European Journal of Contemporary Education
E-ISSN 2305-6746
2025. 14(3): 374-385
DOI: 10.13187/ejced.2025.3.374
https://ejce.cherkasgu.press

An Analysis of VOS Viewer-Based Digital Resources in Higher Education

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Abstract

With the continuous advancement of global digital transformation, digital resources have been increasingly used in teaching, economics, management and other fields, and have become an important tool to improve the quality of education, promote the integration of disciplines and promote educational equity. Using VOS viewer, this study analyses the keyword co-occurrence, clustering and temporal evolution of digital resources literature in the Web of Science (WOS) database over the past five years to reveal the research focus and development trend of digital resources in higher education. It is found that the application of digital resources in higher education focuses on four main areas: (1) online education and educational equity; (2) the reshaping of educational models by technological innovation; (3) the support of digital resources for the Sustainable Development Goals (SDGs); and (4) interdisciplinary research and collaboration. However, resource quality assessment, cultural appropriateness and data privacy issues remain major current challenges. By collating and analyzing the classification and application of digital resources, this study highlights the need for interdisciplinary collaboration and international resource sharing, and makes recommendations to further optimize the design of resources and improve educational equity. The study provides a theoretical basis for policy makers and educators, among others and indicates a path for the direction of future research on digital resources in higher education.

Keywords: digital resources, higher education, digital transformation, visual analytics.

1. Introduction

The digital transformation of higher education has accelerated significantly in recent years, and digital resources have become indispensable tools for improving the quality of education and promoting educational equity. The popularity of online courses, Open Educational Resources (OER) and virtual laboratories has changed the traditional teaching and learning model and

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created new opportunities for personalized education (Radmehr et al., 2024). However, despite the rapid development and widespread use of digital resources, there is little research on digital resources in higher education and relatively few systematic analyses of research hotspots and emerging trends.

The digital transformation of education has affected and changed teaching and learning practices. Digital educational resources have become important tools to support personalized learning and improve the effectiveness of teaching and learning, including online services, mobile applications and artificial intelligence platforms, which facilitate activities such as assessment and creative learning (Siemens, 2013). The Covid-19 pandemic further highlights the critical role of digital resources in maintaining educational continuity during exceptional periods (Sanz-Labrador et al., 2021). Advances in the digitalization of education optimize the teaching and learning process and develop students' competences. (Antón-Sancho et al., 2021).

Despite the great potential of digital educational resources, there are significant challenges to their effective use. Accessibility issues, especially in less technologically developed areas, remain a barrier to equitable distribution of resources. In addition, cultural adaptation, data privacy issues and the digital divide also hinder digital transformation to some extent (García et al., 2023; Cao et al., 2024; Zhao et al., 2024). Teachers' digital literacy and professional development are also crucial to ensure seamless integration of resources into the educational environment (Heine et al, 2023; Wang et al, 2023; Asante, Novak, 2024; Trgalová, Tabach, 2024).

This study uses the bibliometric and visualization tool VOS viewer to systematically analyze the classification, applications and challenges of digital resources, focusing on their role in higher education. This study aims to (1) identify key research areas of digital resources in higher education, including online education and equity, technological innovation, sustainability and interdisciplinary studies; (2) discover the links between these areas and their wider implications for the education system; and (3) highlight existing challenges and future directions.

The theoretical significance of this study is to contribute to the construction of a comprehensive knowledge framework for digital resources in higher education, while the practical significance is to provide actionable insights for stakeholders, such as policy makers and educators, to optimize the development and application of resources. The results of the study can inform strategies to bridge the digital divide, improve the quality of resources and promote equitable educational opportunities globally.

2. Literature Review

The emergence and development of digital resources has changed the traditional teaching methods and become an integral part of higher education. With the advancement of technology, digital resources play a key role in innovating pedagogy, facilitating resource sharing and addressing sustainable development.

As the global level of technology continues to advance, digital resources are increasingly being used in modern education, especially in higher education. Since the outbreak of the Covid-19 pandemic, there has been a massive increase in research on online education, and digital resources have become an essential teaching tool for teachers (Tang, 2021). Some researchers have categorized digital educational resources to include online services, mobile applications, digital environments and interactive tools (Akhmetshin et al., 2019).

Digital technology has an important role in facilitating the sharing of resources in higher education (Xie, Zhang, 2024). Co-created digital resources in nursing education increase student engagement and knowledge retention by meeting specific pedagogical requirements (Laugaland et al., 2023). Similarly, digital collaborative writing platforms play an important role in facilitating active learning for multilingual students (Pennington et al., 2024). When using digital devices in the classroom, problems with asymmetric access can be effectively addressed through multimodal digital resources when they occur (Vänttinen, 2024).

Emerging trends emphasize co-creation, interdisciplinary integration and sustainability in the development of digital resources. Co-design is particularly necessary for nursing students, and the importance of knowledge sharing and effective communication cannot be overlooked (Nuala et al., 2024). Interprofessional education promotes peer learning, personal growth, teamwork and communication (Cook et al, 2024). In addition, the deep integration of higher education and digital technology is an inevitable trend, assessing higher education and digital infrastructure

development is important to promote the regional integration of higher education and the sustainable development of higher education (Xie, Zhang, 2024).

Despite the rapid development of digital resources, some challenges remain. Digital resources often need to be adapted to different cultural and regional contexts, for example tools designed for Norwegian nursing students need to be adapted to Spanish and UK contexts (Laugaland et al., 2023). The digital divide is a significant barrier, especially in deprived areas, where differences in infrastructure and access limit the availability of digital resources (Barnes, Tour, 2023). Educators, in turn, are unable to effectively integrate digital resources into their practice if they lack adequate training (Pennington et al., 2024).

To address these challenges, policymakers must prioritize the factors of equitable access, cultural adaptability and data privacy protection (Veletsianos, 2021; Zhao et al., 2024). Encouraging interdisciplinary collaboration and co-creation of digital resources can increase their relevance and effectiveness (Laugaland et al., 2023; Barnes, Tour, 2023). In addition, combining digital tools with the concept of sustainable development is conducive to further promoting the modernization of national governance systems and the process of sustainable development (Xu et al., 2024).

In conclusion, digital resources hold great potential to accelerate the development of higher education by fostering innovation, collegiality and sustainability. Addressing barriers to cultural adaptability, data privacy protection and faculty literacy training is also critical. However, by utilizing interdisciplinary collaboration, co-creation and innovative teaching and learning strategies, digital resources can continue to reshape education and provide more equitable and efficient learning environments (Yañez et al., 2023).

3. Methodology

In this study, we searched the Web of Science core dataset on 25th December 2024 for the last 5 years. The search term was 'digital resources', and the search was limited to subject search SSCI. 9189 documents that met the requirements were imported into the VOS viewer, and the year of publication, the country (region) of the authors and the distribution of institutions were statistically analyzed. Its research status and hotspots were analyzed through visualization. Analyze research status, hot spots and trends through visualization results such as keyword node size, thickness of lines between keywords and color distribution.

After importing the literature into the VOS Viewer software, the keyword threshold was set to 50 occurrences. Cluster analysis was performed on keywords that met the requirements, generating a visual keyword co-occurrence network map. In "Network Visualization" (e.g. Figure 5), circles and labels form a keyword element. The larger the node, the more frequent the keyword appears. Furthermore, the connecting line represents the strength of the relationship between the two nodes; the stronger the connection between the keywords, the thicker the line. VOS Viewer also categorizes similar keywords within a research field using different colors. Users can clearly see the specific keywords in each cluster from the "Item" tab, thereby discovering the similarities and differences between current research hotspots and research topics.

In the "Overlay Visualization" visualization (e.g. Figures 3 and 4), time is factored in. Different colors correspond to the years in which the keyword appeared. Bluer colors indicate earlier appearances, while yellower colors indicate later ones. The longer the average duration of a keyword's appearance in a given year, the larger the node.

4. Results and Analyses

The Web of Science core dataset was searched for literature published in the last five years (2020.1.1-2024.12.25) about digital resources, excluding duplicates and ineligible literature, finally 9189 documents were included in the analysis.

4.1. Trends in issuance and annual distribution

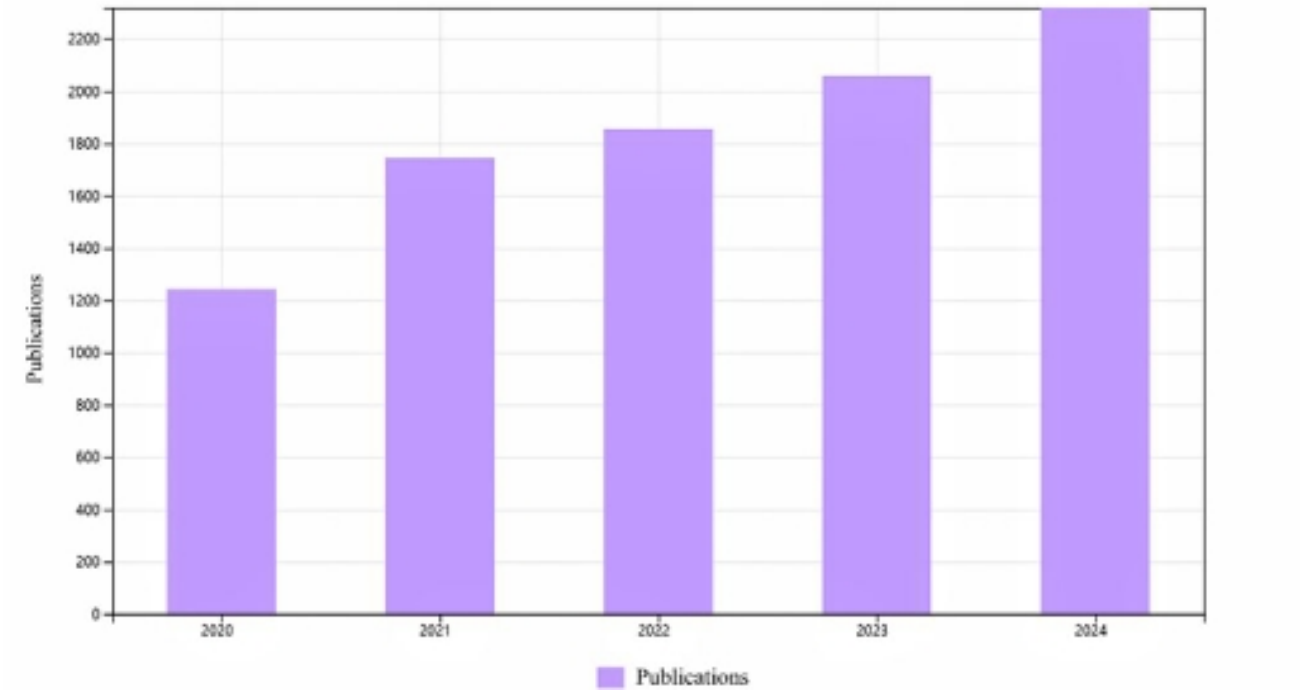

Fig. 1. Yearly Distribution of Literature Published on Digital Resources in the Web of Science Core Dataset (2020–2024)

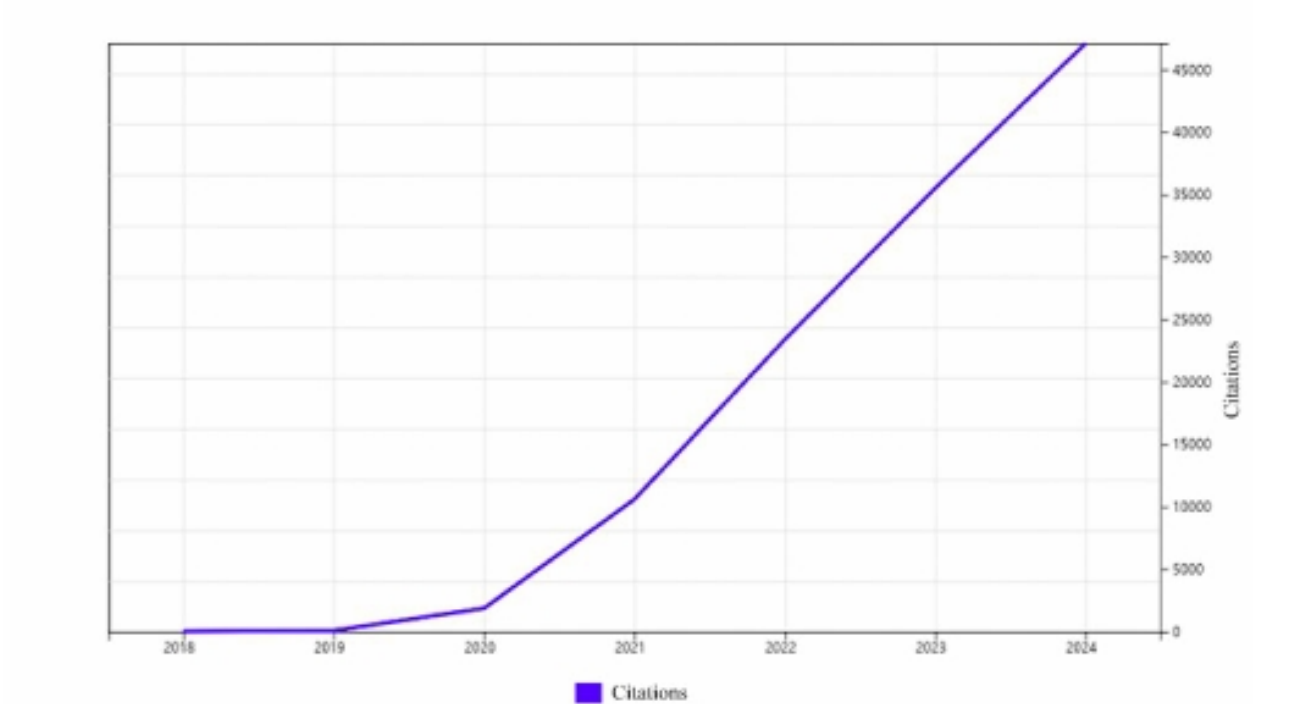

Fig. 2. Annual Citation Frequency of Literature Published on Digital Resources in the Web of Science Core Dataset (2020–2024)

Figures 1 and 2 show the trends in the number of publications and citations for digital resources published in the Web of Science Core Dataset over the past five years. Both the number of publications and the number of citations show a year-on-year upward trend. Figure 1 shows a significant increase in the number of articles related to digital resources in 2021. The data shows that the number of publications in 2020 was 1281, while the number in 2021 was 1775, an increase of 494 articles compared to 2020.

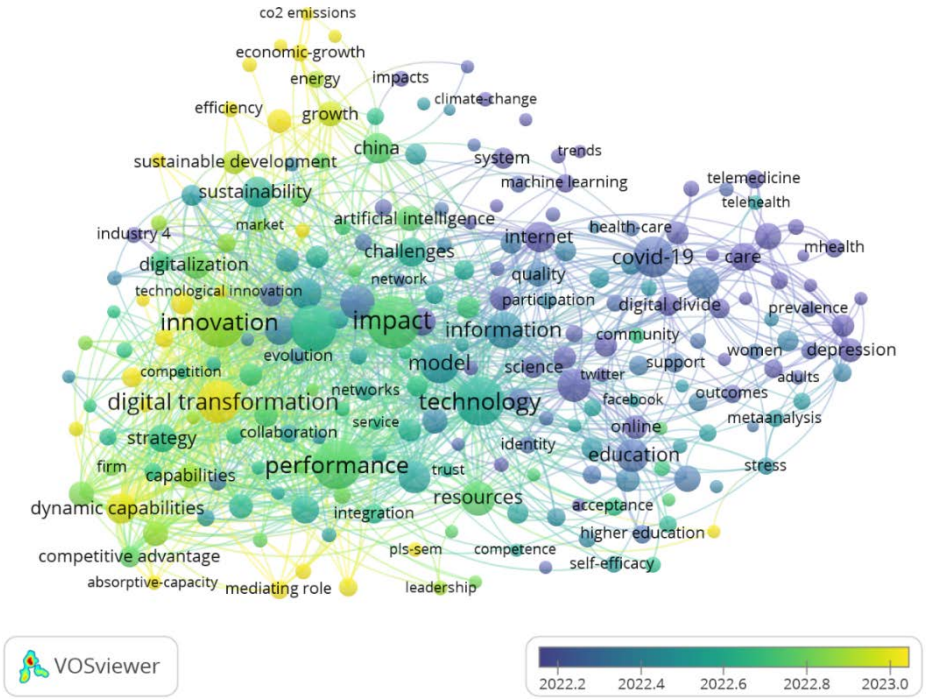

Fig. 3. Overlay Visualization of Digital Resources

As shown in Figure 3, blue indicates keywords that appeared earlier, while yellow indicates newer research hotspots. As shown in Figure 3, research hotspots in recent years have shifted from the covid-19 pandemic and social media to technology, management and innovation, ultimately to digital transformation. These major research hotspots are all resource-related. We also observed a surge in publications related to digital resources in 2021, driven by the covid-19 pandemic.

4.2. Authors

There are 9189 publications from 33523 scholars, of which the top three authors are Sascha Kraus (13), Vikram Patel (12), and Lu Feng (11). Sascha Kraus focuses on business management topics such as strategy and entrepreneurship, Vikram Patel specializes in interdisciplinary global mental health research, and Lu Feng focuses on macroeconomics and economic development, especially in China.

4.3. Issuing Countries

9189 papers were published from 156 countries and regions. Table 1 shows the top ten countries in terms of publication volume. The top three countries in terms of publication volume are China (2417 papers), the United States (1830 papers), and the United Kingdom (1058 papers).

Table 1. Ranking of the top 10 countries in terms of number of publications

Country	**Number of articles issued**
CHINA	2417
USA	1830

Country	Number of articles issued
ENGLAND	1058
AUSTRALIA	703
SPAIN	632
GERMANY	621
ITALY	469
CANADA	463
INDIA	310
NETHERLANDS	287

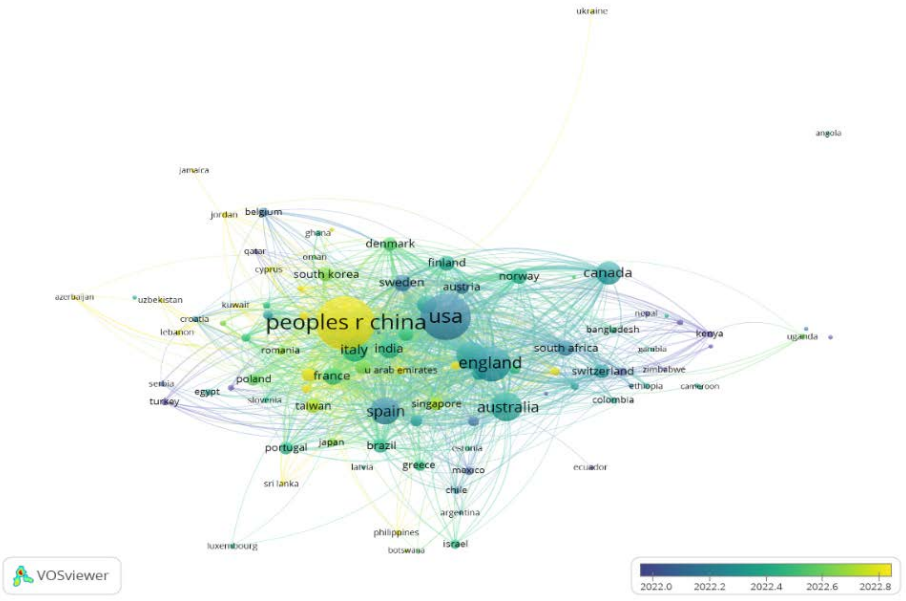

Fig. 4. Overlay Visualization of Issuing Country

Figure 4 shows that China collaborates closely with the US, UK and Germany. However, China's overall publication time is slightly later than that of the UK, US and other countries. Countries like Turkey, Jordan and the Philippines are relatively marginalized.

4.4. Issuing Organizations

According to the WOS core database, 9189 documents come from a total of 8624 organizations. The top ten organizations in terms of the number of issued papers are shown in Table 2. The top three organizations in terms of the number of articles issued are the University of London, the Chinese Academy of Sciences and the University of California system in that order.

Table 2. Ranking of the Top 10 Issuing Organizations

Organizations	Number of articles issued
UNIVERSITY OF LONDON	266
CHINESE ACADEMY OF SCIENCES	211

UNIVERSITY OF CALIFORNIA SYSTEM	160
HARVARD UNIVERSITY	120
UNIVERSITY OF TORONTO	109
WUHAN UNIVERSITY	107
UNIVERSITY COLLEGE LONDON	104
MONASH UNIVERSITY	99
UNIVERSITY OF MELBOURNE	98
UNIVERSITY OF OXFORD	98

4.5. Keywords

After importing the retrieved literature that meets the requirements into the VOS viewer software, a total of 31394 keywords were detected, and 229 keywords with a frequency of occurrence ≥ 50 were detected. Among them, innovation (749 times), impact (842 times), performance (706 times), technology (709 times), management (654 times), digital transformation (521 times), information (402 times), model (466 times), Covid-19 (492 times), resources (352 times).

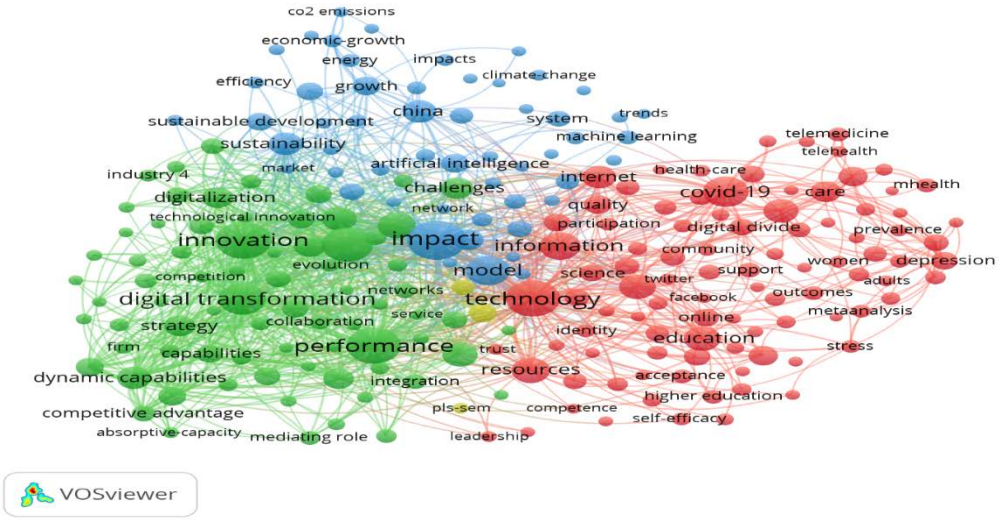

Fig. 5. Network Visualization of Digital Resources

Larger nodes indicate a higher frequency of keyword occurrence, such as “covid-19” “impact” and “digital transformation”. Thicker lines indicate closer connections between keywords. Research areas with similar characteristics share the same color. Therefore, as shown in Figure 5, the application of digital resources in fields such as education, economy and environment presents multi-dimensional hot topics and research trends, which can be roughly divided into the following four directions:

4.5.1. Education and Social Impact

The red clusters have keywords such as “online” “education” “higher education” “information” “technology” and “covid-19”, which demonstrate the core themes of digital resources in education, indicating that research in this field focuses on educational equity and the application and challenges of online education models, the acceptance of online education, and the impact of the digital divide on educational equity. Key directions for research include exploring the effects of

online education and blended learning, and how digital resources can be optimized to enhance the overall efficiency and utility of higher education (Hehir et al., 2021; Aguirre et al., 2022).

4.5.2. Technological innovation and digital transformation

The green cluster has keywords such as “technological innovation” “digital transformation” “performance” and “dynamic capabilities”, reflecting the wide application of digital technology in industries and organizations. Research in this area focuses on digital transformation in education and business driven by technological innovation, analyzing how digital resources can enhance competitiveness and optimize resource outcomes (Gabriele et al., 2024; Anna et al., 2023). In the field of higher education, research has focused on the transformative effect of digital technologies on teaching and learning models, such as optimizing teaching and learning processes through adaptive learning systems and learning management platforms. In addition, the field has explored the cross-cutting value of technological innovations in industries other than education, such as healthcare and business management (Ravik et al., 2024).

4.5.3. Environment and Sustainability

The blue clusters with keywords such as “sustainability” “climate change” “energy” and “efficiency” demonstrate the application of digital resources and technologies in the field of environment and sustainable development. Research has shown that digital resources and technologies have an important role to play in supporting environmental protection, energy efficiency and the realization of the Sustainable Development Goals (SDGs). For example, universities can produce sustainable OER courses that empower students to co-produce OERs about sustainable development (Braßler, 2024). Future research should further explore how technology and education can synergize to promote sustainable development in education, economy and environment.

4.5.4. Interdisciplinary research and collaboration

Core keywords such as “impact” “technology” “model” and “resources” have a large number of nodes on the co-occurrence network graph, indicating that digital resources research has a strong This indicates the strong interdisciplinary nature of digital resources research. From education and technology to economy and environment, researchers have analyzed the impacts of digital resources by constructing multi-disciplinary collaborative models, promoting interdisciplinary innovation. This direction emphasizes the integrated role that digital resources play at the intersection of education, industry and environment, and future research needs to further integrate multiple factors of technological innovation, policy making and educational reform to provide scientific support for educational ecology and social development (Ng et al., 2023).

The keyword co-occurrence network diagram reveals a wide range of applications of digital resources and technologies and their interactions in education, industry and environment. Future research needs to focus on the following areas: improving the efficiency and equity of digital educational resources and promoting innovation in online education models; exploring in depth the role of innovation in supporting business performance enhancement, environmental sustainability, and the transformation of education by digital transformation; and integrating the roles of digital resources in the fields of education, the economy and the environment from a cross-disciplinary perspective, to provide a scientific basis for policymaking and educational practice. Such comprehensive research will provide a more holistic perspective for achieving digital transformation in education and sustainable social development.

4.6. Application of digital educational resources in higher education

The application of digital educational resources in higher education covers a wide range of aspects such as teaching, student learning, faculty development and educational management, providing strong support for the digital transformation of higher education (Trouche et al., 2020). In the field of teaching, online courses (e.g., MOOCs) and blended teaching models have become common forms of application, providing students with flexible learning paths (Yao, 2023). Meanwhile, the introduction of virtual labs and multimedia teaching resources has enhanced the quality and interest of teaching practice, but the problems of insufficient interactivity and lack of authentic experience still need to be addressed. In addition, the instruction received by students incorporates e-learning resources that can be tailored to meet students’ unique learning needs through a customized approach, and the Personalized, Evidence-Based, and Inclusive Learning (PEBIL) model can address the disparities in digital teaching and learning (Hassoulas et al., 2023).

In student-directed learning, digital educational resources reduce the cost of learning and support educational equity through open educational resources (OER). Students use these

resources to independently assess learning outcomes and obtain immediate feedback. However, the variable quality of resources, the way they are accessed, and their potential ethical issues may affect learning outcomes (Zhou, 2024). On the teacher side, HEIs are using digital tools to support curriculum design and teacher training to improve the science and relevance of teaching content. Through data-driven analyses, teachers are able to understand students' learning progress and adjust teaching strategies in real time, which is positive in enhancing teaching effectiveness (Siemens, 2013).

In higher education management, learning management systems (LMS) and educational big data analytical tools have been widely used for resource integration and teaching decision-making. LMS enables centralized management of teaching content, while educational big data provides a scientific basis for teaching resource optimization and academic risk prediction through quantitative analysis of learning behaviors. Nonetheless, the complexity of these systems and their technical adaptability impose high requirements on university faculty and students, requiring further improvements in technical support and user training (Wang et al., 2023).

In conclusion, digital educational resources play an important role in teaching mode innovation, personalized learning path support and educational equity promotion in higher education. However, its application still needs to address the challenges of resource quality assessment, technology adaptation, and data privacy protection. Future research should focus on the long-term effects of digital educational resources in higher education and their deep integration with artificial intelligence and educational big data to support the realization of the overall improvement of education quality (Hashim et al., 2022; Sarva et al., 2023).

5.Discussion

5.1. Differences in digital resource application

Different disciplines experience varying learning outcomes when using digital resources. Disciplines with strong practical, highly structured and simulation-based learning experiences are particularly effective, such as anatomy, clinical skills and computer science (Frøiland et al., 2023). However, the effectiveness of digital resources may be limited in disciplines that prioritize emotional connection, in-depth discussion and critical thinking, such as philosophy and performing arts.

5.2. Limitations of digital resource application

Certain developing and underdeveloped regions, such as Turkey, Jordan and the Philippines, are significantly marginalized in the atlas (e.g. Figure 4). This suggests that promoting digital resources in these countries and regions may face significant challenges, such as insufficient infrastructure, limited funding and uneven resource quality, leading to inefficient or even impossible application (Puiu et al., 2023).

Therefore, digital resources should be designed more specifically, distributed more equitably, and promoted more rationally, based on the characteristics of different disciplines and the development of different countries and regions. In the future, we should also pay more attention to “how to customize digital resources to cultivate students’ abilities according to the characteristics of different subjects” “how to design low-cost, highly adaptable solutions for resource-poor areas”, and “how to establish and improve the support system for the application of digital resources to maximize its application effect while minimizing its risks”.

6. Conclusion

This study uses VOS viewer to analyze the articles on digital resources in the past five years, to show the research overview, hotspots and trends of digital resources from multiple perspectives, and finds that China ranks first in terms of the number of articles, and that the University of London, the Chinese Academy of Sciences, the University of California, and the scholars Sascha Kraus, Vikram Patel, and Lu Feng are more influential. Digital educational resources have become an important part of modern education and are widely used in education, economics and management. These resources, which include online courses, adaptive learning platforms and Open Educational Resources (OER), have excelled in improving the quality of teaching and learning, supporting the design of personalized learning paths and optimizing educational assessment. In addition, digital resources play a key role in teacher professional development, facilitating collaboration and reflection on teaching and learning. The convergence of technologies such as Artificial Intelligence (AI), big data analytics and Virtual Reality (VR) has injected new

vigor into digital education resources. AI-driven adaptive learning enables real-time adjustments to teaching content and enhances learning efficiency, while VR technology provides innovative scenarios for virtual labs and simulated practices. However, the application of digital educational resources still faces multiple challenges, including the lack of a resource quality assessment system, insufficient cultural appropriateness, educational equity issues arising from the digital divide, and data privacy and ethical risks. Future research should focus on optimizing intelligent and personalized educational resources, promoting data-driven education policymaking, and facilitating international resource sharing to achieve educational equity. In addition, the establishment of effective ethical and legal frameworks to regulate data privacy and AI technologies will contribute to the sustainable development of digital educational resources. Through technological innovation and policy support, digital education resources will play a greater role in promoting education quality improvement and global education equity.

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