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Trends and gaps in active learning research: A bibliometric inquiry

Hülya Gür[1], Ahsen Filiz[2*]

[1]*International Sarejova University, Mathematics Education Department, Bosnia and Herzegovina.*
[2]*Biruni University, Education Faculty, Department of Mathematics and Science Education, Istanbul, Turkey.*

Corresponding author: Ahsen Filiz (*Email: afiliz@biruni.edu.tr*)

Abstract

This study conducts a comprehensive bibliometric analysis of research on active learning in education, focusing on key themes, influential works, and trends in the field. A total of 519 studies on active learning were analyzed using the VOSviewer program. The findings reveal that the United States is both the birthplace and the most prolific contributor to active learning research. Notably, co-word analysis indicates frequently occurring keywords such as critical thinking, creativity, cognitive development, active learning in education, and teacher education. Results suggest a relatively low volume of research focused on critical thinking within active learning, highlighting the need for further studies in secondary and high school education, teacher training, and medical education. Additionally, it was concluded that the number of studies on critical thinking in active learning is low and that there should be an increase in studies including students from secondary and high schools, teacher training institutes, and medical education as samples. Overall, this interdisciplinary analysis reveals shifts toward collaborative and digital learning environments, providing insights that can guide educators and policymakers in implementing evidence-based active learning strategies to enhance student engagement and academic outcomes, ultimately advancing the field's understanding of active learning's role in modern education.

Keywords: Active learning, Bibliometric analysis, Education, Interdisciplinary studies, VOSviewer.

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1. Introduction

Active learning is an approach that encourages students to be active participants in the learning process rather than passive listeners. Aimed at developing skills such as critical thinking, analysis, problem-solving, collaboration, and creativity, active learning encourages students to engage actively with the course material to deepen their understanding. In this model, students take responsibility for their learning, a factor that significantly enhances retention. According to

Bonwell and Eison [1] active learning is a form of learning where students do more than simply listen; they interact with the material in meaningful ways.

In recent years, research on learning styles, student thinking, and active participation has emphasized the need for active methodologies in education [2, 3]. Active methodologies encourage students to engage deeply in their learning processes, making them responsible for their own progress [4-7]. The flexibility of these methods allows their application across various fields and subjects, as shown by diverse studies and experiences in different thematic areas [8].

The evolution of active methodologies in education reflects a shift toward approaches that better prepare learners for a technology-driven world. By integrating technology, active learning methodologies facilitate more dynamic and accessible knowledge delivery, a critical factor in our constantly evolving global landscape [9]. As education continues to adapt, active learning remains a key component of methodological innovation, emphasizing student engagement, self-responsibility, and digital literacy.

The applications of active learning in education are diverse. Techniques such as question-and-answer activities, small group work, discussions, problem-based learning, role-playing, simulations, and technology-supported learning all contribute to greater student engagement [10]. Especially in STEM (science, technology, engineering, and mathematics) education, active learning has become a widely adopted pedagogical approach that enhances learning efficiency in many educational institutions [11].

If we examine the definition of bibliometrik; it is "the study of the quantitative aspects of the production, distribution and use of published information". Bibliometric analysis aims to analyse the intellectual structure and development over time in a particular research field, defining productivity in that field and revealing long-term changes [12]. Bibliometric studies are a way to gain in-depth knowledge about a particular topic in a scientific field, and they usually have one important limitation. This limitation, which is considered critical, arises from the usual rigidity of the analysis (by the individual, institution, etc.).

This study presents a bibliometric analysis of research on the role of active learning in education. A total of 569 studies on active learning were selected based on specific inclusion criteria and analyzed using the VOSviewer program. Co-authorship, co-citation, co-reference, and keyword analyses were conducted to examine variables such as the most cited authors, publication years, sources, and contributing countries. The findings reveal that the United States is the most productive country in active learning research, with leading contributors in co-citation analysis. According to keyword analysis, frequently recurring terms include critical thinking, creativity, cognitive development, and teacher education. The findings show that active learning research is increasingly interdisciplinary, with shifts toward collaborative and digital learning environments. This analysis has the potential to guide educators and policymakers in implementing evidence-based active learning strategies, providing deeper insights into the role of active learning in modern education.

2. Materials and Methods

In this context, the Web of Science Core Collection database was scanned for the keyword "active learning" to access research data. As a result of the search in Web of Science, a total of 569 scientific studies were reached. The data was limited to studies conducted in the field of educational sciences and 519 scientific studies published between 1990-2024 were found. Accordingly, the study was conducted using 519 scientific publications.

The detailed information of the 519 publication (publication year, publication type, publication language, title, author name, author country, number of citations, abstract, keywords and bibliography) was used in the study. First of all, the Web of Science database was scanned in the study and the number, type, publication language and citation frequency of scientific studies published in the subject field of "active learning" were determined by years. The time periods in which publications on the subject of "active learning" were concentrated were determined according to the frequency distribution of the studies by year. In addition, the most cited studies were determined. The joint works of the authors who have scientific publications in the field of active learning were examined and the dominant countries of the field were determined in terms of the countries of the authors. During the analysis, if two or more authors from the same country were included in a publication, the country was counted once. In addition, the journals where the important studies cited by the studies in the data set were published were determined. The authors and studies cited by the studies in the data set were also examined within the scope of the study.

In this way, it was aimed to determine the important authors who conducted research in the field of active learning and the studies they produced and to determine the interactions between them. Co-citation analysis allows us to understand the prominent research topics in a certain field in terms of paradigm shifts, the relationship between the dynamics of the intellectual structure and periodic changes. The results of the co-citation analysis allow us to determine the subject clusters in the field of active learning. In addition, word analysis was also performed in the study to determine the concepts used in the studies in the data set and published in the field of active learning. Social network analysis was used to determine the countries of the authors conducting the research and the concepts frequently used in the field of active learning; to determine the authors, studies and the journals in which these studies were published and to visualize the relationships related to these. Social network analysis is a mapping analysis that aims to reveal and visualize mathematical relationship-based patterns using metadata from scientific studies [13, 14]. As a result of the analysis, collaboration and relationship patterns were visualized in the form of cognitive maps; Average silhouette values with statistical significance for network density, modularity, and the structure and performance of the network were calculated for each network. Among these statistical values, network density indicates the scope of the social network and is a measure of how much of the possible relationships are actually established [15]. In other words, network density indicates how much of the potential connections are used in a network [16]. In the study, collaboration between countries was evaluated according to the location of the journals, authors, publications, and concepts that constitute the source of citations on the map and their centrality between them. While each node in the network indicates a country, each connection indicates the relationships between countries. As the number of connections increases, the connections between nodes become thicker [17]. The betweenness centrality metric is defined for each node in a network. Betweenness centrality measures the centrality of a node in a path connecting other nodes in the network [18].

3. Findings

In this study, publications were examined based on the number of publications per year, publication types, languages, citation analyses, country collaborations, co-citation networks, and conceptual orientations. The analysis yielded several key findings. Additionally, a word analysis was conducted, and cooperative and relational patterns were visualized through cognitive maps.

Figure 1 shows the citation and h index analysis of the studies.

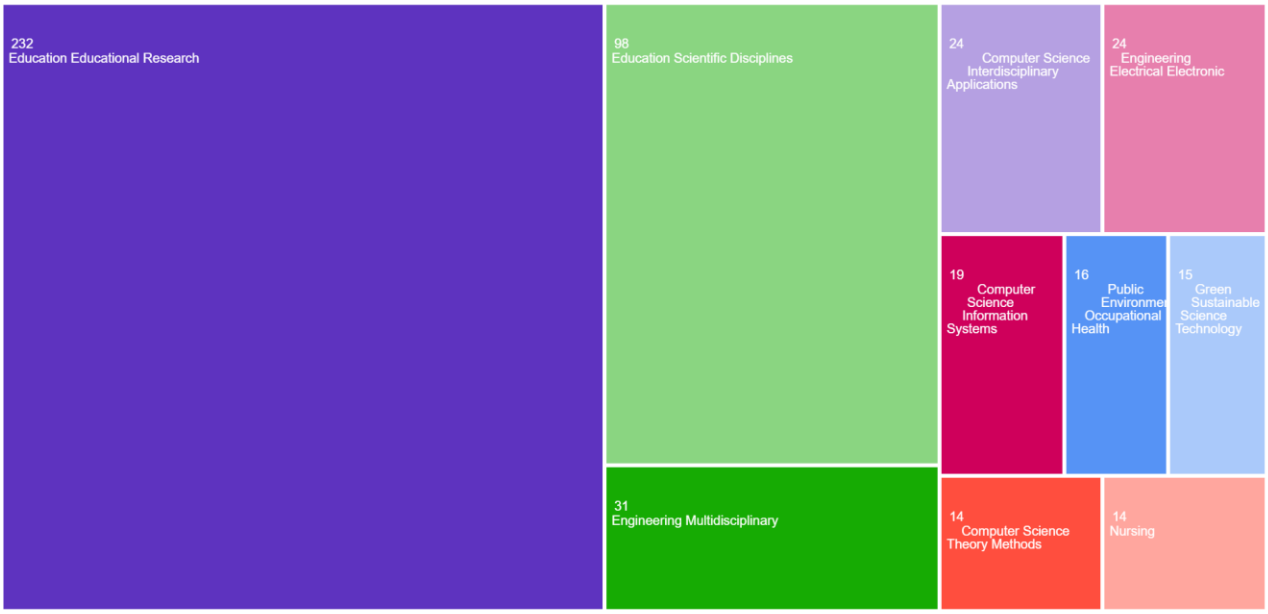

Figure 1.
Citation and H-index analysis.

Total Publications was 519 (1975 to 2024) and Citing Articles 4,698 Analyze Total 4,604 Analyze Without self-citations. Times Cited is 5,113. Total 4,984 Times Cited Without self-citations. Without self-citations 9.85 average per item and H-Index was 37.

Publications and citations are presented in Figure 2.

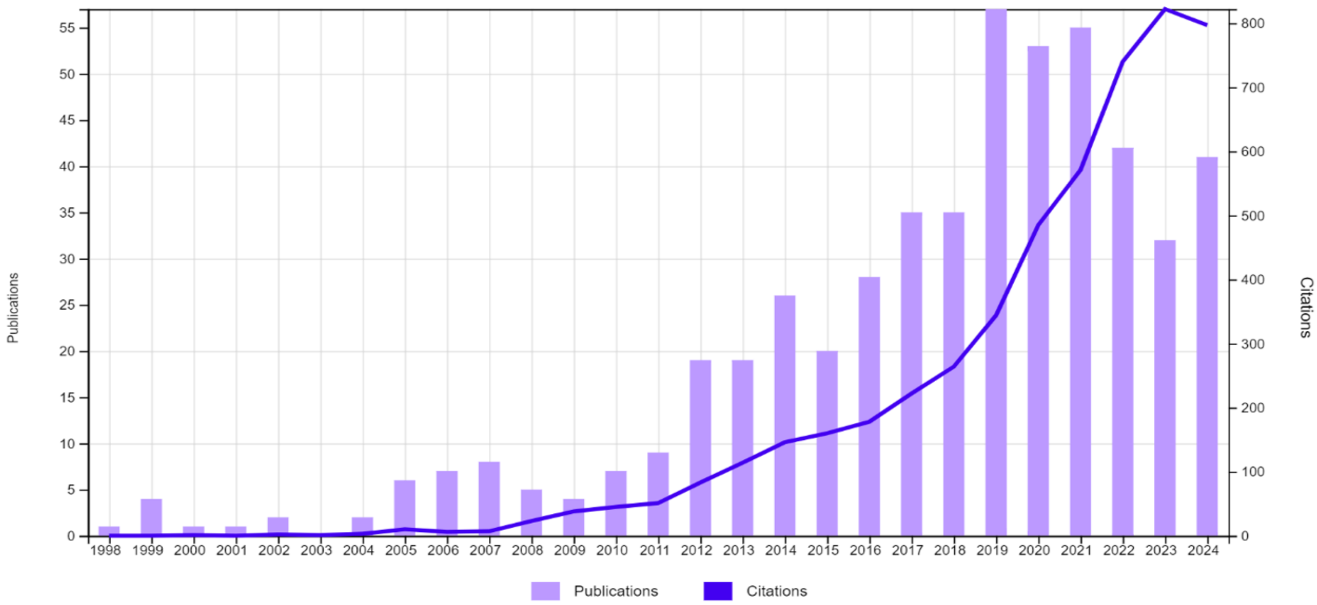

Figure 2.
Publications and citiations.

The Figure 2 shows the trend in the number of publications and citations over the years from 1998 to 2024. Here are some observations: The number of publications has generally increased over time. Initially, from 1998 to around 2007, the growth in publications was quite slow. However, starting around 2011, the number of publications began to increase significantly, reaching a peak in 2021 with over 50 publications. Although there was a slight drop in 2022, the number of publications remains high. Citations (represented by the line) follow a similar upward trend, increasing sharply around 2015. The growth rate of citations is higher than that of publications, indicating that these publications are being referenced frequently in recent years. Citations reached their highest point around 2022, with close to 800 citations, before a slight decline in 2023 and 2024. The number of publications and citations are correlated, with citations generally increasing as more publications are produced. However, the faster growth in citations suggests that recent publications have had a substantial impact, receiving significant attention from the academic community. As a result, this graph indicates a strong research output and impact over the years, with particular growth in the last decade. The slight decline in 2023-2024 may suggest a recent stabilization or a minor drop in research output or citation rate.

The distribution of research publications by journal category, the number of records and their percentage in total are given below (Table 1).

Table 1.
Top ten journals.

Journal name	Record count	% of 569
	Education Educational Research	232
Education Scientific Disciplines	98	18.882%
Engineering Multidisciplinary	31	5.973%
Computer Science Interdisciplinary Applications	24	4.624%
Engineering Electrical Electronic	24	4.624%
Computer Science Information Systems	19	3.661%
Public Environmental Occupational Health	16	3.083%
Green Sustainable Science Technology	15	2.890%
Computer Science Theory Methods	14	2.697%
Nursing	14	2.697%
Computer Science Artificial Intelligence	13	2.505%
Environmental Sciences	13	2.505%
Health Care Sciences Services	12	2.312%
Biochemistry Molecular Biology	10	1.927%
Cell Biology	10	1.927%
Chemistry Multidisciplinary	10	1.927%
Computer Science Software Engineering	9	1.734%
Environmental Studies	9	1.734%
Social Sciences Interdisciplinary	9	1.734%
Information Science Library Science	8	1.541%

This table presents a breakdown of research publications by journal category, along with the record count and the percentage of the total count (569). Education Educational Research is the most prominent category with 232 records, constituting a significant portion of the total. This indicates a strong research focus in educational research. Education Scientific Disciplines is the second-largest category, with 98 records, accounting for 18.88% of the total. This suggests a substantial focus on scientific aspects within the field of education. Categories like Engineering Multidisciplinary (5.97%), Engineering Electrical Electronic (4.62%), Computer Science Interdisciplinary Applications (4.62%), and Computer Science Information Systems (3.66%) show notable contributions, indicating interdisciplinary research in both engineering and computer science fields. Other computer science categories, such as Computer Science Theory Methods, Computer Science Artificial Intelligence, and Computer Science Software Engineering, highlight a broad range of research interests in computer science. On the other side, categories like Public Environmental Occupational Health (3.08%) and Green Sustainable Science Technology (2.89%) reflect a focus on sustainability and environmental health. Additionally, Health Care Sciences Services and Nursing show that health-related research also contributes significantly to the total records. Fields such as Biochemistry Molecular Biology, Cell Biology, and Chemistry Multidisciplinary contribute around 1.93% each, indicating some cross-disciplinary interest in biological and chemical sciences. Social Sciences Interdisciplinary and Information Science Library Science are also represented, showing the diverse nature of research covered. Overall, the table indicates a diverse research output, with a primary emphasis on educational research, followed by substantial contributions from interdisciplinary applications in engineering, computer science, environmental studies, and health sciences. This distribution suggests a broad spectrum of research interests with a particular focus on education and applied sciences.

Table 2 presents the journals and conferences where the largest number of documents were published.

Table 2.
There were the most documents published in journals.

Source	Number of the Document
Proceedings of the 2020 IEEE Global Energy	11
Education Science	8
Sustainability	8
Abstract of papers of the American Chemistry Journal	8
European Journal of Engineering Education	7
Faseb Journal	7
International Journal of Engineering Education	6
12th International Conference on Education	6
11th International Conference of Education	5
Medical Science Educator	5
Interface- communicacao Saude Educacology communicacao	5

The table shows the journals and conferences with the highest number of documents published, highlighting key sources of research dissemination in this dataset. Proceedings of the 2020 IEEE Global Energy has the most publications with 11 documents, indicating significant research activity or contributions related to global energy issues within that year. Education Science, Sustainability, and Abstract of Papers of the American Chemistry Journal each have 8 publications, reflecting a strong emphasis on education, sustainability, and chemistry research topics. Conferences like the 12th International Conference on Education and the 11th International Conference of Education have notable representation with 6 and 5 publications, respectively. This highlights the importance of conferences in the education field as key venues for research presentation and discussion. Journals such as the European Journal of Engineering Education and International Journal of Engineering Education have 7 and 6 publications, respectively, indicating a robust focus on engineering education. Faseb Journal and Medical Science Educator also have a substantial number of documents, suggesting ongoing research in medical and biological sciences. The journal Interface- comunicação Saúde Educação (with 5 documents) emphasizes interdisciplinary communication, particularly in the areas of health and education.

Overall, this distribution shows a strong emphasis on conferences and journals related to education, engineering, and sustainability, with both journals and conferences serving as significant outlets for sharing research findings across these fields. The presence of interdisciplinary sources also reflects a diverse research approach that bridges education, health, and engineering.

The most cited articles of the journals are given in Table 3.

Table 3.
Most cited articles of the journals.

Source	Citation
Sustainability	222
European Journal of Engineering Education	222
Education Science	181
International Journal of Engineering Education	51
Proceedings of the 2020 IEEE Global Energy	31
Interface- communicacao Saude Educacology	28
Medical Science educator	10
Faseb Journal	7
12th International Conference on Education	5
11th International Conference of Education	**1**

This table lists the most cited articles from various journals and conferences, showing where impactful research is being recognized. Sustainability and the European Journal of Engineering Education have the highest citation counts, with 222 citations each. This suggests that articles published in these journals are particularly impactful and widely referenced, especially in topics related to sustainability and engineering education. Education Science also has a high citation count (181), indicating that research published in this journal is influential within the education research community. Overall, this citation data suggests that journals focused on sustainability, engineering education, and general education research have the highest impact, with other sources showing varying levels of influence across fields like global energy, health education, and interdisciplinary studies. This highlights the prominence of sustainability and engineering education research in the academic community.

The network visualisation showing the connections and relationships between academic journals is given in Figure 3.

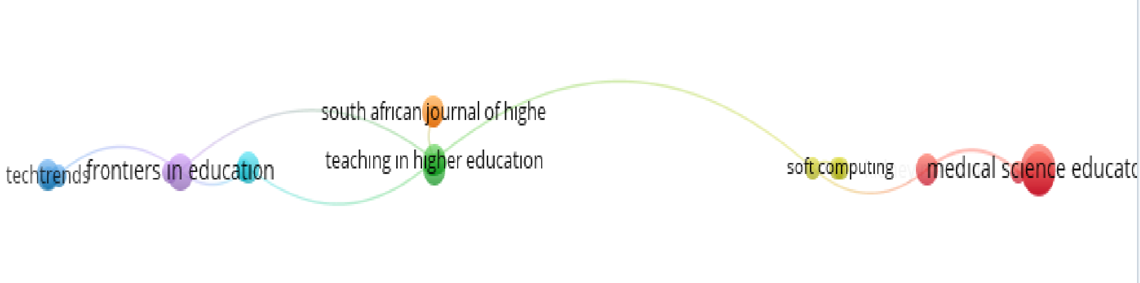

Figure 3.
Network relations between journals.

The image appears to be a network visualization showing connections or relationships between different academic journals. The journals are arranged in clusters, with lines connecting them, suggesting possible relationships such as citation patterns, co-authorship, or thematic similarity. For instance, Teaching in Higher Education and South African Journal of Higher Education are linked, possibly indicating a thematic relationship around higher education research. The color and size of the nodes vary, which might signify the prominence or centrality of certain journals within this network. For example, Medical Science Educator and Soft Computing have larger, red-colored nodes, indicating that these journals may have more connections or higher influence within the network. Journals like Frontiers in Education, Teaching and Teacher Education, and Medical Science Educator suggest a strong focus on educational topics. Soft Computing suggests some interdisciplinary overlap, possibly in areas where education research intersects with computer science and technology. Overall, this network graph suggests clusters of journals with thematic overlap, particularly around education and computing. The connections indicate relationships that could be based on shared citations, collaborative research topics, or interdisciplinary studies, with certain journals (e.g., Medical Science Educator and Soft Computing) appearing more central within this network.

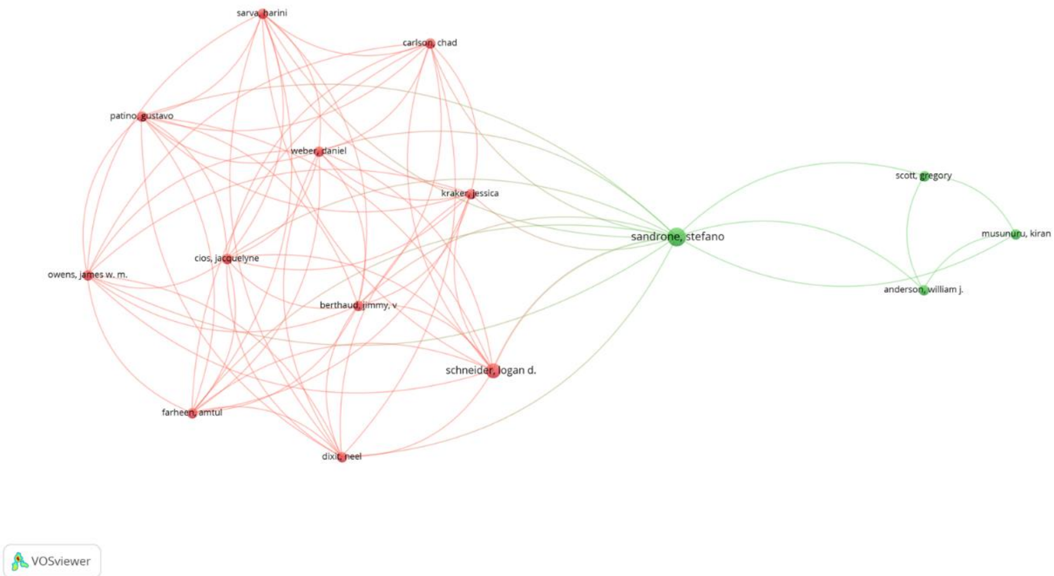

Figure 4.
Authors collaboration network.

Figure 4 shows a co-authorship network created using VOSviewer, which visualizes relationships between authors based on collaboration patterns.

1. Clusters of Collaboration:
   - The network is divided into two main clusters, indicated by the red and green colors, each representing groups of authors who frequently collaborate.
   - The red cluster is dense, with multiple connections between authors, suggesting a tightly knit group where authors like Sanford, Patrick, and Owens collaborate frequently. This could indicate a research team or a group of researchers working in a similar field or on related projects.
2. Central Authors:
   - Sandro Stefano appears central in the green cluster and connects with authors like Scott Peggy and Anderson William J., suggesting that Sandro may act as a bridge between different researchers or research groups.
   - In the red cluster, Schneider Eugen D. and Berta Susanna are central figures with multiple links, indicating their influence within this group.
3. Inter-Cluster Connections:

- There are a few connections between the red and green clusters, with Sandro Stefano appearing to be the linking author between the two groups. This suggests that Stefano collaborates across both clusters, possibly facilitating interdisciplinary research or cross-team communication.

4. Isolated Collaborations:

- A few authors in the green cluster, such as Murray Kiran and Scott Peggy, have fewer connections within the network, indicating more specialized or limited collaborative interactions within the broader group.

Overall, this co-authorship network reveals a highly collaborative group (red cluster) and a smaller, more loosely connected group (green cluster), with Sandro Stefano acting as a key connector between them. This structure suggests collaborative teams with both internal and external links that might enhance interdisciplinary research and knowledge sharing.

Organization	Documents	Citations	Total link strength
tecnol monterrey	9	192	8
univ aveiro	6	34	19
univ minho	6	95	18
univ alberta	4	27	5
univ salamanca	4	34	5
auburn univ	4	60	3
univ extremadura	4	75	3
hong kong polytech univ	4	49	2
univ granada	4	105	0
ımperial coll london	3	56	17
univ lisbon	3	9	12
univ michigan	3	62	12
univ washington	3	15	12
univ portucalense	3	15	11
univ sydney	3	84	10
univ colorado	3	136	7
univ valencia	3	0	7
aalborg univ	3	88	6
purdue univ	3	16	6

Figure 5.
Universities to which the authors with the most publications are affiliated.

The Technology of Monterrey University has 9 documents; Averie University has a 6 document and so on. If we look to the highest citation was University of Helsinki, Florida University; Miami University; the Technology Monterrey University and so on.

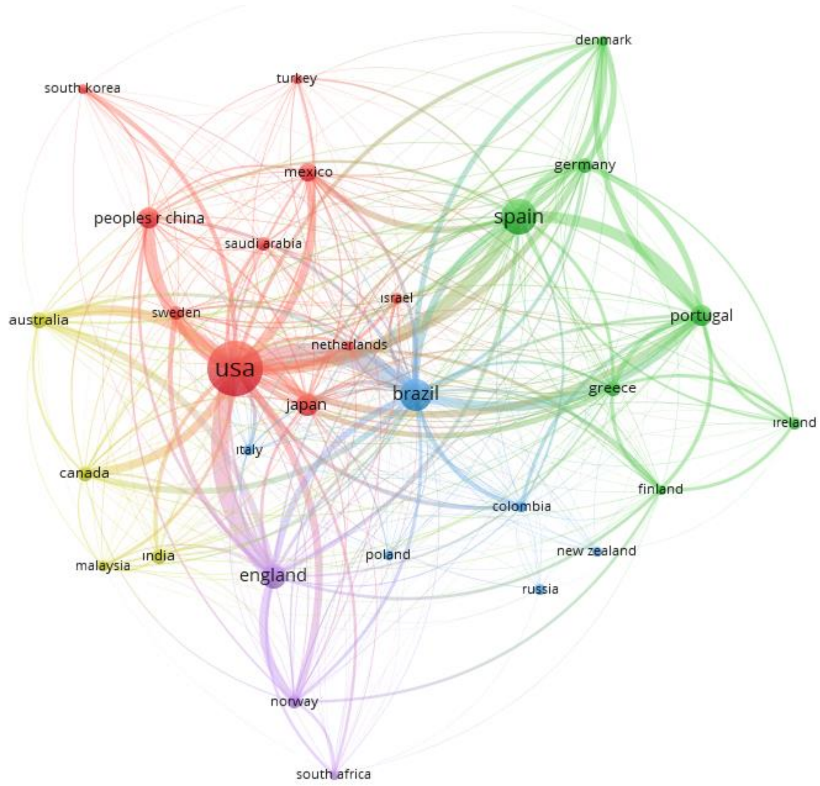

Figure 6.
Country collaboration network.

Table 4 shows the authors, publications, journals and most cited articles.

Table 4.
Authors, publications, journals and most cited articles.

Author	Name of Publication	Time and Journal	Average per year	Cited (Highest first)
Dickey [19]	Three-dimensional virtual worlds and distance learning: two case studies of Active Worlds as a medium for distance education	May 2005, Brıtısh Journal Of Educatıonal Technology, 36 (3) , pp.439-451	204,52	5113
Graffam [20]	Active learning in medical education: Strategies for beginning implementation	2007, Medical Teacher, 29(1), pp 38-42	12.39	223
Al-Zahrani [21]	From passive to active: The impact of the flipped classroom through social learning platforms on higher education students' creative thinking	2015, British Journal of Educational Tecnology, 46(6), pp1133-1148.	16.6	166
Kassens-Noor [22]	Twitter as a teaching practice to enhance active and informal learning in higher education: The case of sustainable tweets	2012, Active Learning in Higher Education, 13(1), pp.9-21	12.54	163
Niemi [23]	Active learning- a cultural change needed in teacher education and schools	2002, Teaching and Teacher Education, 18(7), pp 763-780	7.09	163
Mitre, et al. [24]	Active teaching-learning methodologies in health education: current debates	Cienta&Saude Coletiva, 13, pp.2133-2144.	8	136
Stewart, et al. [25]	Active-Learning Processes Used in US Pharmacy Education	2011, American Journal of Pharmaceutical Education	8.03	113
Hernández-de-Menéndez, et al. [26]	Active learning in engineering education. A review of fundamentals, best practices	2019, International Journal of Interactive Design and Manufacturing , 13(3), pp909-	17.33	104

	and experiences	922.		
Hartikainen, et al. [27]	The Concept of Active Learning and the Measurement of Learning Outcomes: A Review of Research in Engineering Higher Education	2019, Education Science, 9(4)	16.33	98
Berkhout, et al. [28]	Context matters when striving to promote active and lifelong learning in medical education	2018 Medical Education 52 (1), pp.34-44	13.14	92
Niemi and Nevgi [29]	Research studies and active learning promoting professional competences in Finnish teacher education	2014 Teaching And Teacher Education 43 , pp.131-142	8.18	90
Boctor [30]	Active-learning strategies: The use of a game to reinforce learning in nursing education. A case study	2013 Nurse Education In Practice 13 (2) , pp.96-100	7.33	88
Lonsdale, et al. [31]	A cluster randomized controlled trial of strategies to increase adolescents' physical activity and motivation in physical education: Results of the Motivating Active Learning in Physical Education (MALP) trial	2013 Preventive Medicine, 57 (5), pp.696-702	6.58	89
Børte, et al. [32]	Barriers to student active learning in higher education	2023 Teaching In Higher Education 28 (3) , pp.597-615	15	75
MacVaugh and Norton [33]	Introducing sustainability into business education contexts using active learning	2012, International Journal Of Sustiinability In Higher Education, 13 (1) , pp.72-87	5.38	70
Christie and De Graaff [34]	The philosophical and pedagogical underpinnings of Active Learning in Engineering Education	2017, European Journal Of Engineering Education, 42(1), pp.5-16	8.38	67
Murillo-Zamorano, et al. [35]	Gamification and active learning in higher education: is it possible to match digital society, academia and students' interests?	2021, Internaiional Journal Of Educational Technology In Higher Education 18 (1)	16.25	65
Lima, et al. [36]	Active Learning in Engineering Education: a (re)introduction	2017 European Journal Of Engineering Education 42 (1) , pp.1-4	7.75	62
White, et al. [37]	Adopting an active learning approach to teaching in a research-intensive higher education context transformed staff teaching attitudes and behaviours	2016, Higher Education Research & Development 35 (3) , pp.619-633	6.89	62
Shin, et al. [38]	Competency and an active learning program in undergraduate nursing education	2015 Journal Of Advanced Nursing 71 (3) , pp.591-598	6.2	62

Keyword	Occurrences	Total link strength
active learning	188	139
higher education	62	69
engineering education	24	25
problem-based learning	16	22
education	21	20
pedagogy	10	17
project-based learning	11	16
learning	12	15
collaborative learning	8	14
flipped classroom	9	14
blended learning	7	9
educational innovation	7	9
experiential learning	7	9
stem	7	9
stem education	6	9
student engagement	7	9
teaching	8	9
e-learning	7	8
educational technology	7	8
active methodology	8	7
cooperative learning	6	7
gamification	8	7
sustainability	7	7
technology	8	7
nursing education	7	6
medical education	7	5
active methodologies	7	4
motivation	6	4

Figure 7.
Co-occurrence keywords.

The co-occurrence analysis presented in Figure 7 is used to make the relationship between the most frequently used keywords in the studies more evident and to visualise the frequency of co-occurrence of these keywords and the network map.

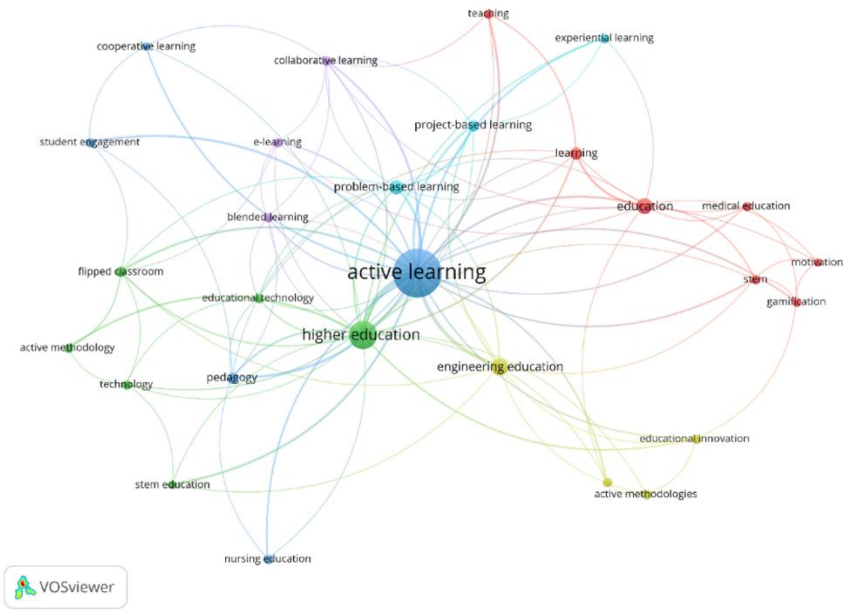

Figure 8.
Co-occurrence network analysis.

In the co-occurrence analysis in the figure, it is observed that the keywords are grouped in six different clusters. Link thicknesses indicate the frequency of co-occurrence of keywords, and link size indicates the number of links. Looking at

the word network map, cluster 1; education, gamification, learning, medical education, motivation, stem, teaching, cluster 2; active methodology, educational technology, flipped classroom, higher education, stem education, technology, cluster 3; active learning, collaborative learning, nursing education, pedagogy, student engagement, cluster 4; active methodologies, educational innovation, engineering education, sustainability, cluster 5; blended learning, cluster 6; experimental learning, problem-based learning, project-based learning.
Citiation of the documents are given in Figure 9.

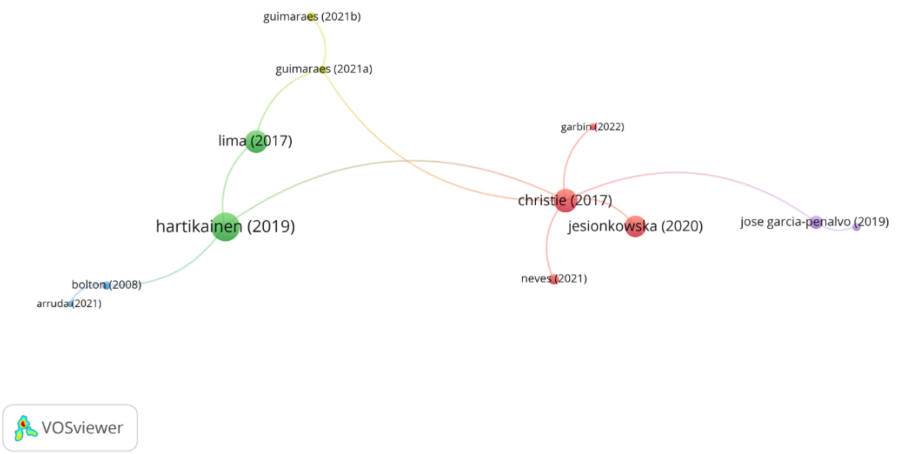

Figure 9.
Citiation of the documents.

Graffam [20] has 223 cited, Al-Zahrani [21] has cited 166, Niemi [23] has cited 163, Kassens-Noor [22] has cited 163, Mitre, et al. [24] has cited 136; Stewart, et al. [25] has cited 113, Hernández-de-Menéndez, et al. [26] has cited 104, Hartikainen, et al. [27] has cited 98, Berkhout, et al. [28] has cited 92.

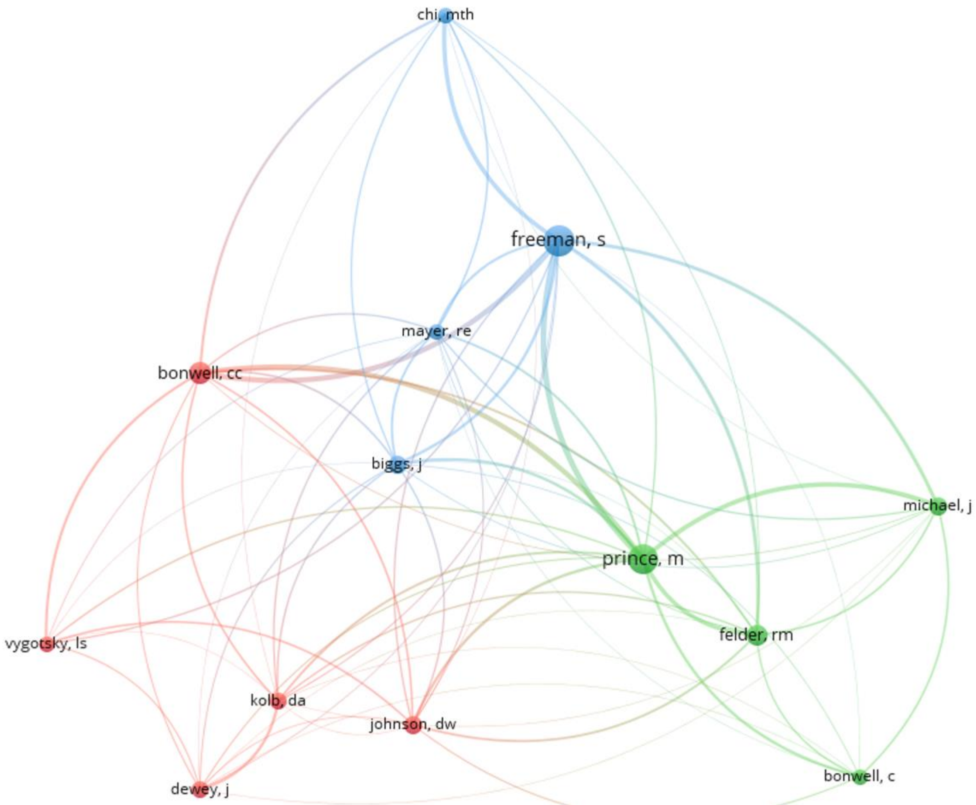

Figure 10.
Co-citiations-authors.

Figure 10 illustrates the network of co-operation between the authors. Collaborating authors are shown in the same colour. Given the multiplicity of co-operation, these are; cluster 1: Bonwell and Eison [1]; Dewey [39]; Johnson [40]; Kolb [41], cluster 2. Bonwell and Eison [1]; Felder and Silverman [42]; Prince [10], cluster 3: Biggs [5]; Chi [43]; Freeman, et al. [11] and Mayer [44].

4. Discussion

The co-authorship network visualized through VOSviewer highlights the collaborative dynamics within a particular academic field or research area. Two main clusters emerged from the analysis, suggesting that there are distinct research groups or subfields represented in this network. The red cluster, which shows a dense web of connections, likely indicates a group of researchers with a high level of collaboration. This tightly knit structure suggests a research team that is working together on related projects, possibly within a specific sub-discipline or research focus. Authors such as Sanford, Patrick, and Owens appear central within this cluster, possibly acting as influential figures or leaders driving the research agenda for this group.

The green cluster, though smaller and less densely connected, also shows key relationships, with Sandro Stefano as a central figure. Sandro Stefano appears to act as a bridge between the two clusters, suggesting an interdisciplinary or cross-collaborative role. This bridging function is essential as it enables knowledge exchange and collaboration between otherwise separate research groups. Such connections can foster interdisciplinary work, which is increasingly valued in research as it addresses complex, multifaceted problems that require input from diverse fields.

The presence of authors like Scott Peggy and Anderson William J. in the green cluster, despite having fewer connections, implies that they might contribute specialized knowledge or niche expertise to the network. The connections between the red and green clusters, though fewer, suggest that there is some degree of overlap or shared interests between these groups. However, the visualization also reveals some isolated collaborations, indicating areas where researchers may benefit from strengthening inter-cluster communication or exploring potential partnerships.

This study's bibliometric analysis offers a comprehensive view of research trends in active learning, revealing key contributors, impactful works, and thematic focuses within the field. The findings indicate that the United States plays a pivotal role as the birthplace and leading contributor to active learning research, which aligns with previous literature highlighting the country's significant influence on educational innovation and pedagogy [11]. The co-authorship network, visualized using VOSviewer, reveals clusters of collaborative groups that drive much of the research activity, with central figures such Figure 3. This indicates a highly collaborative environment that fosters knowledge-sharing and the development of new ideas, particularly within major subfields like cognitive development and teacher education.

The co-citation analysis underscores the foundational role of certain authors, such as Dickey and Al-zahrani, whose work has been instrumental in shaping the understanding and application of active learning principles. The frequent citation of these authors suggests that their theories and findings serve as cornerstones for newer studies, indicating a consistent reliance on well established frameworks to guide active learning research [11].

Interestingly, the co-word analysis highlights recurring keywords such as critical thinking, creativity, and cognitive development, reflecting active learning's broad impact on various educational domains. However, it also reveals a noticeable gap: relatively few studies focus on critical thinking within active learning frameworks, particularly in secondary and high school education, teacher training, and medical education. This aligns with other research indicating that while active learning is broadly encouraged, its specific applications to critical thinking and in secondary education settings remain underexplored [10]. Addressing this gap is crucial, as developing critical thinking skills is often cited as one of the primary objectives of active learning.

The emergence of digital and collaborative learning as growing trends in the co-word analysis indicates an increasing shift towards using technology to facilitate interactive and cooperative learning experiences. This trend, supported by recent literature, suggests that educational environments are evolving to embrace digital tools that can enhance engagement and foster communication among students and educators [45].

5. Conclusion

The VOSviewer co-authorship analysis reveals a collaborative research landscape characterized by two primary groups, each with distinct collaboration patterns. The dense connections in the red cluster suggest a close-knit research team with significant internal collaboration, likely contributing to a robust body of work within their shared area. The green cluster, though less interconnected, includes key bridging figures like Sandro Stefano, who facilitates cross-group collaboration and potentially enhances the network's interdisciplinary reach.

This network structure underscores the importance of both tightly connected research teams and individuals who can bridge gaps between them. These connections can foster a more integrated approach to research, combining expertise from various subfields. Moving forward, fostering more inter-cluster collaborations could enhance the overall impact of research within this network, promoting knowledge exchange and innovative approaches to complex research questions. Encouraging cross-disciplinary projects, workshops, and conferences could also be beneficial to leverage the unique strengths of both clusters and create a more unified research community.

The bibliometric analysis reveals that research on active learning is growing, with a strong foundation of influential works and a collaborative network of authors contributing to the field's development. While the United States remains a key player in producing active learning research, there is also notable international interest, as evidenced by the diversity of contributing countries. Core research themes center on critical thinking, cognitive development, and creativity; however, a gap exists in studies focusing specifically on critical thinking within secondary and high school settings, as well as teacher training and medical education. This gap highlights an opportunity for future research to expand active learning's scope and impact by exploring its application to developing critical thinking and problem-solving skills in these educational contexts.

Overall, the study suggests that while active learning research is well-established in higher education, further studies are needed to extend its principles into other educational levels and domains. The shift towards collaborative and digital learning environments marks an evolution in active learning, as educators increasingly integrate technology to foster interactive, student-centered learning. This evolution provides a pathway for future studies to explore how digital tools and collaborative methods can be leveraged to enhance the effectiveness of active learning in diverse educational settings. Also, the analysis provides valuable insights into the collaborative structure of this academic network and identifies potential areas for further strengthening research partnerships. This knowledge can inform strategic decisions for research planning, resource allocation, and efforts to foster interdisciplinary work.

These research directions, drawn from the VOSviewer network analysis, suggest multiple pathways for advancing the field by leveraging existing collaboration structures and encouraging new partnerships. Emphasizing interdisciplinary research, building capacity among emerging scholars, and fostering inter-cluster collaboration are all strategies that can lead to a more cohesive, innovative, and impactful research environment. By pursuing these directions, the academic network can strengthen its collective knowledge base, contribute to solving complex real-world problems, and ultimately enhance the field's contributions to academia and society at large.

6. Suggestions

Increase Research on Critical Thinking in Secondary Education and Teacher Training: The limited focus on critical thinking within active learning, particularly in secondary and high school settings, represents a significant gap. Future research should aim to address this by examining how active learning can specifically enhance critical thinking skills among younger students. Additionally, teacher training programs can benefit from active learning-based curricula that emphasize developing teachers' abilities to foster critical thinking in their classrooms.

Expand Active Learning Studies in Medical Education: Active learning has shown promise in medical education, yet the number of studies remains low. Future research could explore how active learning strategies like problem-based learning (PBL) and case-based discussions can enhance medical students' clinical reasoning, decision-making, and patient-centered skills. Investigating the impact of active learning on student performance and patient outcomes would provide valuable insights into the effectiveness of these methods in medical education.

Foster Cross-Disciplinary Collaborations for Broader Applications of Active Learning: The co-authorship analysis indicates clusters of collaboration within sub-disciplines. Future studies could benefit from more interdisciplinary collaborations that combine insights from fields like educational psychology, cognitive science, and technology. For example, exploring the intersection of active learning and digital learning could yield innovative approaches that use technology to engage students actively across disciplines.

Encourage Technological Integration in Active Learning Practices: The trend toward collaborative and digital learning points to a growing interest in technology-enhanced active learning. Future research could examine the effectiveness of specific digital tools (such as virtual labs, interactive simulations, and learning management systems) in facilitating active learning. Studies should focus on the conditions under which these tools enhance learning outcomes and how they can be integrated into curricula at various educational levels.

Develop Longitudinal Studies to Assess Active Learning's Long-Term Impact: While active learning is widely regarded as beneficial for immediate academic performance, there is limited research on its long-term impact on students' critical thinking, creativity, and cognitive development. Longitudinal studies that track students over time would help clarify the enduring benefits of active learning and provide evidence for its broader educational impact.

In summary, these suggestions aim to address existing gaps, support interdisciplinary approaches, and encourage innovation through technological integration, thereby contributing to a more comprehensive and effective implementation of active learning strategies in education.

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