Metaverse and Education: A Bibliometric Analysis Based on the Past Twenty Years

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Abstract: This study explores the integration of metaverse-associated technologies such as VR, AR, MR in education, employing bibliometric techniques and VOSviewer software to analyze the field. Drawing from the Science Citation Index (SCI) and Social Science Citation Index (SSCI), 937 papers were preliminarily obtained to identify prevailing themes and emerging trends. Five main research clusters were identified: challenges and attitudes in implementing technology, virtual reality in skill training, college students' self-efficacy and perceptions, interactive educational settings for children, and specific disciplinary knowledge applications. The study contributes to the understanding of the practical application of metaverse technologies in education and may guide future research and development in this rapidly evolving field.
Keywords: metaverse, education, bibliographic

1. Introduction

In 1992, acclaimed American author Neal Stephenson introduced the idea of the 'metaverse' in his cyberpunk science fiction novel 'Snow Crash'. In this vision, he portrayed a 3D space that mirrors the real world where individuals could interact through digital avatars. With the advent of technologies like Virtual Reality (VR), Augmented Reality (AR), Artificial Intelligence (AI), and blockchain, coupled with societal events such as the COVID-19 pandemic which pushed for a transition to virtual interactions, our digital footprint has deepened (Zhang et al., 2022). The metaverse's boundaries are seemingly limited only by our imagination, making it an alluring concept to many (Hwang & Chien, 2022). However, the emerging metaverse is not without its challenges, particularly regarding user privacy (Al-Ghaili et al., 2022). As pointed out by Mystakidis (2022), the battle among dominant corporations to shape this realm will be pivotal in determining future privacy standards for users.

Different interest groups related to the metaverse shape its portrayal based on their distinct perspectives, leading to a varied representation of the metaverse and its

associated technologies (Dolata & Schwabe, 2023). Despite its years of evolution, the metaverse remains an elusive concept without a universally accepted definition. Broadly speaking, its development can be categorized into three progressive stages: (i) digital twins, (ii) digital natives, and (iii) surreality. This progression begins with replicating real-world entities, evolves into innovations grounded in reality, and culminates in an independent realm separate from our reality (Wang et al., 2022). Mystakidis (2022) posits that the metaverse relies on technologies that support multisensory interactions within virtual spaces, among digital entities and people. Extended or Cross Reality (XR)—comprising virtual reality (VR), augmented reality (AR), and mixed reality (MR)—is seen as a vehicle meeting the metaverse's interaction demands. Contrasting traditional VR or AR, Hwang and Chien (2022) emphasize three unique traits of virtual universes: they are 'shared,' 'persistent,' and 'decentralized.' Barrera and Shah (2023), synthesizing literature and industry insights, define the contemporary metaverse as "a technology-driven nexus of scalable and potentially interoperable extended reality environments. These spaces bridge physical and virtual realms, offering experiences marked by their immersion level, environmental authenticity, and social engagement." This characterization distinguishes the metaverse from earlier, simpler virtual worlds. Dolata and Schwabe (2023) attribute the current phase of the metaverse to the rise of VR, AR, NFTs, AI, and more, dubbing it the third wave. They observe that today's metaverse carries hallmarks of formal acknowledgment and platform-independent entitlements related to ownership, authorship, responsibility, and autonomy. These traits pave the way for a socio-economic structure deeply linked to the global economy. In essence, XR technologies stand central to metaverse discourse, acting as a bridge between avatars in the virtual domain and users in the tangible world (Park & Kim, 2022).

Technical support in teaching plays a significant role in education and development (Weisberg, 2011). However, the application of VR, AR, MR, and other simulation devices related to the metaverse in actual teaching lacks comprehensive exploration. This study employs bibliometric methods and analyzes the literature in this field using VOSviewer software to understand the hot topics in research related to the application of metaverse-related simulation technologies in education.

2. Data Set and Research Methodology

All the articles in this study were retrieved from the citation databases of the Science Citation Index (SCI) and Social Science Citation Index (SSCI) and were obtained from the Web of Science (WOS) created by the Institute of Science Information (ISI). In selecting keywords, this study focused primarily on educational journals. Therefore, the following retrieval methods were used for the keywords: TS=("metaverse" OR ("virtual reality" OR "augmented reality" OR "mixed reality" OR "extended reality") AND "education"). Some articles that had no relevance to VR, AR, or the metaverse were excluded, as were review articles. Finally, 937 papers were initially obtained.

3. Results

Based on the network map, it is evident that research in this field primarily forms five clusters. The red section mainly discusses challenges and attitudes toward the application of technology in education. Penn and Ramnarain (2019) used virtual environment simulations to provide visualizations of chemical concepts, improving students' understanding of chemistry concepts and their attitudes toward chemistry learning. Fidan and Tuncel (2019) positively affected learning in physics subjects through Augmented Reality (AR)-assisted Problem-Based Learning (PBL) while enhancing the perceptual abilities of students with disabilities. The yellow section primarily discusses topics related to virtual reality hands-on simulation skill training. Çakiroğlu and Gökoğlu (2019) employed a Virtual Reality Behavior Skills Training (VR-BST) approach to teach basic firefighting skills, incorporating behavioral modeling and on-site training into the learning environment to improve students' behavioral skills. The blue section mainly discusses self-efficacy, impressions, and overcoming issues in higher education, such as Cai et al. (2019), who discuss how AR helps students understand abstract mathematical concepts and enables high self-perceived performance students to apply more advanced strategies when learning mathematics. The green section discusses interactive children's educational environments and framework design topics. Degli Innocenti et al. (2019) developed new VR software systems that help patients better understand medical knowledge and treatment information through VR simulations. The purple section discusses disciplinary knowledge and applications in subject-specific contexts.

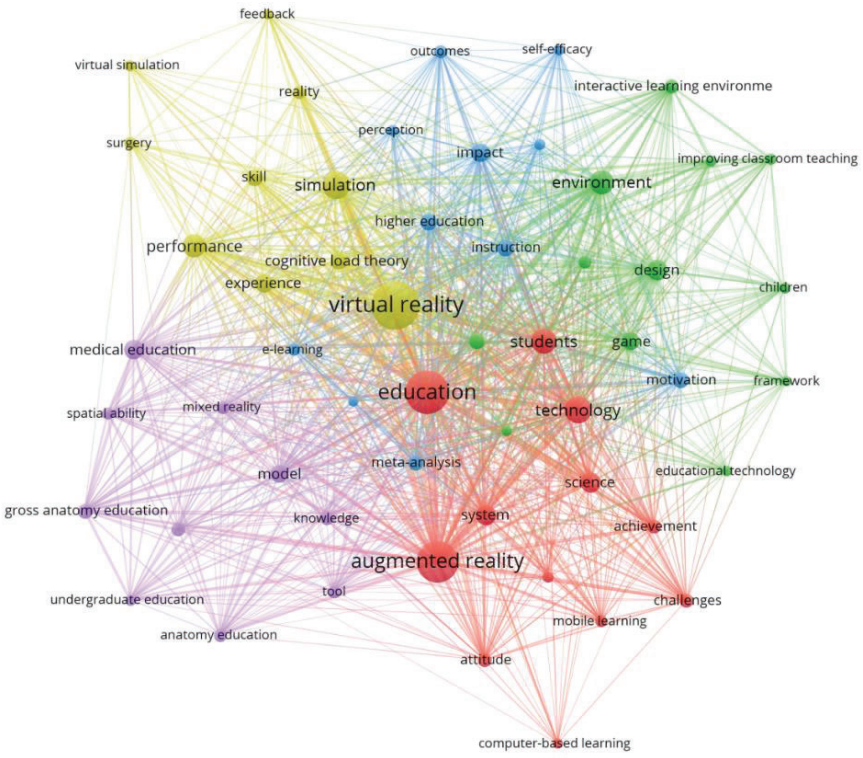

Figure 1. Keyword Map of Terms Occurring 20 Times or More

4. Discussion

Based on the data results, it can be observed that research related to VR places a stronger emphasis on simulating learning through practical skills, while AR stands out more in mobile learning. When designing experiments using VR and AR devices in educational research, most studies focus on individual learning, with limited research discussing the simultaneous use of devices by multiple users or the impact of cooperative learning and multi-user device usage (Back, Tinga, & Louwerse, 2021). Additionally, despite the close relationship between the metaverse and VR/AR technologies, few studies directly link the two, resulting in a lack of research that combines the latest technologies like AI and blockchain with VR/AR (Chatterjee et al., 2021; Abdinejad et al., 2021). This study provides the first analysis and categorization of research on the use of metaverse-based interactive media and XR technologies in education. At its current stage, research in this field is still relatively nascent, primarily focusing on building educational platforms based on VR and AR devices. While some studies have explored the effects of cooperative learning and group learning, discussions regarding the integration of AI, blockchain, and other technologies are lacking.

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