

Augmented Reality for Interactive, Innovative and Fun Science Learning: Systematic Literature Review

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Abstract: The development of the learning process by utilizing current technological developments needs to adapt to the character of 21st-century learning. The fact that 21st-century learning is still not implemented optimally and well enough in schools has encouraged several studies that integrate Augmented Reality technology into science learning. AR Learning Media can visualize science learning concepts for understanding and structure of an object model, making AR a more effective, innovative, and fun media. Where the research objective is to examine Augmented Reality for Interactive, Innovative, and Fun Science Learning: 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 that there are 3 types of Augmented Reality Methods, namely image recognition, Markerless Augmented Reality, Projection Augmented Reality, and Superimposition Augmented Reality; There are 4 things to use Augmented Reality, namely the use of augmented reality (AR) as a learning medium, the use of augmented reality (AR) to train skills, Abstract Thinking Skills, Creative Thinking Skills, Interactive, Innovative and fun. Some fields use AR, namely: entertainment, military training, robotics and telerobotics, consumer design, and medicine.

Keywords: Augmented reality; Education; Science learning

Introduction

Learning media results in communication between educators and students in the learning process. If the learning process does not use media then the learning process will not occur. This is because communication between educators and students is not optimal. Media becomes an intermediary for creating communication, tasked with making it easier for educators and students to communicate so that a teaching and learning process will occur which results in students understanding what the teacher is giving. If the teaching material has been delivered, the student's learning results become feedback for the educator. This feedback is used as material for consideration in the next learning process.

Learning media is a key point in which teachers and students can communicate with each other optimally because learning media is a tool, distribution tool, reinforcement tool, and teacher representative in conveying information carefully, clearly, and interestingly.

Thus, the position of learning media is a very important means of connecting one side and another because it contains information and messages from educators to students. According to Marpanaji et al. (2018), the main function of educational media is as a learning resource. Educational media can replace the function of educators as learning resources because learning resources consist of messages, people, materials, tools, techniques, and environments that

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influence student learning outcomes. According to Abbas et al. (2019), Learning media has a function as a messenger from educators to students in the learning process. Media is the key to creating interaction in the learning process (Fitri & Erita, 2023; Menrisal, 2022). Educators use it as a step to help students receive messages from learning media.

The use of educational media using Augmented Reality can stimulate students' thinking patterns to be interactive, interactive, innovative and fun in thinking critically about problems and events that occur in everyday life because the nature of educational media is to help students in the learning process whether they are present or not. There are educators in the educational process, so the use of educational media with augmented reality can directly provide learning wherever and whenever students want to carry out the learning process. Science is a science that studies nature and events that occur in nature through a group of scientific processes that include the essence of science, namely as a way of thinking, as a way of inquiry, as building knowledge, as well as the relationship between technology and society. In science learning, Augmented Reality technology is needed, which is Interactive, Innovative, and Fun.

AR Learning Media can visualize abstract concepts to understand the structure of an object model, making AR a more effective medium under the objectives of learning media. Augmented Reality is a technology that combines two-dimensional or three-dimensional virtual objects and then projects these virtual objects in real-time (Hutahaean et al., 2022). Augmented Reality is defined as technology that combines the real world with the virtual world, is interactive in real-time, and takes the form of three-dimensional animation (Silva et al., 2023). Developing the learning process by utilizing current technological developments needs to adapt to the character of 21st-century learning. The fact that 21st-century learning is still not implemented optimally and well enough in schools has encouraged several studies that integrate Augmented Reality technology into science learning. Utilization of Augmented Reality as one of the current technologies to train 21st Century Thinking Skills

In this way, AR can create interaction between the real world and the virtual world, all information can be added so that the information is displayed in real-time as if the information were interactive and real. The AR concept itself was first introduced by Thomas P. Caudell in 1990 in The Term 'Augmented Reality'. Three characteristics indicate a technology applies the AR concept (Mendoza-Ramírez et al., 2023; Alkhabra et al., 2023); Able to combine the real world and the virtual world; Able to provide information interactively and in real-time; Capable of displaying in three dimensions. AR

can be used to help visualize abstract concepts for understanding and structure of object models in science learning and others.

Augmented Reality aims to simplify things for users by bringing virtual information into the user's environment (Arena et al., 2022). AR improves user perception and interaction with the real world. Previous research has been conducted on Augmented reality in architecture and construction education: state of the field and opportunities (Hajirasouli & Banihashemi, 2022); Analyzing augmented reality (AR) and virtual reality (VR) recent developments in education (Al-Ansi et al., 2023), but no research examines Augmented Reality for Interactive, Innovative, and Fun Science Learning: Systematic Literature Review. Based on the background above, this research aims to examine Augmented Reality for Interactive, Innovative, and Fun Science Learning: Systematic Literature Review.

Method

We conducted this study as a systematic review following PRISMA guidelines (Page et al., 2021). The PRISMA guidelines provide several things to consider in preparing a systematic review. In this study, we will mainly focus on several key items: Types of AR Methods, Utilization of augmented reality (AR), and Fields where AR technology is applied, This helps form the basis of our assessment. Initially, we collected the latest studies on Augmented Reality for Interactive, Innovative, and Fun Science Learning: A Systematic Literature Review, based on several selected keywords. Then, we apply eligibility criteria to the collection. We selected only literature published in 2017 or later to provide an overview of current trends. Apart from that, we limited 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.

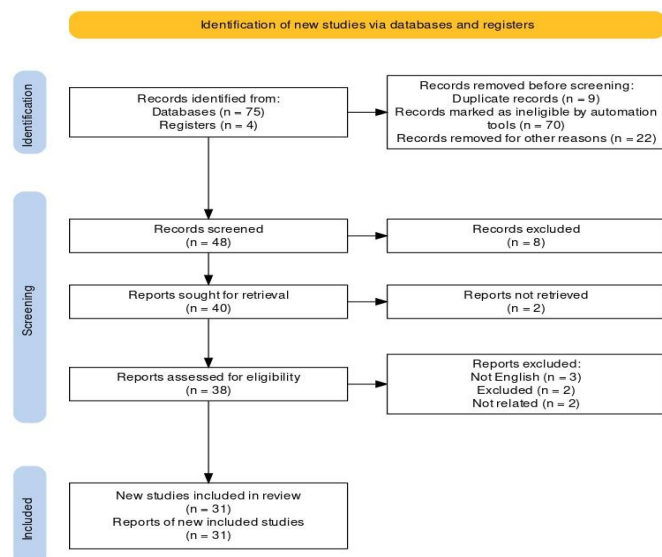


Figure 1. Flow of the literature search process based on PRISMA guidelines

Complete articles published in international journals 2015-2023, indexed in databases, and with the theme Augmented Reality for Interactive, Innovative, and Fun Science Learning: Systematic Literature Review.

Types of AR methods below: Marker-Based Augmented Reality: Some people call it image recognition; Because this type of AR requires special visual objects and a camera to scan them. Visual objects can take any form, from printed QR codes to custom symbols. This AR device also calculates the position and orientation of markers to position content. That way, the marker will display a digital animation that can be seen by the user; Markerless Augmented Reality: This type is what makes Augmented Reality widely used. Markerless AR uses GPS technology, a speed meter, a digital compass, and an accelerometer embedded in the device to provide data based on your location. The markerless augmented reality technology found on your smartphone device has a location detection feature.

Table 1. Types of Augmented Reality Methods

Source	Augmented Reality Method Type
(Devagiri et al., 2022); (Zhang, 2017)	image recognition
(Mulia & Bangun, 2023); (Jumarlis & Mirfan, 2018); (Boediono et al., 2023)	Markerless Augmented Reality
(Xiang et al., 2021); (Chien et al., 2022); (Lee et al., 2015)	Projection Based Augmented Reality
(Yahya & Dahanayake, 2021); (El Filali & Krit, 2018)	Superimposition-Based Augmented Reality

This type is commonly used for direction mapping, and other location-based mobile applications; Projection Augmented Reality: Projection-based Augmented Reality works by projecting artificial light onto a real surface. In some cases it allows users to interact with it. It's like the holograms you see in sci-fi genre films like

Star Wars. AR can detect interactions between users and projections through changes; Superimposition Augmented Reality: Superimposition Augmented Reality can replace the original appearance with an augmented one, either fully or partially. This is where object recognition plays an important role.

Table 2. Use of Augmented Reality

Source	Utilization of Augmented Reality
(Elmunsyah et al., 2019); (Rusli et al., 2023)	Use of augmented reality (AR) as a learning medium
(Anggraini et al., 2020); (Suryanti et al., 2020); (Demircioglu et al., 2023); (Arifuddin et al., 2022)	The use of augmented reality (AR) trains critical thinking skills
(Nandyansah et al., 2020); (Faridi et al., 2021); (Singh & Ahmad, 2024)	Abstract Thinking Skills
(Perifanou et al., 2022); (Dutta et al., 2023); (Valladares Rios et al., 2023); (Haleem et al., 2022); (Efendi et al., 2023); (Yulian et al., 2022)	Creative, Interactive, Innovative and Fun Thinking Skills

Augmented Reality can be used in the learning process because it supports learning to be more interactive, one of which is science learning. Augmented Reality is one of the technologies currently developing, teachers are required to be able to adapt to current technological developments; Augmented Reality is considered to be able to train critical thinking skills because students need the ability to imagine and understand an image which is called visual literacy skills. Visual Literacy is the ability to construct meaning

from images. Visual literacy uses skills as a toolbox and is a form of critical thinking that enhances intellectual abilities.

This indirectly states that augmented reality media can train critical thinking skills by developing students' visual literacy. Augmented Reality media has images that function as visual media so it is related to visual literacy; Augmented Reality is used to train Visual literacy skills. Visual literacy ability is an ability that refers to the ability to interpret, relate, and make sense

of information conveyed in visual or image form. Based on this, Augmented Reality, apart from being able to be used to train critical thinking skills, can also be used to train abstract thinking skills; Abstract thinking skills are skills in defining cases, events, or things that have not yet happened, where students can make predictions, draw appropriate conclusions and solve problems without having to directly deal with real things, conditions or events.

Augmented Reality can be used to train abstract thinking skills because to understand the information conveyed by Augmented Reality media, students need the ability to imagine objects that are not directly encountered. Augmented Reality can be used to train Thinking Skills. Augmented Reality as one of the technologies that is starting to be applied in the education sector is currently an interactive technology

that allows us to interact directly with virtual objects in the real world.

The use of innovative technology in learning by combining Augmented Reality in science learning activities will influence interactive, innovative, and fun creative thinking skills. Interactive, innovative, and fun creative thinking skills are something that can be trained and developed continuously. The use of AR in learning will help teachers build interactions with students because the media used by teachers is a new experience received by students. The class atmosphere is challenging, and fun, and students have the freedom to carry out activities and interact with the teacher and other students. Interactions in learning that have been created well will help the formation of participants' creative thinking skills.

Table 3. Fields that Apply AR Technology

Source	Fields that apply AR technology
(Parekh et al., 2020); (Savela et al., 2020); (Villagran-Vizcarra et al., 2023)	Entertainment
(Soni & Kaur, 2023); (Wang et al., 2020); (Liu et al., 2018); (Boyce et al., 2022); (Ullo et al., 2019); (Harris et al., 2023)	Military Training
(Zhao et al., 2017)	Robotics and Telerobotics
(Zeng et al., 2023)	Consumer Design
(Venkatesan et al., 2021); (Pantelidis et al., 2018)	Medical

Fields that apply AR technology are Entertainment: The world of entertainment needs AR to support the effects that will be produced by the entertainment. For example, when a weather journalist predicts the weather forecast, he stands in front of a green or blue screen, then with AR technology, the green or blue screen turns into an animated image of the weather, so it is as if the journalist enters the animation. Military Training (Military Training): The military has implemented AR in their combat training. For example, the military uses AR to create a war game, where soldiers will enter the game world, and it is as if they were fighting a real war; Engineering Design: An engineering designer needs AR to display their design results in real time to clients.

With AR clients will know, more detailed specifications about their designs; Robotics and Telerobotics: In the field of robotics, a robot operator, uses a visual imaging driver to control the robot. So, the application of AR is needed in the world of robots; Consumer Design: Virtual reality has been used in promoting products. For example, a developer uses virtual brochures to provide complete information in 3D, so that customers can clearly understand the products being offered; Medicine (Medical): Imaging technology is very much needed in the world of medicine, for example, for the introduction of surgery, the introduction of making viral vaccines, etc. For this

reason, the medical field applies AR to visualize their research.

Conclusion

AR has benefits for interactive, innovative, and fun science learning when applied also to science learning. Science is a science that studies nature and events that occur in nature through a group of scientific processes that include the essence of science, namely as a way of thinking, as a way of inquiry, as building knowledge, as well as the relationship between technology and society. In science learning, virtual reality technology is needed. meaningful and fun. By using Augmented Reality (AR) which can combine virtual objects in two dimensions or three dimensions into a real environment and then display or project them in real time. AR is a concept of combining the virtual world with the real world to produce information from data taken from a system on a designated real object so that the boundary between the two becomes increasingly thin.

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Author Contributions

Conceptualization, A. W. P., A. R., R. A., and N. W. P.; methodology, A. W. P.; validation, A. R. and. R. A; formal

analysis, N. W. P.; investigation, A. W. P, and A. R.; resources, R. A. and. A. W. P; data curation, N. W. P.: writing—original draft preparation., R. A. And A. R.; writing—review and editing, N. W. P.: visualization, A. W. P. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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