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Science E-Module Based on Augmented Reality (AR) to Improve Students' Critical Thinking Skills: Systematic Literature Review

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ABSTRACT

The development of technology in the field of education has presented innovations that can support a more interactive and effective learning process. Augmented reality (AR) is one of the technologies that visualizes something and can be applied to the world of education. This study aims to systematically review the literature that discusses the development of E-science modules based on Augmented Reality (AR) in an effort to improve students' critical thinking skills. The method used is a literature review. By searching for references of at least 5 articles in journals that are analyzed inclusively and exclusively so that they are referenced according to the objectives to be achieved. The literature search was carried out through electronic databases assisted by Harzing's Publish or Perrish which includes Google Scholar, Eric, Crossef and ScienceDirect using keywords such as "Augmented Reality", "E-science modules", "critical thinking skills", and "education". Studies published between 2020 and 2024 are the main focus of this study. From the results of the data collection, 1050 articles were filtered and re-selected to produce 7 articles which were the results of selection according to more in-depth inclusion and exclusion criteria including title, abstract and discussion content. Thus it can be concluded that the AR-based Science E-module has great potential to be applied in learning to improve students' critical thinking skills. This study recommends further development and testing in the context of science education.

Keywords: *Augmented Reality, E-module IPA, critical thinking skills, systematic literature review*

1. Introduction

In the 21st century, teachers need to improve students' scientific knowledge because these skills are important for solving problems through collaborative scientific thinking. Researchers need scientific competence to identify and apply the knowledge they have gained during their research [1]. Science has many benefits, including improving students' thinking patterns for the better, improving personality and behavior, and instilling a sense of responsibility.

Education is an important aspect for students to achieve high progress and prosperity [2]. Education serves as a future investment that ensures an increase in the quality of life. The quality of education reflects the quality of human resources (HR), which is the main investment for the future. The development of information and communication technology (ICT) is very rapid in various fields of life. The field of education is also not free from the development of information and communication technology (ICT). According to Nur Ani and Istiqomah, one of the uses of information and communication technology in the field of education is the use of multimedia as a supporting tool for the learning process [3]

Education and technology are closely related. Education drives the birth of technology, while technology plays a role in advancing education [4]. The industrial revolution 4.0 demands equalization of technology in various fields. In line with the development of the times, technology has also spread to various sectors, including education [5]. In the educational aspect, the learning system implemented by teachers that does not make sufficient use of learning media causes students to easily feel bored and less interested in paying attention to lessons, especially science lessons [6]. In science learning, teachers generally develop two- and three-dimensional media. With the advancement of technology, science learning media now also include digital development. Learning media plays an important role in supporting the learning process, from elementary to college level. Teachers can choose or create media that are appropriate to the material, student conditions, and school situations. Examples of media that are often used in science learning include virtual laboratories, Schoology, augmented reality, e-portfolios, animations, page flips, Edmodo, Edumedia, Appy Pie, digital microscopes, PowerPoint, picture cards, Flash, scrapbooks, and comics.

One of the most popular technological innovations today is augmented reality (AR). AR is a technology that enriches the real world with computer-generated digital content, such as text, images, and videos. This technology has three main characteristics, namely the combination of real and virtual elements, direct user interaction, and object registration in 3D space. AR provides new experiences and freedom to users by allowing 3D virtual objects to move and be seen from various angles, just like real objects [7].

Augmented reality (AR) technology is used in various fields, including education. The use of AR in learning aims to convey material or information through visual animation. This technology has advantages and disadvantages in its application in the learning process. According to Ilmawan Mustaqim, some of the advantages of AR are: 1) More interactive; 2) Efficient in its use; 3) Can be applied to various types of media; 4) Facilitates modeling of simple objects by displaying several elements, 5) Relatively low manufacturing costs; 6) Easy to use [8].

Based on the description above, the researcher will conduct a literature study to determine the use of digital learning media in the form of e-module science based on augmented reality to improve students' critical thinking skills. This research was conducted by reviewing reference articles in previous articles that have been published on Google Scholar, Publish Or Perish, and Eric.

2. Methods

This study is a systematic review using the Preferred Reporting Items for Systematic Reviews and Meta-analyses method, commonly called PRISMA. The articles used in this literature review are articles obtained using electronic data-based applications assisted by Harzing's Publish or Perrish, which include Google Scholar, Eric, Crossef, and ScienceDirect using keywords such as "augmented reality," "e-science module," "critical thinking skills," and "education." The articles were then sorted according to the research topic so that 7 research articles were collected, which were considered to be representative of all research articles on the development of augmented reality (AR)-based science e-modules to improve students' critical thinking skills in junior high schools. The articles used were 7 articles published in the last 5 years. In selecting articles used in writing literature, inclusion and exclusion criteria are needed to select the main research. The results of the data search with these criteria will later be used by the author to conduct an article review [9]. The inclusion and exclusion criteria for this literature are shown in Table 1 below:

Table 1: Inclusion and exclusion criteria

Inclusion Criteria	Research articles published in 2020 – 2024, Research Topics on Development, E-Modules, Augmented Reality (AR), Critical Thinking Skills Literature from proceedings, Articles/Journals, theses, and scientific papers
Exclusion Criteria	Research articles that cannot be accessed in full Not in the field of Education

After determining the criteria, the next step is to select articles to be compiled in the literature review. This article selection process can be illustrated through diagram 1:

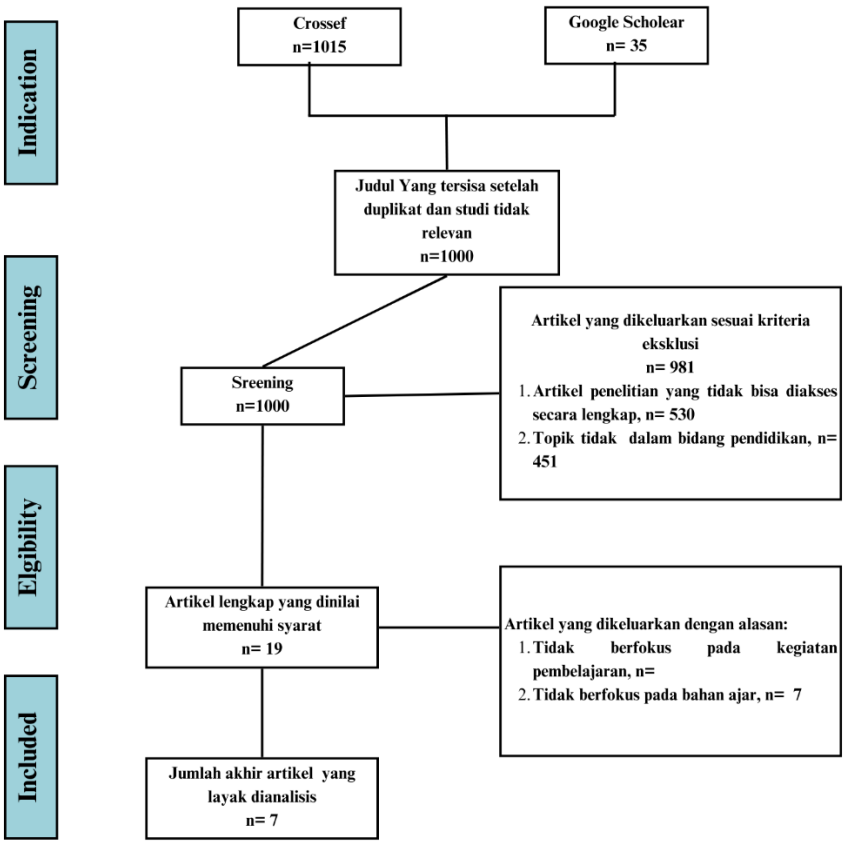

Figure 1: PRISMA diagram

The data analysis method applied is a narrative approach, which aims to provide a description of student learning outcomes based on science process skills by applying a problem-based learning model [10]. Based on the search results, 1050 articles were obtained that were considered in accordance with the research theme raised, then combined and screened to see whether the studies in the articles were the same or not. After screening, 19 articles were obtained that were in accordance with the study to be conducted by the author. From the 19 articles, the screening results will be re-selected based on eligibility according to the inclusion and exclusion criteria, and 7 articles will be obtained, which will then be reviewed.

3. Results and Discussion

Augmented reality (AR) is a 3D-based technology that combines real and virtual world elements simultaneously and can be displayed through the camera on an Android device [11]. AR technology can be used on mobile phones with the Android operating system because this platform supports teaching strategies implemented by teachers in the learning process in today's digital era [12].

Augmented reality (AR) can be used to visualize abstract concepts and understand the structure of an object model. Through AR media, students can develop intellectual skills in building and understanding the meaning of the visuals displayed, which is part of the critical thinking process [13].

From 7 articles reviewed using the SLR research method, data extraction was then carried out by analyzing data based on the author's name, title, and results, which are important data in the article. The results of the data extraction can be seen in Table 2.

Table 2: Relevant Articles

No	Authors	Year	Title	Research result
1	Alfina Salsabila, Pramudya Dwi Aristya Putra, Zainur Rasyid Ridlo	2024	DEVELOPMENT OF INTERACTIVE TEACHING MODULES USING AUGMENTED REALITY IN SCIENCE LEARNING IN JUNIOR HIGH SCHOOL TO IMPROVE CRITICAL THINKING SKILLS	The results of this study state that the interactive learning module assisted by augmented reality to improve critical thinking skills of grade VIII students is included in the very valid category with a percentage of 90%, broken down very practically with a percentage of 93%, broken down very practically with a percentage of 90%, and broken down moderately in the effectiveness test using an N-gain value of 0.68. Based on this, the interactive learning module assisted by augmented reality that was developed is very feasible and practical to use in learning activities.
2	Ahmad Ariadi, Ahmad Suriansyah, Ratna Purwanti	2023	IMPLEMENTATION OF EXCELLENT LEARNING MODEL AND AUGMENTED REALITY MEDIA TO IMPROVE STUDENTS' CRITICAL THINKING SKILLS	The problem in this study is the low learning activity and high-level thinking skills of students in learning. The cause is because learning is not centered on students and has not encouraged the development of high-level thinking skills. This will have an impact on low student learning outcomes and problem-solving abilities. Efforts to overcome these problems are by implementing the Excellent model and augmented reality media.
3	Aprilia Lulita Nadya Hidayat, Nur Ahmad, Zainur Rasyid Ridlo, Pramudya Dwi Aristya Putra, Firdha Yusmar	2024	Developing an Augmented Reality-Based Textbook on Heat and Transfer Materials to Improve Students Critical Thinking Skills	Based on the results, augmented reality-based textbooks are very valid, practical, and effective in showing an increase in the critical thinking skills of junior high school students, with the observed increase falling into the high category, specifically by 0.71.
4	Dini Ashari	2023	ANALYSIS OF THE UTILIZATION OF AUGMENTED REALITY (AR) LEARNING MEDIA TO IMPROVE CRITICAL THINKING SKILLS	The results of the study show that learning media based on augmented reality will give students a lot of practice in the process of thinking, understanding, and analyzing existing problems. In addition, the use of augmented reality as a learning medium can have an influence and be able to improve thinking skills in students.
5	Ratna Azizah Mashami, Khaeruman Khaeruman, Ahmadi Ahmadi	2021	Development of Integrated Contextual Learning Modules Augmented Reality to Improve Students' Critical Thinking Skills	The results of this study include: 1) the module is declared very feasible with an average score of 90%; 2) the module can improve students' critical thinking skills as indicated by a significant value of 0.00 at a 95% confidence level and an average N-gain score of 58%

				(moderate); and 3) students gave very good responses to the learning process using the module. Thus, the Augmented Reality integrated contextual learning module has been successfully developed.
6	Rizka Oktaviyanti, Ulum Fatmahanik, Wirawan Fadly	2023	Development of STEM-Based Teaching Materials by Utilizing Augmented Reality to Improve Critical Thinking Skills	The teaching materials are very good at providing students' interest in learning, and the materials and language are easy to understand. The teaching materials are also effective in improving students' critical thinking skills in vibration, wave, and sound materials with an N-gain score of 60.34 or a moderate improvement category.
7	Tiya Ayu Retnaningtiyas, Nadi Suprapto, Hainur Rasid Achmadi	2021	Literature Study on the Utilization of Augmented Reality Media to Improve Students' Critical Thinking Skills	research related to the use of augmented reality media that has been conducted with the aim of describing and interpreting relevant information related to the use of augmented reality media to improve critical thinking skills in students. From the results of the literature study, it can be concluded that the use of augmented reality media is effective in improving students' critical thinking skills.

According to data from selected articles, students today are more enthusiastic about learning that is related to real life and involves modern technology. The combination of real and virtual elements is possible with the use of appropriate display technology, while interactivity is achieved through special input devices, and optimal integration requires an accurate tracking system [14]. The development of augmented reality (AR)-based media can effectively train critical thinking skills, including cognitive skills such as interpretation, analysis, and explanation [15]. In addition, the application of AR technology can increase learning motivation and expand material opportunities, thus facilitating the formation of concepts [16]. As an interactive learning medium, AR can help students learn more easily and make learning more meaningful.

The use of augmented reality (AR) as a learning medium can encourage critical thinking patterns towards problems and events in everyday life. Through this medium, it is expected that students can analyze problems and show creativity and activeness in the learning process. AR can be applied in various forms, such as student worksheets (LKS), educational games, e-modules, applications, or as a tool in practicums. However, each learning medium has advantages and disadvantages. According to Siahaan et al., the advantages of AR include: 1) making learning media more interactive; 2) displaying virtual objects realistically; 3) can be applied to various types of media; and 4) is easy to use. On the other hand, the disadvantages of AR as a learning medium include: 1) sensitivity to changes in perspective; 2) still limited benefits in some learning contexts; and 3) requiring time in the development process [17].

4. Conclusion

Based on the results and discussion, it can be concluded that by utilizing current technological developments in the learning process, such as the development of E-Module Science learning media based on augmented reality, students will practice a lot about the thinking process and understanding and analyzing existing problems. In addition, the use of Augmented Reality as a learning medium can have an influence and be able to improve critical thinking skills in students. AR-based E-module Science has great potential to be applied in learning to improve students' critical thinking skills.

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