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EVALUATING THE ROLE OF AUGMENTED REALITY IN ENHANCING EDUCATIONAL PRACTICES

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Abstract: This study aims to explore the implementation of Augmented Reality (AR) technology in education, focusing on its application, integration with teaching content, challenges faced by educators, and potential solutions. The objective is to assess the current state of AR adoption in teaching and provide recommendations for improving its implementation. A quantitative survey methodology was employed, collecting educators' responses focusing on their AR technology experiences. Data analysis involved calculating mean scores and standard deviations to gauge perceptions of AR's effectiveness, challenges, and support needs. Findings indicate that AR adoption in teaching remains moderate, with teachers reporting limited infrastructure support, high preparation time, and technical difficulties as major barriers. Additionally, integrating AR with existing curricula poses challenges. To enhance AR implementation, the study recommends a few strategies, including comprehensive teacher training, greater institutional support, the development of high-quality AR-integrated teaching materials, and dedicated technical support teams. These strategies can facilitate a more seamless integration of AR into educational settings and improve its impact on student learning outcomes.

Keywords: Augmented reality, educational technology, AR integration, teaching challenges, pedagogical innovation.

INTRODUCTION

Information and communications technology (ICT) has drastically changed communication, training, and work processes (Vázquez-Cano et al., 2020). In recent years, universities have also undergone a transformation driven primarily by globalization, internationalization, student characteristics, and ICT advancements. This transformation presents a significant challenge for higher education institutions in terms of the skills that faculty and students need to develop, leading to necessary adaptations in the curricula to align with these new competencies (Veretekhina & Novikova, 2019; Tereliansky et al., 2019; Huang and Karduck, 2017). Therefore, universities must take on an innovative role, integrating new technologies such as AR (Bacca Acosta et al., 2019), as highlighted in the Horizon 2012 and 2016 reports (Durall et al., 2012; Johnson et al., 2016). AR, in particular, has emerged as a promising technology with extensive potential for educational applications (Alkhattabi, 2017; Cabero-Almenara et al., 2016; Cabero-Almenara et al., 2019; Dube & Ince, 2019). AR emerged in the early 1960s within informatics and science, driven by advancements in computer-based technologies, including faster and more efficient processors, real-time rendering techniques, and the development of position-tracking systems and artificial vision (Edwards, 2013; Karlsson, 2015). These innovations enabled applications that superimpose images, 3D models, texts, and other digital elements on real-time video captured by cameras.

Since then, AR has been recognized as a paradigm that merges the physical world with digital objects, offering high levels of natural interaction through artificial vision techniques that facilitate simple user interactions (Wong et al., 2018). However, despite its potential, the adoption of AR in higher education remains inconsistent, with different challenges related to accessibility, faculty readiness, pedagogical integration, and institutional support (Shwedeh et al., 2024). Many educators still lack the necessary skills and training to effectively implement AR in their teaching, and there is limited research on best practices for integrating AR into curricula across diverse disciplines. Furthermore, while AR has been recognized for its ability to bridge the gap between digital and physical learning experiences, its effectiveness in fostering digital literacy and preparing students for the evolving job market is not yet fully understood. There is a need to explore how universities can systematically adopt AR to enhance teaching methodologies while addressing barriers such as technological infrastructure, cost, and resistance to change. Without a structured approach to implementing AR in education, its full potential may remain unattained, limiting its impact on student learning outcomes. Therefore, this study aims to investigate the application, challenges, and opportunities for integrating AR in higher education, providing insights that can enhance institutional policies and pedagogical strategies.

LITERATURE REVIEW

The ubiquity of digital information in our daily lives is blurring the boundaries between the physical and virtual worlds. AR presents digital information directly within the real world, allowing users to engage with their surroundings without needing to focus on a device screen (Kun et al., 2019; Liberati, 2014). Unlike other interaction paradigms, AR keeps users connected to their real-world context, generating an augmented reality without isolating them from their environment (Liarokapis, 2006). By leveraging users' visual and spatial abilities, AR enhances the real world with additional information, rather than immersing users in a virtual world confined to a computer.

The higher education sector is evolving alongside technological advancements, adapting pedagogical models to the developments brought about by digitalization. Digital literacy must be integrated across all educational levels, particularly in the final stages of education, to prepare citizens for a job market undergoing constant digital transformation (Verhoef & Du Toit, 2018; Veretekhina et al., 2020). It is essential to analyze how educational institutions manage the implementation of technological advancements, especially AR, to ensure the effective adaptation of resources, content, and objectives (Müller & Parzych, 2019). In higher education, AR technology is used to enhance student learning, enabling observation of physical elements through mobile devices engagingly and interactively, thus facilitating the study of content. AR also improves information retention, serves as a valuable tool for teaching and learning, and supports practices by aiding the understanding of complex phenomena (Veretekhina et al., 2020). Educational technologies aim to visualize change to make it feasible and achievable.

The application of AR in education goes far beyond the traditional teaching model. For example, in science education, AR can visually present complex concepts such as molecular structures and chemical reactions through three-dimensional models, helping students better understand and remember th

em (Wu et al., 2013). Similarly, in history education, AR can dynamically present past events, cultural heritage, and other content, so that students feel as if they are there, and deeply feel the background and details of history. This immersive experience not only enhances students' motivation to learn but also develops their critical thinking and problem-solving skills (Tang, 2024). In addition, AR has the potential to personalize instruction. By combining students' learning progress, interests, and ability levels, AR can provide customized learning content to better meet the learning needs of different students. This personalized learning method can not only improve learning efficiency but also enhance students' self-confidence and independent learning ability (Cabero-Almenara et al., 2019).

The Potential and Challenges of AR in Education

At present, the application of AR in education also faces some challenges. First, the high cost of technology may be a barrier to the adoption of AR technology by educational institutions (Shwedeh et al., 2024). Secondly, teachers need to possess certain technical abilities in the teaching process, which puts forward higher requirements for the professional development of teachers (Dunleavy & Dede, 2014). Finally, how to effectively combine AR technology with curriculum content to truly serve students' learning is also a question that educators need to think about (Ibanez & Delgado-Kloos, 2018). In short, as an innovative educational tool, AR has broad prospects for development. With the continuous progress of technology and the update of educational concepts, the application of AR in education will be more extensive and in-depth. By combining digital elements with the real world, AR can not only improve students' learning experience but also drive innovation in educational models and open new opportunities for future educational development (Kocak et al., 2019; Yuliono & Rintayati, 2018).

Currently, despite the significant educational potential of AR, its effective implementation is not easy. Koçak et al. (2019) emphasized that the successful application of AR requires careful instructional design and careful planning, especially in terms of how to integrate it with specific teaching objectives. If AR technology is not closely integrated with course content and learning objectives, it may lead to a significant reduction in its effectiveness and even distract students. In addition, the use of AR technology needs to overcome many technical and teaching barriers. For example, educational institutions must have the corresponding technical infrastructure, such as high-performance equipment and stable network connections, which may be a challenge for schools with limited resources. Currently, teachers also need to receive professional training so that they can effectively integrate AR technology into teaching. This includes not only how to operate the device, but also how to design teaching activities that can fully utilize the advantages of AR.

These studies jointly emphasize a core point: although AR has broad prospects in education and has the potential to change traditional teaching models, its successful implementation is highly dependent on

overcoming multiple technical and teaching barriers. Educators must fully consider how to closely integrate AR technology with teaching objectives during the teaching design stage to ensure that it can truly enhance students' learning outcomes in practical applications. In addition, schools and educational institutions also need to invest sufficient resources to provide teachers with the necessary support and training to ensure that they can effectively use AR technology. In general, the application of AR technology in education is full of opportunities, but its success still depends on careful planning and effective implementation.

METHODS

Research design

This study employed a quantitative research design to systematically investigate the integration of augmented reality in enhancing educational practices, focusing on educators' perceptions, adoption, challenges, and its impact on teaching. Quantitative research allows for the collection of broad, numerical data, which can be systematically analyzed to identify patterns and trends (Creswell, 2014). A structured survey questionnaire was distributed as the primary data collection instrument, designed to gather information on the application of AR technology in higher education. By using a Likert scale, the questionnaire captures the respondents' attitudes and perceptions, providing measurable insights into their views. The Likert scale will range from 1 (Strongly Disagree) to 5 (Strongly Agree) to assess attitudes, experiences, and challenges related to AR in education.

Instrument

This research used a structured questionnaire to collect data on respondents' attitudes toward AR technology in higher education. The questionnaire was designed based on a 5-point Likert scale, which is widely applied in educational and social science research for capturing subjective attitudes and perceptions effectively (Joshi et al., 2015). This method provides reliable quantitative data to analyze respondents' overall attitudes and experiences regarding AR technology. The items in this questionnaire were adapted from previous research on AR technology in education to ensure validity and relevance (Wu et al., 2013; Bower et al., 2014; Akçayır & Akçayır, 2017). The questionnaire consisted of 20 items, divided into three sections: (1) the current application of AR technology in teaching, (2) the challenges teachers face in implementing AR, and (3) recommendations for improving AR integration. Each section was designed to explore specific aspects of AR application and teachers' experiences with the technology, such as its impact on student engagement, technical difficulties, and institutional support.

FINDINGS

Table 1

The Application of AR Technology in Teaching

Items	Mean	SD
I currently use AR technology in my teaching	2.96	1.13

I have a clear understanding of the basic functions and applications of AR technology.	3.14	1.07
The use of AR technology has improved my teaching effect.	3	1.09
Student engagement and interest increased significantly when AR technology was used.	3.06	1.05
AR technology helps students better understand complex concepts.	3.07	1.06

The survey results indicate that the application of AR technology in teaching remains moderate. The statement "I currently use AR technology in my teaching" received a mean score of 2.96 (SD = 1.13), suggesting that while some educators incorporate AR into their teaching, widespread adoption is still limited. Additionally, respondents reported a moderate understanding of AR functionalities (Mean = 3.14, SD = 1.07), indicating that while many educators have some familiarity with AR, their expertise in utilizing it effectively is still developing. The perceived impact of AR on teaching methods was neutral, with a mean score of 3.00 (SD = 1.09), suggesting that while some teachers find AR beneficial, others may not have observed significant improvements in their pedagogical approaches. Similarly, the belief that "Student engagement and interest increased significantly with AR technology" scored 3.06 (SD = 1.05), showing a slight inclination towards agreement but not a strong consensus.

Table 2

Integration of AR Technology and Teaching Content

Items	Mean	SD
AR technology can be smoothly integrated into my teaching content.	3.05	1.11
I have enough room to apply AR technology in the course design.	2.95	1
The application of AR technology promotes students' in-depth learning of the course content.	2.85	1.18
In the application of AR technology, course structure and scheduling need to be significantly adjusted.	2.88	1.19
The visual capabilities of AR technology are crucial to conveying course content.	2.97	1.08

The results suggest challenges in seamlessly integrating AR into the curriculum. The statement “AR technology can be smoothly integrated into teaching” received a mean score of 3.05 (SD = 1.11), indicating a neutral stance. Educators expressed some concerns about the availability of opportunities to apply AR, with “I have enough room to apply AR technology in teaching” scoring 2.95 (SD = 1.00). Likewise, “The application of AR technology promotes student-centered learning” had a mean of 2.85 (SD = 1.18), showing hesitation about AR’s role in fostering independent learning. The complexity of integrating AR was evident in “In the application of AR technology, course structure and content need major adjustments”, which had a mean of 2.88 (SD = 1.19), indicating that curriculum adaptation is a concern. Additionally, AR’s visual capabilities (Mean = 2.97, SD = 1.08) were seen as beneficial but not yet fully optimized for educational use.

Table 3

Challenges Teachers Face When Using AR Technology

Items	Mean	SD
I lack the hardware support needed to implement AR technology (e.g., AR glasses, tablets, etc.).	2.9	1.08
The preparation time and effort required to implement AR technology is too onerous.	3.1	1.16
I think there is insufficient support and funding for the use of AR technology in schools.	2.92	1.08
I have encountered technical issues or glitches when implementing AR technology.	3.04	1.05
There are some difficulties in combining AR technology with existing curriculum content.	2.79	1.04

The data highlights significant barriers to AR adoption. A lack of infrastructure is evident in the "I lack the hardware support needed to implement AR" statement, which had a mean of 2.90 (SD = 1.08). Another challenge is the time and effort required for AR preparation, with the statement "The preparation time and effort required to implement AR is too high" scoring 3.10 (SD = 1.16). This suggests that teachers perceive AR as time-consuming and demanding in terms of lesson planning. Support and funding issues were also raised, with "I think there is insufficient support and funding for AR technology" scoring 2.92 (SD = 1.08). Additionally, technical difficulties were frequently encountered, as indicated by "I have encountered technical issues or glitches while using AR" (Mean = 3.04, SD = 1.05). Finally, the difficulty of aligning AR with educational content was highlighted in "There are some difficulties in combining AR technology with existing teaching materials" (Mean = 2.79, SD = 1.04), showing that current resources may not be well-suited for AR integration.

Table 4

Suggestions to Solve the Problem of AR Technology Implementation

Items	Mean	SD
Providing more training and technical support will help me better use AR technology.	2.82	1.1
Schools should invest more resources (e.g., equipment, software) to support the application of AR technology.	2.89	1.08
More teaching resources that integrate AR technology with existing curriculum standards should be made available.	3.06	1.04
The establishment of a dedicated technical support team can help solve technical problems encountered when using AR technology.	3.07	1.18

Schools should provide more time and instructional design support for teachers using AR technology.	2.93	0.93

The survey responses indicate that teachers believe more support and resources are needed. The statement "Providing more training and technical support for AR technology" had a mean score of 2.82 (SD = 1.10), suggesting that educators recognize the need for training but may not have access to adequate opportunities. Investment in AR infrastructure was another key recommendation, with "Schools should invest more resources (e.g., equipment, software) in AR technology" receiving a mean score of 2.89 (SD = 1.08). Additionally, the need for better teaching materials was highlighted in "More teaching resources that integrate AR technology should be developed" (Mean = 3.06, SD = 1.04). Technical support was also a priority, as "The establishment of a dedicated technical support team for AR technology" scored 3.07 (SD = 1.18), reflecting a strong need for specialized assistance. Finally, "Schools should provide more time and instructional flexibility for teachers to explore and apply AR" had a mean score of 2.93 (SD = 0.93), indicating that time constraints are another major challenge.

DISCUSSION

The application effect of AR technology in teaching

Because of its interactive and immersive characteristics, AR technology has proven to have significant educational value in many disciplines. The survey shows that teachers generally believe that AR is effective in helping students understand complex concepts and increase engagement. Alghamdi et al. (2021) point out that the interactive capabilities of AR technology can significantly improve students' learning experience, especially for disciplines with abstract concepts, such as science and engineering, by visualizing the abstract content and enabling students to more intuitively understand the learning material. Similarly, Küçük et al. (2016) studied the impact of AR on students' cognitive load and found that AR can reduce students' cognitive load when learning complex topics and effectively improve learning efficiency and knowledge retention.

Key challenges in implementing AR technology

Although teachers are positive about the teaching effect of AR, the data reflect that they are experiencing difficulties in hardware equipment, technical support, and professional training. Limitations on these aspects suggest that the current educational environment may not be sufficient to adequately support the effective application of AR. Ivanova (2018) point out that the implementation of AR often requires high-quality hardware support and a stable network environment, and many schools have gaps in these infrastructures, limiting the promotion and application of AR. In addition, Alzahrani (2020) found that teachers need to receive specialized technical training when applying AR to meet instructional design challenges brought about by new technologies. The lack of corresponding training of teachers may lead to the great loss of the AR application effect.

Improvement suggestion

To promote the application of AR technology in higher education, educational institutions need to provide adequate technical support and resource investment. Fegely and Cherner (2023) suggested that the establishment of technical support teams and regular teacher training can effectively reduce the technical problems in the application of AR by teachers so that it can be more efficiently integrated into teaching design. In addition, research shows that to achieve the best educational results from AR, schools need to optimize curriculum design to better integrate AR technology (Jones & Smith, 2022).

CONCLUSION

The study provides a comprehensive look at the use of AR technology in higher education, revealing its potential to enhance teaching outcomes and student engagement, while also identifying key challenges in its practical implementation. Through the analysis of the data, the research points out that AR technology can provide students with a highly interactive and immersive learning experience, especially in the disciplines requiring spatial cognition such as science, engineering, and medicine. However, when teachers use AR technology, they generally encounter difficulties in equipment support, technical operation, and funds, which affects the widespread promotion of AR in education. To promote the application of AR technology in higher education, the research proposes to strengthen technical support and equipment investment, provide systematic teacher training, and increase policy and financial support. These measures not only help improve the technical literacy of teachers but also ensure that AR technology is more effectively integrated into curriculum design to meet the teaching needs of different disciplines. Future research suggests focusing on the combination of AR and artificial intelligence (AI) to further improve the personalization and interactivity of education. In addition, the study points out that a sound evaluation and feedback mechanism should be established to optimize the educational application of AR technology through regular collection of student feedback and teaching effect evaluation. Overall, this study provides a valuable reference for educational institutions and policymakers on the application status and development direction of AR technology in higher education and lays a theoretical foundation for the realization of digitalization and development of education.

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