Research Status and Development Trends of Experiential Learning in Music Education: A Bibliometric Analysis

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Received: August 18, 2025 Accepted: September 21, 2025 Online Published: October 21, 2025

doi:10.5430/jct.v14n4p138 URL: https://doi.org/10.5430/jct.v14n4p138

Abstract

A global commitment has been observed toward the incorporation of experiential methodologies into education. Experiential learning strategies have been increasingly integrated into classrooms across various educational levels, and their use has been recognized as a core competency for educators (Council of Europe, 2018). The primary aim of this study is to analyze academic research concerning the application of experiential learning in music education. A sample was obtained from the Web of Science Core Collection, encompassing publications from January 1, 2014, to July 20, 2025. Multiple bibliometric tools, including GraphPad Prism v8.0.2, CiteSpace (6.2.4R), and VOSviewer (1.6.18), were employed to examine publication trends, relevant journals and authors, geographic distribution, keywords, and emerging research themes. The study analyzed 817 relevant publications spanning 76 countries and regions, 1,140 institutions, and 2,865 authors. The analysis demonstrated that (1) publication volume has shown a consistent upward trajectory, accelerating post-2019 with a peak anticipated in 2024; (2) the United States has led in both publication count (310, 37.94%) and citation frequency (5,111), followed by China; (3) the *Journal of Chemical Education* has been identified as the most prolific journal; and (4) research focal points have shifted from foundational topics such as categorization and integrated learning development to contemporary themes including active learning and concept drift. Looking ahead, two prominent areas of focus are anticipated to involve the integration of artificial intelligence and neural networks in music education, and the amalgamation of experiential learning with innovative pedagogical strategies.

Keywords: experiential learning, music education, bibliometrics, visual analysis, research trends

1. Introduction

There is a rich intellectual history of integrating experiential learning into music education that can be traced back to constructivist theories and traditions of practice. Educational philosophers like John Dewey (1938) stressed direct experience as a means of learning, an idea which was later codified by the Experiential Learning Theory proposed by Kolb (1984). Experiential practices in the world of music have long been manifest in practice-based learning using ensembles, training through performance, and creative workshops that emphasize the learning process of doing over the learning process of knowing. Preliminary studies early in the 20th century placed the idea of experiential music pedagogy on the periphery of educational conversation, and pioneering literature (Lewis and Williams, 1994; Osterman, 1998) succeeded in establishing reflective practice and active engagement as key elements of learning that counted. This trend has grown substantially in the last twenty years, as experiential learning has ceased to be the byword of a few experiments on the edge of mainstream pedagogy and has become a primary learner-focused teaching and learning approach that values creativity, collaboration, and agency.

Over the past decade, the field of music education has undergone a significant transformation. A renewed interest has emerged in experiential and learner-centered teaching methodologies (Huhtinen-Hildén & Pitt, 2018; Jiang, 2024). Recent bibliometric research has indicated a marked increase in scholarly publications addressing experiential learning, predominantly originating from the United States, the United Kingdom, and Canada (Azeez & Aboobaker, 2024). Experiential learning has shifted from the periphery to the core of educational discourse (Gortan-Carlin and Močinić, 2017). As constructivist learning theories have gained prominence, practice-based learning platforms have emerged, and reflective practice has been increasingly incorporated into educational settings (Kopish et al., 2021).

Scholars have explored the evolution of these strategies, tracing their development from basic classroom applications to sophisticated, theory-driven models that promote creativity, collaboration, and inclusivity (Kayes & Kayes, 2021). Simultaneously, the COVID-19 pandemic has catalyzed major breakthroughs, as the rise of remote instruction has spurred demand for innovative experiential learning solutions adaptable to online environments (Li, 2022). This decade-long trajectory indicates an expanding body of research that warrants comprehensive bibliometric analysis, highlighting the ways in which policy shifts, academic trends, and pedagogical innovations have reshaped music education globally. Despite the increasing academic interest in experiential learning in the field of music education, the available research on the topic often remains divided and narrowed down to specific practice or national setting. Though bibliometric studies have been undertaken in greater areas of education, a synthesis of the research trends on experiential learning studies in music education around the world is lacking. This gap creates a barrier to a sophisticated perception of the global development of experiential approaches, particularly in the context of new technologies and the changes after the pandemic. The present research thus aims at closing this gap by carrying out a massive bibliometric review of the literature published between 2014 and 2025.

This study addresses the following research questions:

RQ1: How has the distribution of significant publications, national institutions, and research contributions in experiential learning within music education evolved over the past decade?

RQ2: What have been the primary research focal points in studies on experiential learning within music education during this period?

RQ3: What recent advancements have emerged in experiential learning research in the context of music teaching over the past ten years?

1.1 Defining Experiential Learning in Music Education

For the purposes of this study, experiential learning in music education is defined as a set of pedagogical approaches involving direct musical engagement through hands-on practice, active participation, and reflective interaction with musical concepts and practices. This definition includes traditional methods, such as ensemble participation and performance-based instruction. The conceptualization is situated within the broader research landscape of music education to ensure terminological clarity prior to analyzing the specific research trends and theoretical frameworks revealed through bibliometric analysis.

It has been demonstrated that experiential learning in music education can have a wide-interdisciplinary applicability and be relevant to many research fields, including philosophical underpinnings (Boucher and Moisey, 2019), development of creativity (Dandan Dai, 2018; Aycan, 2021), technology-based learning (Yao and Li, 2023; Bing Mei and Yang, 2021), reflective practice (Benjamin et al., 2022; Carey et al., These complex aspects highlight the holistic nature of experiential learning scholarship as it relates to the study of contemporary music education.

1.2 Theoretical Bases of Experiential Learning

Based on these philosophic groundings as explained in Experience and Education (1938) by John Dewey, experience based learning has been identified to be a paradigm shift based approach to abstract instruction. The works of William James, Kurt Lewin, Jean Piaget, Lev Vygotsky, Carl Jung, Mary Parker Follett, Carl Rogers and Paulo Freire among other rejecters of mass media such as drugs expanded further on this theoretical basis, and their work together made available deeper insights into experiential human learning (Passarelli and Kolb, 2012). The Experiential Learning Theory (ELT), by David Kolb, integrates all these different views into an overall synthesis that has had an impressive impact on education, including music education.

Kolb (1984, p. 41) defined learning as the process of creation of knowledge by changing experience and proposed four stages of the learning cycle, namely concrete experience, reflective observation, abstract conceptualization and active experimentation. The cyclic nature of this process allows learners to actively work on experience, think reflexively, formulate theoretical information, and put them into practice (Kolb and Kolb, 2005). This framework has been extremely useful within the context of music education because it is more than adequately suited to the multidimensional nature of musical education itself--that is, by enabling a behavioral approach to learning with active participation, a cognitive approach to learning with reflective and analytical thinking, and an emotional approach to learning with personal attachment to musical experiences.

1.3 Experiential Learning Problems and Novelties of Music Education

Modern literature has provided a number of complex issues linked to the use of experience-based learning in music education. Teacher incompetence has been identified as a main hindrance. A lack of content, pedagogical, and technological knowledge has been noted among teachers in resource-constrained settings, which restricts the likelihood of teachers successfully applying inquiry-based practices (Akuma & Callaghan, 2020). An overview of the China National Knowledge Infrastructure (CNKI) has shown the lack of instructional material and specific research focusing on the needs of teachers in the implementation of experiential learning (Wang et al., 2023). The enduring nature of the traditional, teacher-centered forms of instruction has also been a major barrier. In a systematic review, Yu and Leung (2019) found that, in spite of curricular changes that encourage more practical interactions, many music lessons still focus on theoretical learning rather than experiential learning experiences. Likewise, in the analysis of Wu (2024), it was proposed that current assessment practices do not adequately reflect practical musical skills and creativity, and this indicated a mismatch between experience-oriented curricular objectives and assessment practices. Additionally, Chen (2021) stated that time constraints and lack of instructional support has adversely influenced the occurrence and quality of creative musical experiences, even though it is included in curriculum guidelines.

To address these obstacles, different novel methods have been suggested. The use of the experiential learning models has shown encouraging results. Gortan-Carlin and Močinić (2017) proposed that teacher preparation to teach music effectively in the primary level has been enhanced by the acquisition of musical competencies through the experiential learning cycle, as proposed by Kolb. The method of teacher education has also changed. Martinjak (2016) has shown that experiential combination of didactic and methodological teaching has had a positive impact on pedagogical evolvement. Kopish et al. (2021) focused on the importance of cross-cultural experience learning as a way of developing global teaching skills, preparing teachers to work in more diverse educational environments.

These data indicate that, regardless of institutional barriers, transformation of the music education that is still based on traditional approaches to the more engaging and creative types of pedagogical models is possible through the process of teacher development, pedagogical changes, and innovations in the assessment.

1.4 Use of Bibliometric Analysis in Music Education

The use of bibliometric analysis as a potent methodological instrument to study intellectual organization and maturation of music education research has become increasingly popular. The usefulness of 2020-2025 applications has been demonstrated in mapping scholarly trends, discovering those who are most influential, creating collaborative networks, and uncovering prominent patterns in how knowledge is generated and spread throughout the discipline.

An impressive confirmation has been made by Ma and Wang (2025), who searched the Web of Science Core Collection and found 825 articles in 392 journals, dating between 1991 and 2024. They found an average growth rate of 12.07% in technology-related music education research per year. Four main areas of research were identified: integration and interaction with technology, adaptive learning and innovative pedagogies, educational structures and performance, and the inclusive involvement of children and adolescents. The given bibliometric method helped to track the development of the themes and define the new research perspectives, especially in the area of distance teaching and higher education innovations.

Vicente-Nicolasa and Sánchez-Marroqui (2024) conducted a complementary bibliometric study discussing 1,001 papers, published between 1978 and 2022 by 1,372 authors in 293 journals. They found that their annual growth was 11.96, and since 2010 exponential growth has been seen. Ten major trends related to research were found, including the following areas: methodology, teacher training, technology, creativity, innovation, performance, emotional engagement, music therapy, interculturality, and inclusive education.

Modern bibliometric research has made more sophisticated use of analytic software, and VOSviewer, CiteSpace, and Bibliometrix/Biblioshiny are the major software platforms. Networks of co-occurrence and keyword clustering have been visualized with VOSviewer (van Eck and Waltman, 2023), whereas CiteSpace provides distinctive features of burst detection and temporal trends (Chen, 2023). Bibliometrix is a comprehensive set of analytical tools that can be used to conduct full-scale bibliometric research (Aria and Cuccurullo, 2024). These innovative applications have given key insights to researchers, educators, and policymakers- they have brought light to the present state of music education research, and have also shown new trends and cooperation opportunities that can greatly influence the future trajectory of the field.

2. Method

The core collection of Web of Science (WoSCC) was chosen as the primary data source since it is extensively covered and indexed in a standardized form; therefore, guaranteeing reliability of bibliometric information. On 20

July 2025, a search was conducted of publications on experiential learning in music education with references to publications published between 1 January 2014 and 20 July 2025. The search terms were: TS = (experience-based learning) OR TS = (hands-on learning) OR TS = (experience) OR TS = (music) OR TS = (music education) OR TS = (music teaching) OR TS = (music learning) OR TS = (music instruction) OR TS = (music pedagogy) OR TS = (musical training) OR instrumental OR vocal OR choir OR orchestra OR ensemble OR TS = (music therapy) OR TS = (music performance).

The publications had to address the issue of experiential learning directly in music education, be published on or after 2014, and in English, and must be presented as a peer-reviewed article or a review, in order to be eligible. Articles were sieved out on grounds of not being relevant to the topic, lack of peer review, and other languages besides English. Following the screening, WoSCC exports the bibliographic records (titles, abstracts, key words, authors and references listed) in plain text and BibTex formats. The data also needed to be edited so that data integrity was guaranteed and that the keywords were standardized, that is, by merging together such synonyms as hands-on learning and manipulatives.

Three bibliometric tools were then used to analyze and manipulate the filtered dataset. GraphPad Prism (version 8.0.2) was used to produce the descriptive statistics and trends of annual publications. Citation bursts, co citation cluster and spatial evolution of research topics were recognized in CiteSpace version 6.2.4R. VOSviewer (version 1.6.18) was used to construct the knowledge maps and co-authorship, co-citation, and key-word co-occurrence networks. The results of these analytical tools generated a study capable of capturing these structural patterns and dynamics of the experiential learning research on music education.

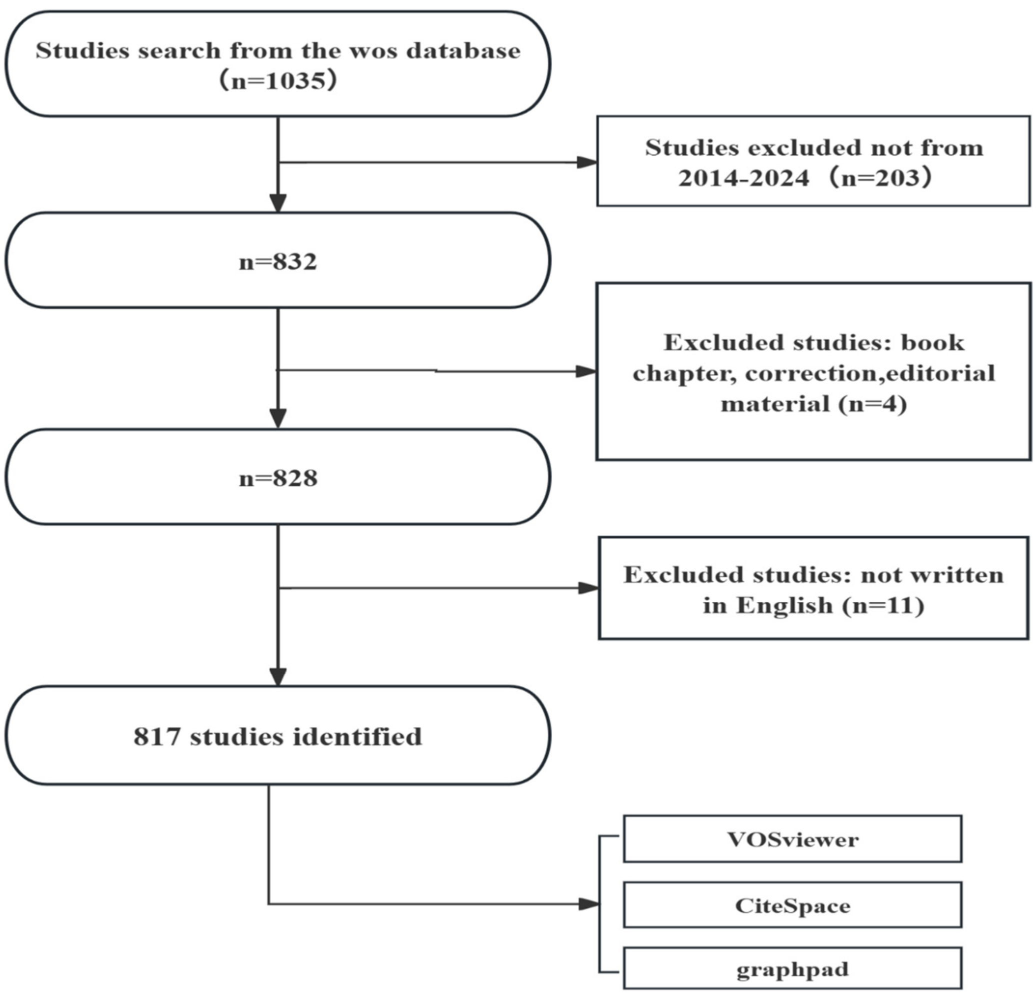


Figure 1. Literature Retrieval Flow Chart

3. Results

3.1 Publication Trends

The analysis revealed that between January 1, 2014, and July 20, 2025, a total of 817 publications related to experiential learning in music education were indexed in the Web of Science Core Collection (WoSCC). These publications originated from 76 countries or regions, 1,140 academic institutions, and 2,865 individual authors.

Since 2014, the annual volume of publications in this domain has demonstrated a steadily increasing trajectory (Figure 2). This trend can be segmented into two distinct phases. The first phase, spanning from 2014 to 2019, was characterized by fewer than 60 publications per year, indicating a period of emerging academic interest in the topic. Following 2019, the number of publications increased rapidly, peaking in 2024, reflecting the field's accelerated growth and growing academic acceptance.

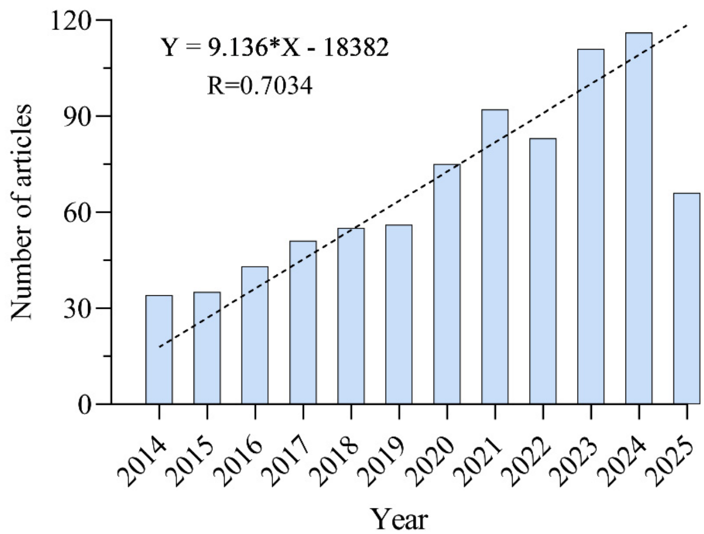


Figure 2. Annual Number of Publications

Between January 1, 2014, and July 20, 2025, a total of 817 publications on experiential learning in music education were indexed in the Web of Science Core Collection (WoSCC). These publications originated from 76 countries and regions, 1,140 institutions, and 2,865 authors.

A gradual increase in annual publication volume has been observed since 2014 (Figure 2). This trend can be divided into two distinct phases. The first phase, spanning from 2014 to 2019, was characterized by fewer than 60 publications per year, reflecting emerging academic interest in the field. The second phase, beginning after 2019, exhibited a marked acceleration in publication output, culminating in a peak in 2024. This pattern indicates significant expansion and enhanced academic visibility of experiential learning within music education.

3.2 Countries and Institutions

Research on the application of experiential learning in music education has been carried out across 76 countries and regions. Figures 3 and 4 illustrate the annual publication volumes of the top 10 contributing countries over the past decade. The top five countries in this field include the United States, China, the United Kingdom, Australia, and Canada. The United States contributed 37.94% of the total publications, substantially surpassing all other countries and highlighting its leading role in advancing research in this area

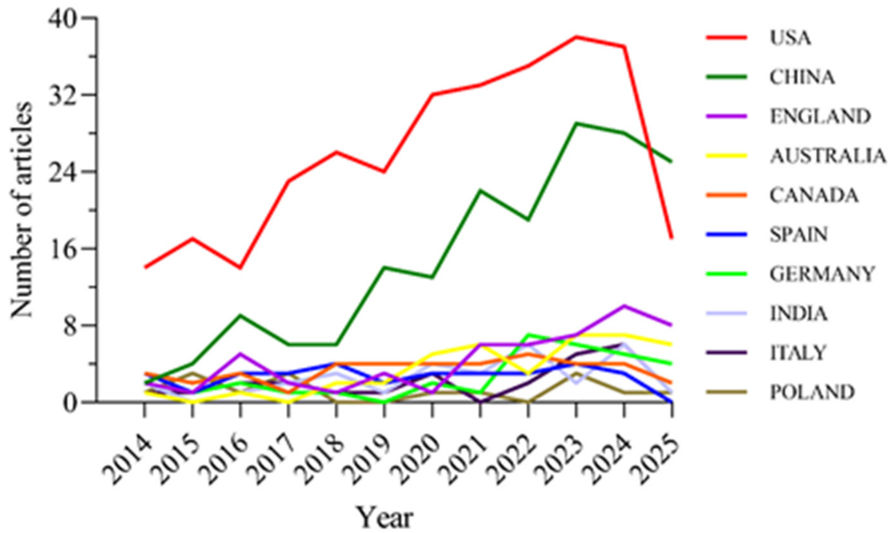


Figure 3. Line Graph Depicting National Document Issuing

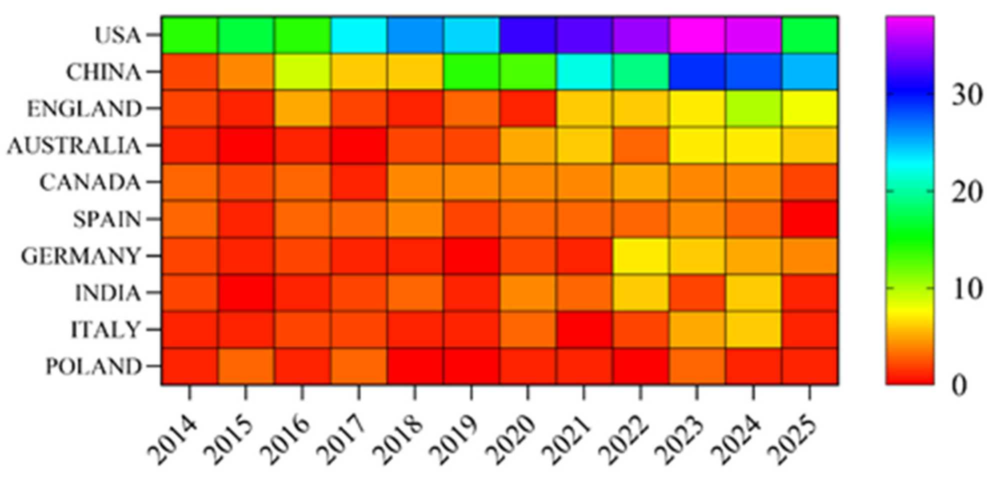


Figure 4. Heatmap of National Issuances

Research on the application of experiential learning in music education has been carried out across 76 countries and regions. Figures 3 and 4 illustrate the annual publication volumes of the top 10 contributing countries over the past decade. The top five countries in this field include the United States, China, the United Kingdom, Australia, and Canada. The United States contributed 37.94% of the total publications, substantially surpassing all other countries and highlighting its leading role in advancing research in this area.

Among the top ten countries and regions in terms of publication output, the United States has received 5,111 citations (Table 1), significantly exceeding the citation counts of other countries. Its citation-to-publication ratio of 16.49 ranks fifth, indicating a generally high impact of its publications. China ranks second in both publication count (177) and total citations (2,726), while ranking sixth in citation-to-publication ratio (15.40), reflecting a growing but still maturing research influence in the field.

Table 1. Countries/Regions Ranked by Number of Published Papers

Rank	Country/region	Article counts	centrality	Percentage (%)	Citation	Citation per publication
1	USA	310	0.43	37.94%	5111	16.49
2	CHINA	177	0.25	21.66%	2726	15.40
3	ENGLAND	52	0.14	6.36%	1050	20.19
4	AUSTRALIA	40	0.13	4.90%	430	10.75
5	CANADA	40	0.03	4.90%	442	11.05
6	SPAIN	32	0.05	3.92%	608	19.00
7	GERMANY	32	0.07	3.92%	1038	32.44
8	INDIA	31	0	3.79%	298	9.61
9	ITALY	25	0.05	3.06%	489	19.56
10	POLAND	15	0	1.84%	75	5.00

Figure 5 illustrates the strong collaborative relationship between the United States and China, the two leading nations in publication output. The United States has developed robust research ties with Australia, Canada, and Poland, while China shows closer collaboration with India, Germany, and Spain. Furthermore, the United States has produced a large volume of highly cited publications and exhibits a network centrality value of 0.43, indicating its central role and preeminent influence in the global research landscape on experiential learning in music education.

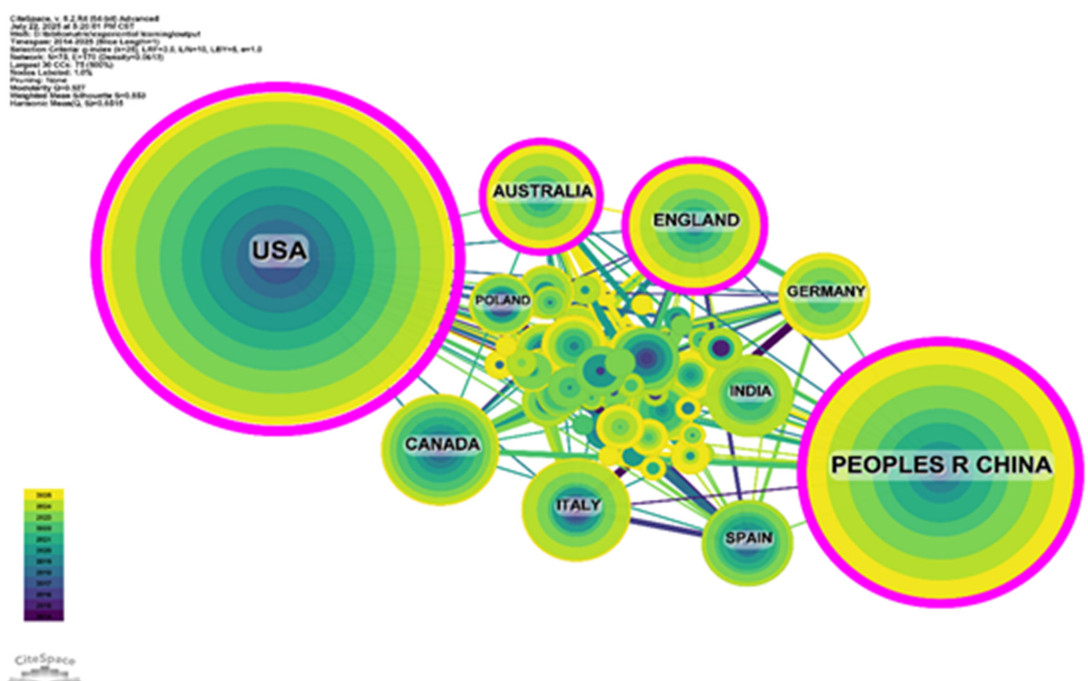


Figure 5. National Cooperation Network

A total of 1,140 institutions contributed to the dissemination of scholarly publications on experiential learning in music education. Among the top ten institutions by publication volume, seven were based in the United States, with one each located in China, the United Kingdom, and India (Table 2, Figure 6). The United States Department of Energy (DOE) recorded the highest output, with 17 publications, 822 citations, and an average of 48.35 citations per paper. The University System of Ohio ranked second, with 14 publications and 61 citations (4.36 citations per publication), followed by the University of California System, which produced 13 publications and received 186 citations, averaging 14.31 citations per paper. Further analysis indicated that both domestic and international institutions tend to collaborate primarily with organizations within their own countries. To enhance scholarly exchange and broaden the global impact of research in this field, greater cross-national collaboration is encouraged to reduce institutional silos and foster international academic integration.

Table 2. Institutional Publications

Rank	Institution	Country	Number of studies	Total citations	Average citation
1	United States Department of Energy (DOE)	USA	17	822	48.35
2	University System of Ohio	USA	14	61	4.36
3	University of California System	USA	13	186	14.31
4	Indian Institute of Technology System (IIT System)	India	11	72	6.55
5	University of London	England	11	80	7.27
6	Argonne National Laboratory	USA	10	80	8.00
7	Purdue University	USA	10	179	17.90
8	Purdue University System	USA	10	179	17.90
9	Massachusetts Institute of Technology (MIT)	USA	9	383	42.56
10	Chinese Academy of Sciences	China	7	241	34.43

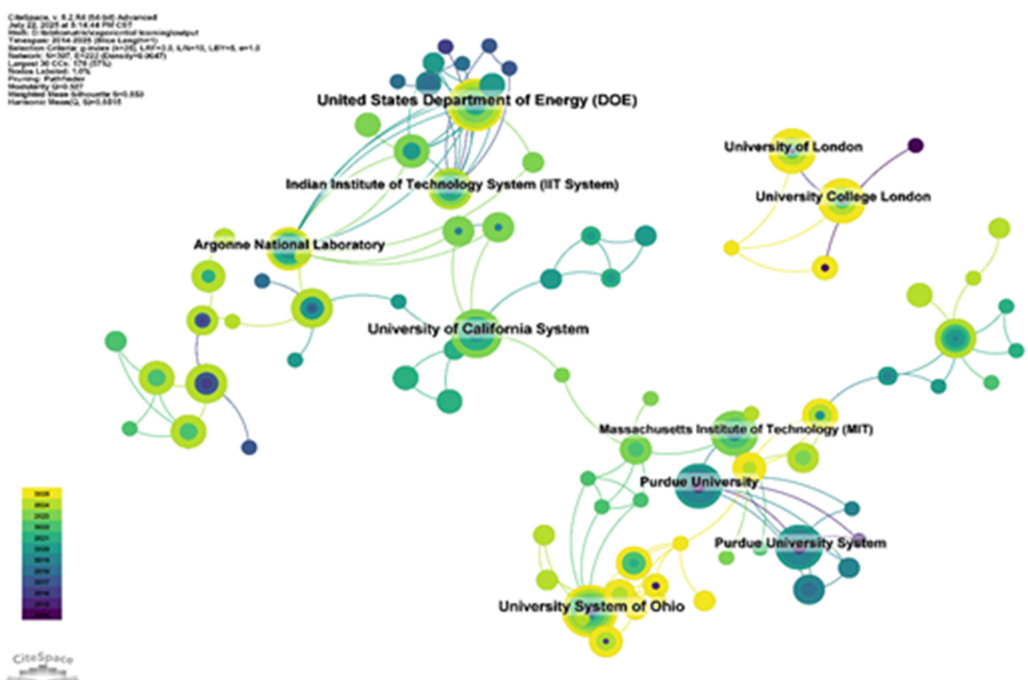


Figure 6. Institutional Cooperation Network

3.3 Journal Analysis

The ten most high-output and frequently cited journals in the field are listed in Tables 3 and 4. The *Journal of Chemical Education* was identified as the most prolific journal, contributing 170 articles (20.81%) related to experiential learning in music education. It was followed by the *International Journal of Music Education* (11 articles, 1.35%), *IEEE Access* (8 articles, 0.98%), *Journal of Chemical Physics* (8 articles, 0.98%), and *Reliability Engineering & System Safety* (7 articles, 0.86%).

Among the top ten journals, Reliability Engineering & System Safety had the highest recorded impact factor, reaching 11.0. Additionally, 90% of the journals were indexed in the Q1 or Q2 quartiles, indicating that the majority of relevant research was published in journals with high academic visibility and impact.

Table 3. Journal Publication Scale

Rank	Journal	Article counts	Percentage（817）	IF	Quartile in category
1	journal of chemical education	170	20.81%	2.9	Q1
2	international journal of music education	11	1.35%	1.2	Q2
3	ieee access	8	0.98%	3.6	Q2
4	journal of chemical physics	8	0.98%	3.1	Q2
5	reliability engineering & system safety	7	0.86%	11.0	Q1
6	music education research	6	0.73%	1.1	Q3
7	engineering applications of artificial intelligence	5	0.61%	8.0	Q1
8	ieee transactions on knowledge and data engineering	5	0.61%	10.4	Q1
9	expert systems with applications	4	0.49%	7.5	Q1
10	ieee transactions on neural networks and learning systems	4	0.49%	8.9	Q1

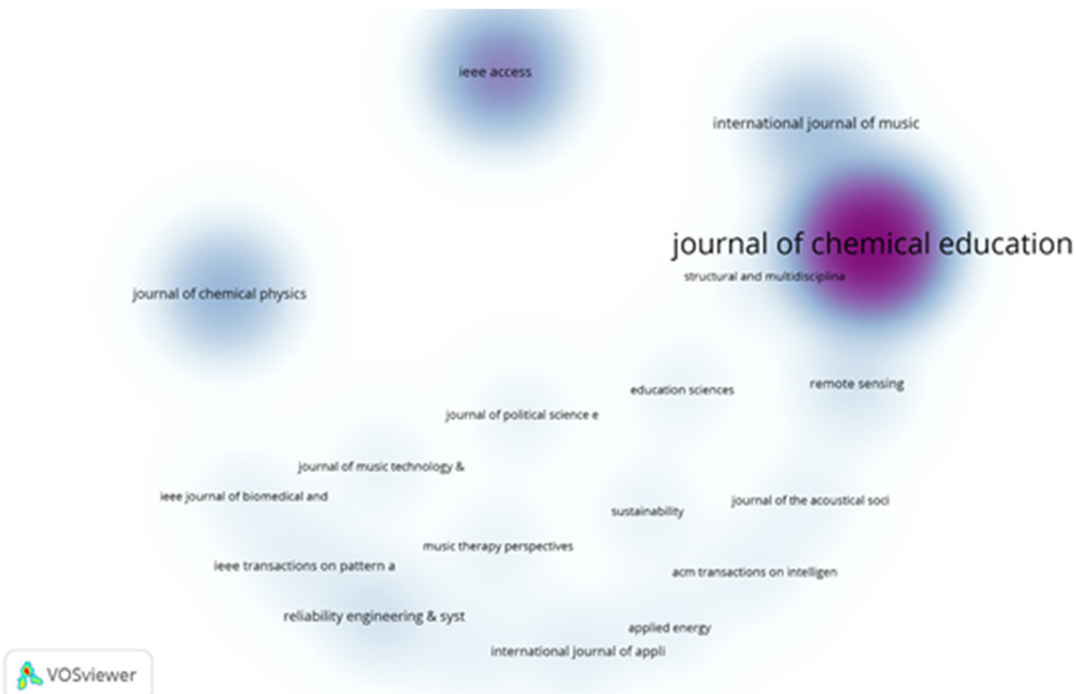


Figure 7. Density Map of Journal Articles Published

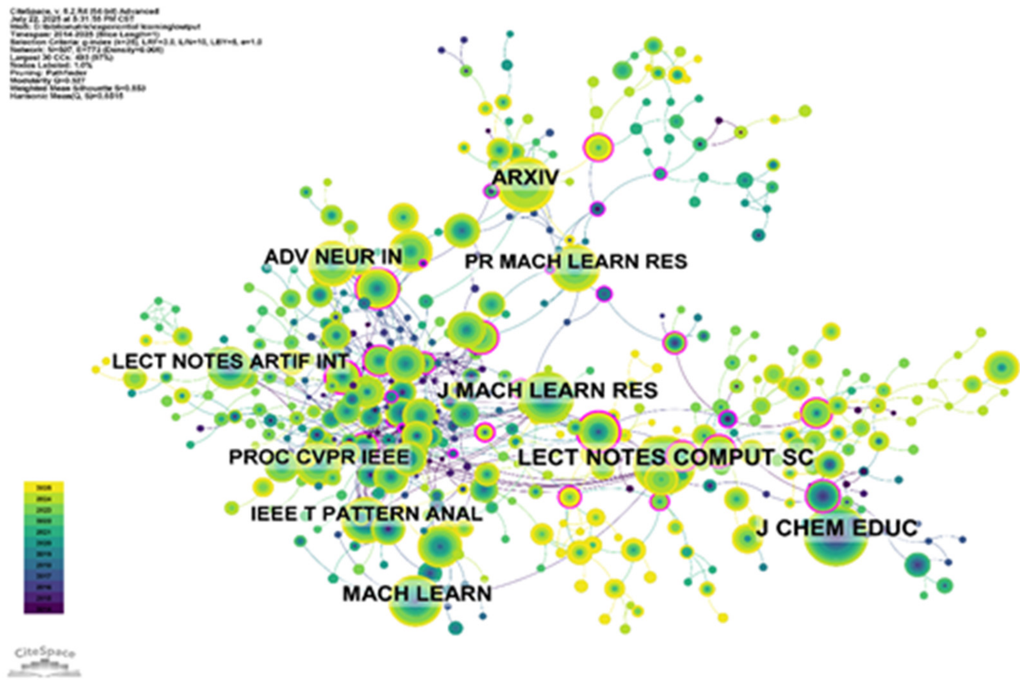


Figure 8. Co-citation Network Diagram of Journals

The impact of an academic journal is commonly evaluated based on its co-citation frequency, which reflects its perceived significance within the scientific community. As shown in Figure 8 and Table 4, J CHEM EDUC was the most frequently co-cited journal, with 182 citations, followed by LECT NOTES COMPUT SC with 171 citations, and J MACH LEARN RES, which received 140 citations. PROC CVPR IEEE was cited 103 times and had the highest recorded impact factor (25.27) among the top ten most co-cited journals. Additionally, 50% of these co-cited journals were indexed in the Q1 or Q2 quartiles, underscoring their high academic impact and recognition within the field.

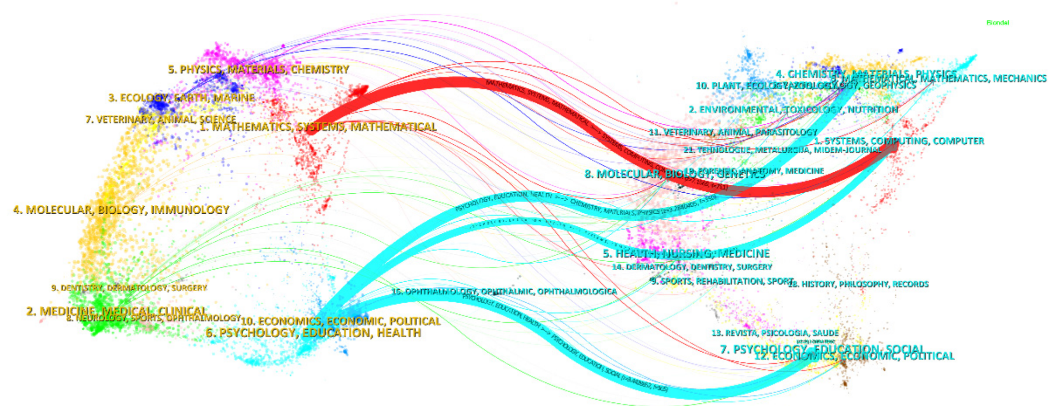


Figure 9. Dual-layered Map of Journals

A double map overlay, as shown in Figure 9, depicts the thematic distribution of academic publications. The colored tracks represent citation linkages, with citing journals positioned on the left and cited journals on the right. From the results, four principal colored citation pathways can be identified, specifically, research published in journals related to chemistry, materials, and physics; psychology, education, and social sciences; and systems, computing, and computer science, with a predominant focus on psychology, education, and health-related journals. Additionally, journals in the systems, computing, and mathematical fields have produced research with notable mathematical contributions and high citation rates.

Table 4. Journal Co-Citation Table

Rank	Cited Journal	Co-Citation	IF（2024）	Quartile in category
1	J CHEM EDUC	182	2.9	Q1
2	LECT NOTES COMPUT SC	171	-	-
3	J MACH LEARN RES	140	5.2	Q1
4	MACH LEARN	138	2.9	Q2
5	ARXIV	138	-	-
6	ADV NEUR IN	113	-	-
7	PROC CVPR IEEE	103	25.27	Q1
8	IEEE T PATTERN ANAL	99	18.6	Q1
9	PR MACH LEARN RES	99	-	-
10	LECT NOTES ARTIF INT	94	-	-

3.4 Author and Co-Citation Analysis

Table 5. Table of Authors' Publications and Co-Citations

Rank	Author	Count	Rank	Co-cited author	Citation
1	Cooks, r. Graham	6	1	Settles b	113
2	Kotsiantis, sotiris	6	2	Gal y	55
3	Krawczyk, bartosz	6	3	Breiman l	52
4	Liu, weike	6	4	Seung hs	50
5	Wozniak, michal	6	5	Freund y	45
6	Zhang, hang	6	6	Lakshminarayanan b	32
7	Borges, endler marcel	5	7	Lewis dd	31
8	Giannakis, georgios b.	5	8	He km	31
9	Liu, qingbao	5	9	Kolb da	29
10	Mitchell, helen f.	5	10	Zhang y	29

Table 5 lists the ten most prolific authors in the field of experiential learning in music education. Collectively, these authors authored 56 publications, accounting for 6.85% of the total output in the discipline. R. Graham had the highest number of publications, totaling six, followed by Sotiris Kotsiantis, Bartosz Krawczyk, Weike Liu, Michal Wozniak, and Hang Zhang, each of whom also contributed six articles (Figure 10).

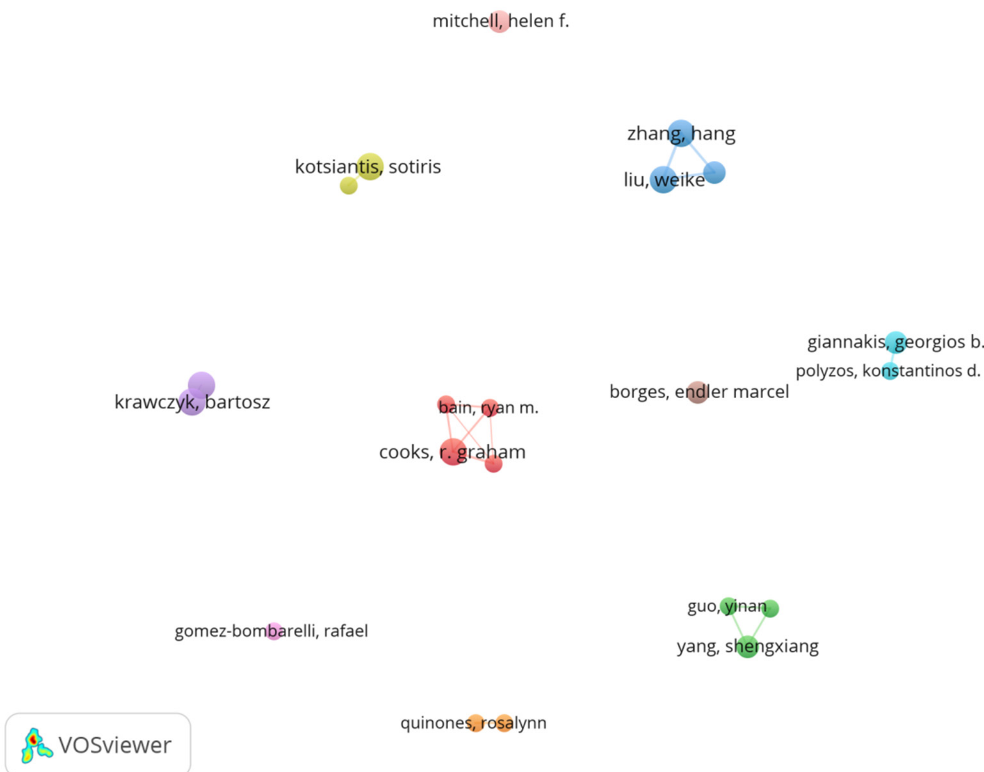


Figure 10. Diagram of Author Collaboration Network

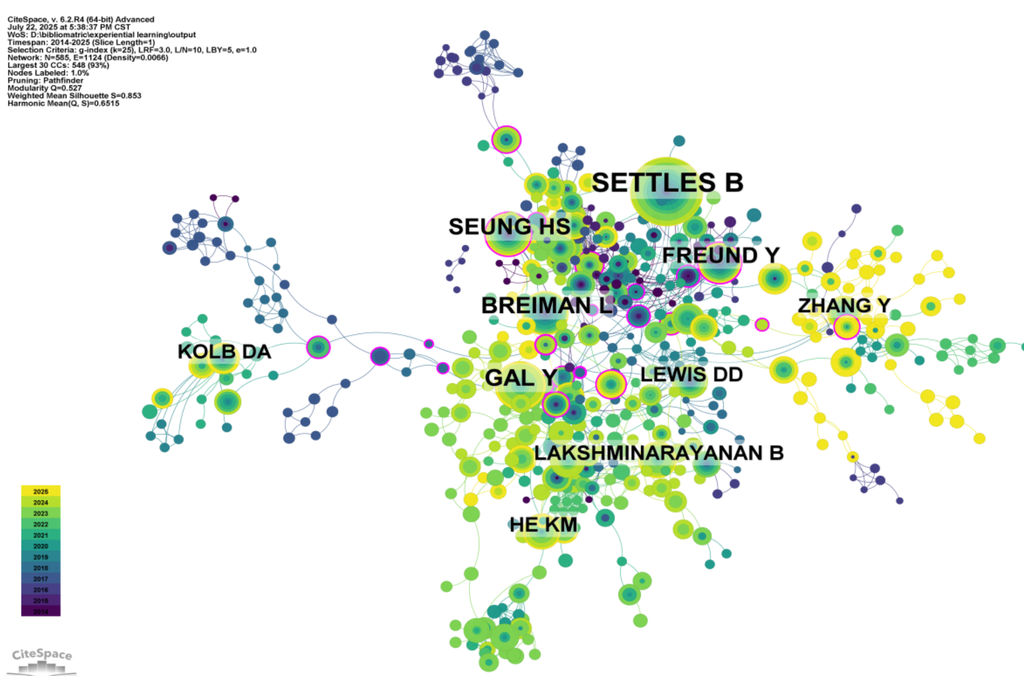


Figure 11. Network of Author Citations

Figure 11 and Table 5 present the ten most co-cited and most frequently cited authors, respectively. Nineteen authors were cited more than twenty times each, reflecting the substantial impact and recognition of their work within the scholarly community. The most prominent nodes in the co-citation network correspond to Settles B (113 citations), Gal Y (55 citations), and Breiman L (52 citations), indicating their influential role in shaping the intellectual foundation of experiential learning in music education.

3.5 Analysis of Co-Cited References

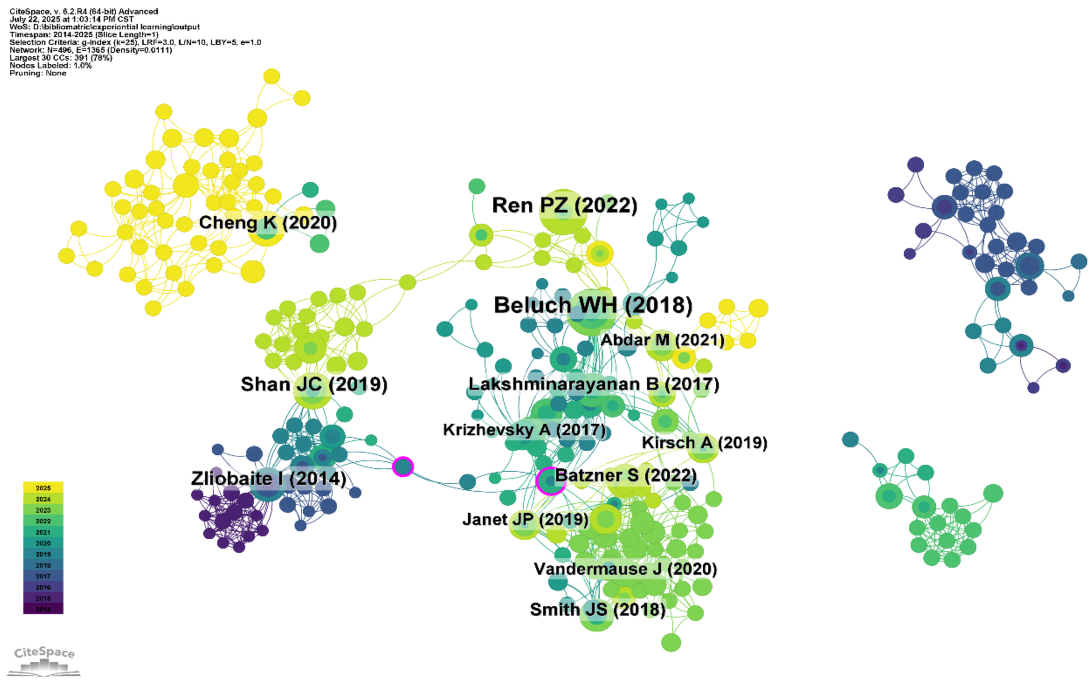


Figure 12. Co-Citation Literature Network Diagram

The co-citation network comprised 496 nodes and 1,365 linkages, analyzed over the ten-year period from 2014 to 2024 (Figure 12). Among the top ten most co-cited works, the most prominent German contribution was the article titled "The Power of Ensembles for Active Learning in Image Classification," authored by Beluch W.H. and published in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR). The article asserts that deep learning methodologies have become the prevailing standard for addressing complex challenges in image processing, particularly image classification. A persistent limitation of deep learning is the substantial need for large, annotated datasets, which are often prohibitively expensive to obtain—especially in sensitive fields such as medical imaging diagnostics. Active learning methodologies have been proposed to alleviate this annotation burden. The study explores several recent active learning strategies tailored for high-dimensional data and convolutional neural network classifiers. Ensemble-based techniques, Monte Carlo Dropout, and geometric approaches are evaluated. Results suggest that ensemble-based methods outperform alternatives, offering superior predictive performance and more reliable uncertainty estimation—a factor underpinning many active learning algorithms. A comparative analysis is conducted to examine the causes of Monte Carlo Dropout's lower effectiveness in uncertainty estimation. Experimental results are presented for the MNIST and CIFAR-10 datasets, with approximately 12,200 labeled images used to achieve 90% test-set accuracy. Additional findings are presented for a highly class-imbalanced diabetic retinopathy dataset, demonstrating that integration-based active learning can reduce data imbalance during collection.

Table 6. Co-citation Analysis of Literature

Rank	Title	Journal	author	Total citations
1	The power of ensembles for active learning in image classification	PROC CVPR IEEE	Beluch WH	20
2	A Survey of Deep Active Learning	ACM COMPUT SURV	Ren PZ	16
3	Online Active Learning Ensemble Framework for Drifted Data Streams	IEEE T NEUR NET LEAR	Shan JC	13
4	Active Learning With Drifting Streaming Data	IEEE T NEUR NET LEAR	Zliobaite I	11
5	Structural reliability analysis based on ensemble learning of surrogate models	STRUCT SAF	Cheng K	10
6	Less is more: Sampling chemical space with active learning	J CHEM PHYS	Smith JS	9
7	On-the-fly active learning of interpretable Bayesian force fields for atomistic rare events	NPJ COMPUT MATER	Vandermause J	8
8	A review of uncertainty quantification in deep learning: Techniques, applications and challenges	INFORM FUSION	Abdar M	8
9	Learning under Concept Drift: A Review	IEEE T KNOWL DATA EN	Lu J	7
10	Variational Adversarial Active Learning	IEEE I CONF COMP VIS	Sinha S	7

Ranked second among the most co-cited works is the article titled “A Survey of Deep Active Learning,” published in ACM Computing Surveys and authored by Ren P.Z. The article posits that active learning (AL) aims to maximize model performance while minimizing the number of labeled examples required. In contrast, deep learning (DL) typically necessitates large datasets to optimize its extensive parameter space, enabling effective feature extraction. With the rapid development of internet technologies, an era characterized by information overload has emerged, providing unprecedented access to large volumes of data. Consequently, deep learning has received widespread academic interest and experienced rapid advancement. However, scholarly attention to active learning has remained relatively limited. This disparity is largely due to the fact that, prior to the widespread adoption of deep learning, traditional machine learning required fewer labeled samples, leading to early neglect of active learning methods. Despite advances across various domains, much of deep learning’s success has been attributed to the availability of large-scale, labeled datasets. Yet, the acquisition of such data is often time-consuming and resource-intensive, particularly in areas such as speech recognition, medical imaging, and information extraction. As a result, active learning is now gaining increased recognition as a cost-effective alternative. Active learning has thus emerged as a promising research direction for maintaining the high performance of deep learning while reducing annotation costs. In this context, the field of Deep Active Learning (DeepAL) has developed. Despite significant research activity, a comprehensive synthesis of DeepAL remains unavailable—a gap that this survey seeks to address. A rigorous classification of existing studies is offered, along with a systematic review of current developments from an application-oriented perspective. Challenges, limitations, and future research opportunities in DeepAL are also analyzed.

Co-citation and temporal clustering analyses were conducted (Figures 13 and 14). Early research hotspots were identified in clusters such as classification task (Cluster 3), Arduino-based uniaxial tensile testers (Cluster 4), multisource integration (Cluster 9), ensemble learning (Cluster 10), and commercial liquor quality analysis (Cluster 14). Mid-stage research focuses included Bayesian neural networks (Cluster 2), iron quantification (Cluster 7), ensemble techniques (Cluster 8), efficient design space exploration (Cluster 12), and multiclass classification (Cluster 15). Recent and emerging trends were observed in interatomic potential modeling (Cluster 0), surrogate-assisted reliability analysis (Cluster 1), online semi-supervised active learning ensemble classification (Cluster 5), training ensemble strategies (Cluster 6), data stream learning (Cluster 11), and vegetative biomass analysis (Cluster 13).

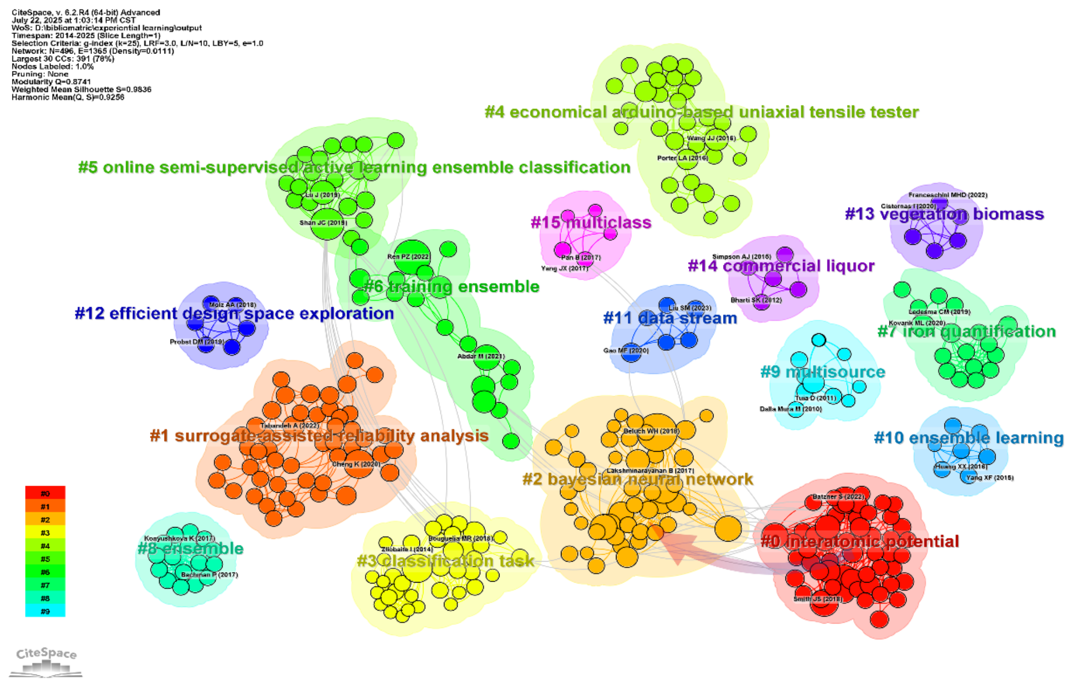


Figure 13. Clustering of Co-cited Literature

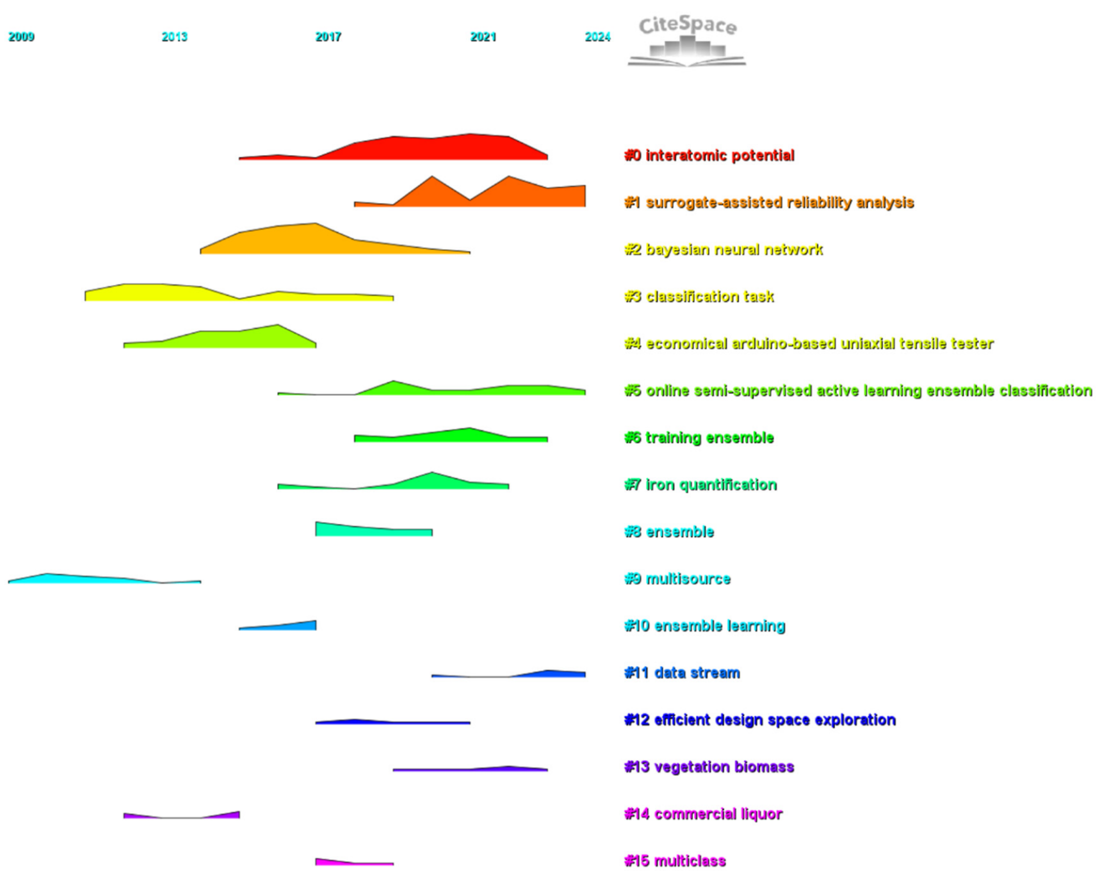


Figure 14. Peak Map of Co-cited Literature

3.6 Keyword Analysis

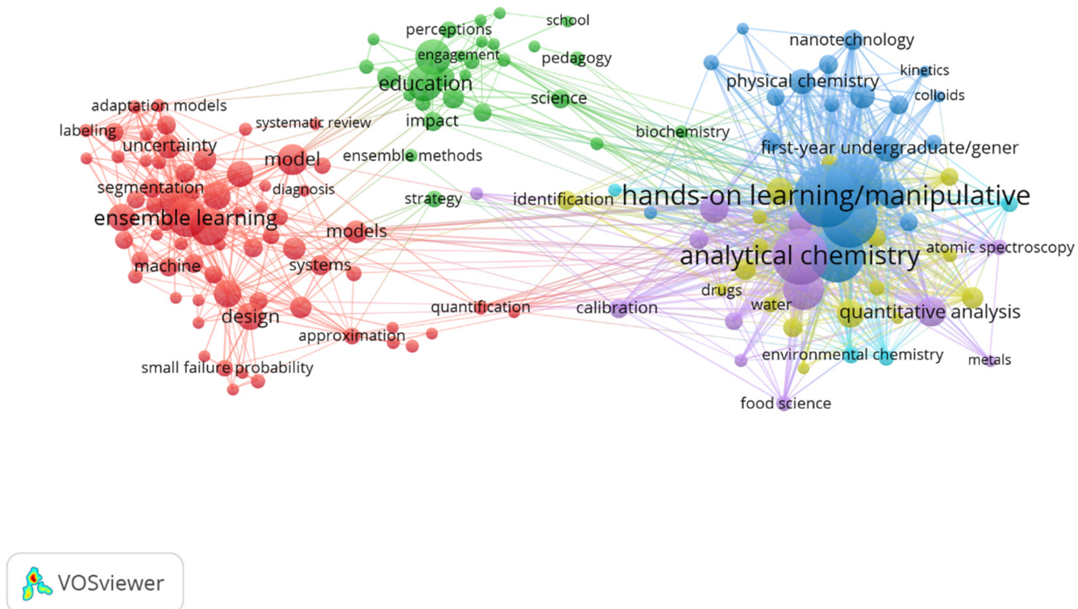


Figure 15. High-Frequency Keyword Network Diagram

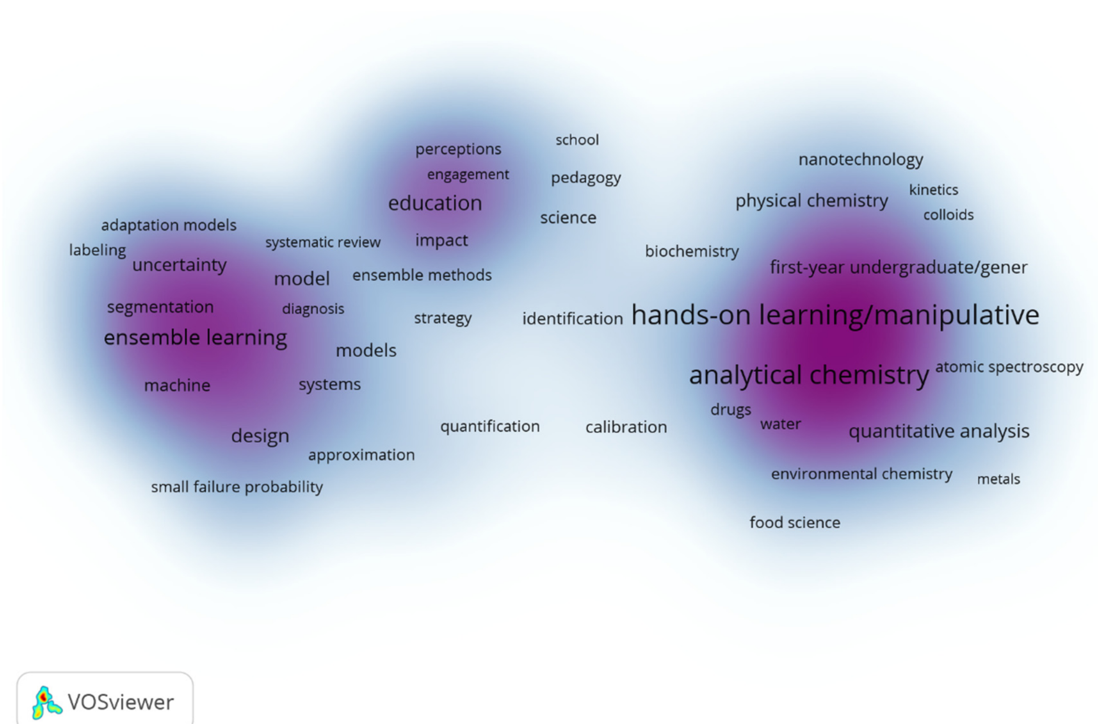


Figure 16. Keyword Density Map

Table 7. Table of High-Frequency Keywords

Rank	Keyword	Counts	Rank	Keyword	Counts
1	hands-on learning/manipulatives	129	11	ensemble	33
2	analytical chemistry	102	12	model	33
3	instrumental methods	101	13	quantitative analysis	30
4	upper-division undergraduate	101	14	hands-on learning	28
5	laboratory instruction	98	15	spectroscopy	27
6	second-year undergraduate	53	16	design	26
7	ensemble learning	50	17	algorithm	25
8	machine learning	49	18	concept drift	25
9	education	43	19	deep learning	25
10	experiential learning	41	20	mass spectrometry	24

Analyzing keywords offers a concise overview of a research domain and its developmental trajectory. Keyword co-occurrence analysis using VOSviewer revealed that the most frequently occurring terms were hands-on learning and manipulatives (129 occurrences), followed by analytical chemistry (102), instrumental methods (101), upper-division undergraduate education (101), and laboratory instruction (98) (Table 7; Figures 15 and 16).

After removing redundant terms, a keyword network was constructed comprising 162 keywords with a minimum occurrence threshold of 10. This network resulted in six distinct thematic clusters: (1) Cluster 1 (Red): Contains 67 keywords related to artificial intelligence, active learning, neural networks, prediction, concept, labeling, simulation, regression, reliability analysis, transfer learning, and uncertainty. (2) Cluster 2 (Green): Includes 28 keywords such as achievement, anxiety, children, creativity, motivation, higher education, ensemble methods, music education, and biochemistry. (3) Cluster 3 (Blue): Comprises 21 terms including colloids, electrochemistry, spectroscopy, organic chemistry, materials science, kinetics, and hands-on learning. (4) Cluster 4 (Yellow): Encompasses 17 keywords related to inquiry-based learning, curriculum, collaborative learning, synthesis, decision-making, and problem-solving. (5) Cluster 5 (Purple): Contains 13 keywords such as atomic spectroscopy, manipulatives, metals, quantitative analysis, and sample quality. (6) Cluster 6 (Sky Blue): Includes 4 keywords: chromatography, construction, graduate education, and environmental chemistry.

To illustrate temporal keyword trends, a volcano map was generated using CiteSpace (Figures 17 and 18). Current research hotspots include hands-on learning, manipulatives, experiential learning, active learning, and concept drift. These terms reflect the growing focus on learner-centered, technology-enhanced, and data-driven instructional methods within music education and related fields.

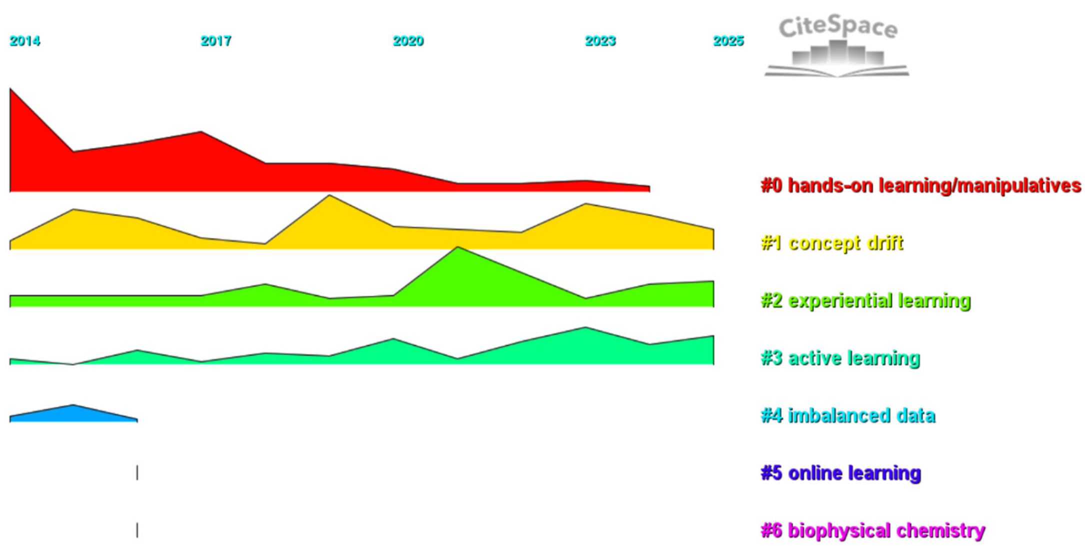


Figure 17. Keyword Clustering Peaks Map

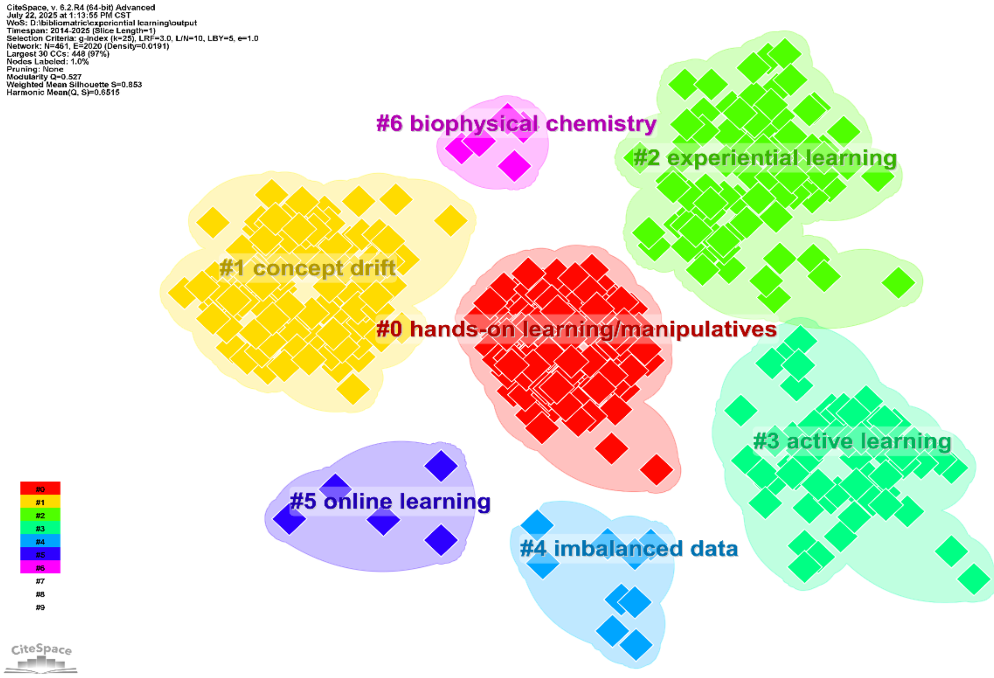
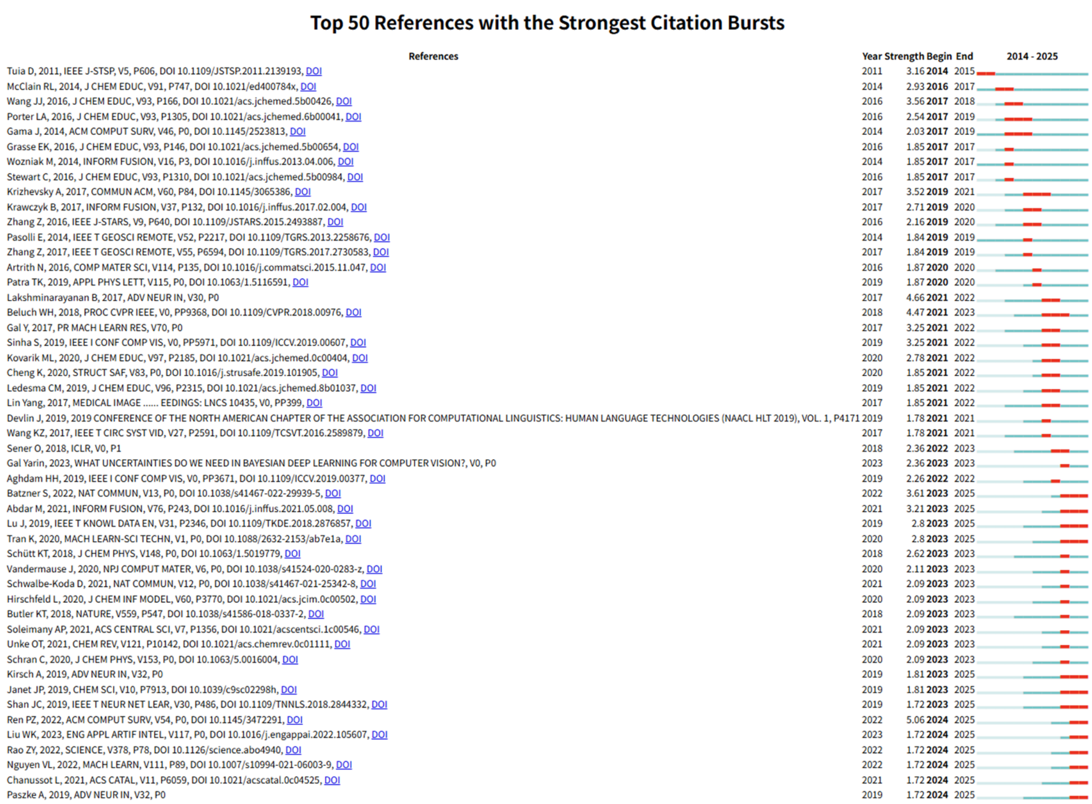


Figure 18. Keyword Clustering Map

3.7 Analysis of Co-Cited References and Keywords



Top 50 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	2014 - 2025
Tuia D, 2011, IEEE J-STSP, V5, P606, DOI 10.1109/JSTSP.2011.2139193, DOI	2011	3.16	**2014**	2015	
McClain RL, 2014, J CHEM EDUC, V91, P747, DOI 10.1021/ed400784x, DOI	2014	2.93	**2016**	2017	
Wang JJ, 2016, J CHEM EDUC, V93, P166, DOI 10.1021/acs.jchemed.5b00426, DOI	2016	3.56	**2017**	2018	
Porter LA, 2016, J CHEM EDUC, V93, P1305, DOI 10.1021/acs.jchemed.6b00041, DOI	2016	2.54	**2017**	2019	
Gama J, 2014, ACM COMPUT SURV, V46, P0, DOI 10.1145/2523813, DOI	2014	2.03	**2017**	2019	
Grasse EK, 2016, J CHEM EDUC, V93, P146, DOI 10.1021/acs.jchemed.5b00654, DOI	2016	1.85	**2017**	2017	
Wozniak M, 2014, INFORM FUSION, V16, P3, DOI 10.1016/j.inffus.2013.04.006, DOI	2014	1.85	**2017**	2017	
Stewart C, 2016, J CHEM EDUC, V93, P1310, DOI 10.1021/acs.jchemed.5b00984, DOI	2016	1.85	**2017**	2017	
Krizhevsky A, 2017, COMMUN ACM, V60, P84, DOI 10.1145/3065386, DOI	2017	3.52	**2019**	2021	
Krawczyk B, 2017, INFORM FUSION, V37, P132, DOI 10.1016/j.inffus.2017.02.004, DOI	2017	2.71	**2019**	2020	
Zhang Z, 2016, IEEE J-STARS, V9, P640, DOI 10.1109/JSTARS.2015.2493887, DOI	2016	2.16	**2019**	2020	
Pasolli E, 2014, IEEE T GEOSCI REMOTE, V52, P2217, DOI 10.1109/TGRS.2013.2258676, DOI	2014	1.84	**2019**	2019	
Zhang Z, 2017, IEEE T GEOSCI REMOTE, V55, P6594, DOI 10.1109/TGRS.2017.2730583, DOI	2017	1.84	**2019**	2019	
Artrith N, 2016, COMP MATER SCI, V114, P135, DOI 10.1016/j.commatsci.2015.11.047, DOI	2016	1.87	**2020**	2020	
Patra TK, 2019, APPL PHYS LETT, V115, P0, DOI 10.1063/1.5116591, DOI	2019	1.87	**2020**	2020	
Lakshminarayanan B, 2017, ADV NEUR IN, V30, P0	2017	4.66	**2021**	2022	
Beluch WH, 2018, PROC CVPR IEEE, V0, PP9368, DOI 10.1109/CVPR.2018.00976, DOI	2018	4.47	**2021**	2023	
Gal Y, 2017, PR MACH LEARN RES, V70, P0	2017	3.25	**2021**	2022	
Sinha S, 2019, IEEE I CONF COMP VIS, V0, PP5971, DOI 10.1109/ICCV.2019.00607, DOI	2019	3.25	**2021**	2022	
Kovarik ML, 2020, J CHEM EDUC, V97, P2185, DOI 10.1021/acs.jchemed.0c00404, DOI	2020	2.78	**2021**	2022	
Cheng K, 2020, STRUCT SAF, V83, P0, DOI 10.1016/j.strusafe.2019.101905, DOI	2020	1.85	**2021**	2022	
Ledesma CM, 2019, J CHEM EDUC, V96, P2315, DOI 10.1021/acs.jchemed.8b01037, DOI	2019	1.85	**2021**	2022	
Lin Yang, 2017, MEDICAL IMAGE ...... EEDINGS: LNCS 10435, V0, PP399, DOI	2017	1.85	**2021**	2022	
Devlin J, 2019, 2019 CONFERENCE OF THE NORTH AMERICAN CHAPTER OF THE ASSOCIATION FOR COMPUTATIONAL LINGUISTICS: HUMAN LANGUAGE TECHNOLOGIES (NAACL HLT 2019), VOL. 1, P4171	2019	1.78	**2021**	2021	
Wang KZ, 2017, IEEE T CIRC SYST VID, V27, P2591, DOI 10.1109/TCSVT.2016.2589879, DOI	2017	1.78	**2021**	2021	
Sener O, 2018, ICLR, V0, P1	2018	2.36	**2022**	2023	
Gal Yarin, 2023, WHAT UNCERTAINTIES DO WE NEED IN BAYESIAN DEEP LEARNING FOR COMPUTER VISION?, V0, P0	2023	2.36	**2023**	2023	
Aghdam HH, 2019, IEEE I CONF COMP VIS, V0, PP3671, DOI 10.1109/ICCV.2019.00377, DOI	2019	2.26	**2022**	2022	
Batzner S, 2022, NAT COMMUN, V13, P0, DOI 10.1038/s41467-022-29939-5, DOI	2022	3.61	**2023**	2025	
Abdar M, 2021, INFORM FUSION, V76, P243, DOI 10.1016/j.inffus.2021.05.008, DOI	2021	3.21	**2023**	2025	
Lu J, 2019, IEEE T KNOWL DATA EN, V31, P2346, DOI 10.1109/TKDE.2018.2876857, DOI	2019	2.8	**2023**	2025	
Tran K, 2020, MACH LEARN-SCI TECHN, V1, P0, DOI 10.1088/2632-2153/ab7e1a, DOI	2020	2.8	**2023**	2025	
Schütt KT, 2018, J CHEM PHYS, V148, P0, DOI 10.1063/1.5019779, DOI	2018	2.62	**2023**	2023	
Vandermause J, 2020, NPJ COMPUT MATER, V6, P0, DOI 10.1038/s41524-020-0283-z, DOI	2020	2.11	**2023**	2023	
Schwalbe-Koda D, 2021, NAT COMMUN, V12, P0, DOI 10.1038/s41467-021-25342-8, DOI	2021	2.09	**2023**	2023	
Hirschfeld L, 2020, J CHEM INF MODEL, V60, P3770, DOI 10.1021/acs.jcim.0c00502, DOI	2020	2.09	**2023**	2023	
Butler KT, 2018, NATURE, V559, P547, DOI 10.1038/s41586-018-0337-2, DOI	2018	2.09	**2023**	2023	
Soleimany AP, 2021, ACS CENTRAL SCI, V7, P1356, DOI 10.1021/acscentsci.1c00546, DOI	2021	2.09	**2023**	2023	
Unke OT, 2021, CHEM REV, V121, P10142, DOI 10.1021/acs.chemrev.0c01111, DOI	2021	2.09	**2023**	2023	
Schran C, 2020, J CHEM PHYS, V153, P0, DOI 10.1063/5.0016004, DOI	2020	2.09	**2023**	2023	
Kirsch A, 2019, ADV NEUR IN, V32, P0	2019	1.81	**2023**	2025	
Janet JP, 2019, CHEM SCI, V10, P7913, DOI 10.1039/c9sc02298h, DOI	2019	1.81	**2023**	2025	
Shan JC, 2019, IEEE T NEUR NET LEAR, V30, P486, DOI 10.1109/TNNLS.2018.2844332, DOI	2019	1.72	**2023**	2025	
Ren PZ, 2022, ACM COMPUT SURV, V54, P0, DOI 10.1145/3472291, DOI	2022	5.06	**2024**	2025	
Liu WK, 2023, ENG APPL ARTIF INTEL, V117, P0, DOI 10.1016/j.engappai.2022.105607, DOI	2023	1.72	**2024**	2025	
Rao ZY, 2022, SCIENCE, V378, P78, DOI 10.1126/science.abo4940, DOI	2022	1.72	**2024**	2025	
Nguyen VL, 2022, MACH LEARN, V111, P89, DOI 10.1007/s10994-021-06003-9, DOI	2022	1.72	**2024**	2025	
Chanussot L, 2021, ACS CATAL, V11, P6059, DOI 10.1021/acscatal.0c04525, DOI	2021	1.72	**2024**	2025	
Paszke A, 2019, ADV NEUR IN, V32, P0	2019	1.72	**2024**	2025	
Cano A, 2022, MACH LEARN, V111, P2561, DOI 10.1007/s10994-022-06168-x, DOI	2022	1.72	**2024**	2025	

Figure 19. Cited Literature Emergence Map

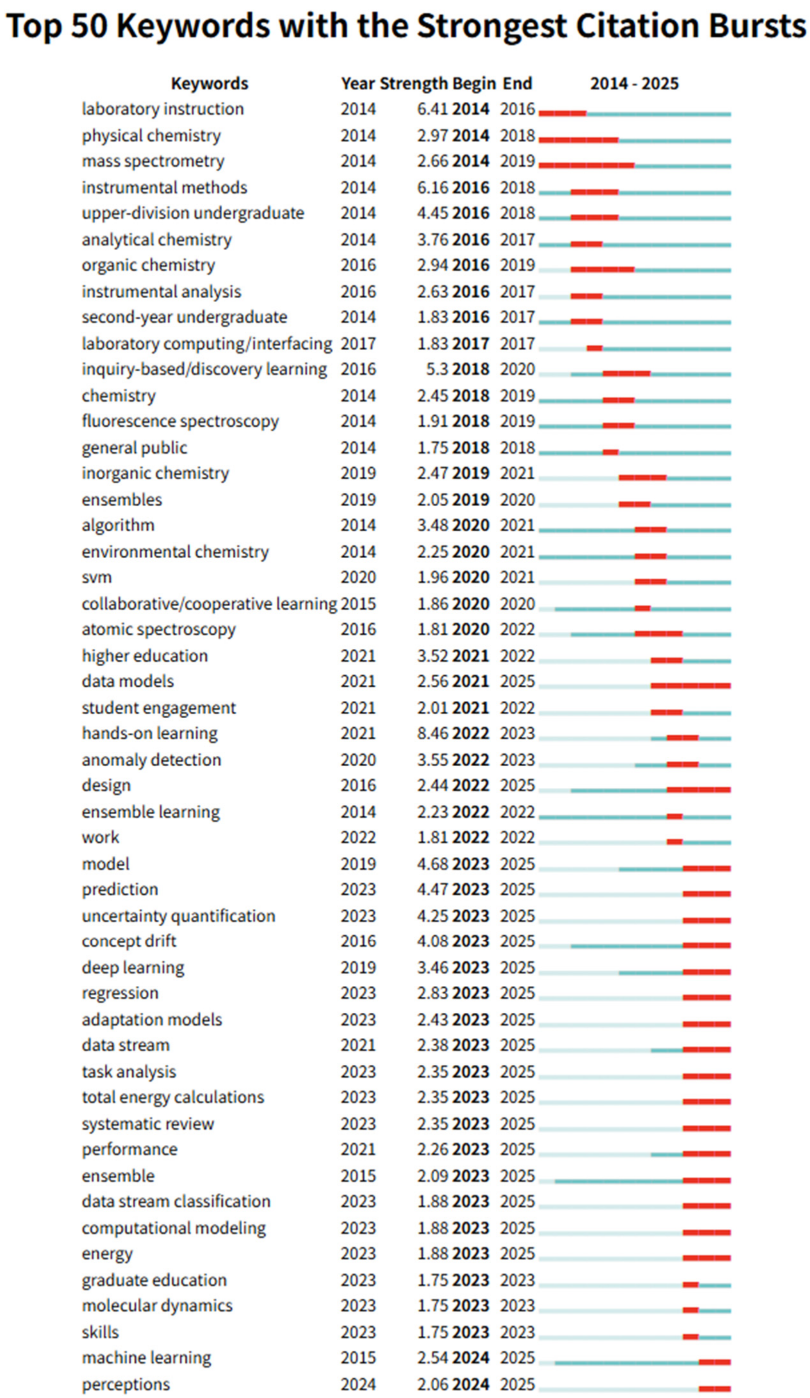


Figure 20. Keyword Emergence Map

Using CiteSpace, the 50 strongest citation bursts in the field of experiential learning in music education were identified, representing references that received an exceptionally high frequency of citations during a specific time interval. Forty-nine of these fifty references were published between 2014 and 2025, suggesting consistent citation activity over the past decade. Notably, 14 of these references are currently experiencing peak citation intensity (Figure 19), indicating that interest in experiential learning within music education is likely to continue growing. Among the references with significant citation bursts is the article "A Survey of Deep Active Learning" (Ren, P.Z.), which emphasizes the potential of active learning to reduce annotation costs while maintaining the robust learning performance associated with deep learning. The study offers a formal classification of existing research and a comprehensive review of application areas, current limitations, and future directions in Deep Active Learning

(DeepAL). In parallel, CiteSpace's burst keyword analysis identified 453 mutated terms, of which the 50 exhibiting the strongest citation bursts were analyzed in detail (Figure 20). These terms indicate both the current focal areas and the potential future trajectories of research in the domain. The emergence and sustained burst activity of terms such as experiential learning, active learning, manipulatives, concept drift, and hands-on learning reaffirm their centrality in ongoing academic discourse and their importance as evolving research hotspots.

4. Discussion

4.1 Evolution of Research Distribution and Global Contributions

This bibliometric analysis offers significant insights into the progression of experiential learning research within music education over the past decade. The steady growth in publication volume from 2014 to 2025, with marked acceleration beginning in 2019 and peaking in 2024, responds directly to Research Question 1 (RQ1) by illustrating the field's transition from an emerging area of inquiry to a recognized component of mainstream educational discourse. This trend suggests that experiential learning methodologies have been increasingly recognized as essential pedagogical tools in music education.

The geographical distribution of research contributions highlights both global engagement and notable disparities. The United States' leading role—accounting for 37.94% of total publications and 5,111 citations—reflects significant national investment in music education research infrastructure. China's position as the second-largest contributor (21.66% of publications) suggests increased acknowledgment of experiential learning's relevance across varied educational contexts. However, the concentration of high-impact research within developed nations underscores persistent global inequities in research capacity—an especially important issue given the universal cultural relevance of music education.

Institutional-level analysis confirms these patterns, with seven of the ten most productive institutions based in the United States. The prominent role of the U.S. Department of Energy and technical universities such as MIT suggests a previously unanticipated intersection between music education and research environments traditionally focused on science, technology, and engineering.

4.2 Research Hotspots and Thematic Evolution

The analysis of research hotspots (RQ2) identified four distinct thematic clusters characterizing current research priorities in experiential learning within music education. The predominance of hands-on learning and manipulatives (129 occurrences) reinforces the field's emphasis on practical, experiential methods. This finding supports the foundational theoretical framework proposed by Kolb (1984) and is consistent with contemporary pedagogical trends favoring active and embodied learning experiences.

It is interesting to note that the prominent usage of terms that denote analytical chemistry and methodological instrumentation is indicative of an unexpected cross-over in methodology. This interdisciplinary overlap can be interpreted as the application of scientific measurement methods to gauge the results of musical learning, and an emphasis on progressively more complex methods to measure the success of experiential learning. The common terminology of laboratory instruction further supports this reading, suggesting that empirical methods that have typically been popular in STEM fields are being implemented in music education research.

The changing dynamics of keywords reflect how the field has followed previous paths of early focus on categorization tasks and integrated learning development into more adaptive pedagogical approaches that emphasize active learning and concept drift. The recent trend of machine learning and algorithmic software becoming research fodder is indicative of the growing integration of artificial intelligence into the music education specific fields, specifically assessment, personalization, and instructional design, and represents a significant technological breakthrough in the provision of experiential learning.

4.3 State of the Art Development and Future Projections.

Regarding the answer to Research Question 3 (RQ3), two main frontiers which define the direction of experiential learning in music education in the future were named. The biggest advancement is the synergy between artificial intelligence and neural networks in relation to music education. With the growing popularity of words like deep learning, ensemble methods, and concept drift, as seen in recent publications, this technological integration is likely to mean that experiential learning settings will become more and more integrated with AI to provide personalized and adaptive musical experiences based on specific learner profiles.

The second significant phenomenon refers to the combination of experiential learning and creative pedagogical strategies. It is indicative of an increasingly realized need to provide good music teaching that requires both scaffolded experiential systems and the room in which students can express their creativity through the arts. The twin focus seeks to resolve an old pedagogical dilemma: how to balance the development of technical skill with creative exploration opportunities. The results show that existing education programs are increasingly finding success in harmonizing these competing priorities.

The forward thrust of the field is further supported by the citation burst analysis. There are 14 publications with high citation rates that are currently in the peak citation wave, which means it has maintained interest in scholarship. Instead of this being a symptom of theoretical saturation, it is typical of disciplines where innovation is accelerating and where different theoretical approaches are diversifying, and helps to support the idea that experiential learning in music education is a developing and dynamic discipline.

4.4 Methodological Implications and Limitations

The unexpected prominence of terminology related to chemistry and analytical instrumentation warrants cautious interpretation. Although initially appearing disparate from traditional music education research, this pattern may reflect the increasing adoption of rigorous empirical techniques for assessing learning outcomes in experiential music programs. Such methodological sophistication constitutes a notable advancement in the quality of educational research, facilitating enhanced evaluation of the effectiveness of experiential learning interventions.

However, several methodological limitations must be acknowledged. The bibliometric approach employed in this study is contingent upon the scope and structure of the Web of Science Core Collection, which is likely to underrepresent practitioner-oriented literature and culturally specific studies published in non-English languages. This may introduce a bias toward Western, academically focused perspectives. Furthermore, the apparent dominance of U.S. and Chinese research output could be attributed in part to database indexing priorities rather than genuine disparities in research productivity.

The journal analysis indicates a degree of disciplinary dispersion, with music education research appearing across a range of technical, educational, and interdisciplinary journals. While this diversity may support constructive interdisciplinary exchange, it also suggests a lack of dedicated publication venues specializing in experiential music education. This fragmentation may hinder the consolidation of a coherent scholarly community and limit the visibility of research in this evolving domain.

4.5 Practical Implications for Music Educators

The findings present several practical implications for music educators. The demonstrated effectiveness of hands-on learning approaches offers empirical validation for performance-based and participatory pedagogies that are commonly employed by practitioners in the field. The increasing integration of technological tools and assessment methods suggests that educators are encouraged to adopt digital platforms and data-driven strategies to improve the impact of experiential learning.

Furthermore, the emergence of AI-assisted instructional platforms suggests that future music education is likely to incorporate intelligent tutoring systems capable of delivering personalized feedback and adaptive learning pathways. Music educators ought to be prepared for this technological evolution, while simultaneously preserving the human-centered and creative dimensions that are foundational to high-quality music instruction.

4.6 Theoretical Contributions and Future Research Directions

This analysis offers theoretical advancement for experiential learning theory through the demonstration of its successful application and evolution within music education contexts. The identification of four distinct research clusters establishes a conceptual framework for understanding how experiential learning is expressed across various musical domains, including performance-based practice and technology-enhanced environments.

Future research is encouraged to address several critical gaps revealed in the present study. Comparative investigations that examine the effectiveness of experiential learning across diverse cultural and educational contexts would offer valuable insights into universal versus context-dependent pedagogical principles. Furthermore, longitudinal studies that track long-term musical development among students engaged in sustained experiential learning programs could reinforce the empirical foundation supporting these instructional models.

The integration of neuroscience methodologies into experiential music education research has been identified as a promising avenue for future inquiry. Such interdisciplinary approaches may reveal how hands-on musical engagement influences cognitive development and neural plasticity. In turn, this line of research could provide biological validation for experiential learning theories and guide the design of more sophisticated and evidence-informed pedagogical strategies.

5. Conclusion

The current bibliometric analysis demonstrates the notable growth and diversification of literature on experiential learning in music education in the period of 2014-2025. Empirical evidence suggests that the United States and China are the global leaders in the production, and inter-institutional partnerships are gaining gains over time. Thematic interrogation indicates a strong concern with praxis-oriented and reflective approaches; and in parallel, current trends concentrate on the integration of artificial intelligence, machine learning, and adaptive learning approaches into experiential music pedagogies. Despite these advancements, there are still significant gaps in the content in cross-cultural comparative research, longitudinal outcomes measurement, and the provision of scholarly forums in which experiential music education is the sole focus. The gap between these deficits requires intensifying global interactions and developing a stricter body of evidence to support the effectiveness of experiential pedagogies. Future research must also question cross-disciplinary paradigms, including aspects of neuroscience and educational technology, to clarify the inquisitive and creative dividends experienced through experiential music learning. Determining global trends, new directions, and knowledge gaps, the work provides an empirical basis of the integration of experience learning practice and the development of pedagogy in music education at the global level.

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Koch, S., Pawlowski, C. S., Skovgaard, T., Mygind, L., Meyer, M. R. G., Andersen, H. B., Troelsen, J., & Pawlowski, C. S. (2021). Exploring implementation of a nationwide requirement to increase physical activity in the curriculum in Danish public schools: A mixed methods study. *BMC Public Health, 21*(1), Article 2073. https://doi.org/10.1186/s12889-021-12152-2

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Acknowledgments

We greatly appreciate the valuable contributions of our community advisory committee members. We would also like to thank the Faculty of Music and Performing Arts, Universiti Pendidikan Sultan Idris and all the academic and administrative staff involved for their technical assistance throughout the study.

Authors contributions

Xue Han Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review and editing. X.H. conceived the research idea, developed the methodology framework, conducted the comprehensive literature search and data collection from Web of Science Core Collection database, performed bibliometric analysis using CiteSpace and VOSviewer software, created all visualizations and figures, and wrote the initial manuscript draft.

Christine A/P Augustine Supervision, Conceptualization, Writing – review and editing, Validation, Project administration. C.A.A. provided academic supervision and guidance throughout the research process, contributed to the conceptual framework development, validated the methodological approach and analytical procedures, critically reviewed and edited the manuscript for academic rigor and clarity, and oversaw the overall project administration.

Shared Contributions Both authors collaboratively refined the research questions, interpreted the bibliometric results, discussed the implications of findings, and finalized the manuscript for submission. Both authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Funding

Not applicable.

Competing interests

The authors declare that they have no competing interests. No financial or non-financial benefits have been received or will be received from any party related directly or indirectly to the subject of this article. The research was conducted in the absence of any commercial or financial relationships that could be construed as potential conflicts of interest.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Sciedu Press.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request. The bibliometric data was extracted from the Web of Science Core Collection database. All search strategies, inclusion/exclusion criteria, and analytical procedures are detailed in the methodology section to ensure reproducibility. The raw data files generated through CiteSpace and VOSviewer analysis can be provided to support the findings of this study.

Data sharing statement

No additional data are available.