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Virtual Reality in Education: Opportunities and Challenges

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Abstract

Virtual Reality (VR) is a cutting-edge technology that generates immersive, interactive, three- dimensional environments in which users can engage in simulated experiences. VR, which first gained popularity in the entertainment industry, is now being used in a variety of fields, including education and professional training. In educational contexts, virtual reality is emerging as a strong tool for teaching, exploration, and self-discovery. It promotes individualized learning, encourages creativity, and improves conceptual understanding through dynamic and interactive 3D models. Immersing kids in virtual settings allows for deeper comprehension and memory retention. It fosters personalized learning, ignites creativity, and enhances understanding through interactive 3D models. This paper presents an overview of VR's impact on education, addressing both its benefits and potential drawbacks. It emphasizes the positive impact VR plays in many educational environments, with a special focus on its applications in STEM (Science, Technology, Engineering and Mathematics education. Furthermore, the article investigates future approaches for integrating VR into learning environments and outlines important problems that must be overcome to fully realize its revolutionary potential. Overall, this review provides a thorough examination of how virtual reality is affecting the future of education, presenting chances to improve learning outcomes for students across various age groups and academic fields.

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Introduction

Virtual reality is an emerging technology that delivers a computer-generated simulation of an environment that may be interacted with in an apparent real-time manner. VR technology has been employed in a variety of industries, including medical training, engineering and entertainment, but it also has significant educational potential (Bendeck *et al*.,2020). VR technology in education allows learners to interact with real-life scenarios without leaving the classroom. One of the primary advantages of implementing VR in education is that it provides a more immersive and engaging learning experience (Megat *et al.,* 2020). VR can transport learners to difficult-to-access places, such as historical monuments, outer space or even within the human body. Students are able to better understand the subject and engage with the learning material when they are given a unique perspective.

Xie Biao *et al*. (2021). Have provided a review of the use of VR in the training domain. The relative effectiveness of VR-based training and non-VR traditional training such as videos is still being investigated. VR is also being effectively used in the architectural, automotive, and aerospace design to understand the spatial relations between the various aspects/components of the environment being designed. It is expected that VR would eventually find its implementation at higher abstraction levels than procedural and skills training. Instead of arranging physical models or field trips, educational institutions can generate a virtual environment that can be accessed by multiple students simultaneously. Moreover, technology can create a secure and regulated learning environment for students, particularly when working with complex machinery or hazardous materials.

The use of VR in education has the capability to revolutionize the learning experience for students through immersive and captivating encounters that can enhance their comprehension of the subject (Meyer *et al*., 2019). Providing an interactive VR experience has the potential to connect theoretical concepts with practical applications, thereby equipping students with the confidence to face future challenges. With the continuous advancement of technology, it is highly probable that VR will become an essential component of the education system, offering students a potent means to amplify their learning.

The relevant literature section provides a summary of various studies that have explored the use of virtual reality (VR) technology in education. (Leung *et al*.,2018). Examined how VR-based learning environments could support different learning

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theories, such as constructivist learning theory and social cognition theory. Chen focused on how VR technology can be used to enhance learners' engagement and participation in the learning process, particularly in the context of constructivist learning Checa and Bustillo (2020) conducted a review of proposals for serious games in immersive VR environments and provided recommendations for improving these tools. (Radianti *et al*., 2019) analyzed the existing research on the use of immersive virtual reality (IVR) in higher education and highlighted its potential for creating engaging learning environments. Overall, the relevant literature suggests that VR technology can provide immersive and engaging learning experiences and understanding learning theories can aid in designing effective VR-based learning interventions. This study aims to review recent research on the application of learning theories in VR-based education, conducting a thorough analysis of each learning theory and educational approach across different educational levels.

In their study Leung *et al.* (2018) analyzed the impact of VR technology on learning theories in education. The authors discussed four prominent learning theories, namely constructivist learning theory, situated learning theory, embodied cognition theory and social cognition theory, and they presented how these theories could be implemented in VR-based learning environments. Additionally, the authors demonstrated how VR-based learning environments could provide opportunities for learners to experience immersive and interactive learning situations, which can facilitate the application of these learning theories. For example, VR technology can create a virtual environment that closely mimics real-world situations, allowing learners to engage in active learning and knowledge construction. Additionally, VR-based learning environments can provide learners with social interaction opportunities, facilitating the application of social cognition theory. Overall, (Leung *et al*.,2018) study shed light on the potential of VR technology to enhance learning in education and provided insights into how established learning theories could be applied in VR-based learning environments.

Additionally, Chen (2009) examined how VR technology can be utilized to support constructivist learning principles. Specifically, the article emphasizes how VR's technical abilities can improve learners' participation and engagement during the learning process. The article introduces the VRID model as a way to provide clear instructions on designing and developing virtual learning environments that align with the principles of constructivist learning.

In their review Checa and Bustillo (2022) examined 135 proposals for serious games in immersive VR environments. The review analyzes the forum, nationality and date of publication of the articles, as well as the application domains, target audience, design, technological implementation, performance evaluation procedure and results. The aim is to identify the standards of the proposed solutions and differences between training and learning applications and provide recommendations for the improvement of these tools. The study provides a basis for future research on serious games in immersive VR environments, which can enhance both learning and training tasks.

Virtual Reality in Education

Virtual reality, or VR, is taking off in education with an increasing number of schools adopting the technology. VR allows students to experience destinations from across the world without ever having to leave the classroom (Hamilton *et al*.,2021). Imagine students being able to explore the pyramids of giza whilst sat at their desks. This is what virtual reality education allows. Virtual reality technology can provide students fun, interactive learning experiences that can help them better understand and retain complicated ideas. Students can study and interact with things and phenomena that might be challenging or impossible to access in a regular classroom setting by using VR to imitate real-world surroundings. Additionally, VR enables design adaptive and personalized learning experiences that are tailored to the needs and learning preferences of certain students.

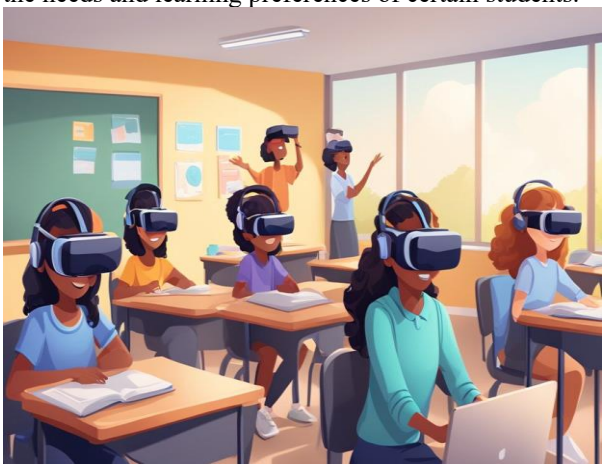

Figure 1. Shows a cross-section of student in the classroom with virtual reality headset

Although virtual reality (VR) technology in education is still very young, it has already showed promise in terms of increasing student engagement, motivation, and retention and has the potential to revolutionize both teaching and learning. Therefore, it is crucial to investigate VR's effects on education, as well as its

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possible advantages and drawbacks. By enabling immersive and engaging educational experiences, virtual reality (VR) technology has the potential to completely transform how we teach and learn. Virtual reality (VR) can give students the chance to explore abstract ideas and real-world situations that are difficult or impossible to replicate in a typical classroom setting. For instance, VR in science classes can give students a more participatory and interesting approach to understand complicated scientific topics like the human body or the operation of the solar system

How does VR work?

A type of VR known as 360VR is most commonly used in education. With this type of VR, real-world locations are captured with specialist cameras and equipment. The footage is then taken back to the studio where it is produced into VR content. The VR content can then be viewed on VR headsets or projected onto walls in what are known as immersive classrooms.360VR can be used in education to teach pupils about the world around them. What's more, virtual reality has a unique ability to inspire and engage students. Students can experience locations that would not be possible or too expensive to visit in person. In this way, VR can open a whole new world of possibilities to teachers and schools.

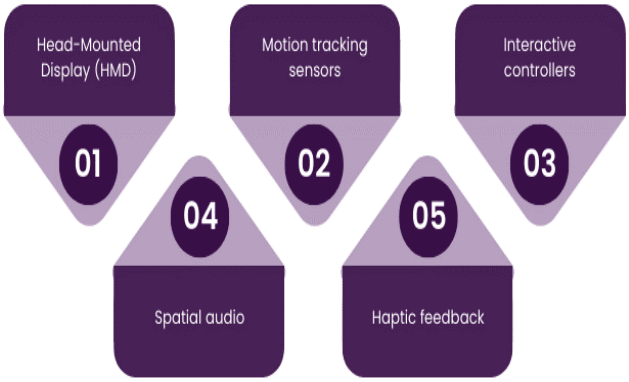

Figure 2 shows how virtual reality works

The Effectiveness of Virtual Reality in teaching STEM subjects: Science, technology, engineering, and math (STEM) subjects can be taught and learned in better ways thanks to virtual reality technology. Through immersive and interactive learning experiences that mirror real-world situations, virtual reality can provide students the chance to explore and interact with complicated ideas in a way that is more fun and memorable. In STEM topics, Bennett *et al.* (2019) opined that virtual reality can help students visualise and engage with abstract ideas that could be challenging to understand through conventional teaching approaches. For instance, VR can help students learn about the characteristics of electromagnetic fields or the behavior of subatomic particles in physics. Students in engineering can create and test prototypes in a virtual environment using virtual reality which allows them to iterate and improve their designs more quickly and effectively than in a physical laboratory.

Virtual Reality and Immersive Learning: One of the most common and effective ways of utilizing VR in education is via virtual reality classrooms, or immersive classrooms. An immersive classroom is a teaching room in which images are projected onto the internal walls of the room. This creates a virtual environment within the classroom. The immersive aspect of VR offers students a highly dynamic and engaging learning environment that can improve learning outcomes (Moher *et al.,* 2009). VR can help to establish a sense of presence and immersion by immersing pupils in a realistic and immersive environment, which can enhance memory recall and knowledge retention. Additionally, VR can help students practice and apply topics in a simulated setting, enabling them to gain knowledge and practical skills. VR simulations, for instance, can allow students to practice surgical operations in a secure and controlled setting during medical training, assisting them in developing the skills required for real-world application. It is crucial to take the learning objectives into account while creating efficient VR experiences and to match the latter with the former. Students should have the chance to practice and apply topics in a realistic and immersive setting as part of the VR experience.

Virtual field trips: Academic studies have long since championed the benefits of using immersive technology to enhance the learning experience, and virtual field trips represent a cost-effective way for students to visit real-life locations across the world. Instead of reading about Ancient Greece from a textbook, users are able to visit the Acropolis of Athens and the Parthenon in virtual reality.

Not only can virtual field trips provide an enjoyable experience away from the classroom, research has shown it has the ability to improve students' intrinsic motivation to learn. Replace lectures and non-interactive tools with virtual engagement and participation, and students find new ways of connecting with the material.

Virtual field trips also provide the added advantage of increased accessibility; a much cheaper alternative than visiting far-off destinations that might otherwise test a school's budget.

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Figure 3 VR headsets bringing engineering closer to the student

How can virtual reality help students?
There are so many ways in which virtual reality can help students but the main points are below:

Students learn better through experience: VR provides students an opportunity to learn through experience, in contrast to the traditional methods of reading and writing.

VR has the ability to inspire: Being able to see and experience extraordinary locations within the classroom is completely unique to VR and it is inspirational to students.

VR sparks the imagination and encourages creative thinking: The immersive experience that VR provides is unparalleled in teaching. Students are "transported" out of the classroom and their imagination is allowed to flourish.

VR in education promotes peer interaction: Throughout the VR experience, students are encouraged to interact with each other. Afterwards, they are eager to share their thoughts and discuss their experiences.

VR engages students: Many students get bored with classic teaching methods. The modern technology of VR gets students' attention like nothing else. We find that students instantly want to try out the VR.

VR provides realistic travel experiences: Using VR, schools can provide students with travel experiences that would not be possible or practical. Schools can save time and money whilst providing students with incredible experiences.

VR in the classroom is inclusive: With VR, every student gets the same opportunity to enjoy the experience. Unlike traditional school trips that can be too expensive for parents or too impractical for their children, VR is for all students.

VR offers memorable educational experiences: Long after the VR has finished, students remember the experience and they are eager to reflect on it in future

Drawbacks of VR in Education: The practical implementation of virtual reality in the classroom is an expensive process. One must consider the initial costs of purchasing the devices and the ongoing costs of training for teachers and school personnel. For this reason, schools with limited budgets may not make VR a priority.
Due to these limitations, VR technology must improve to become widely available in schools and other institutions. However, the cost of these systems has decreased as time goes by and is becoming more and more affordable.
Key stakeholders at all education levels must carefully consider how to implement VR tools in the curriculum. Understanding how VR can contribute to achieving the pedagogical goals of the lesson is a crucial aspect of successful implementation. VR needs to be part of a broader plan that includes many ways to encourage students to learn and experiment.
Something that educators and decision-makers alike need to keep in mind when using VR in the classroom is the potential for the exclusion of non-VR users. Reasons such as motion sickness and various visual or auditory impediments may make it challenging or impossible for some students to participate in VR-based class activities. It is vital to ensure equal access to this technology to all students to ensure that they have a positive experience in the classroom and that they achieve their learning potential.
As previously mentioned, the cost of the investment in VR equipment can be a barrier, especially for educators in low-income areas. Alternative methods of access to VR content should always be available to ensure that all students have the same learning possibilities.

Conclusion
Virtual Reality (VR) is revolutionizing the educational landscape by offering immersive, interactive, and highly engaging learning experiences. It holds tremendous potential to transform traditional teaching methods by enabling students to explore complex subjects, practice real-world skills in safe environments, and learn at their own pace. From virtual field trips to medical simulations and 3D visualizations of abstract concepts, VR opens doors to new and more effective ways of learning that were previously unimaginable. However, the adoption of VR in education is not without its challenges. High

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implementation costs, limited access to advanced technology, lack of teacher training, and concerns about screen time and physical health are significant barriers. Additionally, the development of quality, curriculum-aligned VR content remains a work in progress. While virtual reality presents remarkable opportunities for enhancing educational outcomes, its successful integration requires careful planning, investment, and support. To fully leverage VR's benefits, educators, policymakers, and technology developers must work collaboratively to address the challenges, ensuring equitable access and effective use of this transformative technology in classrooms worldwide.

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