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AUGMENTED REALITY TECHNOLOGY IN EDUCATION: A LITERARY STUDY ON SCIENCE LEARNING

Kasmudin Mustapa *[1]
Universitas Tadulako, Indonesia
kasmudinfkipuntad@gmail.com

Nanda Aprilia Lampasio
FKIP UNTAD, Indonesia
liaalampasio71@gmail.com

Zaenab
FKIP UNTAD, Indonesia
tunggalazaenab62@gmail.com

Abstract

In the study of literature on the use of Augmented Reality (AR) technology in science learning, some important conclusions were found. The use of AR in science learning can improve student understanding of concepts, student involvement, critical thinking skills, and student information retention. The visual and sensory experiences provided by AR help students visualize complex concept, increase their motivation in learning, and strengthen their understanding of science concepts studied. However, it is important to continue doing further research to understand the impact of AR on student learning performance and how to effectively integrate this technology into student learning experiences. These conclusions may vary depending on the context and characteristics of different students, so the use of AR should be tailored to students' needs and follow the best guidelines.

Keyword: Technology, Augmented Reality, Science Learning.

Introduction

In today's digital age, learning technology over time has changed the world of education (Sitopu et al., 2024). Starting with E-learning, Mobile learning, Gamification-based learning, Learning Analytics and Augmented Reality and Virtual Reality (VR). These technological developments have shifted the traditional learning paradigm towards more interactive, personal, and flexible learning. (Guna et al., 2024). Integrating these technologies into the learning process can enhance student motivation, engagement, and overall understanding. One of the technologies used today is Augmented Reality (AR). (Lee, K. 2012).

Augmented Reality is a technology that blends the real world with virtual objects, creating immersive and interactive experiences. In AR, virtual objects that

[1] Correspondence author.

overlap with the real world can be seen through devices such as smartphones or AR glasses. This technology allows users to see and interact with virtual object that appears to be in the actual world. (Carmigniani et al., 2011).

AR has emerged as an innovative and exciting tool for use in education. AR blends the real world with virtual objects, so that users can see and interact directly with them in their real environment. The application of AR in learning, in science learning, has shown promising potential (Arena et al., 2022)

The use of AR in science learning has benefits; 1) Better visualization: AR allows students to see virtual objects in the real world, so they can visualize abstract and complex science concepts better. For example, students can see molecular models in chemistry or see the interactions of planets in the solar system directly. This helps students understand concepts that are difficult to understand just by text and picture explanations. 2) Interactive experiments and simulations: In learning science, experimental practice and simulation are crucial. AR allows students to conduct interactive experiments and simulations in virtual environments. For example, students can conduct experiments without the risk of fire or explosion in a physical lab room. It gives students the opportunity to observe and understand the concepts of science through practical experience. 3) Practical lessons: AR can also be used to involve students in practical activities. For example, students can use AR devices to identify and observe plants or animals in their environment. This allows students to learn about biodiversity and ecosystems in person. 4) Collaboration and interaction: The use of AR in science learning allows students to collaborate and interact in problem-solving or exploration. Students can share their AR experiences with their friends and work together to a deeper understanding of these science concepts. 5) Experience drives motivation: The use of AR in science learning creates an exciting and challenging learning experience. Students are actively engaged in learning, which can increase their learning motivation. AR also provides an opportunity for students to develop critical skills, such as data analysis and problem solving in a scientific context (Silva et al., 2003; De Pace et al., 2018).

Overall, AR provides an immersive and interactive learning experience in science learning. It enables students to visualize and understand science concepts in a better way, enhance student motivation and involvement, and facilitate collaboration and interaction among students. (Manuri, F., & Sanna, A. 2016).

The use of AR in education has shown many benefits. In the context of science learning, AR can enhance student engagement and interest in learning materials. By visualizing science concepts interactively, AR helps students understand concepts that are abstract and difficult to understand. AR can also enhance student problem-solving skills and creativity by providing practical and real-life experiences (Yuen et al., 2011).

AR has some advantages in science learning. First, AR enables students to interact directly with virtual objects that represent complex science concepts. This

allows students to observe and understand concepts in a deeper way. Second, AR provides a fun and exciting learning experience. Using AR technology, students can explore and experiment in a secure virtual environment, without being constrained by real-world constraints. Third, AR can facilitate collaboration and interaction among students. Using AR in science learning can create opportunities for students to collaborate in solving problems or conduct joint experiments. (Antonioli et al., 2014).

Thus, the use of Augmented Reality (AR) technology in education, especially in science learning, has great potential to improve student learning quality and understanding of concepts. This literature study aims to combine existing research findings to provide a more comprehensive understanding of the usefulness and benefits of AR in science learning.

Research Method

The research method carried out in this research is a literary method. The literary research method, or also known as literary study, is an approach in research involving the collection and analysis of literature relevant to the subject of research undertaken (Champe & Kleist, 2003; Tharenou et al., 2007).

This method allows researchers to search and use other research references from various reliable sources to gain a better understanding of the subject under investigation (Punch, 2013; Adhabi & Anozie, 2017). In literary studies, researchers use several steps; 1) Keyword search: This method involves searching for relevant keywords in catalogues, indexes, or search engines to find literature related to the topic of research. 2) Content analysis: This technique involves identifying, categorizing, and analyzing the content of the related literature to understand the issues that arise in the research. 3) Systematic survey: It involves the process of collection, evaluation, and synthesis of relevant literature for specific research questions. (Zed, 2004; Sugiyono, 2010; Suyanto, 2015).

Result and Discussion

Augmented Reality Technology (AR)

Augmented Reality (AR) technology began a few decades ago. The concept of AR began to form in 1968 when Ivan Sutherland, an engineer, developed a computer system called "The Sword of Damocles," which can be considered one of the earliest forms of AR. However, it was not until the 1990s that the term "Augmented Reality" was used by Tim Caudell, a researcher at Boeing. (Sanderson, J. 1996).

AR technology began to gain further attention and development in the late 20th and early 21st centuries. In 2004, researchers in Germany introduced AR to mobile phones. Since then, AR has undergone rapid development and applied in a variety of fields, including marketing and tourism. (Boyce, M., Degterev, A., & Yuan, J. 2004).

Nowadays, AR technology is evolving, allowing users to put digital elements into the real world and interact with them in real time. AR is becoming more easily accessible through smartphones, smart glasses, and other devices, opening up new opportunities in the gaming, education, health, and design industries. (Wagner et al., 2005).

Augmented Reality (AR) is a technology that combines real-world elements with digital elements, thereby creating an interactive and immersive experience. In AR, digital information such as images, videos, sounds, or 3D objects is displayed in real-time context, via devices such as smartphones, smart glasses, or other devices. (Liao, T. 2019).

The main purpose of AR is to enrich the user's perception of the environment around them by providing additional relevant information, enhanced visualization, or deeper interaction with objects or physical environments. AR can be used in a variety of fields, including gaming, education, medical, design, construction, tourism, and so on. (Aukstakalnis, S. 2016).

AR technology operates using sensors, cameras, and data processing to track user position and orientation as well as recognize objects and their surroundings. Through the use of techniques such as marker-based tracking, motion sensors, or augmented reality markers, AR can combine digital elements with the real world accurately. (Sun et al., 2019).

With the continuous development of technology, AR is becoming more sophisticated and accessible by a variety of devices, thereby offering new potential in creating more immersive and useful experiences for users, including in education.

Use of AR in Education

Education is a process involving the transfer of knowledge, skills, values, and culture from older generations to younger generations. It involves learning and teaching in a variety of contexts such as schools, colleges, and informal environments. (Hairiyanto et al., 2024).

Learning is a mental process carried out by an individual to acquire new knowledge, understanding, skills, attitudes, or values. It can occur in a variety of ways, including reading, listening, discussing, observing, or experiencing directly (Tubagus et al., 2023). Learning is an active process in which an individual is involved in learning. It involves understanding, absorption of information, and the formation of new concepts and skills that can be applied and used in different situations. (Aslan & Shiong, 2023).

Learning can take place at various levels, from preschool to higher education and even outside the formal curriculum. (Muharrom et al., 2023). The learning process can involve teachers, instructors, or mentors who provide information and guidance to individuals to learn. However, learning can also be self-learning, with individuals taking their own initiative to find new knowledge and experience.

Effective learning involves giving relevant stimulus, organizing information in an easy-to-understand format, providing an opportunity to practice and apply knowledge, and providing constructive feedback. A conducive learning environment is also important for creating an effective learning experience, including adequate learning resources, social support, and a positive atmosphere. (Nurhayati et al., 2023).

Lifelong learning is also very important, as education and knowledge evolve rapidly. Individuals need to continue to develop and update their knowledge and skills to keep up with developments in certain areas (Nurdiana et al., 2023).

Finally, it is important to remember that education, learning, and learning are unique processes for each individual. Everyone has a different learning style, different learning speed, and different learning preferences. It is important for educators and learners to understand individual preferences and needs to create effective and meaningful learning experiences.

With the evolution of the times, as educators and teachers are not free from the learning media or technology used. So with that, it's important for teachers to consider learning goals and choose technology wisely (Erwan et al., 2023). Technology is not a substitute for teachers, but a tool that can help improve the learning experience of students. Teachers still play an important role in planning, facilitating, and guiding the learning process. In addition, teachers also need to pay attention to digital access and gaps among students. It is important to ensure that all students have equal access to technology and learning opportunities provided by technology. (Sarmila et al., 2023).

The technology used in the learning process today is Augmented Reality (AR) (Aditama et al., 2019). The use of augmented reality in education has provided great potential in changing the way learning and teaching. Here are some examples of the use of AR in education; 1) Interactive Visualization: AR allows students to see three-dimensional (3D) objects in real environments. For example, students can observe planets in the Solar System or organs in the human body virtually, allowing them to understand concepts more visually and interactively. 2) Simulation and Experimentation: Using AR, students can perform simulations and experiments in a secure and controlled virtual environment. For example, they can conduct virtual chemistry experiments or build building models in an AR environment, digging conceptual understanding in a more practical way. 3) Enhanced Collaboration: AR can also be used to enhance collaboration among students. They can collaborate in AR projects, share ideas, and interact with similar educational content in an AR environment together. 4) Curriculum Enrichment: AR can be used to enrich the curriculum by offering a deeper and more exciting learning experience. For example, combining text with an AR object, learning video, or audio content that animates the learning material. 5) Virtual tourism: In the field of history or geography, AR can be used to take students on virtual tours, help them experience historical places or see

geographical locations directly from within the classroom (Mustaqim, I. 2016; Muhammad et al., 2022).

The use of AR in education can help increase student interest, engagement, and understanding by leveraging exciting and innovative technologies. In addition, AR can also facilitate equal access to educational resources by enabling students to learn through more affordable devices such as smartphones.

AR Excellence in Science Learning

Augmented Reality (AR) is a technology that combines the real world with digital elements to create enriched experiences. In science learning, AR has several advantages that can enhance students' understanding and interest in science materials (Unawan, R.D. 2020). Here are some of the advantages of AR in science learning: 1) Abstract Concept Visualization: AR allows students to describe abstract science concepts in a more visual and realistic way. For example, using AR, students can see three-dimensional models of molecules, planets, or biological processes in their everyday environment. This helps students visualize and understand difficult concepts more concretely. 2) Interactive Learning: AR can provide an interactive and in-depth learning experience. Students can interact directly with virtual objects, perform experimental simulations, or perform manipulations in an AR environment. This helps students actively engage in learning, improving information understanding and retention. 3) Providing Direct Feedback: In science learning, AR can provide direct feedback to students about the results of experiments or simulations they are doing. Students can see the effects of their actions instantly so that they can make adjustments and deepen their understanding. 4) Enhance Collaboration and Communication: AR can facilitate collaboration and communication among students in the context of science learning. For example, students can collaborate in solving problems or conducting science projects using the AR element. They can share experiences and explain science concepts more clearly and persuasively through the AR elements. 5) Learning motivation: The use of AR in science learning can increase student motivation and interest. (Setyawan, B., & Fatirul, A. N. 2019; Vari, Y. 2021; Asikin, N., Nevrita, N., & Alpindo, O. 2019).

AR can be used in a variety of science learning contexts, from traditional classrooms to interactive science museums. However, it is important for teachers to choose and integrate AR applications wisely and in accordance with the desired learning goals.

The learning process of science is an attempt to develop a student's understanding of scientific concepts and principles, as well as to develop scientific thinking skills. In addition, it is also necessary to ensure that the classroom environment supports science learning, such as equipping science laboratories with the necessary

equipment, and using relevant resources such as textbooks and online materials. (Pringgar, R. F., & Sujatmiko, B. 2020).

The impact of AR use on learning motivation

The use of Augmented Reality (AR) in learning contexts can have a significant impact on student learning motivation. Student learning motivation is the student's urge, interest, or desire to learn. High learning motivations are essential in creating an effective learning environment and in achieving optimal learning outcomes. (Khan, T., Johnston, K., & Ophoff, J. 2019).

Factors that can influence student learning motivation, include: 1) Clear Objectives: Students who have clear and specific goals in learning are more likely to have high motivation (Haddar et al., 2023). Clear goals will help students to focus and remain motivated in achieving desired results. 2) Relevance and Relationship: Students will be more motivated when they understand the correlation between the subject matter and their everyday life or interests and goals. Making learning relevant to the experience and the real world students can improve their learning motivation. (Sulastri et al., 2023). 3) Positive Feedback: Positive feedback and proper reinforcement will enhance student learning motivation. Giving praise or recognition to student achievements can provide a positive boost that increases their motivation to continue learning and developing (Tuhuteru et al., 2023). Previous achievements can boost student confidence and provide additional motivation to better results. 5) A Supporting Learning Environment: A positive, inclusive, and supportive learning environment will influence student learning motivation. Teachers who provide emotional and academic support, as well as positive peers, can increase student learning Motivation. Stimulating the interest of students through interesting methods and associating material with their own interests can increase learning motivation (Aslan & Pong, 2023). 7) Intrinsic appreciation: Students who feel that they have control over their learning process and can meet basic psychological needs such as autonomy, competence, and connectivity will be more intrinsically motivated. 8) Achievable Challenges: Students need to be given adequate challenges in learning. A achievable challenge, in which students see the possibility of success in achieving goals, can increase their learning motivation. (Astuti et al., 2023).

So with that, for teachers to build and nurture student learning motivation by creating a positive, relevant and exciting learning environment. Using diverse learning strategies, giving positive feedback, and stimulating student interests will help boost their learning motivation.

One way to motivate students is to use Augmented Reality (AR), the positive impact of using AR on learning motivation; 1) Interesting Learning Experience: AR creates an exciting and immersive learning experience using virtual elements that enrich the real environment. This unique and new learning experience can increase student

interest and curiosity in the learning process. 2) Real World Context Relevance: AR enables the integration of science concepts or learning materials into the student's real world context. This makes learning more relevant and meaningful to students, which in turn can increase their motivation in studying the material. 3) Learning Through Challenges: AR can provide interactive challenges to students in the form of a game or mission-based scenario. Students will be motivated to complete the challenge and move to the next level. A sense of achievement and success in facing these challenges can increase student learning motivation. 4) Collaborative learning: AR can also encourage students to work together in a team or group in solving a specific task or challenge. This collaboration can increase student learning motivation as they interact and share ideas with their peers, as well as feel actively engaged in the learning process. 5) Direct Feedback: In AR use, students often get direct feedback about their understanding through AR visualization and simulation. This instant feedback can provide additional motivation to students to continue learning and improve their understanding. 6) Personalization of Learning: AR enables personalization of learning by allowing students to choose a path or difficulty level that suits their abilities. By presenting material in an exciting and challenging way, AR can motivate students to continue learning and improve their skills. 7) Students Control and Control Aspects: By using AR, students can feel that they own and control their learning experience. They can choose to explore and check information in AR scenes according to their interests and wishes. It can enhance the intrinsic motivation of students in learning (Anuar et al., 2021; Chen, Y. C. 2019; Chin et al. 2019) In using AR in learning, it is important for teachers to plan and integrate these technologies wisely. Adapting the AR experience to clear learning goals and providing appropriate challenges and feedback can help increase student learning motivation.

The Impact of AR Usage on Concept Understanding

The use of Augmented Reality (AR) in learning has a positive influence on students' understanding of concepts. Students' understanding of concepts can be described as their level of understanding of the concepts or ideas taught in learning. It involves an in-depth understanding, the ability to link concepts to relevant situations and examples, and the capacity to apply concepts in different contexts. A strong understanding of concepts is an important indicator of learning success and high-level thinking skills (Yoon et al., 2017).

The impact of using AR on understanding concepts includes; 1) Realist Visualization: AR allows students to see abstract or complex concepts in a more realistic visual form. For example, in lessons about planets in the Solar System, students can use AR to see three-dimensional models of each planet, with accurate size and scale. This realistic visualization can help students understand concepts better. 2) Interactive Learning: Using AR, students can interact directly with virtual objects in real

environments. For example, in biology lessons about cell structure, students may use AR to enlarge and examine cell structure details interactively. Interactive learning such as this can improve students' understanding of concepts because they can follow 3D modeling directly. 3) Practical Experience: AR allows students to have a practical experience with the concepts they are learning. For example, in physics lessons on the laws of motion, students can use AR to build motion models and see the effects of variable changes such as speed or mass. This hands-on experience can help students connect concepts to real situations and deepen their understanding. 4) Motivational Enrichment: Using AR in learning can provide an exciting and enjoyable learning experience for students. An attractive learning environment will motivate students to engage more in the learning process, which in turn can improve their understanding of concepts. 5) Collaboration and collaboration: AR can also be used for collaborative-based learning, where students can work together in teams to explore and solve problems. Collaboration among students can enhance understanding of concepts through discussion and exchange of ideas (Chen et al., 2016; Cai et al., 2021).

However, it is important to remember that the use of AR is only a tool in learning, and not alone can guarantee a good understanding of the concept. The mode of use, the benefits obtained, and its continuity need to be considered in order to use AR in learning to be effective. It is also important to involve teachers in designing learning with relevant ARs in order to maximize their influence on students' understanding of concepts.

The Effect of AR Use on Critical Thinking Ability

Augmented Reality (AR) or augmented virtual reality has become increasingly popular in learning. AR allows students to visualize and understand complex or abstract concepts better through immersive visual experiences. Besides, the use of AR can also affect students' ability to think critically (Faridi et al., 2021).

Critical thinking is the ability to question, analyze, evaluate, and integrate information critically and logically. It involves the ability to identify strong arguments, recognize errors in reasoning, investigate claims made, and make decisions based on existing evidence.

The ability to think critically is an essential skill in learning and problem-solving. This ability helps students to look at situations more holistically, develop more critical perspectives, and make rational and informed decisions. The ability to think critically also helps students to recognize bad designs, analyze information, and face complex challenges in everyday life.

Aspects in the ability to think critically, among others: 1) Analysis: Ability to separate information into smaller components, identify relationships, and recognize patterns or trends. 2) Evaluation: The ability to evaluate information and existing arguments, recognize the weaknesses of logic or lack of evidence, and develop

informed opinions. 3) Interpretation:The ability to interpret and give meaning to given information, link information to existing knowledge, and identify the assumptions underlying such information. 4) Synthetic: The capacity to integrate information from various sources, combine different ideas, and form a new understanding. 5) Evidence: The ability to investigate and find relevant evidence, using logical reasoning, and to form strong arguments.

To develop students' critical thinking skills, it is important to provide an opportunity for students to think in depth, encourage open discussion and reflection, ask challenging questions, and encourage analytical and evaluative thinking. Problem-based education, active and collaborative learning approaches, as well as the use of relevant technology and resources can also stimulate the development of critical thinking skills of students.

A number of studies have shown that using AR can improve students' critical thinking skills. A study conducted by Akcayir and akcayir (2017) showed that students who learned using AR scored higher on the critical-thinking skills test compared to students who studied using conventional methods. They stated that the use of AR makes students more active in learning and improves their ability to make connections between different concepts.

Other research conducted by Wu and Wu (2013) showed that the use of AR in science learning can improve students' ability to think critically. They stated that using AR allows students to visualize complex concepts, such as biological or physical processes, more clearly and in detail. It helps students understand concepts better and enhances their ability to carry out analytical and evaluative thinking.

In addition, using AR can also help students to develop critical thinking skills through the use of appropriate thinking strategies. For example, students can develop critical thinking skills through observing and solving problems related to complex concepts. In AR learning, students are often asked to identify problems and find solutions to them through observation and analysis on virtual objects. (Demircioglu et al., 2023).

In conclusion, the use of AR can enhance students' ability to think critically through the visualization of complex concepts, using appropriate thinking strategies, and influencing students to become more active in learning. It can help students in developing the critical thinking skills needed in their daily and future lives.

Conclusion

The conclusion of the literature study on the use of Augmented Reality (AR) technology in science learning is as follows: 1) Enhanced understanding of concepts: The use of AR in science study can help students to gain a better understanding of complex or abstract concepts. AR enables students to visualize these concepts in a more concrete way, thus making it easier for students to understand them. 2) Increase

student engagement: AR can increase student engagement in science learning. With the use of interactive and immersive technology, students become more active in the learning-teaching process. They became more interested and motivated in studying the concepts of science. 3) Developing critical thinking skills: AR can help students develop critical-thinking skills. By visualizing complex concepts, students can use appropriate thinking strategies, solve problems, and conduct analytical and evaluative thinking. 4) Increased information retention: AR can enhance student information retaining. Through visual and sensory experiences, students can remember and remember the information taught better. It can strengthen their understanding of the concepts of science studied.

However, it should be noted that although the use of AR in science learning has great potential, further research is still needed to explore further about its impact on student learning performance and how to effectively integrate these technologies into student learning experiences. These conclusions are based on literary studies that have been carried out and may vary depending on the context, implementation, and different student characteristics. Therefore, in implementing AR technology in science learning, it is important for educators to adapt to the needs of students and follow the best guidelines available.

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