


## Policy on the Use of Augmented Reality (AR) Technology in Learning: Opportunities and Challenges

Deding Ishak

STAI YAPATA AI-Jawami, Bandung, Indonesia

Article Info	ABSTRACT
<p><b>Keywords:</b> education policy, augmented reality, learning technology, opportunities, challenges.</p>	<p>The development of digital technology has driven a transformation in the education system, one of which is through the use of Augmented Reality (AR) technology in the learning process. AR enables the integration of virtual objects into real environments, thereby enhancing interactivity, conceptual understanding, and student engagement. However, the implementation of AR in learning is inseparable from policy aspects that regulate infrastructure readiness, educator competency, curriculum, as well as ethical aspects and equitable access to technology. This study aims to analyze the policy of using Augmented Reality technology in learning by examining the opportunities and challenges faced in its implementation. The research method used is a qualitative approach with a literature review of various regulations, educational policies, and relevant previous research findings. The results indicate that the use of Augmented Reality (AR) technology in learning has significant potential to improve the quality of learning through the visualization of abstract concepts, increased engagement and motivation to learn, experiential learning, personalized materials, and strengthened student collaboration. AR can create a more interactive, contextual, and meaningful learning experience, thus supporting conceptual understanding and the development of 21st-century skills. However, AR implementation still faces various challenges, such as high costs, disparities in technology access, limited digital literacy, technology dependency, curriculum and content readiness, and potential health impacts. Therefore, AR utilization needs to be supported by appropriate policies, infrastructure, and pedagogical strategies for effective, equitable, and sustainable implementation within the education system.</p>
<p>This is an open access article under the <a href="https://creativecommons.org/licenses/by-nc/4.0/">CC BY-NC</a> license</p> 	<p><b>Corresponding Author:</b> Deding Ishak STAI YAPATA AI-Jawami, Bandung, Indonesia <a href="mailto:dedingishak@yahoo.com">dedingishak@yahoo.com</a></p>

### INTRODUCTION

The development of information and communication technology has brought significant changes to various aspects of life, including education. This is evident in the emergence of e-learning and various online learning platforms currently available (Abdullah, 2024). Various innovative learning media have also emerged to support the teaching and learning process, such as learning that can occur without the constraints of space and time. Digital transformation has driven the birth of various learning innovations aimed at improving the effectiveness, efficiency, and quality of the teaching and learning process (Yasin et al., 2023). The use of technology in learning is no longer merely an option but has become a necessity

to meet the demands of education in the global era and a knowledge-based society (Paling et al., 2024).

One rapidly developing technology that is beginning to be adopted in education is Augmented Reality (AR). Augmented Reality (AR) is a technology that combines the real world with the virtual world. This technology enables direct interaction (real-time) and displays content in the form of three-dimensional animations (Aditama et al., 2019). The application of AR has spread across various fields, where it is used to combine the real world with the digital world without altering the reality of the object. Text and images are identified as means of displaying information. AR technology enables the integration of virtual objects into real-time environments, creating a more interactive and contextual learning experience. In the context of learning, AR is considered capable of helping students understand abstract concepts, increasing learning motivation, and strengthening memory through engaging visualizations (Mustaqim, 2016).

The use of Augmented Reality in learning has the potential to improve learning outcomes, student engagement, and critical thinking skills. AR also provides opportunities for educators to develop innovative, student-centered learning methods (Parinussad et al., 2024). According to Lahallo et al. (2016), this technology allows teachers to add virtual objects in the form of augmentations. This is useful for reconstructing real objects invisible to the naked eye. AR also facilitates the visualization of objects that are difficult to observe, such as human organs or similar objects (Mauludin et al., 2017). AR also frees the teaching and learning process from the constraints of space and time, allowing students to learn anywhere and anytime (Dhiyatmika et al., 2015). Based on the description above, this article aims to examine the application of Augmented Reality (AR) technology in interactive learning about nature and the environment.

Despite its significant potential, the implementation of Augmented Reality technology in learning cannot be separated from the role of education policy (Japar et al., 2024). Policy is the primary foundation for regulating the direction, strategy, and limitations of technology use in educational settings. Without clear and targeted policies, AR utilization risks suboptimal implementation, uneven implementation, or even creating new problems within the education system (Aksentad et al., 2023).

Several studies have demonstrated the positive impact of AR technology in education. Research by Santosa et al., 2021 revealed that AR can increase student engagement and learning effectiveness by providing interactive simulations. Furthermore, AR technology allows students to practice practical skills without the risk of physical injury (Setiono et al., 2024), such as in engineering and machine maintenance. However, key challenges reported by previous research include limited digital infrastructure, lack of training for educators, and the high cost of developing relevant AR content. Thus, there is still room to explore the application of AR in the context of vocational education, especially in developing countries (Lutfiah, 2024).

In Indonesia, policies on the use of educational technology continue to evolve in line with the national digital transformation agenda. The government encourages the integration of technology into learning through various programs and regulations. However, to date,

policies specifically governing the use of Augmented Reality technology in learning remain relatively limited, so its implementation in the field relies heavily on the initiatives of educational institutions and educators.

In addition to the opportunities it offers, the use of AR in learning also faces various challenges. These challenges include limited technological infrastructure, educator readiness and competence, disparities in technology access between regions, and ethical and data security issues. This situation demands policies that bridge the gap between the technology's potential and the reality of implementation on the ground.

Policies on the use of Augmented Reality technology in learning need to be designed comprehensively, considering pedagogical, technological, social, and economic aspects. Appropriate policies not only encourage learning innovation but also ensure equitable access, sustainable implementation, and protection for all educational stakeholders. Thus, policies become a strategic instrument in ensuring the effective and responsible use of AR.

Based on this description, this research is crucial to examine policies on the use of Augmented Reality technology in learning by examining the opportunities and challenges that accompany it. This research is expected to provide academic contributions in the development of educational policy studies and become a reference for policy makers, educational institutions, and educators in formulating strategies for utilizing AR to improve the quality of learning.

## METHOD

This study uses a qualitative approach with a literature review method to analyze the policy of using Augmented Reality (AR) technology in learning. Research data was obtained from various relevant secondary sources, including books, scientific journal articles, and research reports discussing the application of AR in learning. Data sources were selected purposively, considering the relevance, credibility, and currency of the information to obtain a comprehensive picture of the opportunities and challenges of using AR in the context of education policy (Sugiyono, 2019). Data analysis was conducted using descriptive-qualitative analysis techniques through the stages of data collection, data reduction, data presentation, and drawing conclusions. The classified data were analyzed to identify policy patterns, opportunities for AR utilization, and challenges of its implementation in learning. The results of the analysis were then systematically interpreted to produce conclusions that can provide applicable and sustainable policy recommendations to support the integration of Augmented Reality technology in education (Nasution, 2020).

## RESULT AND DISCUSSION

### Opportunities for Using AR in Learning

#### 1. Visualizing Abstract Concepts

The use of Augmented Reality (AR) technology in learning opens up significant opportunities for visualizing abstract concepts that have been difficult to grasp through conventional learning methods. AR enables the presentation of three-dimensional virtual objects that can

be displayed directly in the real environment, allowing students to observe the shape, structure, and relationships between the parts of a concept more concretely. In fields like chemistry, AR can display molecular structures in interactive 3D, helping students understand chemical bonds and atomic structure visually. Meanwhile, in biology, AR technology enables detailed visualization of human anatomy, allowing students to learn about organs and body systems without relying entirely on two-dimensional images in textbooks.

In addition to enhancing conceptual clarity, AR-based visualizations also contribute to improved conceptual understanding and learning retention. Direct interaction with virtual objects encourages active student engagement in the learning process, making learning more meaningful and contextual. With exploratory learning experiences, students not only passively receive information but also construct knowledge through observing and manipulating virtual objects. This demonstrates that AR has strategic potential as an innovative learning medium capable of bridging the gap between abstract theory and concrete understanding in the learning process.

## **2. Increasing Engagement and Interest in Learning**

The use of Augmented Reality (AR) technology in learning offers significant potential for increasing student engagement and interest in learning through the presentation of interactive and dynamic learning experiences. AR allows students to interact directly with learning materials in the form of visuals, audio, and animations integrated with the real environment. This interaction makes the learning process more engaging than conventional methods, which tend to be one-way. When students are actively involved in exploring the material, their attention and focus can increase, making learning more enjoyable and less monotonous.

In addition to increasing engagement, AR-based learning experiences also contribute to increased student motivation. Learning that presents elements of novelty and advanced technology can stimulate curiosity and encourage students to be more enthusiastic in participating in learning activities. This high motivation positively influences students' attitudes toward the subject, which ultimately can increase participation, persistence, and learning outcomes. Thus, AR has the potential to be an effective learning medium for creating an active, innovative, and student-centered learning environment.

## **3. Experience-Based Learning and Simulation**

Augmented Reality (AR) technology offers significant opportunities to support experience-based learning and simulation by providing a safe, interactive, and contextual learning environment. With AR, students can simulate various learning activities that mimic real-world conditions, such as virtual science experiments, without facing safety risks or limited laboratory facilities. These simulations allow students to directly observe processes, test hypotheses, and understand cause-and-effect relationships, ensuring that learning is not merely theoretical but also practical.

Furthermore, AR enables digital field trips, which can take learning experiences beyond the classroom without the constraints of cost, distance, and time. Through realistic visualizations of virtual environments and objects, students can explore places, such as historical sites, natural ecosystems, or industrial facilities, that are difficult to reach in person.

These simulation-based and exploration-based learning experiences encourage active engagement and a deeper understanding of the learning material. Thus, AR serves as an innovative medium that can enrich students' learning experiences while expanding access to practical, experiential learning.

#### **4. Personalized Learning**

Augmented Reality (AR) technology opens up significant opportunities for personalized learning by providing content that can be tailored to the needs, abilities, and characteristics of individual students. Through AR, learning materials can be designed in various difficulty levels, visual formats, and interaction types, allowing students to access content at their own pace. This flexibility allows students to review material they haven't yet grasped or move on to more complex material without having to rely entirely on the overall classroom pace.

In addition to adjusting the learning pace, AR-based personalization can also accommodate different student learning styles, including visual, auditory, and kinesthetic. Presenting materials in the form of three-dimensional objects, interactive animations, and exploratory experiences helps students learn in a way that best suits their preferences. This not only improves conceptual understanding but also fosters independence and confidence in the learning process. Thus, the use of AR in learning has the potential to create an inclusive, adaptive learning environment that is oriented towards the individual needs of students.

#### **5. Improved Collaboration**

Augmented Reality (AR) technology provides opportunities to improve the quality of collaboration between students through collaborative learning based on digital interaction. Several AR applications allow students to access and interact with the same virtual objects simultaneously, either within a single classroom or across a digital network. This encourages discussion, the exchange of ideas, and collaboration in understanding concepts and completing learning tasks. With the active involvement of each group member, the learning process becomes more participatory and oriented towards collaborative problem-solving.

In addition to enhancing social interaction, AR-based collaborative learning also contributes to the development of 21st-century skills, such as communication, collaboration, and critical thinking. When students work together to explore virtual objects and solve simulated problems, they learn to share roles, respect the opinions of others, and make decisions collectively. This demonstrates that AR functions not only as a learning medium but also as a strategic tool in building an effective collaborative learning environment and supporting the development of students' social competencies.

### **Challenges of Using AR in Learning**

#### **1. High Implementation Costs**

One of the main challenges in using Augmented Reality (AR) technology in learning is the high implementation costs, particularly related to hardware procurement and content development. Implementing AR requires supporting devices such as devices, tablets, or AR headsets with specific specifications for the application to run optimally. This situation presents a barrier for many educational institutions, particularly schools in areas with limited budgets and technological infrastructure, potentially widening the gap in technology access between regions.

In addition to hardware costs, developing quality AR content also requires significant investment. Creating AR-based learning materials requires technical expertise, specialized software, and a relatively long development time. Content that is not well designed pedagogically and technically can actually reduce learning effectiveness. Therefore, this cost challenge requires policy support, collaboration with industry, and a sustainable funding strategy to ensure the equitable and optimal use of AR in learning.

## **2. Technology Access Gap**

The technology access gap is a significant challenge in implementing Augmented Reality (AR) in learning. The use of AR requires adequate devices and a stable internet connection for the application to run optimally. However, not all students, especially those in remote areas or those with limited socioeconomic status, have access to compatible devices and adequate internet access. This situation has the potential to hinder the equitable use of AR in learning and create inequalities in the quality of educational services.

Furthermore, disparities in technology access can widen the digital divide between regions and social groups. Students with better access to technology will experience richer and more innovative learning experiences, while students with limited access risk being left behind. This suggests that the implementation of AR in learning must be accompanied by policies oriented towards equitable access, such as strengthening digital infrastructure, subsidizing devices, and developing content that can be used offline. Thus, the use of AR can support inclusivity and equity in the education system.

## **3. Limited Digital Literacy**

Limited digital literacy is a significant challenge in the implementation of Augmented Reality (AR) technology in learning. Both educators and students often lack the knowledge and skills to operate AR devices and optimally utilize their features. For educators, these limitations can hinder their ability to design, integrate, and manage AR-based learning in accordance with pedagogical objectives. Meanwhile, for students, low digital literacy can lead to difficulties in understanding how to use technology, diverting the focus of learning to technical aspects.

Beyond technical aspects, digital literacy also encompasses critical skills in using technology wisely and responsibly. Without adequate training, AR use has the potential to be ineffective or simply used as a means of entertainment, rather than as a meaningful learning medium. Therefore, systematic efforts are needed through training, mentoring, and digital competency development for educators and students. Policy support and programs to improve digital literacy are key factors in ensuring the effective and sustainable use of AR in learning.

## **4. Dependence on Technology**

Over-reliance on technology is one of the challenges in implementing Augmented Reality (AR) in learning. Learning processes that rely heavily on AR devices and applications are vulnerable to various technical issues, such as software glitches, hardware damage, or unstable internet connections. When these technical issues occur, teaching and learning activities can be disrupted or even halted, reducing the effectiveness of learning and disrupting student concentration.

In addition to impacting the smoothness of learning, reliance on technology also has the potential to reduce educators' flexibility in classroom management. Educators who rely too heavily on AR without preparing alternative learning methods may experience difficulties when the technology is unavailable. Therefore, the use of AR needs to be positioned as a learning support tool, not as the sole medium. A balanced approach between the use of technology and conventional learning methods is crucial to ensure the learning process remains effective despite technical challenges.

### **5. Curriculum and Content Development**

Curriculum and content development are crucial challenges in implementing Augmented Reality (AR) technology in learning. The integration of AR into the learning process requires curriculum adjustments to ensure the technology's use aligns with learning objectives, competency outcomes, and student characteristics. Without appropriate curriculum adaptation, AR use has the potential to become merely a visual complement without significantly contributing to learning outcomes. Therefore, systematic curriculum planning is necessary to ensure AR is pedagogically integrated, not merely technologically.

In addition to curriculum adaptation, the availability of relevant and high-quality AR-based educational content is also limited. AR content development requires collaboration between educators, technology developers, and subject matter experts to ensure the material presented is not only visually appealing but also accurate and aligns with educational standards. The lack of contextualized content tailored to local needs can hinder the optimal use of AR. Thus, this challenge underscores the importance of policy support, innovation, and cross-sector collaboration in the sustainable development of AR curricula and content.

### **6. Health and Ergonomic Issues**

Health and ergonomic issues are challenges that require serious attention in the use of Augmented Reality (AR) technology in learning. Prolonged use of AR devices has the potential to cause physical impacts, such as eye strain, visual fatigue, headaches, and neck and postural discomfort. This condition can occur due to constant eye focus on digital displays, screen lighting, and poor ergonomic device usage. If not managed properly, these impacts can disrupt student comfort and concentration during the learning process.

In addition to physical impacts, AR use also has the potential to cause disorientation or cognitive fatigue in some users, especially when interacting with virtual objects intensively. Students who are not accustomed to using this technology may have difficulty adjusting visual perception to the real environment. Therefore, the implementation of AR in learning needs to be accompanied by appropriate usage duration settings, ergonomic interface design, and education on safe and healthy device use. This approach is crucial to ensure that AR use is not only pedagogically effective but also safe for students' health.

## **CONCLUSION**

AR holds great potential as an innovative learning medium capable of improving the quality of student learning processes and outcomes. Through the visualization of abstract concepts, experiential learning and simulations, and personalized materials, AR can bridge the gap between theory and practice. Interactive and contextual presentation of materials encourages

active engagement, increases interest and motivation to learn, and strengthens conceptual understanding and knowledge retention in students. Furthermore, the use of AR also contributes to the development of 21st-century skills, such as collaboration, communication, and critical thinking. AR-based collaborative learning creates a participatory learning environment and fosters the ability to work together to solve problems. AR's flexibility in accommodating different learning styles and speeds makes it a potential tool for creating more inclusive, adaptive, and individual-oriented learning. However, the implementation of AR in learning still faces several challenges that cannot be ignored. High implementation costs, gaps in technology access, limited digital literacy, and dependence on technological devices are key obstacles to the equitable and sustainable adoption of AR. In addition, the challenges of developing relevant curriculum and content, as well as attention to user health and ergonomics, require careful planning and management to ensure AR usage does not negatively impact the learning process. Therefore, the use of AR in learning requires comprehensive policies, strengthening of technological infrastructure, increasing digital literacy among educators and students, and cross-sector collaboration between educational institutions, government, and industry. With a balanced approach between technological innovation and pedagogical principles, AR has the potential to become an effective, safe, and sustainable learning tool to improve the quality of education in the digital era.

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