Volume 16 Number 1 (2024)
January-June 2024
Page: 507-518

E-ISSN: 2656-9779
P-ISSN: 1907-6355
DOI: 10.37680/qalamuna.v16i1.4697

QALAMUNA
JURNAL PENDIDIKAN, SOSIAL, DAN AGAMA

Exploring Global Trends and Innovations in Educational Technology: A Bibliometric Analysis of Emerging Paradigms and Key Contributions

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Received: 22/01/2024 Revised: 19/04/2024 Accepted: 10/06/2024

Abstract

This study aims to investigate the latest trends in educational technology and identify emerging innovations in the scientific literature using the Bibliometric Analysis method. The background of the research confirms the importance of an in-depth understanding of the latest developments in technology-based education, given the rapid changes taking place in this domain. The results highlight the significant influence of countries such as the United States, Russia, Brazil, and China in initiating and realizing educational technology innovations. In addition, the study identified several significant journals, such as "Educational Technology Research," "Education and Information," and "Journal of Dental Education" that play a crucial role in documenting and disseminating information about the latest developments in educational technology. Another interesting finding is the emergence of the keyword 'gaming' as an innovation that increasingly dominates the educational technology literature, showing a trend towards game-based play and learning approaches in educational contexts. The conclusion of this study provides valuable insights for practitioners and researchers in the field of educational technology. This information can inform educational strategies, develop innovative projects, and direct future research to better understand and utilize educational technology in the learning process.

Keywords Education; Technology; Bibliometrics

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1. INTRODUCTION

Educational technology refers to using technology in an educational context to enhance learning and teaching experiences. More than just utilizing hardware and software, educational technology integrates traditional teaching methods with modern technological solutions (Munawar et al., 2022). Educational technology encompasses a variety of elements, including mobile applications, online learning platforms, interactive simulations, analytical tools for progress monitoring, as well as a variety of learning aids that take advantage of technological sophistication (Adriani et al., 2023a; Aida et al., 2022). Educational technology affects the teaching and learning process and closely relates to various fields, such as educational psychology, instructional design, education management, and information and communication technology. The integration of technology in education paves the way for various new approaches to designing curricula, measuring learning progress, and addressing individual challenges learners face.

The importance of research in educational technology impacts the development of innovative educational solutions and contributes significantly to the expansion of educational accessibility (Abdillah et al., 2021; Abdullah et al., 2019). Alfiyah et al. (2021) Around the world, there are still many challenges in achieving inclusive and equitable education for all individuals, especially in remote areas, underprivileged communities, and minority communities. With the existence of educational technology, the accessibility of education can be significantly expanded. Educational technology enables students to study anywhere and anytime, overcoming geographical and time barriers (Evendi, 2022). For example, individuals who live in remote areas or cannot physically attend school can still access education through online courses and online learning platforms. It also provides opportunities for students with physical limitations or special needs to learn in a way that suits their needs.

The importance of research in educational technology is also expanded by the rapid changes in educational demands and needs in this digital age (Abouelenein & Nagy Elmaadaway, 2023). Technology continues to evolve rapidly, and with it come new challenges and opportunities in the field of education. Without continuous research, educators and policymakers will find it challenging to keep up with the latest developments and adopt technology effectively in the learning process (Yamakami et al., 2022). In-depth research is needed to identify the latest trends in educational technology, analyze their impact, and develop appropriate strategies to integrate those technologies into the curriculum (Poblete et al., 2020). Without solid research, the risk of a gap between technological progress and educational practices being left behind will be even greater. Therefore, research in educational technology is becoming increasingly urgent to ensure that education can continue to develop according to the demands of the times and the needs of society.

In previous studies, various positive impacts of the use of technology in education have been revealed. This includes improved learning outcomes, increased student motivation, and the development of critical skills necessary to deal with the modern world. However, the research also highlights emerging challenges, such as the widening digital divide and difficulty effectively integrating technology into curricula (Amri et al., 2022; Crisiana et al., 2022; Jonatan & Waruwu, 2023).

However, further exploration of educational technology is needed to understand how educational technology has changed the current educational landscape. It involves identifying the latest trends and looking for innovations and novelties in this field. For this reason, bibliometric research becomes relevant to looking at trends, evaluating the research direction taken, and looking for potential for discoveries and development of new concepts.

Through a bibliometric approach, we can track the progress of research on educational technology over time, identify trending topics, and see how the flow of research has changed over time. Bibliometric analysis is a scientific approach used to measure, analyze, and describe characteristics and patterns in the scientific literature (Muhammad & Triansyah, 2023). It will help us understand how education and technology interact with each other and provide insight into the direction that future research in this area might take.

2. METHODS

This study adopts a bibliometric approach to detail and analyze literature related to educational technology. A bibliometric approach is an analytical method that uses bibliographic data and metrics to measure, evaluate, and understand the impact or pattern of scientific communication in a particular field of research or discipline (Huda et al., 2023). Data was obtained from the Dimension AI database using the keyword "educational technology." The identification process begins with a complete counting technique, followed by screening to limit the range of years and types of publications. Furthermore, the feasibility process filters data from educational journals, ensuring relevance to the study context.

The data collection process begins with the identification stage using the keyword "educational technology." A total of 8765 data were found, and after a screening stage by year and type of publication, the analyzed data was reduced to 6785. Furthermore, through the feasibility stage, only data derived from educational journals were considered, resulting in 5931 data entering the conclusion stage to be analyzed with VOSviewer. The following is an overview of the series of data collection processes.

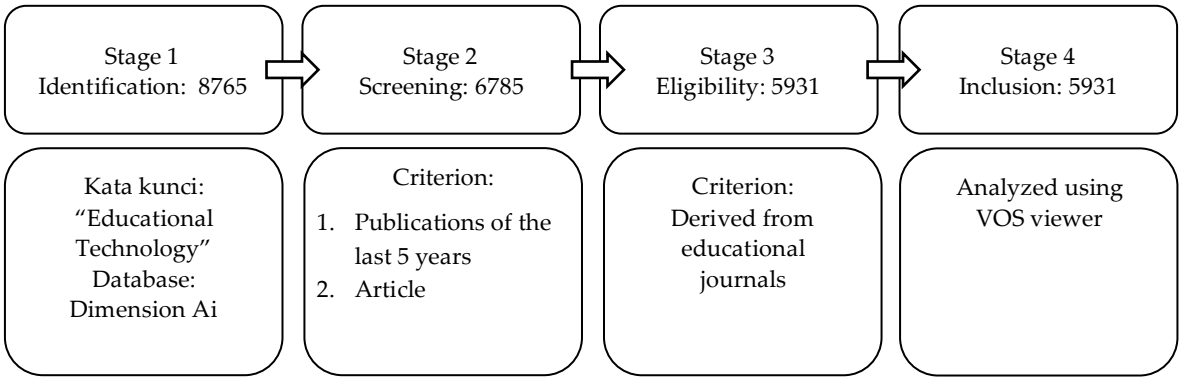

Figure 1. Stages of Data Collection

Data analysis was carried out qualitatively using a bibliometric approach. The data analysis tool used is VOSviewer, which can extract and visualize information from 5931 filtered data. VOSviewer allows analysis of relationships between studies and generates linkage maps between keywords (Muhammad & Triansyah, 2023).

Analysis using VOSviewer will provide a visualization of collaborative research networks, describe keyword frequencies, and provide deep insight into research trends in educational technology. The results of this analysis not only help understand the contributions of related literature but also provide a foundation for building an in-depth and comprehensive conceptual framework. By understanding collaboration patterns between researchers, emerging keyword trends, and changes in research topics over time, this analysis will provide valuable guidance for future research, especially in developing curiosity in learning contexts.

Through collaboration network visualization, researchers can identify critical researchers and the most influential research groups in this field and understand how these collaborative networks develop. Additionally, keyword frequency descriptions will allow identifying the most frequently researched topics emerging trends, and new developments. This allows researchers to identify gaps in existing literature, explore new relevant topics, and direct research focus in more impactful and innovative directions.

By utilizing VOSviewer analytics, researchers can maximize their understanding of the contributions of educational technology literature and utilize them to support the progress and evolution of the field. This analysis will also help develop more focused and effective research strategies and design studies that can significantly contribute to the understanding and application of technology in education. Overall, this analysis serves as an evaluative tool and a strategic guide for research and development in educational technology, ensuring that the research efforts undertaken have high relevance and impact (Voskoglou & Salem, 2020).

3. FINDINGS AND DISCUSSIONS

The number of publications obtained at the inclusion stage reached 5,931 selected publications in the last decade, especially from 2019 to 2023. All data sources used in this analysis come from articles, meaning 100% of the data is taken from relevant academic publications. These publications cover various topics and issues in educational technology, providing a comprehensive overview of

developments, trends, and significant contributions over the period. This analysis allows the identification of critical themes, collaboration patterns between researchers, and keyword trends that can provide in-depth insights for further research in the future.

Publication Trends 2019-2023

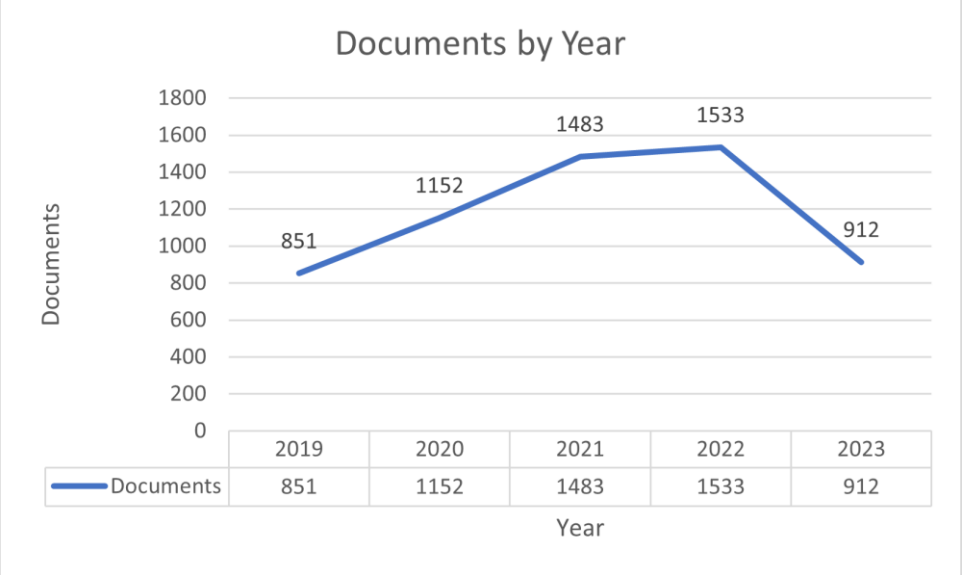

Figure 2. Publication Trends 2019-2023

The result of the publication trend on educational technology is as many as 851 articles on this topic in 2019. In the following year, namely 2020, there was an increase with 1152 articles, which continued to increase in 2021 with 1483 articles. In 2022, it is still stable with an increase of only around 1%, namely 1533 articles, before experiencing a decrease in 2023 with 912 articles.

Analysis of publication trends in the figure reveals an interesting pattern in the development of educational technology in recent years. In 2022, there was a surge in publications, indicating that this topic has gained significant attention within the academic and practitioner communities (Lin et al., 2022). Over the past five years, each year has seen an increase in publications, reflecting a consistent interest in research on this topic. This indicates that education and technology are increasingly becoming the focus of attention in society. It should be noted that the most significant increase occurred from 2020 to 2021, with a jump of 331 publications. The COVID-19 pandemic that hit the world during this period significantly impacted education. Distance learning is a critical solution that encourages increased research and innovation in the application of technology to support the educational process (Ahmady et al., 2021; Almansour & Kurt, 2022). This explains the considerable spike in publications that year.

Given the significant increase in the number of publication trends, it is essential to note the saturation of research on this topic with many similar or overlapping studies that have resulted in some less innovative or repeatable studies, suggesting further research may need to focus on deeper or innovative aspects of educational technology. In 2023, the decline in publication trends is likely due to delays in data reporting or because research interest in the topic stabilizes after a significant surge in previous years (Adriani et al., 2023a). Further developments this year must be monitored to understand whether this trend will continue or change.

Bibliographic Coupling Country

Bibliographic coupling country was obtained from extracting 5931 vosviewers in complete counting, resulting in network images of countries related to this study. A cluster of relations between these countries was formed. The clusters are shown with different color networks in Figure 3.

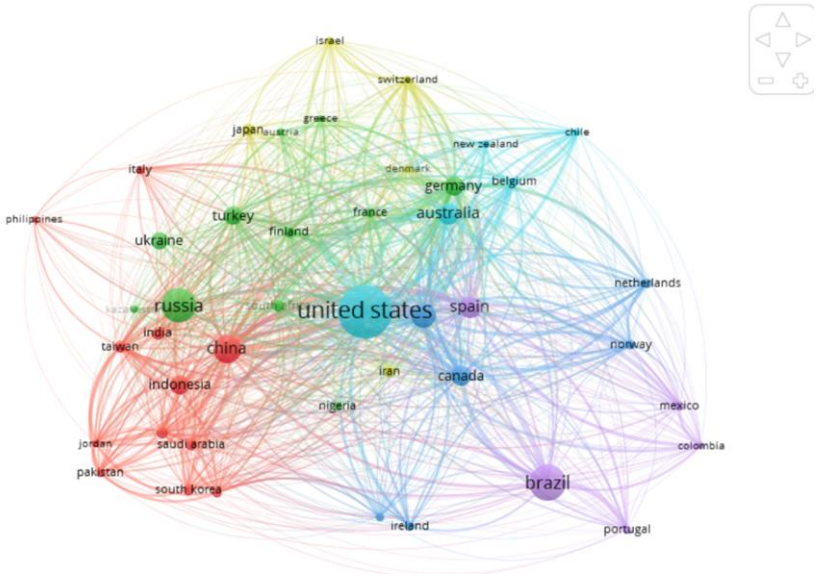

Figure 3. Bibliographic Coupling Country

The second image provides in-depth insight into educational technology publication trends in different countries worldwide, each cluster showing different colors reflecting diverse research trends and interests in different regions. This provides a clear picture of how educational technology is in demand globally, with several vital findings identifiable. The use of different colors for each cluster indicates variation in research interest in educational technology in different countries, suggesting that this topic is of interest to almost all over the world, but there are differences in the extent to which each country is involved in the research (Frith, 2023). Interactive relationships can be seen in blue, dark blue, green, purple, yellow, and red clusters. This indicates collaboration or linkage in research between countries in the same cluster. For example, countries in the blue cluster can interact with each other in educational technology research. Large dots among certain countries indicate higher research interest and contribution to educational technology. Countries like the United States, Russia, Brazil, and China seem to be highly interested in this topic. This could be due to factors such as population size, level of technology development, or government initiatives to support research in this area (Celdrán et al., 2020). The image above can provide insight into collaboration opportunities between countries with similar interests in educational technology. For example, countries in the same cluster can cooperate on research or knowledge exchange to develop better technology-based education solutions. It is essential to monitor these trends as educational technology continues to evolve and has excellent potential to improve education worldwide. Collaboration between countries can accelerate innovation and understanding in this field, bringing more significant benefits to global education.

Bibliographic Coupling Source

Bibliographic Coupling Source forms 6 clusters with Cluster 1 in red, cluster 2 in green, cluster 3 in yellow, cluster 4 in dark blue, cluster 5 in purple, and cluster 6 in light blue. These clusters can be seen in Figure 4.

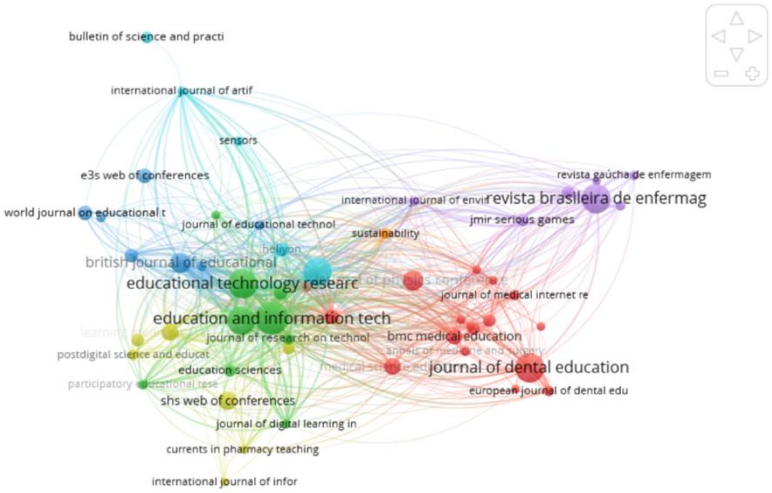

Figure 4. Bibliographic Coupling Source

Figure 4 shows pairs of journal bibliographies with different color relationships, indicating connectivity between these journals based on citations and research collaborations. Journals with circles with the most significant dots indicate the largest number of documents, reflecting high publication frequency. Based on the number of individual documents, journals such as "Educational Technology Research," "Education and Information," and "Journal of Dental Education" are the ones with the most publication trends. This shows that these journals play an important role in documenting and discussing developments in educational technology.

In particular, "Educational Technology Research" and "Education and Information" are the leading platforms for the publication of research that explores technological innovation and applications in educational contexts. Likewise, the "Journal of Dental Education" makes a significant contribution to combining modern technology with the practice of dental education. This shows the importance of these journals in shaping academic and practical discourse on educational technology.

However, these data show that mathematics learning is not closely related to educational technology. This opens up great opportunities for further research in developing educational technology approaches and strategies that can be applied in the context of mathematics learning. Researchers can explore how augmented reality (AR), virtual reality (VR), and game-based learning can improve understanding of mathematical concepts, student engagement, and learning outcomes. Additionally, further studies could be conducted to explore the integration of artificial intelligence (AI) in providing personalized and adaptive learning for students in mathematics. By researching more deeply how educational technology can be integrated into mathematics learning, it is hoped that more effective methods and tools can be found to help students understand complex mathematical concepts. This research can also identify challenges and opportunities in applying educational technology in mathematics and provide practical recommendations for educators and policymakers to adopt appropriate technology. Overall, this will enrich the educational technology literature and significantly improve the quality and effectiveness of mathematics learning(Abouelenein & Nagy Elmaadaway, 2023; Acioly-Regnier, 2020). By understanding the role and contribution of specific journals in the educational technology literature, researchers can better direct their research and explore areas still uncovered in technology education's development.

Bibliographic Coupling Document

Links and citations are critical indicators to measure the impact of a study in the scientific community. The more links and citations an article receives, the more influential and relevant the research will be in the scientific literature. Figure 5 shows significant information about the top 19

studies in the field of educational technology based on the number of citations and links used.

Document	Citations	Total link strength
bond (2020)	256	77
bond (2019)	118	57
chen (2020b)	200	49
kemp (2019)	85	43
bond (2021)	124	31
wang (2019)	99	31
lai (2019)	31	30
hong (2021)	36	29
camilleri (2022)	30	29
chen (2020a)	89	23
chen (2019)	43	23
luan (2020)	83	20
hew (2019)	102	20
valverde-berrocoso (2020)	199	19
suh (2022)	62	17
nazari (2021)	34	16
raman (2021)	43	14
christopoulos (2021)	42	13
renz (2020)	60	12

Figure 5. Bibliographic Coupling Document

The most influential study in this publication trend by "Bond (2020)" ranked first with 256 citations and 77 links pointing to the article, showing that this article significantly impacts educational technology literature and is often referenced by other researchers. This article may contain concepts, methods, or findings of great value to the research community. It can be seen that "Bond (2019)" also ranked second with 57 links and a total citation of 118. This suggests that researchers under "bond" may have done consistent and relevant work in two consecutive years, with their 2020 and 2019 studies gaining significant attention. The article "Chen (2020)" ranked third on this list with 49 links and 200 citations. This shows that the research conducted by "Chen" in 2020 also had a significant impact and was noticed by the research community.

The articles that appear on this list can be considered a good starting point for researchers who want to undergo further research in educational technology (Bond et al., 2021). Referring to research that has gained much attention can help researchers understand essential trends, theories, or methodologies in this field.

Keyword Relationships

Keyword Relationships formed from 5931 articles on educational technology are presented in Figure 6. There are 5 clusters with different focuses in each cluster.

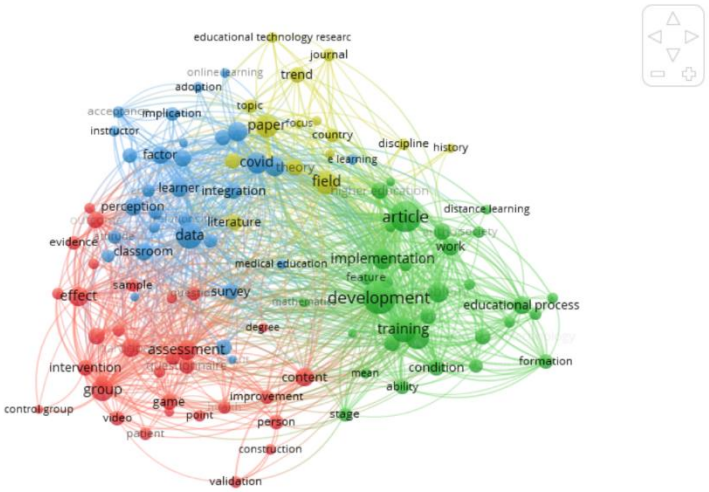

Figure 6. Keyword Relationship

The publication trend keyword with the topic of educational technology in Figure 5 combines clusters with different colors, and these colors are clusters that can be used to divide the focus of research related to this field. Keywords displayed The circle with blue and green colors is the main focus, which is the largest cluster with the same result of 31 items, followed by the red cluster being the second focus with the results of 28 items and the last cluster as well as being the focus of research which is the yellow cluster with the results of 15 items. There are 105 keywords in Figure 5. The keyword with the most extensive circle among other circles is the focus of the first research. Namely, keywords (data, covid, article, development, training) are keywords with the most prominent circles in the blue and green clusters. This reflects the considerable role played by education technology in responding to the pandemic, collecting data, and developing better education solutions. The keywords that are the focus of the second study are (assessment, effect, and group) with the largest circle in the red cluster reflecting the focus on understanding the impact of technology on learning and assessment methods in educational environments. The third research focus that is focus of research is keywords that have the most extensive circle among other circles, namely (field and paper) are keywords with the most prominent circles in the yellow cluster, which can reflect interest in involving research methods and case studies in educational technology (Abadi et al., 2018; Abboud, 2020; Abdullah, 2020). A dominant research focus in educational technology can help researchers and practitioners establish relevant research themes (Angraini et al., 2022; Bilal et al., 2022). It can also help in planning more in-depth research and focusing on the most critical aspects of this field by understanding the clusters and keywords that dominate, and further research can be more focused and relevant to the latest trends in educational technology (Adriani et al., 2023b; Allman et al., 2023; Antee, 2020).

Keyword Novelty

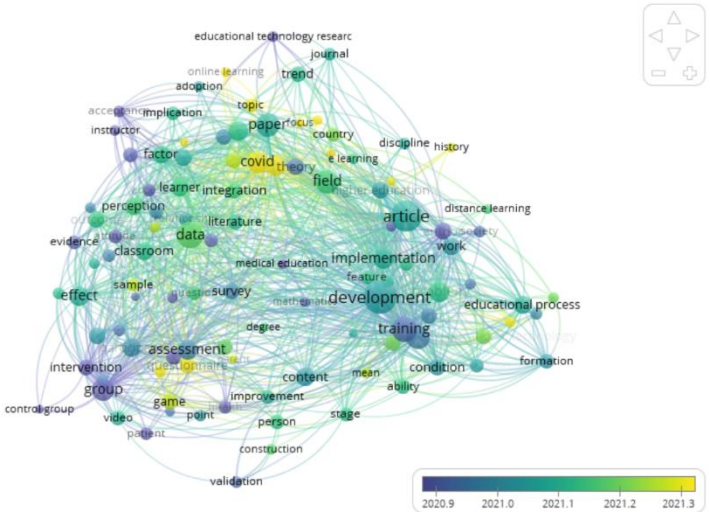

Figure 7. Keyword Novelty

Based on Figure 7, several colors can be seen indicating the development of keywords in educational technology, starting from blue, which indicates use around 2020, green around 2021, and yellow, meaning the keyword has only been used in the last few years. Keywords with yellow circles indicate new themes, such as 'COVID,' 'topic examples,' and 'gaming.' Keywords that are not linked to other keywords indicate the possibility of a new problem or research focus that has not been researched much before, and this opens up significant opportunities for researchers to explore new aspects of educational technology. Based on these findings, several research recommendations can be proposed. First, new themes, such as the use of technology during the COVID-19 pandemic in the education sector, are interesting topics for further research. This research could focus on the long-term impact of changes occurring during the pandemic on teaching methods, technology adaptation by teachers and students, and the effectiveness of distance learning. Second, the theme of 'games,' which emerged as an

innovation, shows the tendency for a game approach and game-based learning in the educational context. Further research could explore how game-based learning can increase student motivation and engagement and impact learning outcomes.

Furthermore, analysis of keywords not linked to other keywords can lead researchers to explore new topics that have not been widely researched. This could include research on educational technologies developed for students with special needs, using artificial intelligence (AI) to personalize learning, or implementing blockchain technology in educational data management.

Additionally, longitudinal research that measures the long-term impact of educational technology use is essential. For example, examining how technological adaptation accelerated by the COVID-19 pandemic affects students' digital readiness and their skills in facing future challenges (Afifah & Istiqomah, 2022; Agustin & Fernandes, 2022; Ahmady et al., 2021). Case studies of schools and universities that have successfully implemented educational technology effectively can also provide valuable insight into the success factors and challenges faced in this process. With the recommendations of this research, it is hoped that it can significantly contribute to the educational technology literature and help direct further developments in this field. Identifying new themes and potential unresolved problems is essential in understanding trends and directing research in the most relevant and impactful directions. Researchers can use this analysis to explore new aspects of educational technology and provide innovative solutions to existing challenges (Brandão, 2022; Bruderer, 2020).

4. CONCLUSION

Based on the data above, the development of educational technology in recent years has experienced a surge in publications, reflecting the high interest in this field. Major spots are seen in several countries: the United States, Russia, Brazil, and China. Journals such as "Educational Technology Research," "Education and Information," and "Journal of Dental Education," have become significant players in documenting the development of educational technology. This shows the importance of the role of these journals in directing discussion and understanding in this field. As Bond pointed out in 2020, the most influential research reflects a significant contribution to the educational technology literature and is often referenced by other researchers. This shows that in-depth research can have a significant impact in directing developments in this field. The analysis of keywords and their relationships opens the door for further research on the latest developments in educational technology that can be explored further. Another interesting finding is the emergence of the keyword 'game' as an innovation that increasingly dominates the educational technology literature, showing the tendency of game approaches and game-based learning in the context of education. The relationship between keywords also opens up research opportunities on new aspects that have not been widely researched. Several research recommendations can be used as the focus of further exploration in educational technology. First, comparative research on the development of educational technology in countries with a high surge in publications, such as the United States, Russia, Brazil, and China, can provide in-depth insights into the policies, implementation, and challenges each country faces. Second, the analysis of the impact of significant journals such as "Educational Technology Research," "Education and Information," and "Journal of Dental Education" on the direction of educational technology development is essential to understand how publications in these journals affect teaching policies and practices. Third, an in-depth study of Bond's 2020 research needs to be conducted to understand its contribution to the educational technology literature and how other researchers adopt it.

Furthermore, research on the effectiveness of game approaches and play-based learning in the context of education can explore their impact on learning motivation, student engagement, and learning outcomes. Analysis of keyword trends in educational technology publications is also essential to identify emerging and under-researched research areas, such as 'games,' 'virtual reality,' and 'artificial intelligence.' The development and evaluation of new educational technologies, such as augmented

reality (AR) and virtual reality (VR)-based applications, needs to be undertaken to assess how these technologies can enhance the learning experience (Frith, 2023; Karalekas et al., 2023). Case studies in schools and universities that have successfully implemented educational technology effectively can provide insight into the success factors and challenges faced and their impact on student learning outcomes (Afni & Huda, 2023). Finally, longitudinal research to measure the long-term impact of educational technology on students' learning outcomes, digital skills, and readiness to face future challenges is essential to provide a comprehensive picture of the effectiveness of educational technology in the long term. With the recommendations of this study, it is hoped that it can significantly contribute to the literature on educational technology and help direct further developments in this field.

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