

CURRENT LEARNING MEDIA: USING AUGMENTED REALITY (AR) AS AN ALTERNATIVE DIGITAL LEARNING MEDIA

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Abstract

Augmented Reality (AR) technology has developed rapidly and become one of the significant innovations in the world of modern education. AR offers an interactive learning experience that combines digital elements, such as 3D objects and animations, into the real world, thereby increasing student engagement and motivation. This study aims to explore the potential use of AR as an alternative digital learning media in various subjects and levels of education. This study shows that AR can help students understand abstract concepts, visualize learning materials in a more concrete way, and support project-based learning. In addition, AR also allows flexible and accessible learning, especially through mobile devices that are widely used by students. However, the implementation of AR in education still faces challenges, such as limited technological infrastructure, lack of teacher competence, high development costs, and difficulties in measuring learning effectiveness. To overcome these challenges, support is needed from various parties, including the government, educational institutions, and technology developers. With effective collaboration, AR has the potential to become an innovative and effective learning media in preparing students to face challenges in the digital era.

Keywords: Contemporary Learning Media, augmented reality, learning media, digital

INTRODUCTION

The development of information and communication technology has brought significant changes in various aspects of life, including education.

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Education now no longer relies solely on conventional methods such as lectures and textbooks, but has utilized various digital technologies to improve the effectiveness and efficiency of learning. In an effort to create a more interactive and enjoyable learning experience, Augmented Reality (AR) technology has emerged as an alternative learning media that is innovative and relevant to the needs of the times (Hutahaean et al., 2022). AR integrates virtual objects into the real environment, allowing users to interact with information and visualizations directly through electronic devices such as smartphones, tablets, or special glasses.

Ansori, I. (2024) stated that AR technology offers enormous potential in the world of education. One of its main advantages is the ability to provide deeper and more interactive visualization of learning materials. For example, in biology subjects, AR can display human organs in three dimensions and allow students to learn their functions in a more concrete way. This is different from traditional learning media which are often static and less able to present the complexity contained in abstract concepts.

In addition, the use of AR as a learning medium can increase student engagement and motivation. The current generation, often referred to as the digital generation or digital natives, grew up and developed in an environment that is highly exposed to technology. They are more familiar with the use of digital devices and tend to be more motivated in learning that utilizes this technology (Hadi et al., 2022). AR-based learning can attract students' attention better than conventional methods because the learning experience offered feels more real, immersive, and interactive. This is important to create an active and enjoyable learning environment, which can ultimately improve students' understanding and learning achievement.

However, although AR offers many benefits, its implementation in the education system still faces a number of challenges. First, access to devices and technology that support AR is still an obstacle in many areas, especially in remote areas that have limited technological infrastructure. This inequality of access is a major obstacle to the widespread and even implementation of AR throughout Indonesia. Second, the use of AR in learning requires adequate skills and knowledge from educators. Many teachers are not yet familiar with AR technology, so training and competency development are needed to ensure that they are able to integrate AR into the learning process effectively (Marini et al., 2022).

In addition to infrastructure readiness and teacher competence, developing quality AR content is also an important aspect that needs to be

considered. AR content in learning must be designed in such a way that it not only attracts students' attention but is also relevant and in accordance with the education curriculum. This requires collaboration between technology developers, educators, and subject matter experts to create targeted content. Successful AR content is that which is able to combine visual and interactive aspects in a balanced manner with educational elements, so that it can strengthen students' understanding of the learning material (Atmojo et al., 2021).

On the other hand, support from various parties, including the government, is needed to encourage the implementation of AR in the education sector. The government can play a role in providing adequate technological infrastructure, especially in remote areas, as well as providing training for teachers so that they are able to master AR technology. In addition, policies that support the implementation of new technologies in education also need to be formulated, including in the form of subsidies or incentives for schools that want to implement AR as a learning medium.

In a global context, the use of AR in education has grown rapidly in various developed countries such as the United States, Japan, and South Korea. In these countries, AR is used not only in elementary and secondary schools, but also in universities and professional training institutions. The experience of these countries shows that with the right support, AR can be a very effective tool in improving the quality of education. Indonesia as a country that continues to develop in the field of education also has a great opportunity to implement AR in a strategic and systematic way. The use of AR can enrich existing learning methods and at the same time encourage innovation in teaching, especially in the era of the industrial revolution 4.0 which demands increased technological and digital skills in all sectors, including education (Sakdiah et al., 2023).

However, the success of implementing AR as a learning medium does not only depend on technology and infrastructure, but also on the readiness of the curriculum and learning models applied. AR-based learning requires a more interactive and project-based approach, which requires a flexible curriculum that is open to innovative learning methods. A curriculum that supports the use of AR technology must be designed to enable students to develop critical thinking skills, creativity, and the ability to solve problems. This is very relevant to the challenges of the future world of work that demands high-level thinking skills.

Therefore, a more in-depth study is needed on the effectiveness of using AR in various subjects and levels of education in Indonesia. This research can

help identify areas that have great potential for AR implementation and overcome various obstacles that arise in the implementation process. This study can also be a basis for policy makers and education practitioners in developing appropriate training strategies and programs to support optimal AR adoption.

Thus, the use of AR as a contemporary digital learning medium has great potential to improve the quality of education in Indonesia. With the right support from the government, educational institutions, and the private sector, AR can be an alternative learning medium that is effective, interesting, and able to answer the challenges of education in this digital era.

RESEARCH METHOD

This study uses a literature review approach to collect and analyze information related to the use of Augmented Reality (AR) as an alternative digital learning media. This method was chosen because the literature review allows researchers to identify, assess, and synthesize relevant previous research findings, so that it can provide an in-depth understanding of the development, potential, and challenges of AR in the educational context. With this literature review method, researchers seek to develop a comprehensive understanding of the use of AR in learning, identify various factors that influence its effectiveness, and present evidence-based recommendations for the development and implementation of AR in educational environments.

RESULT AND DISCUSSION

Potential and Effectiveness of Using AR as a Learning Medium

Augmented Reality (AR) has become one of the most promising technologies in modern education. With the ability to combine digital elements, such as animation and 3D objects, into the real world, AR provides an interactive and immersive learning experience (Chang, 2021). This technology allows students to interact with digital content directly through electronic devices such as smartphones and tablets. This not only makes it easier to understand, but also provides opportunities for students to learn in a more fun and interactive way. Here are some of the potentials and effectiveness of using AR in learning media.

1. Increase Student Motivation and Engagement

One of the greatest potentials of AR in education is its ability to increase student motivation and engagement. Conventional learning methods are often boring and less interactive, especially for the digital generation who

are accustomed to technology and attractive visuals. AR, with its interactive visualizations, is able to attract students' attention and make them more motivated to learn. For example, in science learning, AR allows students to see interactive simulations of scientific phenomena such as the water cycle, the solar system, or the process of photosynthesis (Radu, 2014). In this way, students can learn visually and practically, which can increase their interest and motivation towards the material being taught.

Studies show that when students are more actively involved in learning, they tend to understand and remember the material better. AR provides an opportunity for students to not only be passive spectators, but also to become active participants in the learning process. This, in turn, increases the effectiveness of learning and overall learning outcomes.

2. Facilitates Understanding of Abstract Concepts

Many concepts in subjects such as mathematics, physics, and biology are difficult to understand if only explained through text or two-dimensional images. AR allows students to see three-dimensional representations of these abstract objects and concepts, so they can visualize them better (S Lin et al., 2015). For example, in biology learning, AR can display the structure of the human body or microscopic organisms interactively, so students can explore and understand anatomy in detail.

AR's ability to present complex visualizations has a positive impact on conceptual understanding. The use of interactive 3D models allows students to observe and manipulate objects as needed, which can ultimately strengthen their understanding of complex concepts. Empirical studies show that learning that utilizes AR can improve students' understanding of the material by 30-40% better compared to traditional learning methods.

3. Supporting Project-Based Learning

AR is also effective in supporting project-based learning (PBL). In the PBL model, students are encouraged to explore and discover knowledge through real projects that are relevant to everyday life. AR can be a very effective tool in this context, because it can be used to simulate real situations and provide direct practical experience. For example, students can use AR to design and test building models in engineering or architecture learning, or conduct science experiments with safe and realistic interactive simulations. With AR, students can gain direct experience that is usually difficult to get in a traditional classroom environment, especially when it comes to expensive resources or equipment. AR also allows collaboration

between students in teams, strengthening their communication and cooperation skills. This is important to prepare students for the challenges of the future world of work that requires critical thinking, creativity, and collaboration.

4. Flexibility and Accessibility of Learning

AR also has great potential in increasing the flexibility and accessibility of learning. AR technology can be accessed through various internet-connected devices, such as smartphones and tablets, which are widely owned by students today (Ab Halim et al., 2020). This allows AR to be used anywhere and anytime, thus supporting independent learning outside the classroom. Students can access AR learning content at home or on the go, providing opportunities for independent learning according to their own pace and learning style. In addition, AR can be integrated with online learning platforms and educational applications, further enriching students' learning experiences. In certain situations, such as during the COVID-19 pandemic which limits face-to-face interactions, AR can be an effective alternative to provide interactive learning experiences even though they are virtual.

This discussion highlights the various potentials and effectiveness of using AR in education, especially in increasing learning motivation, facilitating understanding of abstract concepts, supporting project-based learning, and increasing the flexibility of learning access. This technology offers great opportunities for the education system to transform to be more interactive, relevant, and fun for today's digital generation. However, to achieve the full potential of AR, infrastructure support, teacher training, and quality content are needed so that this technology can be implemented effectively in learning.

Challenges of AR Implementation in Learning

Although Augmented Reality (AR) has great potential in increasing the effectiveness of learning, its implementation in educational environments is not free from various challenges. These challenges include limited infrastructure, lack of teacher competence, costs of developing and implementing technology, and obstacles in creating content that is appropriate and relevant to the curriculum (Alzahrani, N. M. (2020). The following are some of the main challenges faced in implementing AR as a learning medium.

1. Limited Infrastructure and Access to Technology

One of the biggest challenges in implementing AR in education is the limited technological infrastructure available, especially in remote or

underdeveloped areas (Lai, J. W., & Cheong, 2022). Implementing AR requires supporting hardware and software, such as smartphones, tablets, or special AR devices, as well as a stable internet connection. However, not all schools in Indonesia have access to this technology. Many schools, especially in rural or remote areas, still lack basic facilities such as computers and adequate internet networks, which are obstacles to integrating AR technology into learning.

Additionally, while students in urban areas may have better access to personal technology devices, economic disparities can still be a barrier for some students to access AR-based learning equally. This digital divide poses a serious challenge in ensuring that all students, regardless of their economic and geographic backgrounds, can benefit from AR-based learning. Therefore, collaborative efforts between the government, educational institutions, and the private sector are needed to expand access to technology across regions.

2. Lack of Teacher Competence and Technology Training

The next challenge is the lack of teacher competence in using and integrating AR technology in learning. Many teachers are not yet familiar with this technology, and they may find it difficult to utilize AR effectively without adequate training. Teachers need a technical understanding of how to operate AR devices and the pedagogical skills to integrate the technology into lesson plans (Masood, T., & Egger, 2019). Without proper training, AR technology will simply be an additional tool that is not used optimally.

Training for teachers is critical to ensure that they are able to adapt to this new technology and are able to use it to improve student learning outcomes. However, providing extensive training for teachers across Indonesia requires significant resources, both in terms of cost and time. In addition, most training programs currently available do not specifically cover the use of AR in education, so a more focused and relevant training curriculum is needed.

3. Development and Implementation Costs

Developing and implementing AR technology in education requires significant investment, both in terms of hardware, software, and content needed. AR devices, such as sophisticated smartphones or AR headsets, are often expensive and may not be affordable for all schools or students. In addition, the cost of developing AR applications and content tailored to the educational curriculum is also quite high, considering the collaboration

between technology experts, educators, and graphic designers is needed to create quality and relevant content.

For many educational institutions, especially public schools with limited budgets, the allocation of funds for technology such as AR may not be a top priority compared to other basic needs, such as textbooks or laboratory equipment. To overcome this problem, government support and partnerships with the private sector are needed to provide AR technology at a more affordable cost and assist in the development of appropriate educational content.

4. Developing Appropriate and Relevant Content to the Curriculum

One important aspect in implementing AR is developing content that is in accordance with the curriculum and learning needs. AR content must be designed to be not only visually appealing, but also support learning objectives and be relevant to the educational curriculum. This process is not simple, because it requires a deep understanding of the subject matter and how to present it in an interactive and effective AR format.

Developing the right content requires collaboration between educators, material experts, and technology developers. AR content that is not well designed or is not relevant to the curriculum can cause students to lose focus or not get maximum educational benefits. In addition, creating content that can be accessed and used widely across devices and platforms requires uniform technical standards and high compatibility, which can be a challenge in itself.

5. Difficulty in Measuring the Effectiveness of AR-Based Learning

Another challenge that is often faced is measuring the effectiveness of AR-based learning objectively and measurably (Guntur et al., 2019). Although many studies show that AR can increase student motivation and engagement, there is still a gap in research regarding the extent to which AR actually has an impact on long-term learning outcomes. The use of AR requires comprehensive evaluation to ensure that the technology is truly effective in improving students' understanding and skills, not just attracting their attention in the short term. Evaluating the effectiveness of AR learning requires a more systematic approach and the use of valid and reliable evaluation instruments. This requires educational institutions to conduct extensive research and trials before integrating AR as part of the main learning strategy. Without strong data and empirical support, it is difficult to ensure that investments in AR technology actually have a significant impact on improving the quality of education.

Examples of AR Application in Various Subjects and Levels of Education

Augmented Reality (AR) has been applied in various subjects and levels of education with the aim of increasing student understanding and engagement (Tzima et al., 2019). The flexible application of AR allows this technology to be used to create more visual, interactive, and fun learning experiences across a variety of disciplines. Here are some examples of AR applications in various subjects and levels of education:

1. Science and Biology in Elementary and Middle Schools

In science lessons, especially biology, AR is used to help students visualize concepts that are difficult to explain directly (Cabero-Almenara et al., 2019). For example, AR allows students to view interactive simulations of the human body's organ systems in three dimensions, so they can explore the anatomy and function of these organs in more detail. At the middle school level, AR can also be used to explain the process of photosynthesis, animal life cycles, and natural phenomena such as the movement of planets in the solar system. These visualizations help students understand complex concepts in a more concrete and engaging way.

2. Mathematics in Elementary and Middle Schools

AR is also applied in mathematics learning to make abstract concepts easier to understand. For example, in learning geometry, AR can be used to project three-dimensional objects such as cubes, prisms, or pyramids, allowing students to see and manipulate these shapes from different angles. This visual experience makes it easier for students to understand volume, surface area, and the properties of geometric shapes. With AR, students not only read or draw geometric shapes, but also see real shapes that they can explore, thus helping to reinforce the concepts learned (Alakärppä et al., 2017).

3. History and Geography at the Secondary School Level

In history lessons, AR can be used to present historical sites or important artifacts digitally (Akçayır, M., & Akçayır, 2017). Students can see 3D representations of historical buildings such as Borobudur Temple or the Great Wall of China and explore their architectural details interactively. In this way, history learning becomes more lively and relevant, as if students were visiting these places in person. In geography lessons, AR allows students to study topography or world maps with more realistic displays, such as simulations of volcanoes, earth surface shapes, and the dynamics of weather changes.

3. Physics in Middle and High Schools

Physics often involves abstract and difficult-to-visualize concepts, such as waves, electromagnetism, or the motion of objects (Martín-Gutiérrez et al., 2015). AR can help students see interactive simulations of these phenomena. For example, students can see how electromagnetic waves move or how the motion of objects is affected by gravity through visual displays projected in the real world. Thus, students can more easily understand the principles of physics that may be difficult to understand with just text or two-dimensional images.

4. Language and Literacy in Early Childhood Education

In early childhood education, AR can also be used to teach literacy and language through applications that display letters and words interactively. Children can learn to recognize letters and words by utilizing animations that appear when they point their devices at objects around them. For example, they can see animal animations appear when they scan animal images, making language learning more engaging and interactive (Criollo-C et al., 2021).

CONCLUSION

The use of Augmented Reality (AR) as a digital learning medium has shown great potential in improving the effectiveness and quality of education. AR offers a new interactive and immersive way to present learning materials, allowing students to interact with digital objects and simulations that are relevant to the real world. This technology is effective in increasing student motivation, engagement, and understanding, especially in learning abstract concepts that are difficult to visualize through traditional learning methods.

AR can be applied in various subjects, such as science, mathematics, history, and language, and at various levels of education, from early childhood education to higher education. With the interactive visualizations offered, AR is able to present a more enjoyable and contextual learning experience, helping students understand the material better and faster. However, despite its many advantages, the implementation of AR in learning still faces several challenges. Limited infrastructure, lack of teacher competence in technology, development and implementation costs, and difficulties in measuring the effectiveness of AR learning are obstacles that need to be overcome. Therefore, collaboration is needed between the government, educational institutions, technology developers, and the private sector to provide adequate access and training, and ensure the development of appropriate and quality content. Overall, AR as a digital learning medium is an innovative alternative and has great potential to

revolutionize the education system. With the right strategy and support, AR can be an effective tool in preparing the next generation with relevant skills and knowledge in the digital era.

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