

## Augmented and Virtual Reality (AR/VR) for Education and Training: An Overview

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### Abstract

Augmented and virtual reality (AR/VR) technologies are transforming the way education and training are delivered. AR/VR provides an immersive experience that engages students and allows them to interact with digital content in a way that feels real. The use of AR/VR in education and training offers a wide range of benefits, including enhanced learning experiences, visualization of complex ideas, interactive and engaging teaching, virtual field trips and simulations, gamification of learning, and improved accessibility for differently-abled students. AR/VR can also break down language and cultural barriers and promote collaborative learning, personalized and customized education. With the growing availability of AR/VR technologies and advancements in hardware and software, the use of AR/VR for education and training is likely to become increasingly widespread in the coming years.

**Keyword:** Augmented Reality, Virtual Reality, Education.

### المخلص:

تعمل تقنيات الواقع المعزز والافتراضي (AR/VR) على تغيير طريقة تقديم التعليم والتدريب. يوفر AR/VR تجربة غامرة تشرك الطلاب وتسمح لهم بالتفاعل مع المحتوى الرقمي بطريقة تبدو حقيقية. يوفر استخدام الواقع المعزز/الواقع الافتراضي في التعليم والتدريب مجموعة واسعة من الفوائد، بما في ذلك تجارب التعلم المحسنة، وتصور الأفكار المعقدة، والتدريس التفاعلي وال جذاب، والرحلات الميدانية الافتراضية وعمليات المحاكاة، وألعاب التعلم، وتحسين إمكانية الوصول للطلاب ذوي القدرات المختلفة. يمكن للواقع المعزز/الواقع الافتراضي أيضاً كسر الحواجز اللغوية والثقافية وتعزيز التعلم التعاوني والتعليم الشخصي والمخصص. مع تزايد توافر تقنيات AR/VR والتقدم في الأجهزة والبرمجيات، من المرجح أن يصبح استخدام AR/VR للتعليم والتدريب واسع الانتشار بشكل متزايد في السنوات القادمة.

الكلمات المفتاحية: الواقع المعزز، الواقع الافتراضي، التعليم

## 1. Introduction

Augmented Reality (AR) and Virtual Reality (VR) are two of the most innovative technologies that have the potential to revolutionize the way education and training is delivered. (Al-Ansi, Abdullah M., et al., 2023).

AR adds digital elements to the real world, while VR creates a completely immersive and interactive digital environment. Both AR and VR provide new opportunities for students to interact with and understand complex concepts, allowing them to engage with learning materials in new and exciting ways.

In education and training, AR/VR can be used to provide hands-on, interactive experiences that foster greater understanding of difficult topics, making learning more engaging, memorable, and effective. It also enables teachers and trainers to create immersive simulations and virtual field trips, providing students with experiences that may be difficult or impossible to replicate in the real world. With AR/VR, education and training can become more accessible, inclusive, and personalized, breaking down traditional barriers and allowing for greater student engagement and collaboration. The technology is still in its early stages, but its potential for transforming education and training is vast, and its use is likely to become increasingly widespread in the future.

Milgram P, et al, 1995 as shown in Figure 1, introduced the concept of the Reality-Virtuality Continuum, wherein conventional reality occupies one end, and entirely computer-generated or VR-based virtual environments occupy the opposite end. Transitioning from the reality side to the VR side involves passing through augmented reality (AR), and moving from VR towards reality situates us in augmented virtuality (AV). The spectrum between AR and AV is referred to as mixed reality (MR). MR not only facilitates user interaction with virtual environments but also enables physical objects from the user's immediate surroundings to become elements for interaction with the virtual environment. MR encompasses applications that go beyond both VR and AR, such as those designed to present a virtual scene for broadcasting the weather forecast, featuring a real human within it.

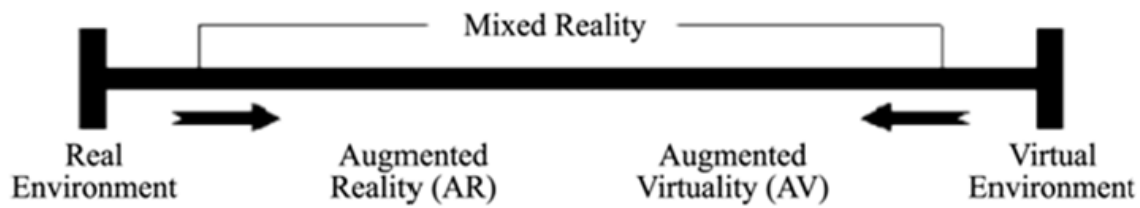


Fig. 1 Virtuality continuum [Milgram P, et al, 1995]

Augmented reality (AR) is an emerging technology that integrates digital information, such as text, images, videos, and 3D objects, into the real world. The term “Augmented Reality” was first proposed by Boeing employees in 1990 (Akçayır, 2017).

Until 1997, Azuma published the first report about AR and proposed a definition of AR which was widely cited (Akbulut, et al, 2018).

The definition of AR in the report included three elements (Figure 2):

- (a) A connection between the virtual world and the real world;
- (b) real-time interaction; and
- (c) 3D-based tracking and positioning. Since then, AR started its explosive development.

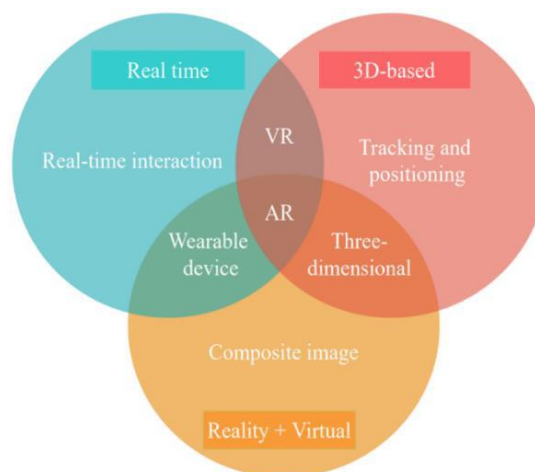


Fig. 2 Three elements of AR summarized from the studies of Azuma [Akbulut, et al, 2018].

Table 1 Augmented Reality vs Virtual Reality

Categories	Augmented Reality (AR)	Virtual Reality (VR)
Definition	Technology that overlays virtual objects onto the real world	Technology that immerses users in a completely virtual environment
User experience	Users see virtual objects overlaid on top of the real world	Users are fully immersed in a virtual environment and cannot see the real world
Hardware	AR can be used on smartphones, tablets, smart glasses, and other devices	VR requires specialized hardware such as headsets or goggles
Use cases	AR can be used in a wide range of applications including education, marketing, gaming, and manufacturing	VR is mainly used for gaming, entertainment, and training
Interactivity	AR can be interactive and responsive to the real world, and can include real-time data and information	VR can be interactive, but is limited to the virtual environment
Realism	AR is less immersive than VR, as it still allows users to see the real world	VR can be highly immersive and can simulate a wide range of experiences
Cost	AR technology is often more affordable and accessible, as it can be used on devices that users already own	VR hardware can be expensive and requires specialized equipment
Potential drawbacks	AR can be distracting and may not be suitable for all applications	VR can cause motion sickness and may not be suitable for all users
Learning outcomes	Enhancing enjoyment, raising the level of engagement and the learning interest, which suggests that students will, therefore, perform better.	Increase in user skills and increase in engagement/motivation. Small effect: Game-based instruction has more impact than simulation-based instruction.

Table 1 shows some differences between Augmented reality and Virtual reality with main subject of categories. In summary, while both AR and VR provide users with a unique and immersive experience, they differ in their approach and application. AR is designed to enhance the real world by overlaying virtual objects and information, while VR is designed to provide a fully immersive and virtual experience. The choice between AR and VR depends on the specific use case and the desired user experience.

## 2. Related Works:

Table 2 contains examples of prior studies exploring various facets of virtual and augmented reality. This study distinguishes itself from earlier research by conducting a thorough examination of research articles cataloged in the Scopus some database from 2008 to 2022. It specifically focuses on investigating trends, recent developments, and research related to virtual and augmented reality in education, with an emphasis on the period encompassing the Covid-19 pandemic and beyond.

Table 2 Related works to VR & AR in Education in some recent years

Reference	Subject	Method	Findings
Coffin et al. (2008)	VR in Education	Software Analysis	Provide instructors with a way to strengthen students' understanding in the classroom by augmenting physical props with virtual annotations and illustrations
Rafał Wojciechowski et al (2013)	Supported learning approaches	Experimental Study	The use of AR environments during lessons could provide extra motivation to learn for young students
Boyles (2017)	VR & AR in Education	Review	Describing usage of AR & AR in enhancing learning and reviewing advantages and disadvantages.
Nguyen and Dang (2017)	Setting up VR & AR learning environment	Designing Model	Designing 3D framework for curriculum based on VR & AR presetting real-world objects
Rau et al. (2018)	Speed reading on VR & AR	Survey	Exploring performance on VR & AR where response time was longer on VR and AR than desktop
Beck (2019)	Immersive learning	Special issue	Integration of technologies including AR & VR to enhance learning environments.
Huang et al. (2019)	AR & VR in Education	Exploratory Study	Virtual reality is more inclusive of spatial presence while augmented reality is more effective in dealing with auditory information
Pellas, N., et al (2020)	STEM education	Scoping reviews	The findings demonstrated the feasibility of employing various devices capable of creating virtual reality applications to enhance instructional design settings.
Sirohi et al. (2020)	Augmented & Virtual Reality applications	Survey	An interdisciplinary review of integration of VR & AR in different area and directions.
Patel et al. (2020)	VR, AR & mixed Reality in education	Survey	Overview VR, AR and Mixed Reality in education and ability of people adaptation of these technologies.
Rashid, S., et al. (2021)	Higher education	Bibliometric analysis	The research ends by asserting that virtual reality is no longer a fanciful or hypothetical technology; rather, it is highly practical and an essential component of the

Reference	Subject	Method	Findings
			present era. The study highlights the considerable untapped potential of VR for exploration, comprehension, and experimentation.
Cieri et al (2021)	Visual and Augmented Reality	Descriptive & case studies	Describing recent VR/AR software, hardware and techniques in pedagogy.
Remolar et al. (2021)	Learning throughout VR & AR	Several Experiments	Supporting gameplay and attractiveness and increasing student's interest to learn.
Scavarelli et al. (2021)	VR and AR in Social Learning	Literature Review	Exploring the recent developments of VR & AR in Social space and several learning theories.
Guo et al. (2021)	Extended Reality (XR) in Education	bibliometric analysis	Exploring the overall productivity of XR and recent development and trends in educational field.
Zwoliński et al. (2022)	Extended reality in management education	Case Studies	Creating a modal for XR-based educational environment by utilizing different XR technologies
Solmaz and Van Gerven (2022)	Integration of extract-based CFD of AR & VR	Architecture Modal	Proposing a component-oriented system architecture and Data simulation with AR/VR
Olbina and Glick (2023).	Integration of AR & VR in Construction Management	Physical model	Improving visualization, improvement in understanding of construction material and improved student communications skills

### 3. Augmented Reality objectives

The objectives of Augmented Reality (AR) vary depending on the context in which it is used. However, some common objectives of using AR technology include:

1. Enhancing the user experience: AR is used to enhance the user's experience by providing a more interactive and immersive experience. By overlaying virtual information onto the real world, AR can provide a more engaging way to interact with the world around us. (Senthilvel S., et al, 2019).
2. Improving learning outcomes: AR can be used in education to improve learning outcomes by providing a more interactive and engaging learning experience. By using AR, students can explore and understand complex concepts in a more tangible and relevant way. (Koparan T., et al, 2023).

3. Increasing sales and marketing: AR can be used in sales and marketing to provide a more engaging and interactive way for customers to interact with products and services. By using AR, companies can create a more memorable and personalized experience for their customers. (Tan, Y. C., et al, 2022).

4. Enhancing safety and training: AR can be used in safety and training to provide a more realistic and immersive training experience. By using AR, trainees can practice and learn in a safe and controlled environment, reducing the risk of injury or mistakes in high-risk situations. (Kamal A., et al, 2021).

5. Improving productivity: AR can be used in manufacturing and other industries to improve productivity by providing workers with real-time information and instructions. By using AR, workers can access information hands-free and improve their accuracy and efficiency. In general, the objectives of using AR technology are to enhance the user experience, improve learning outcomes, increase sales and marketing, enhance safety and training, and improve productivity. By achieving these objectives, AR has the potential to revolutionize the way we interact with the world around us and provide a more immersive and engaging experience. (Sitompul, T. A, et al, 2019).

#### **4. Benefits of using VR/AR in Education**

To recognize the benefits of incorporating VR/AR technologies in education, we turn to the wisdom of a Chinese Proverb: "Tell me, I'll forget; show me, I'll remember; involve me, I'll understand." Unlike traditional education methods that lean toward "telling" learners rather than "involving" them, educational VR/AR applications offer significant advantages by allowing learners to visualize and interact with objects, thereby engaging them in the learning process. According to Siegle (2019), VR and AR offer students the opportunity to explore and learn in environments beyond their physical reach. These technologies allow access to world-famous museums, virtually bringing dangerous or extinct animals into students' surroundings for examination, and facilitating safe conduct of hazardous science experiments without any real-life risks. Pantelidis (2010) outlined various advantages of using VR (and, by extension, AR) in education, such as heightened motivation, improved attention retention, the ability to closely examine digital objects, and fostering active participation rather than passivity. Overall, VR and AR foster a constructivist approach to learning, enabling learners to learn by actively

doing and experiencing. However, despite these advantages, several issues hinder the full exploitation of these technologies in teaching and learning.

## 5. Barriers in using AR/VR in Educational Settings

In 2019, Elmqaddem pointed out that Virtual Reality (VR) and Augmented Reality (AR) are not novel technologies, but their widespread adoption has been hindered by various constraints. One major obstacle, as highlighted by Boyles in 2017, has been the high cost of these technologies, which has limited their use in education to mainly experimental studies. Pantelidis (2010) also acknowledged that there are challenges associated with using VR, including the costs involved, the time required for users to learn how to use the hardware and software, potential health and safety concerns, and the reluctance of some educators to integrate new technology into their courses. However, Pantelidis further suggested that like any emerging technology, these challenges might diminish with time, leading to the integration of VR/AR becoming more commonplace in education. A decade has passed since Pantelidis made this observation, and it would be interesting to examine recent research over the last five years to identify any trends in the effectiveness of VR/AR for education. This analysis could also shed light on whether certain challenges have persisted or gradually been overcome.

## 6. Summary and Remarks

Augmented Reality (AR) and Virtual Reality (VR) have the capacity to transform the realm of education and offer students a more immersive and captivating learning encounter, potentially changing the way we learn. The potential of these technologies has the power to reshape the landscape of education, ushering in greater advantages for students, educators, and educational institutions.

Augmented Reality (AR) has great potential as an educational tool that can enhance the learning experience and engage students in a more interactive and immersive way. By overlaying virtual information onto the real-world environment, AR can provide students with a more engaging and interactive way to explore and understand complex concepts. AR can be used in a variety of educational contexts, such as in science, history, art, and geography, to provide students with virtual field trips, simulations, and experiments that are difficult or impossible to experience in the real world. It can also help to bridge the gap between abstract concepts and real-world examples, making learning more tangible and relevant. However, the



successful integration of AR in education depends on several factors, including the availability of AR technology, access to quality AR content, teacher training and support, and careful consideration of the learning objectives and pedagogical approaches used. Therefore, it is important to approach the use of AR in education with a well-planned strategy that considers the needs of students and the educational context. Overall, AR has the potential to revolutionize education by providing a more engaging and interactive learning experience that enhances student understanding and retention of complex concepts. As AR technology continues to advance and become more widely available, it is likely that we will see more and more educational applications of this exciting technology.

we can anticipate a sustained surge in enthusiasm for integrating augmented reality (AR) and virtual reality (VR) systems into education, particularly in the context of teaching and learning at higher education institutions. This trend is likely to persist, given that these systems can effectively enhance students' skill development for future employment and contribute to the facilitation of remote communication, control, and management systems.

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