STM JOURNALS

Journal of
Advances in Shell Programming

ISSN: 2395-6690
Volume 11, Issue 2, 2024
May–August
DOI (Journal): 10.37591/JoASP

https://journals.stmjournals.com/joasp

Review JoASP

The Double-edged Sword: Evaluating the Benefits and Challenges of AR and VR in Education

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Abstract

Incorporating augmented reality (AR) and virtual reality (VR) into education is transforming traditional learning settings by boosting interactivity, engagement, and accessibility. AR and VR technologies provide immersive experiences that transform theoretical concepts into visual and practical applications, effectively catering to various learning styles. This abstract explores the impact of AR and VR on educational outcomes, examining their applications across various disciplines, including STEM (science, technology, engineering, mathematics), humanities, and vocational training. It discusses the benefits of these technologies, such as improved retention rates, increased motivation, and the ability to simulate complex scenarios that are otherwise impossible in a conventional classroom setting. Furthermore, the abstract discusses the challenges related to adopting AR and VR, including costs, technical obstacles, and the necessity for teacher training. Through a comprehensive review of recent studies and pilot projects, this article aims to provide insights into the potential and limitations of AR and VR in shaping the future of education, highlighting the transformative power of these technologies in creating more effective and inclusive learning environments.

Keywords: Augmented reality, virtual reality, prototyping, accessible education

INTRODUCTION

Augmented reality (AR) and virtual reality (VR), commonly known by their abbreviations, are two transformative technologies revolutionizing screen usage and potentially improving various industries [1]. VR immerses users in a computer-generated environment via a headset, while AR overlays digital images onto the real world using a clear visor or smartphone. The emergence of AR and VR represents a major advancement in educational tools and methodologies [2]. With digital natives filling classrooms, educators are increasingly utilizing AR and VR to make learning more engaging, interactive, and effective. AR enhances the real world by overlaying digital information, providing students with contextually rich content that deepens their understanding of subjects. In contrast, VR offers fully immersive environments, allowing learners to explore and interact with content experientially and hands-on [3].

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Received Date: May 28, 2024
Accepted Date: July 06, 2024
Published Date: July 10, 2024

Citation: Harshit Pratap Singh, G. Soniya Priyatharsini. The Double-edged Sword: Evaluating the Benefits and Challenges of AR and VR in Education. Journal of Advances in Shell Programming. 2024; 11(2): 5–11p.

The use of AR and VR in education covers a broad range of disciplines. In STEM (science, technology, engineering, mathematics) fields, for instance, these technologies allow students to visualize complex structures in three dimensions (3D), conduct virtual experiments, and simulate real-world engineering challenges [4]. In the humanities, VR can transport students to historical sites, recreate significant events, and provide immersive storytelling experiences that deepen their comprehension and empathy. Vocational training programs benefit from realistic simulations that prepare students for hands-on tasks in a safe and controlled environment [5].

Research indicates that AR and VR can significantly improve learning outcomes by catering to various learning styles and needs. Students tend to retain information better and gain a deeper understanding when they can engage with educational content through multiple senses [6]. These technologies also foster higher levels of motivation and engagement, as the novelty and interactivity of AR and VR capture students' attention more effectively than traditional teaching methods.

Despite their potential, integrating AR and VR in education faces challenges. High costs, technical demands, and the necessity for specialized teacher training are major obstacles to widespread implementation [7]. Additionally, there are concerns regarding screen time, potential distractions, and the digital divide that may exacerbate educational inequalities.

This introduction paves the way for an in-depth exploration of AR and VR in education. It will explore the potential benefits and drawbacks of these technologies, review current applications and case studies, and consider future directions for their integration into mainstream education [8]. The aim is to provide a balanced perspective on how AR and VR can be harnessed to create more dynamic, effective, and inclusive learning environments [9].

History and Evolution of AR and VR Devices

The 1980s and 1990s saw the rise of VR in research labs and entertainment industries. However, due to limitations in technology and high costs, VR experienced a decline in popularity and the concept of AR can be traced back to the 20th century with inventions like the "Heads-Up Display" (HUD) in aircrafts and Ivan Sutherland's "Ultimate Display" concept. Later in early 2010 modern resurgence of VR began with the development of affordable, high-quality VR headsets like the Oculus Rift, HTC Vive, and PlayStation VR. In the same era, the rapid growth of smart phones and tablets led to the commercialization of AR. Apps like Layer and Pokemon Go introduced AR to a broader audience. The growth of both AR and VR lad to a new era of gaming, simulations, training, and virtual experiences [10].

AR and VR Impacting Education in Revolutionary Way

AR and VR are screen-based technologies and play a very vital role in education and in modern era use of technologies in modernization education started with evolution in technologies over the period of time. AR and VR were initially used in research labs and eventually entered entertainment [11].

AR and VR have immense potential to transform education through immersive and interactive learning experiences. Their increasing adoption in education in recent years opens up numerous opportunities to impact technology-enhanced learning. AR and VR introduce students with digital experiences which are necessary in modern education and cannot be replaced by traditional methods. Hers is a detailed elaboration on how AR and VR are impacting education.

1. *Engage students in learning environment:* AR and VR can create highly engaging learning environments by transporting students to virtual worlds or overlaying digital content onto the real world. This approach captures students' interest and fosters a more profound engagement with the subject matter [12].
2. *Visualization of complex concepts:* AR and VR can help students visualize difficult concepts easily. For example, in science classes student can explore the solar system in VR, manipulate 3D models of different things in AR. This makes learning more memorable.
3. *Learning by doing:* Using VR goggles allows students to learn through hands-on experience. The realistic experience provided by AR and VR devices help students virtually experiencing the concepts and develop and clear understanding for long lasting and memorable learning.
4. *Presentations enhancement:* Both presenters and students delivering educational presentations can use AR to convey messages and engage the audience by making them an integral part of the presentation. For instance, they can highlight specific concepts or graphics during a lesson.

5. *Prototyping:* AR can be utilized in prototyping. For instance, students might use CAD (computer-aided design) modeling to enhance engagement with specific concepts. Additionally, AR serves as a valuable tool for teaching UX-UI (user experience–user interface) design.
6. *Research and development:* Universities and different companies use AR and VR in research work. AR and VR initially came in research labs and only later at the educational level. It made its space in higher education as well.
   At present, most of the universities and companies are using these innovative technologies in different ways as per their requirement.
7. *Training and learning:* Training and learning are very important aspects of any form of education or businesses. AR and VR are widely accepted for training and learning purpose and it is used in most of the companies and universities to effectively develop skills in learners.
8. *Innovative teaching methods:* Teaching is the most important factor of any educational body. We use various methods to enhance teachings skills to facilitate students or learning to develop a better level of understanding about the given content. Educators can use AR and VR to implement creative teaching approaches that enhance student interest in learning.
9. *Real-world skills:* AR and VR can help in developing real world skills by simulating real-world scenarios. AR and VR helps students develop various practical skills in many fields and industries.
10. *Customized learning:* By using AR and VR various applications can be tailored to meet individual learning needs, offering personalized learning experiences that adapt to student's pace, preferences, and learning styles.
11. *Safe experimentation:* VR provides a safe environment for students to conduct experiments, simulations, or field trips without any risk. This helps them understand the concept easily and safe experiments help students to create new things. It also improves hands-on learning opportunities in subjects such as science, history, and geography.
12. *Multisensory learning:* By incorporating visual, auditory, and sometimes tactile stimuli, AR and VR engage multiple senses. which enhances retention and understanding of education content.
13. *Personalized learning:* AR and VR technologies can adjust to individual learning styles and preferences, providing personalized learning experiences tailored to each student's needs and pace of learning. By the use of this technology, every student can grow and learn in the way they want for better tomorrow.
14. *Hands-on exploration:* AR and VR provide opportunities for hands-on exploration of complex concepts, enabling students to manipulate virtual objects, and interact with simulations in a safe and controlled environment.
15. *Accessible education:* These technologies enhance educational accessibility for diverse learners, including those with disabilities or learning differences, by providing alternative instructional methods and eliminating geographical barriers.
16. *Collaborative learning:* AR and VR platforms facilitate collaborative learning experiences, enabling students to interact with peers and educators in shared virtual spaces, strengthening teamwork, communication, and problem-solving skills.
17. *Preparation for future careers:* By exposing students to emerging technologies like AR and VR education prepares them for future careers in fields where these technologies are increasingly used, such as healthcare, engineering, architecture, and digital design.
18. *Continuous innovation:* The integration of AR and VR encourages continuous innovation in teaching practices and curriculum development, as educators explore new ways to leverage these technologies to enhance teaching and learning experiences.

Above we saw the positive effects of AR and VR in education, whether it is for research purpose or for creative learning and overall development of students. We saw almost 18 different aspects in which AR and VR is positively impacting the education fields and rather revolutionizing education. But technology is always useful and dangerous for us. AR and VR are screen-based technologies, they can help students in numerous positive ways and at the same time they can make them gaming addicts, harm their health, and adversely affect them [13].

Negative Effects of AR and VR in Education

AR and VR undoubtedly offer numerous benefits in education, but they can also present some challenges that need to be addressed. One significant concern is potential for over-reliance on technology, which could lead to a reduction in creative as well as critical thinking and problem-solving skills [14]. Students may end up passively consuming content instead of actively participating in the learning process. Apart from this the risk of physical discomfort or even health issues such as eye strain, nausea, and headaches, particularly with prolonged use of VR headsets. Additionally, the initial cost of implanting AR and VR technology in educational settings can be prohibitive for many institutions, limiting access for students from lower-income backgrounds [15]. Lastly, there is the issue of the privacy and data security, as these technologies often collect sensitive information about users, raining concerns about how that data is stored and used. It is crucial to address these challenges to ensure that AR and VR technologies are implemented in education responsibly and ethically, maximizing their benefits while minimizing their negative impacts.

Here are some key points about how AR and VR negatively affects students and learners:

1. *Isolation:* Prolonged use of VR can lead to a sense of isolation, as students may become detached from the real world and face-to-face interactions. This is one of the most concerning issues, and the bad effects of AR and VR isolation are very serious. Due to personalized use of AR and VR devices of students in their personal space, the social interactions with fellow students get reduced and affects overall personality of learners as well and develops social anxiety in learners [16].
2. *Physical discomfort:* As already mentioned above in general negative effects of AR and VR devices, physical discomfort is also very alarming and hence it too cannot be ignored. Extended use of VR headsets can cause physical discomfort such as eye strain, headaches, and motion sickness, which may hinder learning experiences [17].
   Excessive use of any technologies or depending too much on any technology may cause severe health issues whether it is about students or about people who are working.
3. *Cost causing educational inequalities:* Implementing AR and VR technologies in education can be costly and hence it may be inaccessible for many schools and students, exacerbating educational inequalities. As we know, government in India must provide free and fair education to every child below 14 years of age under the fundamental right – Right to Education – but it is very well known such technologies are hardly used in schools which are charging in lakhs. Then how can these be expected to be widely installed in government schools? Millions of students in India are dependent on government schools and remain unaware of such technologies.
4. *Distraction:* It will be very unfair if we neglect the distraction factor developed due to technological dependency in students. Immersive experiences in AR and VR can sometimes distract students from the learning objectives, as they may become more focused on the technology itself rather than the educational content.
5. *Limited content:* The availability of educational content in AR and VR formats may be limited, leading to a lack of diversity in learning experiences and subjects covered.
6. *Ethical concerns:* The most terrifying concern of modern era is misuse of the data provided by them to certain digital platforms. AR and VR technology raise ethical issues, such as concerns about privacy involving data collection and surveillance in virtual learning environments.
   These points highlight some of the challenges and negative effects associated with integrating AR and VR into educational settings [18]. Now as we all know the positive as well as few negative effects of AR and VR in education, it is also very important to know the use of AR and VR in different educational bodies point wise to understand how much this technology has made its space in modern education era and how much is still left to achieve.

Here are some educational bodies and institutions utilizing AR and VR in modern education [19]:

1. *Harvard University:* Harvard has incorporated AR and VR technologies into various departments, including where students use VR simulations for surgical training and anatomy lessons.

2. *Stanford University:* Stanford utilizes AR and VR in fields like engineering and computer science, offering virtual laboratories and simulations to enhance hands-on learning experiences.
3. *MIT (Massachusetts Institute of Technology):* MIT employs AR and VR technologies across multiple discipline, including architecture, where students can visualize and interact with complex designs in virtual environments [20].
4. *University of California, Berkely:* University of California, Berkeley integrates AR and VR into its curriculum, particularly in subjects like history and archaeology, allowing students to explore historical sites and artifacts in immersive virtual settings [21].
5. *Educational Technology Companies:* Companies like Google, Microsoft, and Oculus (owned by Facebook) develop AR and VR educational applications and platforms used by schools and educational institutions globally [22].

Flowchart of implementation proposal on VR and AR: The flowchart typically outlines the steps and processes involved in introducing these technologies into a particular context, such as a classroom, workplace, and training programs (Figure 1).

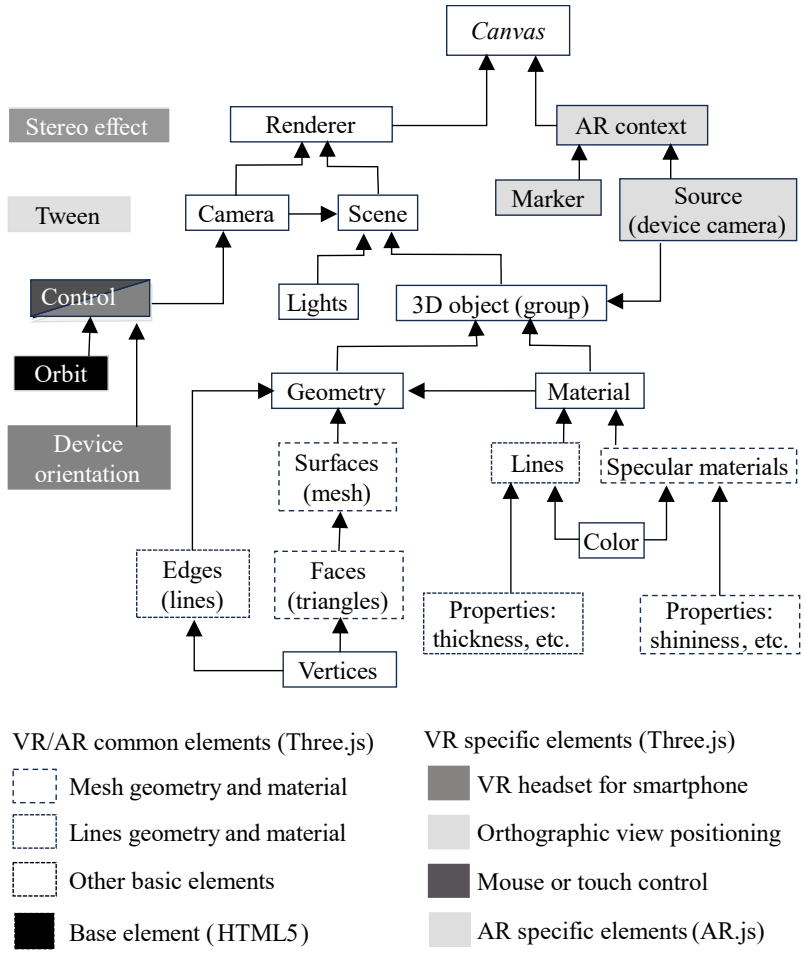

Figure 1. Flowchart of introducing augmented reality (AR) and virtual reality (VR) in workplaces.

CONCLUSION

Tools such as VR and AR have been incorporated into learning objects across various fields of knowledge. However, many teachers still face challenges in content development. The flowchart presented in this study aims to assist teachers with limited computing experience in creating internet applications. This method can be replicated and adapted for new learning objects and similar projects

involving VR and AR. The proposed learning object, utilized as a case study, is applicable across various higher education courses that incorporate technical drawing, including architecture, design, and engineering. Successful implementation of this learning object demonstrates the potential to expand its use to other topics within technical drawing and beyond. Given its nature, the learning object can also be shared with educational institutions in different geographical locations.

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