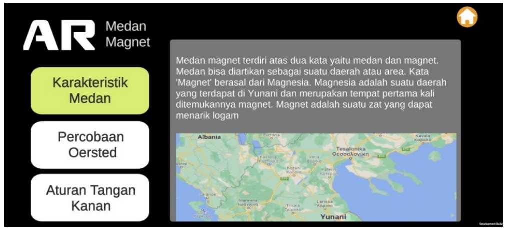
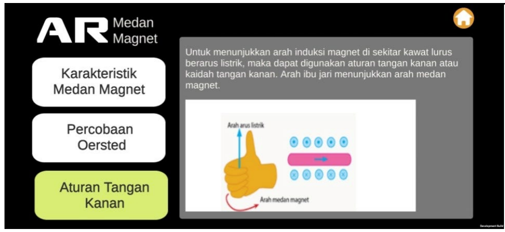
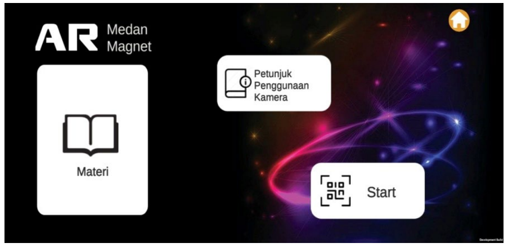
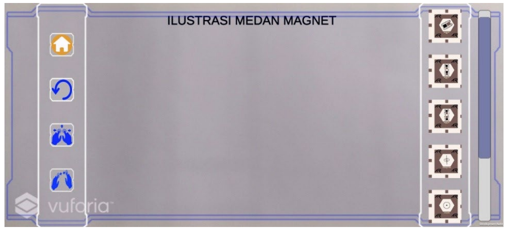
Table 3. 3D object creation

Design	Name
	Direction of the magnetic field on the stem magnet
	Interaction of attraction on 2 poles of different magnetic types
	Interaction of attraction at 2 similar magnetic poles
	The direction of the magnetic field arising on a straight wire
	The direction of the magnetic field arising on the coiled wire
	The direction of the magnetic field arising in solenoids
	The direction of the magnetic field arising in toroid

Development

Expert validity, or the action of having experts evaluate the product, is part of the third stage of development. The development stage is also when the prior design's outcomes will be practically implemented. The study will involve the implementation of wireframe designs into augmented reality applications, which will involve the insertion of objects, marker files, and instructional materials. Some screenshots from *Augmented Reality App* are shown in **Table 4**.

Table 4. Augmented Reality App

Screenshot	Name of page
	Start page of the application
	App main page
	Material selection page
	The part of material page
	The part of material page
	The part of material page
	Camera selection page
	AR Camera Page
	The operation of Camera AR scanned into the marker

Implementation

Implementation efforts including the use of augmented reality media in study subjects comprise the fourth step. At this point, thirty SMAN 8 students participate in product trials. In addition to explaining how to use augmented reality-based physics learning materials, researchers demonstrated how to use them. Following the demonstration, augmented reality materials were sent to physics instructors and students so they could try out the technology. The integration of augmented reality media into the physics teacher education process is now complete. And students were distributed questionnaires to find out the opinions or responses of physics teachers and students regarding AR-based learning media.

Evaluation

In the fifth stage, which is called evaluation, the created augmented reality media are evaluated. The evaluation comprises physics instructors' and students' reactions to the created augmented reality media, as well as the findings of experts' evaluations of the viability of media. This step is among the most crucial according to the development model used since it seeks to determine the product's quality at every research stage and determine whether the media is truly deserving of moving on to the next phase.

Data Collection Instrument

The data collection instrument used is a questionnaire. The questionnaire was used to measure the quality of the media developed. The questionnaire in this study was used to obtain data from validators, physics teachers, and students as evaluation material for the developed augmented reality learning media. There are three items for validator to evaluate which are the match between the material and indicator, the use of language, and the effect for learning strategy.

Data Analysis Techniques

The data that has been collected will be analyzed to find out the assessment and opinion of the products produced.

Product qualification assessment data by experts

The analysis used to test the validity of the content was carried out using Gregory's analysis, with 4 types of score criteria validity. The analysis technique used is based on the understanding of two experts of Gregory's formula, which is written in cross-tabulations as shown in **Table 5** and **Table 6**.

The results of the questionnaire of teacher and student responses were analyzed using the following formula:

$$K = \frac{D}{A + B + C + D} \tag{1}$$

Table 5. Validity of criteria

Validator score	Level of validity
1	Irrelevant
2	Less Relevant
3	Relevant
4	Highly Relevant

Table 6. Gregory's Formula

<table>
<tr><td colspan="2"></td><td colspan="2">Validator 1</td></tr>
<tr><td colspan="2"></td><td>Scores 1-2</td><td>Scores 3-4</td></tr>
<tr><td rowspan="2">Validator 2</td><td>Scores 1-2</td><td>A</td><td>B</td></tr>
<tr><td>Scores 3-4</td><td>C</td><td>D</td></tr>
</table>

Table 7. Likert Scale

Evaluation	Interpretation criteria
75% < x < 100%	Very Decent
50% < x < 74%	Eligible
25% < x < 49%	Not Feasible
0% < x < 24%	Very Unfit

where K is Coefficient Internal Consistency Gregory.

$$P = \frac{f}{N} \times 100\% \tag{2}$$

where P is percentage of questionnaire data, f is number of scores obtained, and N is number of maximum scores.

The decision-making criterion that the development carried out is valid is if the internal consistency coefficient > 0.75. If this has been fulfilled, then it can be stated that the development of the media is consistent and feasible for use with the revision notes provided by the validator are corrected.

Teacher and student response data

The results of such percentages can be grouped in the score interpretation criteria according to the Likert scale, as shown in **Table 7**.

If the score percentage scale value shows above 51%, then the media is suitable for use in the learning process.

Table 8. The result of physics teacher response

Aspects	Score	(%)	Interpretation Criteria
Material Content	23	95.83	Very Decent
Media User	31	96.87	Very Decent
Visual Display	24	100	Very Decent

Table 9. The result of student response

Aspects	Score	(%)	Interpretation Criteria
Material Content	234	97.5	Very Decent
Media User	915	95.31	Very Decent

Result and Discussion

The Result of Physics Teacher Response

Based on calculations on the scale, the results of the analysis are shown in **Table 8**.

The results of the analysis of teacher responses to AR-based learning *media* are classified as "very feasible" in every aspect of media feasibility.

The Result of Student Response

The results of the analysis of student responses to augmented reality-based learning media on the subject of magnetic fields are classified as "very feasible" in every aspect of media feasibility (**Table 9**). Based on the responses of physics teachers and students provide suggestions for creating augmented reality-based learning media on physics *material* with other themes.

The whole result provided the big acceptable regarding augmented reality as learning media of physics in magnetic field material on Senior High School in Selayar Island, Indonesia. In regard to every aspect, including the material content, Media User, and Visual Display show the Very Decent criteria. It means that AR is really fit to use as a learning media and could help every student to visualize and understand the magnetic direction.

Conclusion

The AR-based physics learning media developed has been tested to be very feasible by validators with the assessment category being in category D for all aspects of feasibility with an internal coefficient value of 1 or 100% which means it is at a high level of validity.

The results of the response of physics teachers and students to AR-based physics learning media obtained scores with a percentage scale of 75% - 100% for each aspect of media feasibility that is in the 'very feasible' category, which means that AR-based learning media is suitable for use in learning.

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