A Review of Research on The Use of Augmented Reality in Physics Learning

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Abstract. The aim of this study is to reveal augmented reality on the effect of models in learning physics. This article is a qualitative synthesis of quantitative and qualitative research that investigates the design of learning with augmented reality which is applied in physics learning and its impact on learning. Articles published between 2015 and 2021 were reviewed, and 30 articles were included for detailed analysis and synthesis. The results of the study indicate that integrating augmented reality with teaching materials and learning models is capable to support the process and student learning outcomes. It was also found that problem-based augmented reality made learning more meaningful. Studies related to AR that measure students' critical thinking skills are still minimal. Future research is urgently needed to look in detail at the effect of problem-based augmented reality media on students' critical thinking skills.

1. Introduction
Physic is a part of science that is very influential in the development of technology and natural sciences. One of the lessons that are difficult to reach by most high school students is physics learning [1]. Students with visual thinking have difficulty understanding and mastering the material because they cannot understand and study a phenomenon without visualizing it [2]. Therefore, learning strategies include learning media used by educators to deliver material that greatly influences the process of forming students' concepts [3].

The development of IT technology opens up opportunities for the development of learning media tools that are an attraction and understanding that can be more accepted by students [4]. Digital skills are the main capital for students in facing the progress of all aspects of life, including learning now on digitalization [5]. Digital learning can encourage the formation of other skills for students, therefore a suitable digital media is needed [6]. Augmented reality is one of the media that creates a digital learning environment [6]. Augmented reality (AR) is a digital technology that provides content in the form of virtual images generated by a computer or mobile device to be spread out in the real world in real time. The generated content can be in the form of three-dimensional (3D) models, videos, images, sound and text [7]. Currently, AR is popularly used in the learning process.

In this case, research related to AR in several learning topics has been carried out including those related to human anatomy, language learning, history, chemistry, and mathematics [8]–[12]. Research related to AR in physics learning has also been carried out, this research was made as a form of information through a literature study on the implementation of AR in physics learning [13]–[16]. The main purpose of this study is to reveal augmented reality on the influence model in learning physics.

This study presents a list of literature with the type of AR used, the integrated learning model, the chosen physics concept, and the results of the use of AR on students in physics learning. The formulation of the problem that can be made from this study are:
a. What is the role of AR on the model and its influence in learning physics?
b. How is AR presented in learning?
c. On what physics topic is AR integrated?

2. Method

The type of research used is literature study, by collecting data and information from various related scientific sources [17]. The data collection technique that will be used is secondary data. The secondary data sources used in this study are a number of journals with international publications that can be accounted for, related to the use of Augmented Reality media in physics learning. This study uses a qualitative approach by generating descriptive data from several journals obtained. The stages of data analysis in qualitative research by Miles and Huberman [18] are as follows:

![Data Analysis Process from Miles and Huberman](image)

The first stage in qualitative data analysis is carried out by reviewing journals to obtain data and information needed in research. Second, data reduction is by summarizing, selecting points, and focusing the discussion so that the data obtained has a clearer picture and makes it easier for researchers. Then perform the presentation of the data, namely by presenting a narrative text in the form of a brief description that displays the relationship between subjects and the like. The last stage in qualitative data analysis is drawing conclusions and verification.

At the stage of data collection and reduction, the PRISMA model was adopted with 4 steps; Identification, screening, eligibility, and included. First, a search was conducted through Google Scholar with the keyword “Augmented Reality in Science Education” in the last 10 years. From the 86 articles obtained, then the articles were re-selected based on the subject of "physics", after which they were re-screened by category: research articles and international publications. Figure 2 shows the process of selecting articles in stages by following the PRISMA model [19].
3. Results

Augmented Reality (AR) is one of the emerging technologies in various fields of education such as mathematics and science, because it can be an efficient technological tool to improve learning techniques [20] and increase student activity by bringing them to new learning environments [21]. AR is derived from two words, namely "augmented" which means addition and "reality" which means reality, or if combined it is "addition of reality" (Language Development and Development Agency, 2019). The addition of this reality refers to technology that enhances the sense of reality or "sense of reality" that allows the emergence of digital information in the form of objects in the form of 2D, 3D, animation, or simulation that can be accompanied by sound into the real environment [16]. A study review was conducted to find the relationship between physics learning activities carried out with AR and the results obtained as shown in Table 1.

Table 1. Learning activity and result of AR implementation

| No. | Article | Learning activity    | Result                                                                 |
|-----|---------|----------------------|------------------------------------------------------------------------|
| 1   | [22]    | Discovery learning   | AR with discovery learning creates motivation, confidence and improves learning outcomes because of a good learning environment. |
| 2   | [23]    | Case-based learning  | The use of AR integrated worksheets can train and improve critical thinking skills. |
| 3   | [24]    | Problem based learning | The use of the PBL learning model with AR media can improve learning outcomes, learning motivation, and student attitudes during learning. |
| 4   | [25]    | Traditional lectures | The use of AR increases the desire to learn and has an impact on students' positive attitudes during the learning process. |
| 5   | [26]    | Collaborative Inquiry Learning | AR simulation supports collaborative inquiry learning more than 2D simulation |
Based on table 1, it is found that learning activities with the Discovery Learning model can create motivation, self-confidence and learning outcomes because of the formation of a good learning environment. The same results were obtained when AR was implemented with a Problem Based Learning model, even AR had an impact on changing student attitudes towards a better direction in learning. The same principle is that problem-based learning can train students’ critical thinking skills by integrating worksheets and AR. Critical thinking skills can also be improved by integrating AR in laboratory activities. As for other results, it can be seen that the use of AR with traditional learning only has an impact on the desire to learn and positive attitudes of students. While the use of the model can measure more variables. The type of AR that is developed will certainly affect the research variables you want to measure. Table 2 shows the materials and types of AR and AR-based that have been developed in physics learning development research over the last 10 years with the research category having international publications.

Table 2. Topic, kind of AR and AR-based in physics development

| No. | Article | Topic          | Kind of AR                  | AR-based         |
|-----|---------|----------------|-----------------------------|------------------|
| 1   | [27]    | Optical Devices| 3D object                  | Image-based      |
| 2   | [28]    | Light and Optic| 3D object and video        | Image-based      |
| 3   | [25]    | Convex Lens    | 3D object                  | Image-based      |
| 4   | [29]    | Mechanics      | Simulation                 | Image-based      |
| 5   | [24]    | Force and motion| 3D object, simulation Object, | Image-based      |
| 6   | [30]    | Mechanics      | Simulation                 | Image-based      |
| 7   | [23]    | Physics harmonic| 3D animation and videos   | Image-based      |
| 8   | [26]    | Elastic collision| Simulation                | Image-based      |
| 9   | [24]    | Fluids         | 3D object and simulation    | Image-based      |
| 10  | [31]    | Heat transfer   | 3D animation               | Natural interaction |
| 11  | [32]    | Electromagnetism| 3D animation               | Image-based      |
| 12  | [33]    | Electromagnetism| 3D Object                 | Image-based      |
| 13  | [22]    | Electricity    | Simulation                 | Image-based      |
| 14  | [34]    | Magnetic Field | 3D Object                  | Natural interaction |
| 15  | [35]    | Model atom     | 3D Object                  | Image-based      |
| 16  | [36]    | Electricity    | Videos                     | Image-based      |
| 17  | [37]    | Double Slit    | Simulation                 | Image-based      |
| 18  | [2]     | Magnetic Field | Simulation                 | Image-based      |
| 19  | [38]    | Free fall      | Simulation                 | Real time        |
| 20  | [39]    | Electromagnetism| Simulation                | Image-based      |
Figure 3. Trends of research topic in physics

Table 2 shows that there are 4 studies on the topic "Optics", 6 studies on the topic "Mechanics", 1 study on the topic "Fluids", 1 study on the topic "Temperature and Heat", 1 study on "Atoms", and 6 studies on the topic "Electricity and Magnetism", and 1 study on "Motion". Simple Harmonics". Based on the data, it can be concluded that there is no research on the topic "Kinetic Gas Theory (KGT)", while the KGT topic is considered to contain abstract material and is difficult to understand. As research which states that from 0-4 levels of understanding, students who have partial understanding at the third level are 19%, and students who have partial understanding at the second level are 81% with clear misconceptions [40]. So it is necessary to develop AR media for the topic of KGT as a recommendation from this research. The types of AR used vary, consisting of 3D objects, simulations, videos, animations. The process of displaying AR tends to use image-based.

4. Conclusion
Based on the results of the study review, several conclusions were obtained in response to the formulation of the problem proposed, including:

1. Augmented reality can be used as a support for learning carried out with certain models. Augmented reality can increase student motivation, student involvement in learning, student learning outcomes, and critical thinking skills. AR applied with certain learning models has a more significant impact than AR without learning models.
2. Augmented reality in learning is presented in the form of 3D objects, simulations, videos and animations. AR appearance can be image-oriented, direct or real-time interaction.
3. Physics topics that have been developed in integrating AR include: optics, mechanics, fluids, temperature and heat, atoms, electricity and magnetism, and simple harmonic motion.

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