JPPIPA 10(Special Issue) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Augmented Reality for Science Learning in the 21st Century: Systematic Literature Review

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Received: April 21, 2024
Revised: June 13, 2024
Accepted: August 25, 2024
Published: August 31, 2024

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DOI: 10.29303/jppipa.v10iSpecialIssue.8099

Abstrak: The Era of Revolution 4.0 is marked by the internet and digital technology development. Era of Revolution 4.0 is believed to affect changes in science learning which can train thinking skills of the 21st century. 21st Century Learning emphasizes learning for students on internal skills using Media, Information, and Technology; Thinking, and innovation skills. Augmented Reality is a technological innovation that is currently developing and is being used in science learning by several researchers to train 21st-century skills. The research aims to examine Augmented Reality for Science Learning in abd 21: Systematic Literature Review. The review was conducted based on state-of-the-art methods using the preferred reporting items for reviews and meta-analyses (PRISMA) guidelines. The results of this research explain the focus of 21st Century learning; Augmented Reality has several advantages, Utilization of Augmented Reality for 21st Century science learning. The results of this research explain that the focus of 21st Century learning is: Competency for Critical Thinking, Innovation and Creativity, Communication, and Cooperation; Augmented Reality has several advantages and disadvantages: advantages; Is more involved, Easy to use, Can be used in general in various sources, Describe simple objects, Production that doesn't consume too many lots of expenses, Simple to use; disadvantages: sensitive to changes in perspective, There are few makers, Requires a lot of memory to Utilization of Augmented Reality: Competency for Critical Thinking, Ability to think Abstractly, Ability to Think Creatively.

Keywords: Augmented reality; Science learning; 21st Century

Introduction

The Era of Revolution 4.0 is marked by the development of the internet and digital technology which makes everything exist without limits (Mukri et al., 2019; Javaid et al., 2024; Lee et al., 2018). The Era of Revolution 4.0 which is expected to occur will bring changes in many fields, including learning English using natural science, causing many problems in the learning process (Hameed & Hashim, 2022; Sima et al., 2020). Current knowledge must describe the four characteristics of modern education, which include critical thinking and problem-solving, creativity and innovation, cooperation and communication education (Van Laar et al., 2020; Almulla, 2023). The twenty-first century demands open knowledge and adapting to modern technological advances (Uzorka et al., 2023; Saleem et al., 2024; Niemi, 2021). One of the technological advances that is very commonly used by many people today in various fields is Augmented Reality (AR), which is a technology that augments the real world with computer-generated material such as text, photos, and videos (Zhao et al., 2023; Mendoza-Ramírez et al., 2023; Kiryakova, 2021).

Grow the real world has three main characteristics: a combination of virtual and real-world elements,

How to Cite:
Prananta, A. W., Biroli, A., & Afifudin, M. (2024). Augmented Reality for Science Learning in the 21st Century: Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, *10*(SpecialIssue), 38–44. https://doi.org/10.29303/jppipa.v10iSpecialIssue.8099

interaction with users in real-time, and being registered in Space 3D (Kleftodimos et al., 2023). Enhanced Reality offers new experiences and freedom to users by allowing them to transmit 3D virtual images and view them from any point of view, just like the real thing. Emerging Reality Technology in the learning process can provide learning experiences and teaching capabilities as well as new knowledge in the twenty-first century (Silva-Díaz et al., 2023; Wen et al., 2023). Explains learning methods by utilizing technological advances. There is time to adapt to the characteristics of learning in the modern era in the reality that education in the twenty-first century is still not implemented completely and adequately in educational institutions, thus encouraging several studies that include technology to improve Truth in Science Learning.

Previous research has been conducted regarding augmented reality Analyzing augmented reality (AR) and virtual reality (VR) recent developments in education (Al-Ansi et al., 2023). However, there has been no research that examines augmented reality for 21st-century science learning: Systematic Literature Review. Based on the literature review above, this research aims to examine Augmented Reality for 21st Century Education: A Systematic Literature Review.

Method

We conducted this study as a systematic review following PRISMA guidelines. The PRISMA guidelines provide several things to consider in preparing a systematic review. In this study, we will focus on several main things: focus on 21st century learning; Augmented Reality has several advantages and disadvantages in utilization of Augmented Reality. This helps form the basis of our assessment.

Initially, we collected the latest studies on Augmented Reality for Science learning in the 21st century: Systematic Literature Review, based on several selected keywords. Then, we apply eligibility criteria to the collection. We selected only literature published in 2015 or later to provide an overview of current trends. In addition, we limit the type of literature to only literature in the form of journals and proceedings.

Result and Discussion

Preferred Reporting Items for Systematic Reviews (PRISMA) was the reporting technique used in this study. The research was conducted methodically during the required research phases. The information provided is comprehensive and unbiased and aims to combine relevant research results. The steps of a systematic literature review include developing research questions, literature searches, screening and selecting relevant articles, screening and selecting the best research results, analysis, synthesis of qualitative results, and preparation of research reports. Writing the background and objectives of the research, collecting research questions, searching the literature, selecting articles, extracting articles, assessing the quality of basic studies, and summarizing the material are steps in the systematic literature review research process.

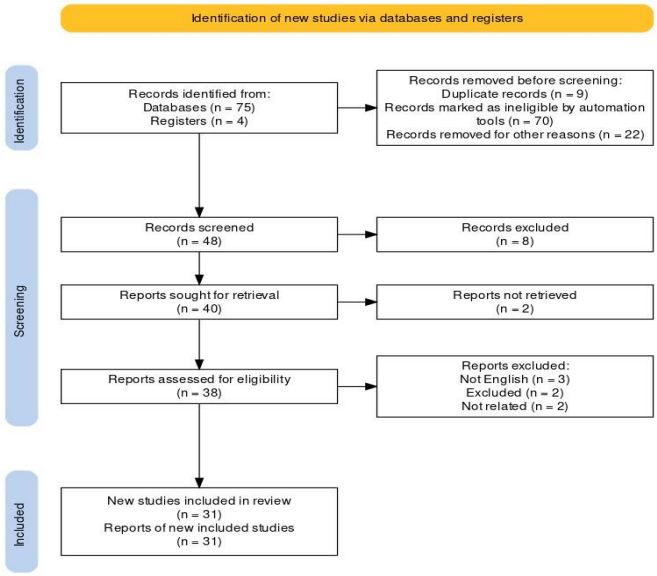

Figure 1. Flow of the literature search process based on PRISMA guidelines

The complete article was published in an international journal 2015-2023, indexed in a database, and has the theme Augmented Reality for 21st century Education: Systematic Literature Review.

Table 1. Focus on 21st Century Skills

Source	Focus on 21st-century skills
(Song & Cai, 2024); (Stehle & Peters-Burton, 2019)	Critical Thinking Competencies
(Wullschleger et al., 2023); (Oyelere et al., 2021); (Salmiyanti et al., 2023a)	Communication and Cooperation
(Refmidawati, 2023); (Dwivedi et al., 2023)	Innovation and Creativity

Education in the 21st century has a paradigm that requires more skills in using critical thinking, finding relationships between theories in the real world, being professional in the field of information technology, communicating, and collaborating. The explanation above is that the current school curriculum is expected to be able to produce graduates who can think critically and collaborate to master technology in the twenty-first

century. Medieval skills are important skills that everyone needs to have to successfully face the problems, challenges, life, and careers of the 21st century. Medieval learning focuses on critical and innovative critical thinking skills, the summary of which includes Problem-Solving with Critical Thinking (Critical research and problem-solving), Communication and Cooperation (Communication and cooperation), creativity, and innovation expression and innovation.

Critical Thinking Competencies

The ability to think critically is a very important skill for someone to be able to overcome various problems in social and personal life. Critical thinking is independence in making decisions that allow for interpretation, analysis, evaluation, and presentation of inferences based on evidence, ideas, methods, standards, or contextual considerations that created the choice. Critical thinking skills can be developed in students with the help of the educational process at school. Critical thinking is very important in learning because, through adequate critical thinking skills, students will not only be able to understand the material from all the material they study but will also have the ability to apply it deeply in everyday life. Critical thinking skills are important for students in science learning, which is very important for connecting and understanding elements in natural and abstract science as a need for interpretation, analysis, and logical evaluation of high-achieving students. Critical thinking competence includes the ability to analyze, synthesize interpret, evaluate, and draw conclusions for students in the modern era.

Communication and Collaboration

The second skill needed in the 21st century is communication and cooperation. Communication skills include the ability to convey ideas clearly and persuasively both orally and in writing, the ability to express opinions, convey opinions in clear sentences and provide instructions that motivate other people with their speaking skills. Collaboration and teamwork can be built based on previous experiences inside and outside school.

Innovation and Creativity

The final skills needed in the twenty-first century, namely innovation and creativity. Construction is one creative example. multidimensional with personality, cognitive, family, education, as well as culture and society variables: Student creativity when learning can be detected through students' innovative thinking abilities. Innovative thinking ability is the ability to think outside conventional thinking patterns, creative individuals can free up existing patterns stored in the human brain. Innovative thinking is the ability to achieve and obtain a large number of possible problem-solving situations that prioritize creative thinking which can be seen through How many responses do you receive? increasingly innovative problems nature (science) is one of the topics for studying natural events that occur in the environment. The ideal science learning method is a procedure that guides students in purchasing goods and procedures which are skills that students can indirectly develop. creatively, this intelligence will be needed by students to support their success at that time.

Table 2. Augmented Reality has Several Advantages and Disadvantages

Source	Augmented Reality has several advantages and disadvantages
(Doukianou et al., 2021a); (Agius & Daylamani-Zad, 2021); (Zhang & Ma, 2023); (Darmawan et al., 2024); (Afandi et al., 2019); (Rifqi Mahmud et al., 2024); (Doukianou et al., 2021b)	Advantages of Augmented Reality
(Plewan et al., 2021); (G. El Asmar et al., 2021); (Akçayır & Akçayır, 2017); (Kolaei et al., 2022); (Manisha & Gargrish, 2023); (Barroso Osuna et al., 2019); (Dewi & Kuswanto, 2023); (Santos et al., 2016)	Disadvantages of Augmented Reality

Augmented Reality is the addition or combination of 3D virtual objects on a device screen with real objects that can interact effectively in real-time, and are created using a computer. Augmented Reality aims to produce technology that provides knowledge about seeing virtual objects that may occur in the real world. Information can be displayed via AR technology on certain things on the internet and displayed in real life with tools such as webcams, computers, Android phones, and unique lenses. According to the review, Augmented Reality will help convey information to users through the projection of the latest information (2D or 3-dimensional objects) into the real world. Enhanced Reality technology is used in various industries only in the educational process.

Augmented Reality learning means conveying information or material in the form of animated displays. Augmented Reality has several advantages as follows: More involved, easy to use, can be used generally and across various sources, depicts simple objects, is cheap to run, and is easy to use. However, the weaknesses according to Scientist, include the following:

sensitivity to changes in viewing angle, a little creative, requires a lot of memory for the equipment placed. Nowadays teachers adapt to advances in modern technology.

Table 3. Utilization of Augmented Reality for 21st-Century Science Learning

Source	Utilization of Augmented Reality for 21st-Century Science Learning
(Garzón, 2021); (Onu et al., 2024); (Dhar et al., 2021)	Competency for Critical Thinking
(Krüger et al., 2022); (Bentwich & Gilbey, 2017); (Yona et al., 2023); (Salmiyanti et al., 2023b)	Ability to think Abstractly
(Koumpouros, 2024); (Garlinska et al., 2023); (Hilken et al., 2022); (Xiong et al., 2021)	Ability to Think Creatively

Educational media requires activity learning according to features of 21st-century learning for instruction 21st-century capabilities:

Competency in Critical Thinking

The wide world as media learning that uses visual technology consists of photos from the included events with image displays from two dimensions to three dimensions. Augmented Reality technology can bring the virtual world back to the real world due to the use of AR technology in Science learning will guide students. to gain an understanding of physics independently. Activity Students are motivated to cover the whole theory of physics shown on the worksheet so teaches students critical thinking skills Augmented reality trains the ability to think critically due to the required student abilities to visualize and understand images concerning literacy skills. Ability to read through visuals and create meaningful images. The visual language uses similar abilities to the box tools and ways of thinking to improve the ability of mentally. This indirectly shows that the media is a bad reality. can teach critical thinking skills by increasing the visual literacy of the participants' students Augmented Reality Media has images that serve as a visual means for there's a whole thing with visual literacy.

Ability to Think Abstractly

Using Augmented Reality to improve one's visual literacy skills. Visual literacy is the ability Refers to capacity to understand, relate, and interpret the information provided in graphic or visual. Thus, it increases Additionally, reality can be used to teach Creating the ability to think critically can also used to improve skills and think abstractly. Critical thinking skills Skills for writing abstracts describe a case, event, or thing that does not occur in places where students can make predictions, come to conclusions, and solve the problem without facing the situation immediately, real situation. Augmented Reality has capabilities used to improve skills Use abstract thinking to understand information disseminated by the media Students need complex realities students' ability to think creatively with objects that are not facing directly directors. Students' abilities think about something that is not facing the need directly

Ability to Think Creatively

Augmented Reality has capabilities used to improve skills and creativity. Enhanced Reality is one technology that is being used in the field of modern education is technology. interactive that lets us directly interact with objects virtual in real life. Technology application to learn with combined AR in academic activities, which will impact skills to think innovatively. The ability to think innovatively is something that can be learned and continues to grow. AR in learning will assist teachers in creating interactions with students because the media used by instructors as experience recently accepted by fellow students. Voice difficult, interesting, and class students' freedom to participate in activities and communicate both with teachers and with other students. Interaction while learning a well-made one will help in skill development and innovative efforts from participants.

Conclusion

Augmented Reality has benefits as an interactive learning medium, direct and real for students to invite imaginative students. Instructional Media Augmented Reality can improve students' interest in learning. Instructional Media Augmented Reality in Training Skills 21st-century thinking depends on activity and ongoing learning. Research Device development learning in science subjects must be able to adapt to developments Current technology is one of them Augmented Reality. Augmented Utilization reality in science learning is necessary to develop based on the model learning that can train students to have 21st-century skills.

Acknowledgments

Thanks to all parties who have supported the implementation of this research. I hope this research can be useful.

Author Contributions

Conceptualization, A. W. P.; methodology, M. A.; validation, A. B.; formal analysis, A. W. P.; investigation, M. A.; resources,

A, B. and. A. W. P.; data curation, M. A.: writing—original draft preparation., A. B.; writing—review and editing, A. W. P; visualization, M. A. All authors have read and agreed to the published version of the manuscript.

Funding
This research was independently funded by researchers.

Conflicts of Interest
The authors declare no conflict of interest.

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