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Application of Mixed Reality Technology in Vocational Education: A Bibliometric Analysis

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ABSTRACT: Mixed reality (MR) technology, which integrates virtual reality (VR) and augmented reality (AR), has emerged as a transformative tool in vocational education by enabling immersive and interactive learning environments. This study aims to analyze the application status, research hotspots, and future development trends of MR technology in vocational education through a bibliometric approach. Data were collected from Scopus and Web of Science databases, resulting in 47 relevant publications after screening. Bibliometric analysis was conducted using Biblioshiny to evaluate publication trends, keyword co-occurrence, influential authors, and collaboration networks. The results indicate a significant increase in research activity following the release of major MR devices such as HoloLens and Vision Pro. Keyword analysis reveals that "mixed reality," "augmented reality," and "professional training" are dominant themes, highlighting the strong focus on immersive learning and skill development. MR applications are widely implemented in engineering, medical training, and professional education, providing safe and efficient simulation-based learning environments. Future research directions emphasize the integration of MR with artificial intelligence, personalized learning systems, and cross-platform applications, as well as improvements in usability and accessibility. This study provides valuable insights for researchers, educators, and policymakers to support the effective and sustainable implementation of MR technology in vocational education.

KEYWORDS: Mixed reality; vocational education; biblioshiny; research trends

1. Introduction

With the rapid development of science and technology, mixed reality (MR) technology—integrating virtual reality (VR) and augmented reality (AR)—has increasingly penetrated various sectors, particularly education [1]. In vocational education, MR technology provides immersive and interactive learning environments that enhance practical training by simulating real-world scenarios [2]. This capability supports skill-oriented learning by allowing students to practice complex procedures safely and repeatedly, thereby improving competency development and learning outcomes [3]. As a result, MR technology has become an important tool for transforming traditional teaching approaches and increasing learner engagement.

Educational innovation remains a central objective of global educational reform, and the integration of MR technology offers new opportunities for developing more effective teaching models [4]. By blending virtual content with real environments, MR technology helps learners better understand abstract concepts while enabling hands-on practice in controlled and risk-free settings [5]. Such features are particularly relevant to vocational education, where practical experience and technical proficiency are essential. Therefore, understanding the current application and emerging trends of MR technology in vocational education is crucial for improving instructional quality and supporting future educational innovation.

This study aims to analyze the application status, research hotspots, and future development trends of mixed reality technology in vocational education [6]. The research focuses on examining how MR technology is currently implemented in vocational learning environments, identifying major research themes and key technological developments, and exploring potential future directions for its integration into vocational education. Through a bibliometric approach, this study is expected to provide useful insights for researchers, educators, and policy-makers to support the effective and sustainable adoption of MR technology in vocational education.

2. Data Source and Research Method

2.1. Data source.

The data for this study were obtained from two major academic databases, Scopus and Web of Science, to ensure comprehensive coverage and high-quality scholarly publications. A systematic search strategy was applied to both databases, and relevant literature was screened based on topic relevance and document type.

The search query used in the Scopus database was: TITLE-ABS-KEY ("Mixed Reality" OR "MR" OR "Extended Reality") AND TITLE-ABS-KEY ("Vocational Education" OR "Professional Training" OR "Job Training").

The search query used in the Web of Science database was: TS = ("Mixed Reality" OR "MR" OR "Extended Reality") AND TS = ("Vocational Education" OR "Professional Training" OR "Job Training").

The search was conducted on July 14, 2024. The document types were limited to journal articles and conference papers, while no restriction was applied to the publication year to capture the full development trajectory of the field. The initial search identified 28 documents from Scopus and 37 documents from Web of Science. After removing duplicates and excluding studies primarily focused on virtual reality (VR) and augmented reality (AR) without explicit mixed reality applications, a final dataset of 47 high-quality publications was retained for analysis.

2.2. Research method.

This study adopts a bibliometric approach to systematically analyze research trends and the application status of mixed reality technology in vocational education. Bibliometric analysis enables the quantitative evaluation of publication patterns, research hotspots, collaboration networks, and influential studies, thereby providing empirical insights for researchers and educational practitioners [7]. The collected data were processed and analyzed using Biblioshiny for bibliometric visualization and statistical analysis [8]. Data preprocessing was first conducted to ensure consistency and completeness, including verification of bibliographic information such as author names, publication years, titles, and source journals. Subsequently, several analytical procedures were performed, including annual publication trend analysis, keyword and thematic analysis, citation analysis, and author and institutional collaboration analysis. Visualization outputs—such as publication trend graphs, keyword co-occurrence networks, word clouds, highly cited document charts, and collaboration maps—were generated to clearly illustrate the structural development and research patterns of mixed reality applications in vocational education. These analyses provide a comprehensive understanding of current research directions and support recommendations for future educational practice and policy development.

3. Results

This section presents the results of the imported literature data analysis based on Biblioshiny, including literature quantity analysis, keyword analysis, author analysis, literature source analysis, highly cited literature analysis, and three-field plot analysis.

3.1. Quantitative analysis of literature.

Research on MR technology in vocational education has evolved from its inception to rapid advancement, as illustrated in Figure 1. The releases of Hololens 1 (2015), Hololens 2 (2019), and Vision Pro (2023) have notably driven a significant increase in studies, underscoring the profound impact of these devices on research activity. With ongoing technological advancements and expanding practical applications, research in this field is expected to continue its growth trajectory, providing essential support for the innovative development of vocational education. By examining annual literature trends in conjunction with key equipment release milestones, as shown in Figure 1, we can gain valuable insights into the evolution of MR technology in vocational education. This analysis enables us to pinpoint research peaks and critical turning points, laying the groundwork for further investigation into research hotspots and thematic analysis.

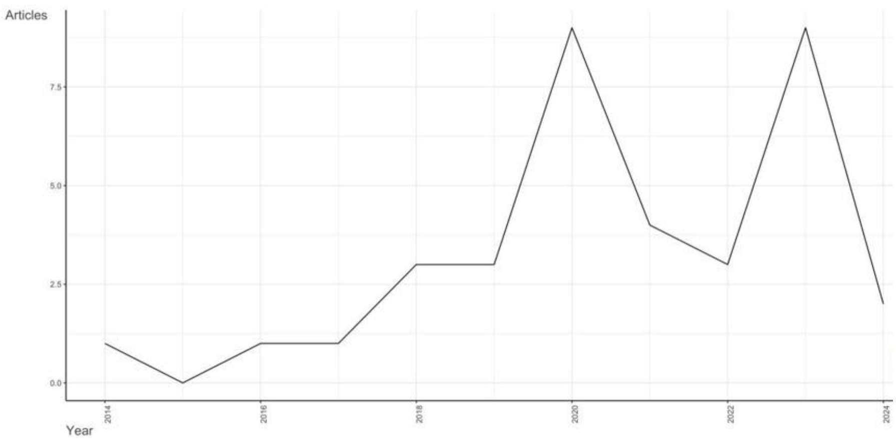

Figure 1. Annual scientific production.

3.2. Keyword analysis.

The keyword cloud map presented in Figure 2 illustrates the frequency of keywords, with varying font sizes indicating their prevalence. The larger the font, the more frequently the keyword appears. Key keywords and their frequencies include: mixed reality (24 times), augmented reality (17 times), professional training (12 times), engineering education (8 times), personnel training (8 times), e-learning (7 times), virtual reality (7 times), professional aspects (6 times), vocational education (6 times), and learning (5 times). From the word cloud map, it is evident that "mixed reality" is the most prominent keyword, highlighting it as a core research topic. Additionally, "augmented reality" and "virtual reality" also hold significant positions, indicating their widespread application in vocational education. Furthermore, the high frequencies of keywords such as "professional training" and "engineering education" suggest a strong focus on the use of mixed reality technology in these areas.

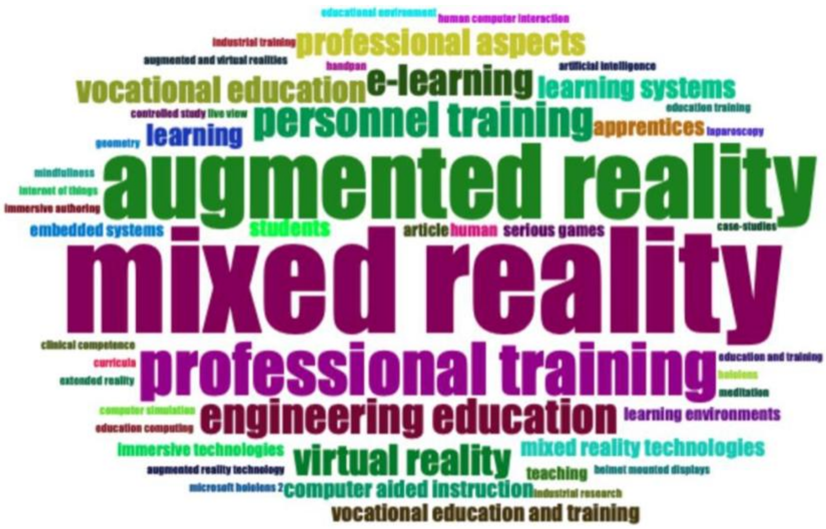

Figure 2. Word cloud.

The keyword co-occurrence network map depicted in Figure 3 categorizes research fields and topics into distinct clusters. Cluster 1 primarily includes foundational research keywords like "vocational education." Cluster 2 concentrates on specific applications and technologies, featuring terms such as "augmented reality," "professional training," and "virtual reality." Cluster 3 presents a broader array of education and technology topics, incorporating keywords like "mixed reality" and "learning."

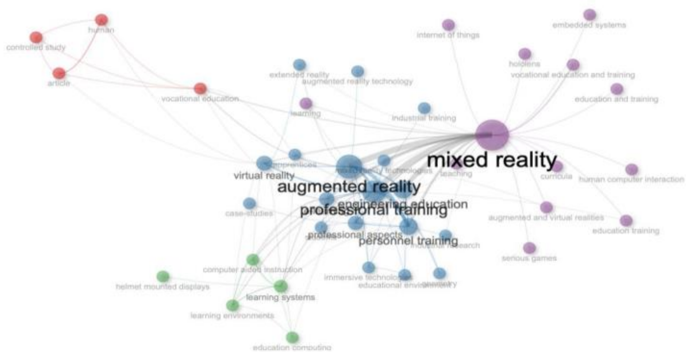

Figure 3. The keyword co-occurrence network map.

Analysis of the co-occurrence network reveals that "mixed reality" occupies a central position within the research landscape, holding the highest PageRank value. This indicates its significant influence and connectivity in the field. Additionally, "augmented reality" and "professional training" exhibit high intermediate centrality values, suggesting their critical role in bridging various research topics.

3.3. Author analysis.

The analysis presented in Figure 4 identifies several core researchers based on their productivity and contributions in the field of mixed reality technology and vocational education. Notably, Bueno-Delgado MV, Canavate-Cruzado G, Garrido-Lova J, and Gomez-Gomez MV made significant contributions in 2019, with their studies showing outstanding citation frequency. Additionally, the research conducted by Abdelrazeq A in 2020 is also recognized as highly influential.

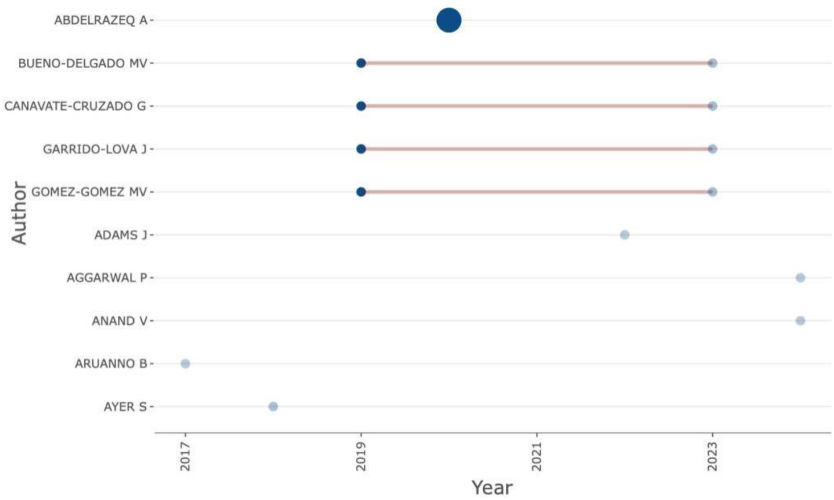

Figure 4. Authors' production over time

3.4. Analysis of literature sources.

Figure 5 highlights the primary source journals for research in mixed reality technology within vocational education, including the *International Journal of Engineering Education*, *Computers & Education*, and the *Journal of Educational Technology & Society*. These journals serve as crucial platforms for publishing and academic exchange regarding MR technology applications in vocational education. The literature source analysis reveals a growing interest in mixed reality technology among various journals and conferences. Notably, contributions from IEEE conference series and ACM journals have significantly increased in recent years. This trend suggests a broad development potential for this research field, along with an ongoing enhancement in the depth and breadth of the research.

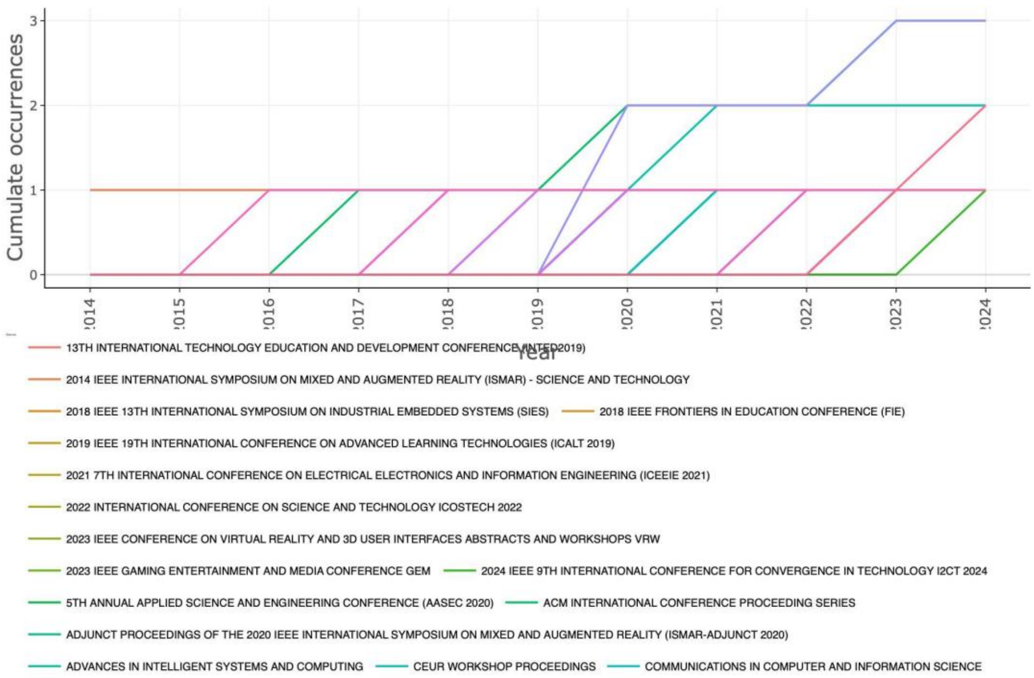

Figure 5. Collaboration network.

3.5. Three-field plot analysis.

Figure 6 presents a three-field chart that provides a comprehensive view of the research landscape surrounding mixed reality technologies in vocational education. By analyzing the relationships between authors, sources, and research topics, several observations can be made. Notable authors such as Barsom EZ, Abdelrazeq A, and Bangash G consistently publish in key conferences and journals, highlighting the importance of these platforms in disseminating research in the field. The distribution of research topics spans a wide range across various conferences and journals, including the ACM International Conference Proceeding Series and *Lecture Notes in Computer Science*, with areas of focus encompassing mixed reality, augmented reality, virtual reality, vocational training, and e-learning. Furthermore, the analysis reveals emerging research hotspots and potential future directions, particularly in vocational training and the application of learning technologies within mixed reality contexts. This integrated analysis is crucial for understanding the current status and trends of MR technology in vocational education and provides valuable guidance for researchers in identifying research directions and appropriate publication platforms.

By analyzing the literature on mixed reality (MR) technology in vocational education, this study reveals the research status, development trends, and possible future directions in this field. Using Biblioshiny's multiple visualization tools, this area of research can be explored in depth from multiple perspectives. The following discussion addresses the main research questions in detail.

4. Discussion

4.1. Practical application of MR technology in vocational education.

The application of MR technology in vocational education is gradually maturing and presents a variety of scenarios. Literature volume analysis shows a significant increase in studies since the release of key devices such as Hololens 1 (2015), Hololens 2 (2019), and Vision Pro (2023). The introduction of these devices has not only promoted technological development but also accelerated the adoption of MR technology in vocational education [9]. In terms of specific applications, MR technology is widely used in professional training and engineering education. Keyword analysis highlights the frequent occurrence of terms such as “professional training” and “engineering education,” indicating that mixed reality has important application value in these areas [10]. For instance, MR technology allows students to train on complex equipment in a virtual environment, enhancing their practical skills. Additionally, MR technology is applied in medical training, architectural design, and other fields to provide a safe and efficient training environment through virtual simulation.

4.2. Current research hotspots and key technologies.

Current research hotspots for MR technology in vocational education primarily focus on mixed reality and augmented reality, professional training and engineering education, and e-learning with virtual reality. Keyword co-occurrence network analysis shows that “mixed reality” and “augmented reality” are core topics of study, reflecting their use in creating immersive learning environments and enhancing learning outcomes. Professional training and engineering education are also prominent research areas, suggesting that MR technology is widely adopted in these fields. Virtual reality allows students to simulate real-world scenarios and gain practical experience [11]. In addition, terms such as “e-learning” and “virtual reality” appear frequently, reflecting the importance of MR technology in digital learning. The integration of e-learning with virtual reality provides students with flexible and diverse learning methods [12].

4.3. Future development directions of MR technology in vocational education.

Based on current research hotspots and technological trends, the future development of MR technology in vocational education can be anticipated in several areas. First, technology integration and cross-platform applications will become more common, with MR technology combined with artificial intelligence and big data analytics to enhance intelligent vocational education, enabling personalized learning and accurate assessment [13]. Second, content customization and the expansion of application scenarios will become more important. MR applications will increasingly tailor content to meet the specific needs of different career fields, and their use will extend beyond traditional engineering and medical fields to areas such as logistics management and financial training [14]. Third, improving user experience and usability will be a key focus. Future research will aim to enhance device comfort, ease of operation, and accessibility. Reducing equipment costs to improve affordability will also be crucial for the widespread adoption of MR technology in vocational education [15]. Finally, collaborative learning and distance education will see significant development. With the advancement of Internet technologies, MR-based distance learning will become increasingly popular, with research focusing on how collaborative learning can be facilitated through MR technology, enabling interaction among students in different geographical locations [16].

5. Conclussion

This study analyzed the application, research hotspots, and future development trends of mixed reality (MR) technology in vocational education using bibliometric analysis through the Biblioshiny tool. The findings show that MR technology has made remarkable progress, particularly in professional training and engineering education, with key devices such as Hololens 1, Hololens 2, and Vision Pro driving both research and practical applications. By creating virtual environments, MR technology provides students with a safe and efficient platform for skill development, significantly enhancing practical training outcomes. Current research primarily focuses on mixed reality, augmented reality, professional training, engineering education, e-learning, and virtual reality, with hardware improvements, software platform development, and optimized content creation identified as key technical directions. Keyword analysis highlights “mixed reality” as the central topic, with “augmented reality” and “virtual reality” also occupying prominent positions, reflecting the widespread application of these technologies in vocational education. Looking forward, the development of MR technology is expected to emphasize technology integration and cross-platform applications, content customization and expanded application scenarios, enhanced user experience and usability, as well as collaborative and distance learning. The combination of MR with advanced technologies such as artificial intelligence and big data analysis is anticipated to further support intelligent, personalized, and accessible vocational education. However, this study has some limitations, including reliance solely on Web of Science and Scopus databases, which may omit relevant literature, and the bibliometric approach, which primarily captures quantitative data without in-depth qualitative analysis. Additionally, the long-term effectiveness and practical impact of MR technology in vocational education require further empirical research. Overall, MR technology holds broad application prospects and significant advantages for practical training and skill cultivation, while future research should focus on technology integration, instructional design, cost-benefit analysis, and long-term educational outcomes. By systematically examining the application and development trends of MR technology in vocational education, this study provides valuable guidance for scholars and practitioners, offering both theoretical support and practical foundations to promote educational innovation and improve teaching quality.

Competing Interests

The authors confirm that there are no financial or personal conflicts of interest that could have influenced the outcomes or interpretation of this study.

Author Contributions

All authors made equal contributions to the conceptualization, methodology, analysis, and preparation of this manuscript. All authors reviewed and approved the final version.

Data Availability

The data supporting the results of this study can be obtained from the corresponding author upon reasonable request.

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