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Development of E-Modules Assisted By Augmented Reality on Alternative Energy Material

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Abstract. The ability to interpret, use, and create visual media to improve processes, decision-making, communication, and learning is known as visual literacy. Learning that trains visual literacy is needed to prepare students' abilities in the future. The purpose of this research is to develop and identify the feasibility of Augmented Reality-assisted E-Module on alternative energy materials in training literacy. The research method used is Research and Development (R&D) with the ADDIE development model. This research only carried out three stages of the ADDIE development model, namely: Analysis, Design, and Development. To identify the feasibility of the E-Module, validation and testing are carried out. Validation was carried out by 3 physics lecturers and 2 physics teachers with a result of 91% (very feasible category). Then in the rumpang test, it showed a readability level of 96.2% (independent category). So it can be concluded that the E-Module is easy to understand and can be used independently by each student.

Keywords: e-module development, augmented reality, visual literacy

1. Introduction

In line with the development of information technology, educational institutions are required to be able to adjust to the development of science. Education must adapt to the alpha generation whose daily activities, such as communicating, reading, watching movies, and even completing tasks, are all connected to the use of various digital devices. This generation has become accustomed to living in an era where almost everything is conveyed through visual language and relies on visual media[1].

The ability to interpret, use, and create visual media to improve processes, decision-making, communication, and learning is known as visual literacy[2]. Visual literacy can also be defined as the ability to understand and create messages from visual displays. A person who has good visual literacy skills, can interpret visual messages correctly. Currently, learning is delivered in the classroom, not all material is suitable to be delivered in the form of text. Students tend to believe something that is already visible to them, and some learning materials cannot all be conveyed if only using text. According to Abbas and Hidayat [3] difficulties in learning physics are caused by students' low interest in physics lessons and the lack of students' ability to understand concepts and mathematical calculations. Physics material can be abstract or concrete, the difficulty of students in studying physics concepts is that they cannot imagine abstract material and have not encountered concrete events. So that visuals are the right choice to convey abstract material or visualizations of objects that are difficult to access.

Developing visual instructional planning is one of the strategic steps that can be used. Making instructional visual media is very necessary in the teaching and learning process[4]. Visual instructional is a series of lesson plans presented in the form of simple, precise, and easy-to-understand visual instructions[1]. So that learning media that suits the needs is needed to solve the problems that have been explained. Training and improving visual literacy skills is the focus of the author in this study.

Learning media functions as a means, intermediary and liaison to disseminate, bring, or convey a message or idea, with the aim of stimulating students' thoughts, feelings, actions, interests and attention [5] In other words, learning media makes the learning process happen to every student. Learning media in the delivery of physics material, especially alternative energy, tends to still be through text or 2D images, and it is also difficult to present objects for students to review so that students have not imagined the picture that exists in the components of alternative energy sources. So a media is needed that can visualize this. One of them is by combining learning media and 3D Augmented Reality visualization[6].

A technology called Augmented Reality combines two-dimensional or three-dimensional virtual objects that allow the projection of virtual objects into the virtual world in interactive, immersion, and realtime[7]. The utilization of AR-technology will be beneficial when combined with teaching materials in physics learning that have abstract concepts[8]. The use of Augmented Reality in learning media serves as a means of support and helps visualize the workings of power plant components.

Research on media development has begun to be developed. In the research, Purwandari, et al., stated that to improve the ability to master concepts, the development of Augmented Reality-based physics modules on vibration and wave materials is categorized as sufficient[9]. Kuswanto concluded that the development of web-based learning media is feasible and recommended to be developed by adding media in the form of videos or questions for evaluation[10]. In the article A. M. Amin [6]it was stated that based on the results of his research, the development of learning media that utilizes Augmented Reality is highly recommended to improve physics learning outcomes. Aprilla, et al [11]conducting research on the development of physics learning media based on Augmented Reality technology. According to the results of the research that has been carried out, namely the development of application prototypes as a means of helping the teaching and learning process of students, it is concluded that it can be a support for the learning process in the 21st century[11].

Based on the description above, research on the development of learning media using Augmented Reality has been carried out a lot, but no one has trained visual literacy skills. Therefore, the author created "Eye on Physics", an E-Module supported by Augmented Reality that offers web-based 3D visual media. Students can use these e-modules as a self-paced learning resource, providing them with reading materials and visualizations about the subject being taught.

The objectives of this research are as follows: 1) Developing E-Module-based physics learning media assisted by Augmented Reality to train visual literacy skills using alternative energy materials; and 2) Identify the validity of the Augmented Reality-Assisted E-Module based on the results of expert validation.

2. Method

The research method used is the Research and Development (R&D) method. According to Sugiyono in [12] the R&D method is a research technique used to create a particular product and test how effective it is. The product developed in this study is an Augmented Reality-assisted E-Module on alternative energy materials. The research model used in this study is the ADDIE development model which includes five stages including, Analysis, Design, Develop, Implementation, and Evaluate. This research only carries out three stages of the ADDIE development model, namely: Analysis, Design, and Development.

The first stage is Analysis, the analysis carried out consists of 3 types, namely needs analysis carried out with field studies and literature studies, then analysis of teaching material development, and curriculum analysis. The second stage is Design, the stages carried out include determining learning outcomes, learning objectives, learning goal flows, and designing visualizations to show phenomena. In addition, the elements that must be designed to support these stages are flowcharts and storyboards. The third stage is Develop, at this stage two steps are carried out, namely the preparation of learning tool instruments and the E-Module feasibility test stage.

Data collection in this study was carried out to analyze the feasibility of the E-Module. This feasibility test was carried out using validation sheets filled out by physics education lecturers and physics subject teachers, as well as a random test conducted by students to assess the readability of the E-Module. The validation sheet uses a Likert scale, with the following options: Strongly Agree (SS), Agree (S), Disagree (TS), and Strongly Disagree (STS). In addition, a column is provided to provide

comments/suggestions for improvements for things that need to be revised. Meanwhile, the rumpang test is in the form of short fill questions that are given after students read the E-Module that is made.

The data analysis technique used is a descriptive analysis method with a combination of quantitative and qualitative approaches. Each validator fills out a validation sheet, then the qualitative data is converted into quantitative data, for the purposes of quantitative analysis, the answers are scored as in Table 1.

Table 1. Likert Scale.

No.	Category	Score
1	Strongly Agree	4
2	Agree	3
3	Disagree	2
4	Strongly Disagree	1

To analyze the validator's response data to the E-Module, the validation data will be processed using the following formula:

$$P = \frac{Data\ collection\ score}{Ideal\ score} \times 100\% \quad (1)$$

Information: P as percentage number, ideal score as high score for each indicator x number of respondents x number of indicators.

Then the level of validation of the students' media is classified in the form of a table to make it easier to draw conclusions. The table is the result of modifications of Riduwan and Kuncoro [13] it will be like Table 2.

Table 2. Eligibility category.

Eligibility Assessment Criteria	Score
Highly Worthy	81% ≤ Score ≤ 100%
Proper	61% ≤ Score ≤ 80%
Quite Decent	41% ≤ Score ≤ 60%
Less Worthy	21% ≤ Score ≤ 40%
Very Unworthy	0% ≤ Score ≤ 20%

The results of the rumpang test are processed in several steps, including:

1. Checking students' answers and adjusting them to the answer key that has been created previously.
2. Calculating the total score of each student
3. Convert the results into a percentage form, using the following formula:

$$q = \frac{y}{n} \times 100\% \quad (2)$$

where q as percentage of students answering the correct questions, y as number of correct student answers, n as total number of questions.

4. Identifying the results of the rumpang test
To identify the results of the rumour test by using the scoring system according to Rankin & Culhame in [14] are as follows.

Table 3. Identification of Rumpang Test Results

Percentage	**Readability Level**	**Category**
$60 \leq X < 100\%$	High	Self-sufficient
$40 \leq X < 60\%$	Keep	Instructional
$40\% < X$	Low	Difficult

3. Result and Discussion

3.1 *Analysis*

This stage starts from analyzing needs based on literature studies and field studies. The author has conducted a field study on 40 students at one of the high schools in the city of Bandung. The field study was carried out in the form of distributing questionnaires about students' visual literacy skills through Google Forms.

From the data obtained, conclusions include, (1) the learning media used in schools is still centered on printed books, (2) students are not proficient in explaining data in the form of graphs or diagrams, making graphs or diagrams, (3) students are not proficient in explaining events that occur abstractly in physics. With the development of learning media in the form of E-Modules assisted by Augmented Reality, it will facilitate and train students' visual literacy skills.

The next analysis is to determine the aspects that need to be considered so that the teaching materials developed are feasible and of good quality to use. The aspects that are used as assessment materials include the feasibility of norms, synchronization of the flow of learning objectives and materials, the correctness of the material in accordance with scientific principles, strengthening the Pancasila student profile, presentation techniques, the use of language in accordance with standards, rules and contexts. Then curriculum analysis is carried out by studying the curriculum and determining learning outcomes.

3.2 *Design*

The Design stage begins by describing the learning outcomes into learning objectives, determining the visual literacy indicators that will be included in the E-Module, as well as adjusting the visual literacy indicators with the learning objectives. Learning objectives are prepared based on the decree of the Head of BSKAP 032/H/KR/2024 concerning Learning Outcomes at each level [15]. Literacy indicators are adapted from [16] adjusted to the designed learning objectives. The design indicators for the E-Module can be seen in Table 4.

Table 4. Learning indicators.

Visual Literacy Indicators	Learning Objectives	Learning Indicators
Constructing Meaning	Explaining Energy	Explain events in daily life that all activities require energy and produce energy.
Visual Thinking	Identifying forms of energy	Identifying kinetic energy through graphics in 3D illustrations.
Visual Thinking	Identifying forms of energy	Identify potential energy through graphics in 3D illustrations.
Visual Discrimination	Identifying forms of energy	Identify the graphical differences between potential energy and kinetic energy and mechanical energy forms through graphs in 3D illustrations
Visual Thinking	Identifying forms of energy	Identifying the heat of the movement of particles when water is heated shown in the 3D illustration
Visual Thinking	Identifying forms of energy	Identifying the form of solar energy from the utilization of the sun in daily life, shown in a 3D illustration
Visual Thinking	Identifying forms of energy	Identifying the form of electrical energy generated from the movement of an electric charge, shown in a 3D illustration
Visual Reasoning	Analyzing the Law of Conservation of Mechanical Energy.	Analyze the Law of Conservation of Mechanical Energy by illustrating in the form of a graph.
Knowledge of Visual Conventions	Explaining the Work	Explain the concept of business by describing symbols and symbols of physics in the form of equations
Critical Viewing	Explaining the Work	Explain about Power (energy flowing per unit of time) and Efficiency. As well as determining the most efficient generator

Visual Literacy Indicators	Learning Objectives	Learning Indicators
Verbo-Visual Association dan Critical Viewing	Explaining renewable and non-renewable energy sources	Explain renewable and non-renewable energy sources by combining visual representations in the form of images, 3D illustrations and verbal
Critical Viewing	Identify policy measures on energy	Identify policy measures on energy from visual messages delivered in the form of GIFs
Verbo-Visual Association	Analyzing the potential of energy sources in Indonesia	Analyze the potential of energy sources in Indonesia by integrating the information presented with the help of related visual media (3D images and illustrations)
Constructing Meaning	Explain how the components in a power plant work	Explain how the components in a power plant work visually and verbally.

The next step is to compile a storyboard containing material from each learning objective, 3D illustrations in AR form, and placement of elements on the E-Module. Storyboard in document format like Figure 1.

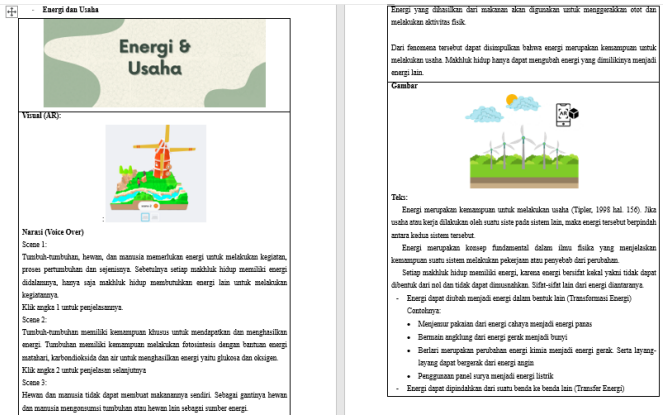

Figure 1. *Storyboard "Eye on Physics".*

3.3 *Development*

At this stage, 3D assets are created that are adjusted to the needs of the material and the preparation of learning media based on storyboards is carried out so that an E-Module is formed.

Figure 2. 3D asset in the form AR.

E-Module is created in the form of a website using Google Sites services. The display of the home page on the E-Module is shown in Figure 3. It contains a description of the E-Module, an explanation of the available features, steps to use the E-Module, and a developer profile.

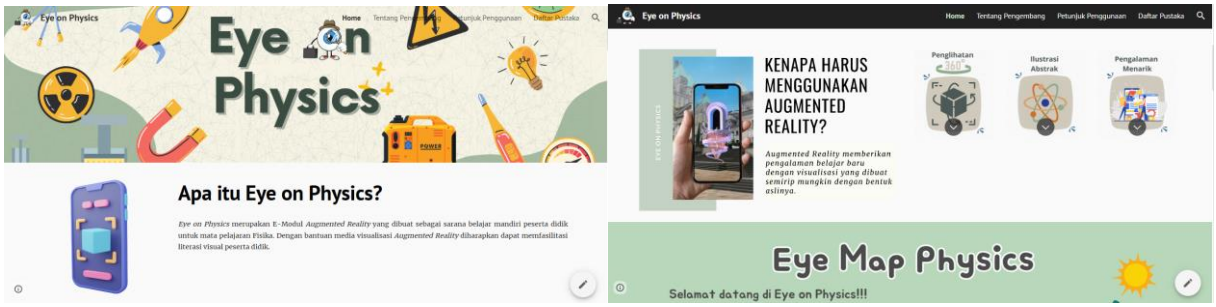

Figure 3. Eye on physics e-module home display.

After that, students will be directed to fill in the attendance. Then there will be a link that leads to the learning objectives section and the order of the main material. Students can choose the material to read, which can be adjusted to the needs of students. The illustrations used can be in the form of AR, images, or videos shown in Figure 4. At the end of the material discussion, there is an evaluation that can be filled in by students as a tool to measure learning outcomes.

Figure 4. Display of the "*Eye on Physics"* e-module.

After the preparation of the E-Module is completed, the author conducts a feasibility test or validation. This validation was assessed by 3 physics education lecturers and 2 physics subject teachers. Based on the calculation of analysis data from expert validation, the percentage of feasibility tests on each indicator listed in Table 5 is obtained.

Table 5. Augmented Reality-Assisted E-Module Feasibility Test

Aspects	Percentage	Category
Norm Eligibility	93.3%	Highly Worthy
Synchronization of Learning Objectives and Materials Flow	86.67%	Highly Worthy
Material Truth in accordance with Scientific Principles	92.50%	Highly Worthy
Strengthening the Pancasila Student Profile	90%	Highly Worthy
Serving Technique	92%	Highly Worthy
Use of Language in accordance with Standards, Rules and Context	92.50%	Highly Worthy
Average	91.17%	Highly Worthy

Based on Table 5, the feasibility test of E-Module by lecturers and teachers for all aspects has been included in the very feasible category except for the compatibility between the test instruments and learning activities that are included in the feasible category. The average score of all aspects was in the very feasible category with a percentage of 91%. This illustrates that the E-Module that has been created has accommodated several aspects such as materials, visual illustrations, and provides a new learning experience for students. They can explore, observe the phenomenon or how an object works with the help of AR illustrations, videos, and images. AR technology can effectively integrate pedagogical, content, and technical knowledge to improve learning outcomes[17]. Several studies have explored the use of AR in education to improve student performance. Then in accordance with the opinion[18] which reveals that fun learning activities are strongly influenced by various factors, one of which is the selection of learning media used must be fun but does not reduce the essence of the material presented,

besides the development of learning media developed using Augmented Reality[19]. This is in line with research conducted by A. M. Amin, which stated that the development of Augmented Reality-assisted learning media is highly recommended to maximize physics learning[6].

To assess the readability of the E-Module that has been made, the author conducted a rumpang test. According to Hajasujana (1997) in [20] The student is asked to understand and complete incomplete sentences (because there are certain parts of the sentences in the module that have been deliberately omitted) to measure comprehension in its entirety. The results of the rump test can be seen in Table 6.

Table 6. Results of the E-Module Cluster Test

Sub Material	Readability Percentage
1	100%
2	96%
3	98%
4	98%
5	96%
6	96%
7	90%
Average	96.2%

From Table 6, the average percentage of the results of the rumpang test in 7 sub-subjects was 96.2%. Based on the scoring system of Ranki da Culhame in[14], it can be concluded that the E-Module has a high level of readability and is included in the independent category. This indicates that the E-Module is easy to understand and can be used independently by each student.

The Augemented Reality rocky e-module on alternative energy materials was created to facilitate students in terms of visuals that are made interesting and provide a new experience in learning physics. The use of this E-Module utilizes Google Sites services that are tailored to the habits of the alpha generation who tend to carry out activities connected to various digital devices. This E-Module can also be accessed anywhere and anytime. It's just that a strong internet connection is needed to be able to access the E-Module quickly and smoothly.

4. Conclusion

The final result of this study is a product in the form of an E-Module assisted by Augmented Reality on alternative energy materials made to train students' visual literacy. This E-Module has passed the feasibility test of 3 physics lecturers and 2 physics teachers with a final result of 91% in the category of very feasible to be used in the next stage, namely Implementation. And a rumpang test has been carried out to measure readability with the final result at a high readability level and in the independent category. So that this E-Module can be used by students independently. This E-Module is designed to facilitate students through interesting visualizations and provide a new physics learning experience. By utilizing Google Sites services, this E-Module is connected to various digital devices so that it can be accessed anytime and anywhere.

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