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AUGMENTED REALITY (AR) AND VIRTUAL REALITY (VR) IN MODERN EDUCATION

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Annotation. This article considers the use of Augmented Reality (AR) and Virtual Reality (VR) in teaching with a focus on more known and effective tools. The case studies involve virtual field trips such as Google Expeditions, STEM simulations (e.g. Labster, GeoGebra, CoSpaces etc.), as well as some medical training (Human Anatomy VR). It also analyzes how such technologies increase motivation, retention, and interdisciplinary learning. Other challenges, such as availability and ethical advances, are also analyzed and supported by evidence and authoritative sources.

Keywords: AR/VR in education, validated technologies, applied STEM immersion, medical education, inclusivity in education.

Introduction. The incorporation of Augmented Reality (AR) and Virtual Reality (VR) into education creates a whole new level of interest in studying. Being interactive and active technologies, these methods facilitate experiential learning as students can practically see and visit historical sites, conduct scientific experiments, and visualize many other processes. At the same time, issues like cost, infrastructural demand, and how to integrate them in the curriculum still exist [1].

Main part. Education in STEM fields is rapidly evolving, and AR/VR offer methods where students learn through doing. For instance, «Labster» is a widely accepted virtual reality platform with over 200 different interactive simulations ranging from genetics and chemistry to physics. It combines gamification elements such as an immersive 3D environment, storytelling and a scoring system that stimulates students' natural curiosity and highlights the connection between science and the real world (shown in Figure 1).

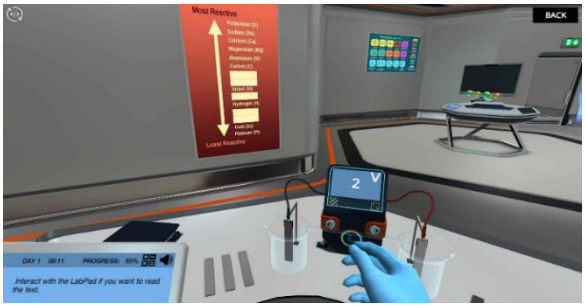

Figure 1 – Labster simulation «Redox Reactions: Discover how batteries work»

In the «Quantum Mechanics Lab» students can test the particle-wave duality hypothesis by performing real world experiments in a completely safe virtual setting. In 2021, Stanford conducted research, and students taught through Labster were 35% more likely to understand the concepts taught as compared to other conventional methods [2].

«Human Anatomy VR» offers 3D models of human organs and systems that help the students experience anatomy dissections (shown in Figure 2). Around 500 medical schools globally use this platform alongside automated interaction quizzes and collaborative features in real time. In a 2022 the study held by Medical Education Journal among 89% of respondents showed that using these tools made students feel better prepared for clinical exams [3].

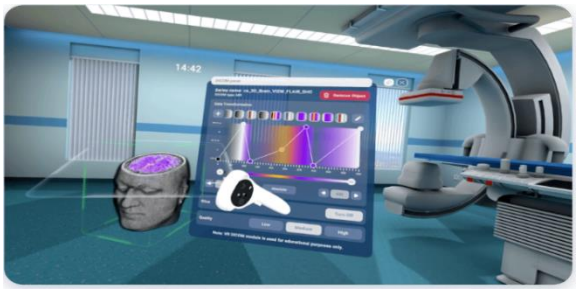

Figure 2 – Human Anatomy VR feature called «VR DICOM»

For mathematics, AR solutions like «GeoGebra AR» are used. It projects moving graphs over real-world objects which assist students in understanding complex concepts in calculus and geometry. It also includes several examples of 3D math objects that you can place on your table, floor or any flat surface around you. In the same manner, «Microsoft HoloLens 2» is used in technical universities for immersive trainings through holograms of real machines and their components.

Students can develop their own interactive projects involving coding by using CoSpaces Edu. The platform allows custom programing of 3D spaces via its block editor or Python scripting. More than 10,000 schools across the globe use the program for various projects such as building virtual ecosystems and reconstructing historical events [4]. Autodesk Tinkercad VR gives learners the ability to collaboratively design 3D models that can be printed in real life inside a virtual workshop. In advanced education, real time collaboration is also available with biochemistry students using Nanome, a VR molecular modeling tool. Researchers from UC San Diego reported a 25% higher completion rate of complex protein-folding tasks with teams using Nanome compared to more traditional methods [5].

Google Arts and Culture's VR tours of the Great Wall and the Louvre enhance historical and cultural education, reportedly improving retention rates by 50%. The New York Public Library's «Insta Novels» uses AR to gamify classic literature, while the BBC's «Civilizations AR» app brings 3D artifacts into classrooms. Despite AR/VR's potential, accessibility remains a challenge, with only 22% of lower-income areas having compatible devices, a gap initiatives like Meta's Education Grants and the free Mozilla Hubs VR classroom aim to address. Microsoft's «Immersive Reader» supports 25 million students globally. Successful implementation also requires teacher preparedness, with resources like «Unity Learn» aiding educators in using AR/VR in STEM and art, and ISTE Certification emphasizing crucial safeguards like data privacy and screen time limits [6, 7].

Conclusion. As for the actual educational offering, Labster, Google Expeditions and Human Anatomy VR are changing the game with affordable and verifiable technologies to aid in learning. There needs to be more focus on access equity, teacher training, and ethical parameters to ensure that these tools can be utilized effectively by all students. Educators can leverage immersive technologies to promote engagement, collaboration and interdisciplinary critical thinking when the focus shifts to real life applications.

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