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A NEW FRONTIER: THE CONVERGENCE OF EMERGING DIGITAL TECHNOLOGY AND HIGHER EDUCATION

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Abstract. The development of technological capabilities creates an opportunity to connect education with the needs of the society of the future. This study aims to contribute to the expansion of discussion on the use of emerging digital technologies in higher educational settings to help their digital transformation. The purpose is to analyze how emerging immersive technologies can contribute to learning and teaching in HE. Through a systematic literature review, the paper identifies the pathway of emerging digital technologies to higher education 4.0 and explores immersive trends and innovations for HE. The results allow us to conclude that emerging immersive technologies are becoming a valuable tool in HEIs.

Keywords: Industry 4.0; Education 4.0; digital technologies; higher education; immersive reality; VR/AR

JEL: *A22, I25, O31*

1. Introduction

In the last few decades, information and communication technologies (ICTs) have significantly changed the way people, societies, economies and organizations function with each other, including higher education institutions and universities. Some of the most important technology plans for educational institutions in 2023 include *classroom modernization, cybersecurity threats, network upgrades, and immersive learning* (Gabaudan et al., 2022). In this regard, this paper aims to explore the future of emerging immersive technologies in higher education.

Emerging immersive technologies, such as virtual reality (VR), augmented reality (AR), mixed reality (MR) and extended reality (XR), are gaining momentum in higher education, transforming teaching, learning, and research. Moreover, the COVID-19 pandemic has played a significant role in accelerating the adoption of educational technology, including immersive learning; has highlighted both challenges and opportunities within the educational technology space. Hence, XR technologies have the potential to play significant roles in teaching, learning, and research practices in higher education settings. The research methodology goes

through a review of the relevant literature on the research questions of the study: *How immersive How emerging immersive technologies highlight the path for digital Higher Education 4.0?*

2. The Pathway of Emerging Digital Technologies towards Higher Education 4.0

2.1. Industry 4.0 and Education 4.0

Industry 4.0 is a term referring to rapid transformations in the design, production, implementation, operation and maintenance of manufacturing systems, products and components. To make the most of Industry 4.0 technologies, business organizations will need to invest heavily in building capabilities in the following dimensions: data and connectivity, analytics and intelligence, transformation to the physical world, and human-machine interaction (Butt et al., 2020).

Today's digital technologies could provide many innovative ideas and solutions, but without investment, competitiveness and growth will not be easily achieved (Yordanova, 2024; Elenkova, 2017). Education is one of the areas in which the fourth industrial revolution, led by technological progress, has had a significant impact. The drastic change in everyday life caused by the COVID-19 pandemic, combined with the general economic crisis, has led to a major change in the way, environment, manner and timing in which the educational process is conducted. Advances in technology have brought opportunities for innovation in the education sector, changing the existing paradigm to its emergence through the fusion of the digital, the biological and the physical (Hopp et al., 2020).

Since the research focus of this paper is on Education 4.0, the author concludes that it is educationally derivative of the Fourth Industrial Revolution. In other words, Education 4.0 is an educational version of Industry 4.0 or its equivalent in the field of education (Himmetoglu et al., 2020). Furthermore, on a comparative basis, Education 4.0 is a refined version of its previous iterations such as Education 1.0, 2.0 and 3.0 in the same way that Industry 4.0 is a refined iteration of its predecessor technologies in the form of Industrial Revolution 1.0, 2.0 and 3.0 and Industry 1.0, 2.0 and 3.0 respectively. Another similarity is that of Web 4.0 when compared to Web 1.0, 2.0 and 3.0, as well as other modern concepts and terms.

Table 1. Comparison of the educational versions 1.0, 2.0, 3.0 и 4.0

EduVersion	Dimensions		
Education 1.0	download education	the era of memorization	one-way, passive educational process
Education 2.0	open-access education	the dawn of internet-powered education	passive and active learning
Education 3.0	open-access education	the era of education as consumption	open, collaborative, flexible and creative education
Education 4.0	open-access education	change-oriented education	an education marked by dynamic, independent, active, innovative and autonomous learning

2.2. The Digital Technologies and Higher Education 4.0

Higher Education 4.0 refers to the evolution and transformation of higher education in the digital age. It encompasses the integration of technology, innovative teaching methods, and a learner-centered approach to enhance the teaching and learning experience (Belmonte et al., 2019; Blessinger & Wankel, 2012, pp. 3 – 14).

Here are some trends and future perspectives for teaching and learning in Higher Education (Mystakidis et al., 2022; Luo et al., 2021):

– ***Blended Learning***: Blending traditional face-to-face instruction with online learning platforms and resources allows for more flexible and personalized learning experiences. This approach combines the benefits of both in-person interactions and digital tools.

– ***Active Learning***: learning methods that engage students in the learning process through activities, discussions and problem solving. This active approach encourages students' critical and creative thinking, collaboration with each other, and enhances students' understanding of the subject itself.

– ***Personalized Learning***: Personalized learning by technology can be achieved by tailoring educational content and delivery to individual student needs, interests, and learning styles. Adaptive learning platforms and data analytics can provide personalized recommendations and feedback.

– ***Competency-Based Education***: Competency-based education focuses on mastering specific skills and knowledge rather than completing a set number of credit hours. This approach allows students to progress at their own pace and demonstrate mastery through assessments.

– ***Lifelong Learning***: Higher Education 4.0 recognizes the importance of continuous learning throughout one's life. Institutions are increasingly offering flexible programs, micro-credentials, and online courses to cater to the needs of working professionals and lifelong learners.

– ***Collaboration and Global Connections***: Technology enables collaboration among students, faculty, and experts from around the world. Virtual classrooms, video conferencing, and online platforms facilitate global connections, cultural exchange, and collaborative projects.

– ***Data-Driven Decision Making***: Institutions are leveraging data analytics to make informed decisions about curriculum development, student support services, and institutional strategies. Data can help identify areas for improvement and enhance student success.

– ***Artificial Intelligence (AI) and Virtual Reality (VR)***: AI and VR technologies have the potential to transform teaching, learning and training experiences. AI-powered chatbots, virtual tutors (Biolcheva & Sterev, 2024), and immersive VR simulations can enhance engagement, provide personalized support, and create realistic learning environments (Chotrov & Bachvarov, 2021; Blagoev, 2022).

These future perspectives reflect the ongoing transformation of higher education to meet the needs of the digital age.

3. Emerging Immersive Technologies in Higher Education

Emerging immersive technologies have been a hot topic in the context of Higher Education 4.0, which refers to the fourth industrial revolution's impact on higher education. In fact, immersive technologies have enormous, hidden potential that is capable of revolutionizing the way students are taught, learn and interact with educational content (Hopp et al., 2020; Rashid et al., 2021).

Research results show that immersive technologies such as virtual, augmented and mixed reality can provide students with more interactive, engaging and attractive learning, which ultimately leads to better retention of information. Therefore, immersive technologies can be used to simulate real-world scenarios, providing students with hands-on experience that can prepare them for their future professional paths and careers.

However, others argue that the implementation of immersive technologies in higher education may not be cost-effective and may not necessarily lead to improved learning outcomes. Additionally, there are concerns about the potential for these technologies to further widen the digital divide between students who have access to them and those who do not (Liubchak et al., 2022).

Overall, it is more than clear that the debate on emerging immersive technologies in the context of Higher Education 4.0 continues to unfold. It is especially important for educators and leaders of relevant higher education institutions to carefully consider the potential benefits and drawbacks of these technologies before implementing them into their curricula and learning process (Santa et al., 2024).

3.1. The Idea of "to immersive"

In todays evolving landscape the concept of "immersion" has become increasingly prominent as boundaries, between the physical and digital realms blur.

What does immersion entail?

At its essence immersion signifies being fully engrossed in an experience to the point where one loses track of their surroundings completely absorbed in the moment. It transcends observation promoting engagement and interaction with the environment whether real or virtual (Hopp et al., 2020; Liubchak et al., 2022).

In a world brimming with distractions immersion offers transformative encounters. Whether through stimuli cognitive challenges or social interactions immersion awakens our senses, minds and relationships. As technology advances and immersive experiences become more accessible to all the potential of immersion to enrich lives and broaden perspectives is limitless. Embracing immersion paves the way, for avenues of creativity and human connection (Asad et al., 2021).

Immersive virtual reality is more engaging with the "**3I"** (Hopp et al., 2020):

– ***Immersion*** – users are immersed in the virtual environment and have a sense of immersion;

– ***Interaction*** – users interact with the virtual object and achieves the corresponding actions and functions;

– ***Imagination*** – user play with the imagination and makes creative simulations in the virtual world, expanding the mind and the imaginable space.

Different Types of Immersion

In a world full of distractions, diving offers profound and transformative experiences. Whether through emotional, cognitive, or social interactions, immersion stimulates emotions, moods, and interactions. As technology evolves and immersive experiences become accessible, immersion's potential to enrich lives and expand horizons known no bounds. Immersion opens doors to creativity and connection in unprecedented ways. This paper suggests and explains some categories (Hopp et al., 2020; Blessinger & Wankel, 2012, pp. 3 – 14):

– ***Cognitive Immersion***: Mental absorption in an enjoy, driven via complex narratives, idea-scary demanding situations, or emotional engagement, creates vital wondering, empathy, and creativeness.

– ***Systems immersion*** may be used to explain when gamers are deeply engaged with the challenges and policies of a recreation, and is similar to a nation of 'float'.

– ***Spatial immersion*** is the sense of a player being found in, or transported to, the virtual international, and is related to the idea of embodiment.

– ***Social immersion*** describes the connection that a player may also develop closer to the characters (AI or human) and the social context of a game.

– ***Narrative immersion*** describes a player's compulsion to peer how a series of events continues, normally in a story, however this is associated with any development, which include exploring new areas or evolving gameplay mechanics.

– ***Sensory Immersion*** involves stimulating the senses to create a charming enjoy. Visuals, sounds, and tactile remarks transport individuals to change realities, heightening their perception of the experience.

3.3. Immersive Trends and Innovations for HE

Looking ahead, the future of immersive reality in Higher Education 4.0 holds great promise. As technology continues to advance, we can expect more sophisticated and immersive experiences. As Immersive Reality continues to evolve, new trends and innovations are expected to emerge in HE. For example, haptic feedback devices that simulate touch and tactile sensations could enhance the realism of virtual environments, allowing students to feel and manipulate virtual objects. Eye-tracking technology may enable personalized learning experiences by monitoring students' gaze and attention, providing real-time feedback and adaptive content (Asad & Malik, 2023).

Another future perspective is the integrated use of Artificial Intelligence (AI) and Machine Learning (ML) algorithms into Immersive Reality. They will play a significant role in making immersive reality more intelligent and responsive. AI-powered virtual tutors can provide personalized feedback and adaptive learning experiences, catering to individual student needs. ML algorithms can analyze student interactions and performance data to provide insights for instructional improvement. Natural language processing and voice recognition technologies can also enable more natural and interactive communication with virtual characters or instructors (Aithal & Maiya, 2023).

Furthermore, the co-use of immersive reality with other emerging digital technologies, such as 5G networks, wearable devices, and Internet of Things (IoT), opens up new possibilities for collaborative and connected learning experiences. For example, students could use AR glasses to collaborate on projects in real-time, accessing and manipulating virtual objects from different locations (Elghobashy et al., 2023).

Of course, the development of more affordable and accessible Immersive Reality devices and applications is also anticipated. This will make the technology more widely available to institutions with limited resources and enable students to access immersive learning experiences from their own devices.

4. Conclusion

The review clearly shows that the immersive reality play significant roles in Higher Education 4.0. While the widespread adoption of VR/AR in higher education may still be a work in progress, it is clear that these technologies can offer new opportunities for exploration and discovery in higher education institutions. In addition, these technologies provide immersive and interactive experiences that can enhance teaching, learning, and overall educational outcomes.

However, it is important for educators and institutions to approach the integration of VR/AR with careful consideration of its challenges and limitations. With good planning, strategizing and investment in the future, VR/AR technologies are poised to become a valuable educational tool in Higher Education 4.0. Moreover, it will

be critical for educators to stay informed about the latest developments in VR/AR and consider how these technologies can be used to enhance teaching and learning in higher education.

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