Exploring potential use cases of immersive technology in physics education

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Abstract. Exploring the transformative potential of immersive technology in physics education, this study presents two simulations: a Virtual Reality (VR) Solar System experience for 9-14 year olds and an Augmented Reality (AR) table top experiment on linear mechanics targeting 16-18 year olds. Developed in Unity, these simulations offer interactive learning experiences aligned with educational curricula. Collaborative development with local teachers ensured relevance and alignment with age appropriate national syllabi. Evaluation in school settings with both students and teachers provided valuable insights into the efficacy of immersive technologies and identified potential future use cases within these educational settings.

Introduction: Immersive technology as a teaching tool

In recent years, immersive technologies such as Virtual Reality (VR) and Augmented Reality (AR) have emerged as powerful tools with immense potential to modernise education, particularly STEM subjects. Following previous proof-of principle simulation development we present two new immersive physics simulations aimed at enhancing physics learning among school-age students. By harnessing the unique affordances of VR and AR, these simulations offer interactive, engaging, and intuitive educational experiences designed to deepen understanding and foster curiosity.

Virtual Reality (VR) immerses users in a wholly computer-generated environment, while Augmented Reality (AR) overlays digital content onto the real world, creating a blended experience that bridges the gap between virtual and physical realms. Together are termed eXtended Reality (XR) and they exhibit unique affordances not attainable through traditional teaching methods. These include "six hooks" [1] which capture properties such as "*making the invisible visible*" [2,3] and comprehension of complex concepts via 3D interaction. Leveraging these hooks, educators can create immersive learning environments that captivate students' interest and facilitate deeper engagement with academic content.

Methodology

The first simulation is a VR Solar System experience designed for students aged 9 to 14. Utilizing the Unity game engine [4] and designed for Meta Quest 2 headsets, this simulation takes users on a journey through the celestial bodies of our solar system. Aligned with school curricula, the experience covers a range of topics, including planetary orbits, seasonal changes, and the roles of moons and satellites. Through interactive exploration and guided information, students gain a deeper understanding of astronomical phenomena in a visually stunning and immersive environment. The visual experience is paired with a dynamic audio accompaniment providing links with the music syllabus.

The second simulation is an AR table top experience aimed at teaching introductory mechanics concepts (SUVAT equations) to students aged 16 to 18. Also developed using Unity, this simulation pairs with Android devices and 3D printed elements to create an interactive learning experience. Students can conduct experiments on projectile motion, manipulating virtual objects overlaid onto their physical environment to explore concepts such as velocity, acceleration, and trajectory. By engaging in hands-on experimentation which is dynamically linked to the key equations, students develop an intuitive grasp of the underlying principles of mechanics, enhancing their problem-solving skills and scientific reasoning abilities.

Both simulations were developed in collaboration with local school teachers to ensure alignment with educational objectives and pedagogical practices. Following development, the simulations underwent evaluation in school settings by both students and teachers. The evaluations sought to assess the effectiveness of immersive technologies in enhancing learning outcomes, as well as to identify potential challenges and opportunities for integration into existing curricula.

Preliminary results

Preliminary findings from the evaluations indicate positive attitudes towards immersive technologies among both students and teachers. Students reported heightened engagement and enthusiasm for learning, with many expressing a preference for immersive experiences over traditional instructional methods. Teachers noted the potential of immersive simulations to supplement classroom instruction and enhance student comprehension of complex scientific concepts. However, challenges such as access to suitable hardware, technical support, and integration into existing curricula were also identified, highlighting areas for further research and development**.**

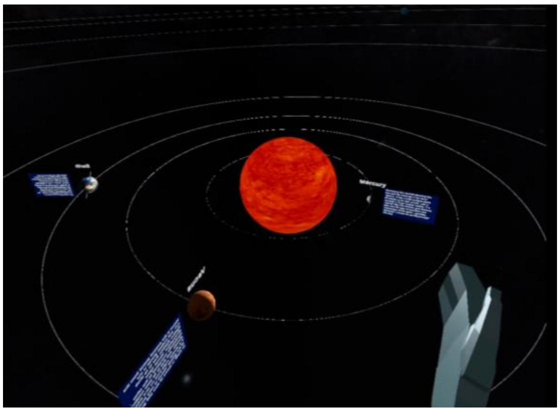

Fig. 1. A representative still image from the VR solar system experience showing the sun, inner planets and their orbits.

References

[1] P. L. Petts, *Extended Reality (XR) Unique Hooks*, National Teaching Repository, 2023 https://doi.org/10.25416/NTR.24707163.v2

[2] M. Akçayır, and G. Akçayır, Advantages and Challenges Associated with Augmented Reality for Education: A Systematic Review of the Literature, *Educ. Res. Rev.* **20** (2017) 1-11.

[3] I. Radu and B. Schneider, What Can We Learn from Augmented Reality (AR)? Benefits and Drawbacks of AR for Inquiry-Based Learning of Physics, in *Conference on Human Factors in Computing Systems - Proceedings* (Association for Computing Machinery), 2019.

[4] J. K. Haas, *A history of the unity game engine*. Worcester, UK: Worcester Polytechnic Institute 2014. Retrieved from http://web. wpi.edu/Pubs/E-project/Available/E-project-030614-143124/ unrestricted/Haas_IQP_Final.pdf