

Research Trends in Interactive Learning Media for Sustainable Education: A Bibliometric Analysis of Scopus Publications (2021-2025)

Kania Yuliyanti^{1*}, Djono², Agus Efendi³

^{1,2,3}Universitas Sebelas Maret, Surakarta, Indonesia

Corresponding Author.

*Email: kania.yuliyanti@student.uns.ac.id

ABSTRACT

This study aims to map research trends related to interactive learning media in the context of continuing education through a bibliometric analysis approach. This study uses publication data obtained from the Scopus database with a time range of 2021–2025, using the keywords "interactive learning", "learning media", and "educational technology". A total of 191 documents were successfully identified and analyzed using the VOSviewer software to visualize the network of keywords, linkage patterns, and thematic structure of the research. The results of the analysis show that there is a significant increase in the number of publications, especially in 2025, which reflects the increasing attention to the integration of technology in learning. Citation analysis showed a total of 1,793 citations with an h-index value of 21, which indicates a fairly good level of scientific impact. The keyword network visualization reveals several key clusters, including technical aspects such as algorithms and adaptivity, interactive learning strategies, technology development, and the direction of continuous research. In addition, density visualization shows that topics such as effectiveness, accuracy, and efficiency are the main focus in the research. Overall, this study shows that the study of interactive learning media develops in a multidisciplinary manner with a strong tendency to evaluate the effectiveness and development of learning technologies. These findings are expected to provide a comprehensive picture for researchers and practitioners in determining the direction of further research development, especially in supporting sustainable education.

KEYWORDS: Interactive learning media¹, bibliometric analysis², sustainable education³, educational technology⁴, research trends⁵

© 2026 International Conference on Multidisciplinary Engagement. All rights reserved.

1. INTRODUCTION

Digital transformation has become part of the global education ecosystem. The acceleration of the integration of digital technology in education reflects the need to create a learning system that is responsive to the dynamics of 21st-century education [1]. Interactive learning media—including interactive video, learning management systems (LMS), gamification, augmented reality (AR), and virtual reality (VR)—have emerged as innovative solutions to improve engagement and learning outcomes [2]. These technologies not only enrich the learning experience, but also open access to education that is more inclusive, flexible, and adaptable to the needs of diverse students. Its significance is even more pronounced when it is associated with the concept of sustainable education, which emphasizes lifelong learning and competency building relevant to global sustainability challenges [3]. This transformation requires a strategic balance between technological innovation and affordability, to ensure that interactive learning technologies are equitably accessible to all students in various socio-economic contexts.

The field of educational technology has grown rapidly in the last decade. Many empirical studies have shown the effectiveness of interactive learning media in increasing students' learning motivation, knowledge retention, and academic achievement. The increasing trend of using online learning, blended learning, and digital learning is increasingly dominating the contemporary education landscape, especially post-COVID-19 pandemic. The growth of scientific publications in the field of educational technology reflects strong academic interest in the topic, with research showing an exponential increase since 2020. The most frequently developed and researched learning media include interactive multimedia, animated videos, and digital platforms that integrate artificial intelligence for learning personalization. Existing research is spread across various subthemes, ranging from LMS development and the use of interactive videos, to the implementation of gamification, augmented reality, and virtual reality in the context of education at various levels and disciplines.[4][5][6]

Although the growth of publications is very rapid, the field has become increasingly complex and fragmented. Researchers face difficulties in understanding the direction of research development, emerging dominant themes, patterns of global scientific collaboration, and research gaps that still need to be addressed [7]. The explosive growth of publications in educational technology research has created challenges for the scientific community to identify priority topics and avoid duplication of research. There are many empirical studies that focus on local contexts or specific topics, but comprehensive mapping of the research landscape is still limited, particularly in linking interactive learning media to continuing education frameworks. Previous bibliometric analyses focused more on general technological aspects in education, rather than specifically examining the relationship between interactive learning media and sustainable development goals [8]. There is no current bibliometric mapping that specifically examines global trends in interactive learning media within the framework of sustainable education, making it difficult for researchers and education practitioners to identify research frontiers, determine future development priorities, and understand regional contributions in the evolution of interactive learning technologies.

To address these gaps, this study uses bibliometric analysis as the main methodological approach. Bibliometrics is a quantitative method to map the structure of knowledge and trends in research development in a field [9]. Bibliometric analysis allows the identification of publication growth patterns, the mapping of the productivity of authors, countries, and the most active journals in producing quality research, the visualization of scientific collaboration networks between researchers and institutions, and in-depth analysis of the dominant research keywords and themes. Bibliometric mapping is also able to identify emerging themes and shifts in research focus that reflect the evolution of paradigms in educational technology. The data for this analysis were taken from Scopus, a leading and credible bibliographic database that includes publications from around the world with multidisciplinary coverage, and has become the standard choice for bibliometric studies in education [5].

This study has a general objective to map the research landscape on interactive learning media in the context of continuing education through bibliometric analysis of Scopus publications for the period 2020–2025. The contribution of this research lies in several main dimensions. First, this study provides a comprehensive and up-to-date overview of the interactive learning media research landscape in the post-pandemic era, a critical period in which the digital transformation of education is experiencing significant acceleration [6]. Second, this study explicitly links interactive learning media research with the conceptual framework of continuing education, which has not been widely done in the bibliometric literature before, while emphasizing the importance of educational equity and accessibility in learning technology design [10]. Third, the findings of this study are expected to provide strategic direction for education researchers and practitioners in identifying priority development areas, information for policy makers in designing equitable and sustainable technology-based educational innovation strategies, and recommendations for further development in aligning learning technology with global sustainability goals [11]. Thus, this research not only contributes to academic understanding but also has practical relevance for a more inclusive, accessible, and sustainable transformation of education at the global level.

2. METHOD

This study uses a quantitative-based bibliometric analysis approach to map and examine the development of the scientific literature related to interactive learning media in the context of continuing education. This approach was chosen because it is able to provide an objective picture of publication productivity, topic development patterns, and knowledge structure in a field of study. Publication data is collected from the

Scopus database due to its reputation as an internationally reputable scientific index that includes multidisciplinary journals and proceedings. The research time span is set for the 2021–2025 period to capture the dynamics of cutting-edge research, especially after the acceleration of digital transformation of education.

Data collection was carried out through the formulation of a systematic search strategy using a combination of keywords relevant to interactive learning media, namely "interactive learning", "learning media" and "educational technology" in the scopus search query. The search process is focused on publication metadata, including titles, abstracts, and keywords, to ensure the suitability of the documents obtained. All data collected then goes through a cleaning stage, including the elimination of duplication, standardization of author and institution names, and alignment of term variations. This stage is important to maintain the consistency and reliability of the data before further analysis is carried out.

Next, the data is analyzed using VOSviewer software to generate bibliometric network mapping. The analysis includes citation networking, author collaboration, and keyword linkage through co-occurrence analysis. Through this process, the research identifies the main thematic clusters, assesses the relationships between concepts, and describes the intellectual structure of the interactive learning media field. The network visualization and clustering results are then interpreted to reveal the direction of research development and identify research gaps that are still open for further study.

3. RESULTS AND DISCUSSION

This research conducted a data search process through a search on the Scopus website, where data retrieval yielded 191 using a combination of specific keywords: "interactive learning", "learning media" and "educational technology" in the Scopus search query. The search was carried out with the type of documents in the form of scientific journal articles. From the entire document, Scopus recorded 1,793 citations with an h-index value of 21. Figure 1 shows the citation metrics of livelihood outcomes.



Figure 1 Citation Metric Analysis

The total number of 191 documents shows the size of the corpus of literature analyzed in this bibliometric study. This figure represents publications that are deemed relevant by the Scopus algorithm based on the suitability of the title, abstract, and keywords to the search terms used. The overall analysis of research trends in this study is based on the collection of such publications.

The value of 1,793 citations illustrates the total frequency with which all documents in the corpus are cited by other publications indexed in Scopus. In general, citation numbers are used as an indicator of the level of attention and utilization of scientific works by the academic community. The higher the number of citations, the more likely it is that the topic being studied has strong relevance and research appeal.

Meanwhile, the h-index of 21 indicates that there are at least 21 documents in the dataset, each of which has been cited at least 21 times. This indicator is often used to describe a combination of the productivity of a publication and its scientific impact simultaneously. This value indicates that some publications in the field of interactive learning media and educational technology have gained a significant influence in the scientific literature.

Overall, the combination of the number of documents, total citations, and h-index values shows that research related to interactive learning media and educational technology in the 2021–2025 period has a fairly developed literature base and shows a good level of scientific visibility. This data provides a solid basis for conducting further research trend analysis.

These findings have strong implications for the sustainable education agenda, especially in supporting the achievement of Sustainable Development Goal (SDG) 4 on quality education and lifelong learning.

Continuing education emphasizes the importance of developing 21st-century competencies such as learning independence, digital literacy, and lifelong learning capabilities, all of which are closely related to self-regulated learning. The integration of digital technology in learning has been proven to be able to expand access to education, increase learning flexibility, and encourage more personalized and inclusive learning [12]. In addition, strengthening self-regulated learning through technology support is also seen as an important prerequisite for the success of lifelong learning in the digital age [13]. Furthermore, the use of pedagogically designed digital learning environments can help build sustainability competencies, as it allows students to develop critical thinking skills, self-reflection, and responsibility towards their own learning process [14]. Therefore, the development of interactive learning media not only contributes to improving the quality of economic learning in secondary schools, but also has strategic relevance in preparing students to become lifelong learners who are adaptive, independent, and ready to face the challenges of sustainable development in the future.

1. Descriptive Analysis and Temporal Trends

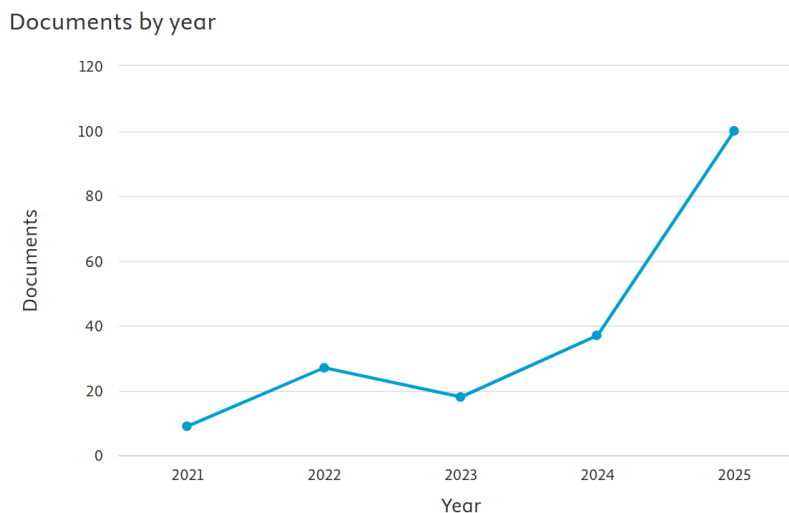


Figure 2. Annual Publication Trends

The distribution of the number of publications per year shows the dynamics of research development quite clearly during the period 2021–2025. In 2021, the number of publications is still relatively limited, namely 9 documents. This condition can be understood as the initial phase of strengthening research interest in the topic of interactive learning media in the framework of educational technology.

In 2022 there was a fairly noticeable increase to 27 documents, almost three times compared to the previous year. This increase indicates the beginning of widespread academic attention to the use of technology in learning. However, in 2023 it will be seen to decrease to 18 documents. These fluctuations suggest that research growth does not take place in a linear manner. This kind of temporary decline is common in the dynamics of scientific publications, for example due to a shift in research focus, publication cycles, or indexation curation processes.

The trend is picking up again in 2024 with 37 documents, which signals a recovery as well as an increase in research interest in this field. The most significant spike is seen in 2025 with 100 documents, the highest number throughout the observation period. This sharp increase indicates a very strong acceleration of research production in the near future.

Overall, the pattern shows an increasing trend with fluctuations. The sharp rise in recent years indicates that the topic of interactive learning media and educational technology is increasingly becoming an important focus in contemporary educational research. This reinforces the assumption that the integration of technology in learning continues to receive greater attention from the academic community and can be understood as part of the shift towards more sustainable education.

The use of digital technology in learning allows the learning process to take place more flexibly, personally, and centered on students, thereby encouraging the formation of lifelong learning skills [15]. In addition, educational technology contributes to expanding access to learning resources, reducing educational opportunity gaps, and supporting the efficient use of learning resources [16]. This digital transformation is also seen as an important component in achieving SDG 4 because it is able to strengthen 21st century competencies and students' readiness to face social and global economic changes [17]. Thus, the development and utilization of interactive learning media not only has an impact on the quality of the learning process in the classroom, but also has a strategic role in supporting the creation of an inclusive education system. adaptive, and sustainability-oriented.

2. Analysis of scientific contributions

Table 1 contains journal contributions that show that publications on interactive learning media are spread across a number of international journals that focus on educational technology, information technology, and learning innovation. This distribution shows that the topics studied are multidisciplinary and not limited to one particular scientific community.

Table 1. Journal Contributions

Journal Name	Number of Articles
International Journal of Interactive Mobile Technologies https://online-journals.org/index.php/i-jim	10
Applied Sciences Switzerland https://www.mdpi.com/journal/applsci	6
IEEE Access https://ieeaccess.ieee.org/	6
Computers and Education https://www.sciencedirect.com/journal/computers-and-education	4
International Journal of Information and Education Technology https://www.ijiet.org/	4
British Journal of Educational Technology https://bera-journals.onlinelibrary.wiley.com/journal/14678535	3
Data and Metadata https://dm.ageditor.ar/index.php/dm	3
Education and Information Technologies https://link.springer.com/journal/10639	3
Educational Technology Research and Development https://link.springer.com/journal/11423	3
Interactive Learning Environment https://www.tandfonline.com/journals/nile20	3

The journal that made the largest contribution was the International Journal of Interactive Mobile Technologies with 10 articles. This dominance shows that the study of interactive learning media intersects with the use of mobile devices and flexible digital technology-based learning.

In the next position are Applied Sciences (Switzerland) and IEEE Access, each contributing 6 articles. The presence of these two journals indicates that research in this field is not only viewed from a pedagogical perspective, but also from the side of technological engineering, computing, and digital system development.

The next contribution came from Computers and Education and the International Journal of Information and Education Technology which each contained 4 articles. These two journals are known to focus on the integration of technology in the learning process, so their existence strengthens the relevance of the research theme to the realm of educational technology.

Several other journals made relatively balanced contributions, each with 3 articles, namely the British Journal of Educational Technology, Data and Metadata, Education and Information Technologies, Educational Technology Research and Development, and Interactive Learning Environments. The evenly distributed in this group of journals shows that research on interactive learning media has a wide publication base and is accepted in various reputable scientific forums.

Overall, the journal's contribution pattern shows that interactive learning media research is developing in a cross-disciplinary publication ecosystem and is increasingly leading to the continuing education agenda. The dominance of journals that intersect with digital technology, computing, and systems engineering indicates that learning transformation is no longer understood solely as a pedagogical issue, but as part of a systemic effort to build an adaptive, inclusive, and sustainable educational ecosystem. The latest literature emphasizes that the integration of digital technology in education has an important role in expanding access to learning, improving the quality of learning, and supporting the achievement of sustainable development goals in the education sector. Studies on Education 5.0 emphasize that technologies such as AI, virtual reality, and digital learning systems enable personalization of learning as well as the removal of barriers to access to education more broadly [18]. In addition, a systematic study of sustainability in computing education shows that research in this field is increasingly directed at the formation of competencies relevant to long-term global challenges [19]. Other research also confirms that the use of digital technology in education contributes to sustainable society development through learning innovation and increased readiness of future generations [20]. The distribution of journal contributions in this study shows that interactive learning media research is not only developing quantitatively, but also moving towards a strategic role in supporting continuous education globally.

3. Analysis of scientific fields

Figure 3 contains the distribution of documents by subject area which shows the distribution of research contributions on interactive learning media topics.

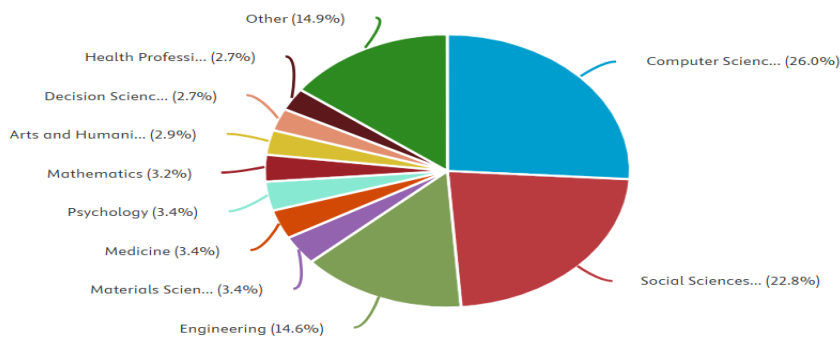


Figure 3. Documents by Subject Area

The Computer Science sector occupies the highest position with a percentage of 26.0%. This shows that the study of interactive learning media is very closely related to the development of digital technology, such as the development of learning software, e-learning systems, artificial intelligence, and computer-based interactive platforms. This dominance indicates that technological innovation is the main driver in the development of interactive learning.

Furthermore, the Social Sciences sector is in second place with a contribution of 22.8%. These findings reflect that the research focuses not only on technical aspects, but also on social and pedagogical dimensions, such as interaction between students and teachers, the effectiveness of learning methods, and the impact of the use of interactive media on the learning process.

The Engineering sector accounted for 14.6% of the total publications. This contribution is generally related to the design and development of hardware and technology systems that support the implementation of interactive learning media, including the integration of technology in the educational environment.

The Other category of 14.9% indicates the contribution of various other fields that are not specifically classified, which indicates the multidisciplinary nature of this topic.

Meanwhile, other fields such as Materials Science (3.4%), Medicine (3.4%), Psychology (3.4%), Mathematics (3.2%), Arts and Humanities (2.9%), Decision Sciences (2.7%), and Health Professions (2.7%) contributed on a smaller scale. Although the percentage is relatively low, the existence of these fields remains important because it shows that research on interactive learning media also includes cognitive aspects, learning behaviors, and applications in educational and health contexts.

The cross-disciplinary distribution shows that interactive learning media research is increasingly directed at efforts to strengthen continuous education through collaboration between technological innovation and pedagogical studies. The involvement of various disciplines shows that improving the quality and equity of education cannot be achieved through technical approaches alone, but requires the integration of an understanding of the learning process, student behavior, and the social context of education. A number of studies confirm that digital transformation has expanded lifelong learning opportunities while increasing students' readiness to face global changes [21]. In addition, the use of educational technology also contributes to developing sustainability competencies, such as critical thinking, collaborative, and complex problem-solving skills [22]. Other research shows that learning technology innovations can strengthen the resilience of education systems through flexible learning models that are adaptive to social dynamics and global crises [16]. The dominance of the fields of technology and social sciences in the analyzed publications confirms that interactive learning media has a strategic role in supporting the realization of inclusive, adaptive, and sustainability-oriented education.

4. Keyword network analysis

The visualization of the keyword network generated using VOSviewer shows the relationship between research topics in the field of interactive learning media. Each node (point) on the map represents a keyword, while the connecting line indicates a relationship or *co-occurrence* between keywords in the document being analyzed. The closer the distance between the nodes, the stronger the relationship between the topics. The results also showed that the research topic was divided into several groups (clusters) characterized by color differences. Each color indicates a set of keywords that often appear simultaneously in publications, so they can represent a specific research theme. Figure 4. Shows the results of the VOSviewer keyword network analysis

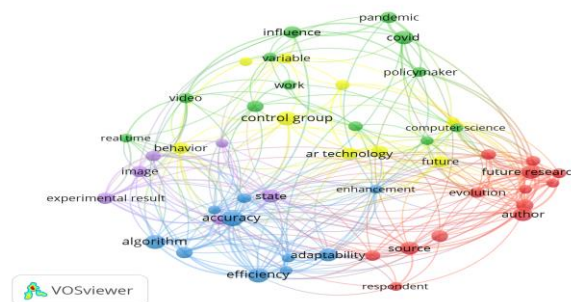


Figure 4. VOSviewer Network Analysis

Based on the map, it can be seen that keywords such as *algorithm* and *adaptability* are in the same cluster (blue) and are quite strongly interconnected. This indicates that research has highlighted a lot of technical aspects, especially in the development of learning systems that are able to adapt to user needs. The concept of adaptivity is important in the context of interactive learning because it allows the system to respond to differences in the characteristics and abilities of learners.

Keywords such as *source* and *future research* appear in the same cluster (red), indicating a link with sustainable education. This shows the relationship between aspects of technology development and learning resources as well as forms of development for sustainable research in the future. In other words, research focuses not only on how the system is built, but also on how the system is used and accessed by users in the future.

The keywords *control group* and *ar technology* which are marked with yellow clusters tend to describe interactive learning processes and strategies. It contains keywords related to student involvement, active learning methods, and interaction-based pedagogical approaches. This cluster emphasizes the importance of interactivity as the key to improving the quality of the learning experience.

The green cluster indicates a focus on the development and utilization of technology in learning. The keywords in this group are related to the use of digital technology, computer-based learning systems, and interactive media innovations such as *influence* and *video*. This indicates that much of the research is directed at the integration of technology to support a more modern and adaptive learning process.

Keywords such as *experimental result* in purple clusters (or other smaller color variations) lead to methodological and analytical approaches, such as the use of bibliometric analysis, systematic evaluation, and data analysis techniques. This cluster plays a supporting role in strengthening scientific research studies.

This division of clusters by color shows that research on interactive learning media is developing multidimensionally. Although each cluster has a different focus, the relationship between the clusters appears to be quite close, which indicates an integration of technology, learning strategies, and evaluation of outcomes in support of sustainable education.

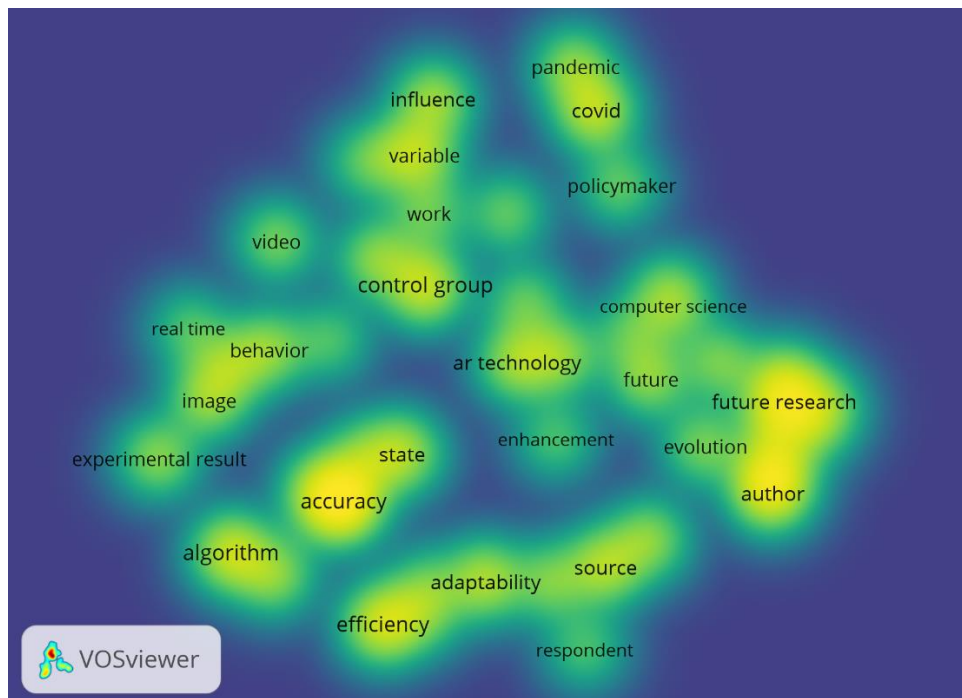


Figure 5. Density Visualization VOSViewer

The density visualization using VOSviewer in Figure 5 shows the density of keyword occurrences in the published under analysis. This map uses color gradation to indicate the intensity of the linkage, where yellow indicates a high frequency of occurrence and relationship, green indicates a moderate level, while purplish blue denotes relatively low density. With this approach, it can be clearly seen which areas are the center of attention in the development of the research.

Based on the map, several keywords such as *future research*, *author*, *accuracy*, *efficiency*, and *control group* are in the area with the brightest color. This condition shows that these topics have a high intensity of occurrence as well as a strong association with other keywords. This indicates that research in this field emphasizes a lot on the aspects of evaluation of results, performance measurement, and the direction of future research development.

On the other hand, keywords such as *ar technology*, *computer science*, *behavior*, and *variables* are in areas with medium density. This position reflects his role as a liaison between the technical aspects and the learning process. These topics not only support the development of interactive learning media, but are also an important part of explaining how technology is applied in educational contexts.

Meanwhile, some keywords such as *video*, *real time*, *experimental results*, and *respondents* appear to be in areas with fader colors. This suggests that its occurrence is relatively more limited or more specific in research. Nevertheless, the existence of these keywords still contributes to enriching the variety of approaches used in the study.

In addition, the emergence of keywords such as *covid* and *pandemic* with a fairly prominent density level shows that the pandemic context still has an influence on the direction of research, especially in the development and utilization of interactive learning media.

The pattern of keyword density shows that the direction of interactive learning media research is increasingly moving towards issues related to education sustainability. The emphasis on effectiveness, evaluation, and future development reflects academic efforts to ensure that technological innovation is truly capable of improving the quality and resilience of the education system. A number of studies confirm that the use of digital technology in learning can expand access to education while supporting flexible learning models that are relevant to the principles of continuous education [23]. Other studies show that the integration of learning technologies plays a role in building the 21st century competencies needed to face long-term global challenges [24]. In addition, the latest study emphasizes that digital transformation in education is an important foundation in creating an adaptive and sustainable education system in the post-pandemic era [25]. Therefore, the results of the density visualization not only illustrate the current research focus, but also affirm its contribution to strengthening continuing education.

5. Analysis of geographic contributions

Figure 6 shows the distribution of publications by country/territory in research on interactive learning media for sustainable education for the period 2021-2025. This visualization provides an overview of geographic contributions to global research development in this field.

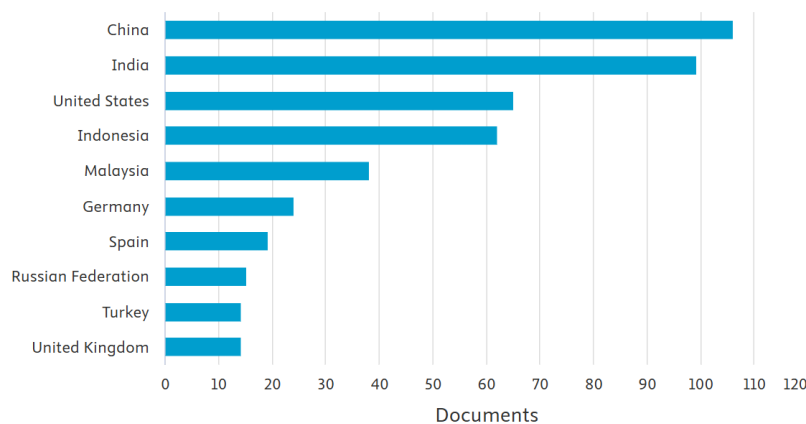


Figure 6. Distributions by Country/Territory

The analysis shows that China ranks first with 106 publications, followed by India with 99 publications. The dominance of these two countries indicates a high level of attention and investment in educational technology development, particularly in the integration of interactive learning media to support digital educational transformation. Furthermore, large research capacity, large populations, and national policies encouraging the digitalization of education are likely driving factors in the high publication productivity in these two countries.

The United States ranks third with 65 publications, followed by Indonesia with 62 publications. Indonesia's relatively high ranking indicates that the issue of interactive learning media has become a significant focus in the national education context, especially after the pandemic accelerated the adoption of digital learning technologies. This finding also demonstrates the increasing contribution of developing countries to the international literature on educational technology.

Malaysia ranks next with 38 publications, followed by Germany (24), Spain (19), the Russian Federation (15), Turkey (14), and the United Kingdom. European countries appearing on the list tend to show stable, but less significant, contributions than Asian countries. This may reflect differences in research priorities, educational policy focus, and the dynamics of learning technology adoption in each region.

Overall, the distribution of these publications shows that research contributions are dominated by Asian countries, particularly China, India, and Indonesia. This pattern indicates a shift in the growth center of educational technology research to Asia and emphasizes the growing role of developing countries in driving digital learning innovation and sustainable education globally.

4. CONCLUSION

The results of this study show that the development of interactive learning media studies in the context of continuing education has increased significantly during the 2021-2025 period. This is characterized by the growth in the number of publications, the high level of citations, and the diversity of contributions from various scientific fields, especially computer science and social sciences. These findings show that the integration of technology in learning has become a major focus in contemporary education research.

The bibliometric analysis carried out also revealed that the research structure in this field was formed through several interrelated thematic clusters. The cluster includes technical aspects of learning system development, interactive learning strategies, evaluation of learning outcomes, and future research development directions. In addition, density visualization shows that the issues of effectiveness, accuracy, and efficiency are the center of attention in the study, while other topics play a supporting role that enriches the research perspective.

Overall, this study succeeded in providing an overview of the landscape and the direction of development of interactive learning media research. In the future, further research is expected to place more emphasis on the integration of technologies that are not only innovative, but also inclusive and sustainable. In addition, further exploration of the research gaps that are still open is needed, especially in linking interactive learning media with the real implementation of continuing education in various contexts.

REFERENCES

- [1] Q. Liu and Y. Li, "Digital-Technology-Enhanced Immersive Learning in Chinese Secondary School Geography Education: A Comprehensive Comparative Analysis of Sustainable Pedagogical Transformation," *Sustainability*, vol. 17, no. 18, p. 8478, Sep. 2025, doi: 10.3390/su17188478.
- [2] S. O. Makinde, B. M. Sulyman, and A. Ibrahim, "Beyond Borders: Leveraging Technology to Achieve Sustainable Development Goals in Education," *International Journal of Universal Education*, vol. 2, no. 2, pp. 90–100, Dec. 2024, doi: 10.33084/ijue.v2i2.8586.
- [3] R. Meylani, "A Critical Glance at Technology's Role in Mathematics Education for a Sustainable Future: Advancing SDG 4 - Quality Education Through a Systematic Review and Qualitative Synthesis," *Journal of Lifestyle and SDGs Review*, vol. 5, no. 2, p. e04566, Jan. 2025, doi: 10.47172/2965-730X.SDGsReview.v5.n02.pe04566.
- [4] N. M. Gumbi, D. Sibaya, and A. Chibisa, "Exploring Pre-Service Teachers' Perspectives on the Integration of Digital Game-Based Learning for Sustainable STEM Education," *Sustainability*, vol. 16, no. 3, p. 1314, Feb. 2024, doi: 10.3390/su16031314.

- [5] R. E. Jiménez Mendieta, “Educational innovation in virtual environments: a systematic review of methodological strategies post-covid-19 (2020–2025),” *Ciencia Latina Revista Científica Multidisciplinar*, vol. 9, no. 4, pp. 7857–7866, Sep. 2025, doi: 10.37811/cl_rcm.v9i4.19372.
- [6] W. Strielkowski, V. Grebennikova, A. Lisovskiy, G. Rakhimova, and T. Vasileva, “AI-driven adaptive learning for sustainable educational transformation,” *Sustainable Development*, vol. 33, no. 2, pp. 1921–1947, Apr. 2025, doi: 10.1002/sd.3221.
- [7] A. M. Omar and M. O. Abdullahi, “A bibliometric analysis of sustainable digital transformation in developing countries’ higher education,” *Front. Educ. (Lausanne)*, vol. 9, Nov. 2024, doi: 10.3389/educ.2024.1441644.
- [8] M. Hamadi and J. El-Den, “A conceptual research framework for sustainable digital learning in higher education,” *Res. Pract. Technol. Enhanc. Learn.*, vol. 19, p. 001, Mar. 2023, doi: 10.58459/rptel.2024.19001.
- [9] A. Yefremenko, I. Shutieiev, H. Poltoratska, A. Melnyk, and N. Dolhopolova, “Research Landscape of E-Learning in Physical Education: 2020–2025,” *Journal of Vasyl Stefanyk Precarpathian National University*, vol. 12, no. 3, pp. 83–100, Sep. 2025, doi: 10.15330/jpnu.12.3.83-100.
- [10] S. Bulathwela, M. Pérez-Ortiz, C. Holloway, M. Cukurova, and J. Shawe-Taylor, “Artificial Intelligence Alone Will Not Democratise Education: On Educational Inequality, Techno-Solutionism and Inclusive Tools,” *Sustainability*, vol. 16, no. 2, p. 781, Jan. 2024, doi: 10.3390/su16020781.
- [11] B. Kurent and S. Avsec, “Synergizing Systems Thinking and Technology-Enhanced Learning for Sustainable Education Using the Flow Theory Framework,” *Sustainability*, vol. 16, no. 21, p. 9319, Oct. 2024, doi: 10.3390/su16219319.
- [12] M. Bond and S. Bedenlier, “Facilitating Student Engagement Through Educational Technology: Towards a Conceptual Framework,” *Journal of Interactive Media in Education*, vol. 2019, no. 1, Sep. 2019, doi: 10.5334/jime.528.
- [13] E. Panadero, “A Review of Self-regulated Learning: Six Models and Four Directions for Research,” *Front. Psychol.*, vol. 8, Apr. 2017, doi: 10.3389/fpsyg.2017.00422.
- [14] G. Cebrián, M. Junyent, and I. Mulà, “Competencies in Education for Sustainable Development: Emerging Teaching and Research Developments,” *Sustainability*, vol. 12, no. 2, p. 579, Jan. 2020, doi: 10.3390/su12020579.
- [15] E. Mukul and G. Büyüközkan, “Digital transformation in education: A systematic review of education 4.0,” *Technol. Forecast. Soc. Change*, vol. 194, p. 122664, Sep. 2023, doi: 10.1016/j.techfore.2023.122664.
- [16] A. Haleem, M. Javaid, M. A. Qadri, and R. Suman, “Understanding the role of digital technologies in education: A review,” *Sustainable Operations and Computers*, vol. 3, pp. 275–285, 2022, doi: 10.1016/j.susoc.2022.05.004.
- [17] UNESCO, *Global Education Monitoring Report 2023: Technology in education: A tool on whose terms?* GEM Report UNESCO, 2023. doi: 10.54676/UZQV8501.
- [18] S. Ahmad, S. Umirzakova, G. Mujtaba, M. S. Amin, and T. Whangbo, “Education 5.0: Requirements, Enabling Technologies, and Future Directions,” Jul. 2023.
- [19] T. H. Kramarenko and V. M. Kramarenko, “The use of digital technologies in education in the context of sustainable development of society,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1415, no. 1, p. 012013, Dec. 2024, doi: 10.1088/1755-1315/1415/1/012013.
- [20] A.-K. Peters *et al.*, “Sustainability in Computing Education: A Systematic Literature Review,” May 2023.
- [21] S. Pokhrel and R. Chhetri, “A Literature Review on Impact of COVID-19 Pandemic on Teaching and Learning,” *Higher Education for the Future*, vol. 8, no. 1, pp. 133–141, Jan. 2021, doi: 10.1177/2347631120983481.
- [22] N. T. H. Nhung, P. T. Kien, M. Q. Khanh, T. T. Tinh, and T. D. P. Phong, “Digital transformation in Vietnam’s education: Opportunities, challenges, and development strategies,” *Multidisciplinary Reviews*, vol. 8, no. 9, p. 2025282, Mar. 2025, doi: 10.31893/multirev.2025282.
- [23] S. Dhawan, “Online Learning: A Panacea in the Time of COVID-19 Crisis,” *Journal of Educational Technology Systems*, vol. 49, no. 1, pp. 5–22, Sep. 2020, doi: 10.1177/0047239520934018.
- [24] C. Redecker, “European Framework for the Digital Competence of Educators,” Luxembourg, 2017.



1st International Conference on Multidisciplinary Engagement

- [25] A. Bozkurt *et al.*, “A global outlook to the interruption of education due to COVID-19 Pandemic: Navigating in a time of uncertainty and crisis,” *Asian Journal of Distance Education*, vol. 15, no. 3, pp. 1–126, 2020.