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PAPER

Transforming Music Education Through Artificial Intelligence: A Systematic Literature Review on Enhancing Music Teaching and Learning

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ABSTRACT

The advent of artificial intelligence (AI) has brought significant and transformative alterations to traditional music education. This study examines the progress of AI technology in music education by conducting a systematic review using the PRISMA methodology. Articles were selected for inclusion based on the criterion of specifically describing the utilization of AI in the instruction and acquisition of music. The search was performed on April 9, 2024, via the Web of Science and SCOPUS databases. The search terms "music education" and "artificial intelligence" were employed to ascertain relevant scholarly research. The group of papers underwent scrutiny by various researchers to ascertain their adherence to the established criteria. The articles that were verified by a minimum of two researchers were chosen. 31 articles were finally screened, and the results were divided into two sections: the development of AI in music education and innovative music pedagogy based on AI. A key finding is that the implementation of bibliometric analyses suggests that AI research in music education is still in its infancy. Prior research has primarily concentrated on music instruction at the university level, with a particular emphasis on the integration of AI in music education in China. In addition, this study identifies four specific facets of AI through the reshaping of music pedagogy: enhancing personalized music teaching, providing timely feedback on learning, supporting interactive experiences, and providing organized digital materials.

KEYWORDS

music education, teaching and learning, artificial intelligence (AI), systematic review, PRSMA statement

1 INTRODUCTION

Traditionally, music education has relied on direct, real-time interaction between teacher and student, a long-standing practice that is rarely challenged. When examining the conventional approaches to music education from a pedagogical

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perspective, it is essential to address the instructional methods of Dalcroze, Kodály, and Orff [1]. These pedagogies have been the cornerstone of music education for almost a century. Even though many new types of music pedagogies have since emerged around the world, they all rely on teachers and students learning together synchronously and face-to-face, as if music education has long been inseparable from this paradigm [2].

The integration of artificial intelligence (AI) with education has been viewed as a significant advancement in the competition for national power, considering both teaching and learning perspectives as well as technological development. The World Digital Education Conference 2024 concentrates on the theme of "Artificial Intelligence and Digital Ethics." The objective of the conference is to exchange national policies and experiences regarding the utilization of AI in education. Additionally, it aims to establish a significant agreement on the significance of AI in enhancing educational progress [3]. The National Education Plan of China outlines four action plans for AI-enabled education. These plans aim to promote the development of AI teaching platforms and provide opportunities for teachers and students to engage with AI technology in educational settings [4]. Consequently, an increasing number of educational institutions and academic disciplines are contemplating the utilization of AI to assist in teaching and learning, in accordance with the educational policies of different nations. Presently, AI is being employed in the field of education through the utilization of intelligent tutoring systems, automated assessment tools, data mining techniques, and learning analytics [5].

Artificial intelligence in music education is a subset of AI and Education (AIEd) that specifically deals with creating and using AI technologies to enhance music education. Literature suggests that automated AI techniques have been applied to music education to improve the quality of music teaching and learning and to improve the experience and engagement in music teaching and learning [6–8]. AIEd is increasingly being adopted across various disciplines. Nevertheless, studies on the influence of AI technology on music education seem to be unclear. Currently, music education academics lack an in-depth understanding of the status of music teaching and learning facilitated by AI technology, specifically in terms of organizing the evidence pertaining to innovative teaching methods in the field of AI-assisted music education [9].

The authors look at the rapid development of AI and the imminence of a systematic review of its applied research in the field of music education. The objective of this study is to thoroughly summarize and analyze the influence of AI on music education over the past ten years using a systematic review methodology. The study aims to identify the main research trends, assess the current progress of AI education in music, and investigate the novel teaching methods in music education facilitated by AI technology. This review was guided by the following research questions:

1. *What is the current state of AI in music education?*
2. *How can AI facilitate the implementation of innovative pedagogy in music education?*

2 MATERIALS AND METHODS

This systematic review follows the PRISMA 2020 guideline, which aims to improve the objectivity and scientific validity of systematic reviews [10]. To achieve this goal, the 27 criteria of PRISMA 2020 were rigorously reviewed and reported.

2.1 Search strategy and selection criteria

According to Okoli [11], systematic review plays a crucial role in academic research by summarizing and analyzing previous research findings and experiences. This process is essential for the advancement of knowledge in a specific field. This systematic review was conducted collaboratively by the three authors. Initially, three authors developed a review protocol in early 2024 to read through the literature to identify the most appropriate keywords and search databases. The authors conducted a comprehensive search of the SCOPUS and Web of Science (WoS) databases, which are widely regarded and extensively utilized in academic research [12] and [13]. Search filters included: 1) topics that used the following key terms, with some variations depending on the database, and 2) articles published in English. The following Boolean string is obtained:

Web of Science: search for Topic: ("music education" AND "artificial intelligence"). And refined by English.

SCOPUS: TITLE-ABS-KEY ("music education" AND "innovation pedagogy" OR "artificial intelligence") AND (LIMIT-TO (LANGUAGE, "English").

The search date was April 1, 2024, and the articles were found to have been published between 2014 and 2023. A total of 171 identification articles were initially recorded, of which 113 were from SCOPUS and 58 from WoS. To facilitate analysis and presentation, the articles were exported into an Excel matrix. This matrix contained specific information such as the author's name, year of publication, title, DOI, and abstract. This enabled the generation of charts and tables to assist in the analysis of data. One author independently conducted the search for articles in the database, following a joint decision by three authors on the search strategy. The other two authors collectively examined the titles and abstracts of the acquired papers. Consequently, any duplicate articles that were evidently unrelated to the subject matter were eliminated. Afterwards, all authors thoroughly examined the complete text of the remaining papers to evaluate their adherence to the inclusion and exclusion criteria outlined in Table 1.

Table 1. Inclusion and exclusion criteria

Inclusion	Exclusion
Available as a full article	Available in non-full-text format
English writing	None English writing
Focus on AI-assisted music teaching and learning environments	Music teaching and learning in traditional setting
Focus on Innovative Artificial Intelligence-based Music Pedagogy	Traditional music pedagogies and non AI teaching methods

During the article review process, articles that were included had to be agreed upon by two researchers, and if there was a disagreement between the authors on the selection of articles it had to be resolved by consensus of all three authors. Ultimately, a total of 31 articles were included in the review by comparing the papers selected by each researcher. All these 31 articles passed the selection of the three researchers. Figure 1 shows the flowchart of PRISMA for this study.

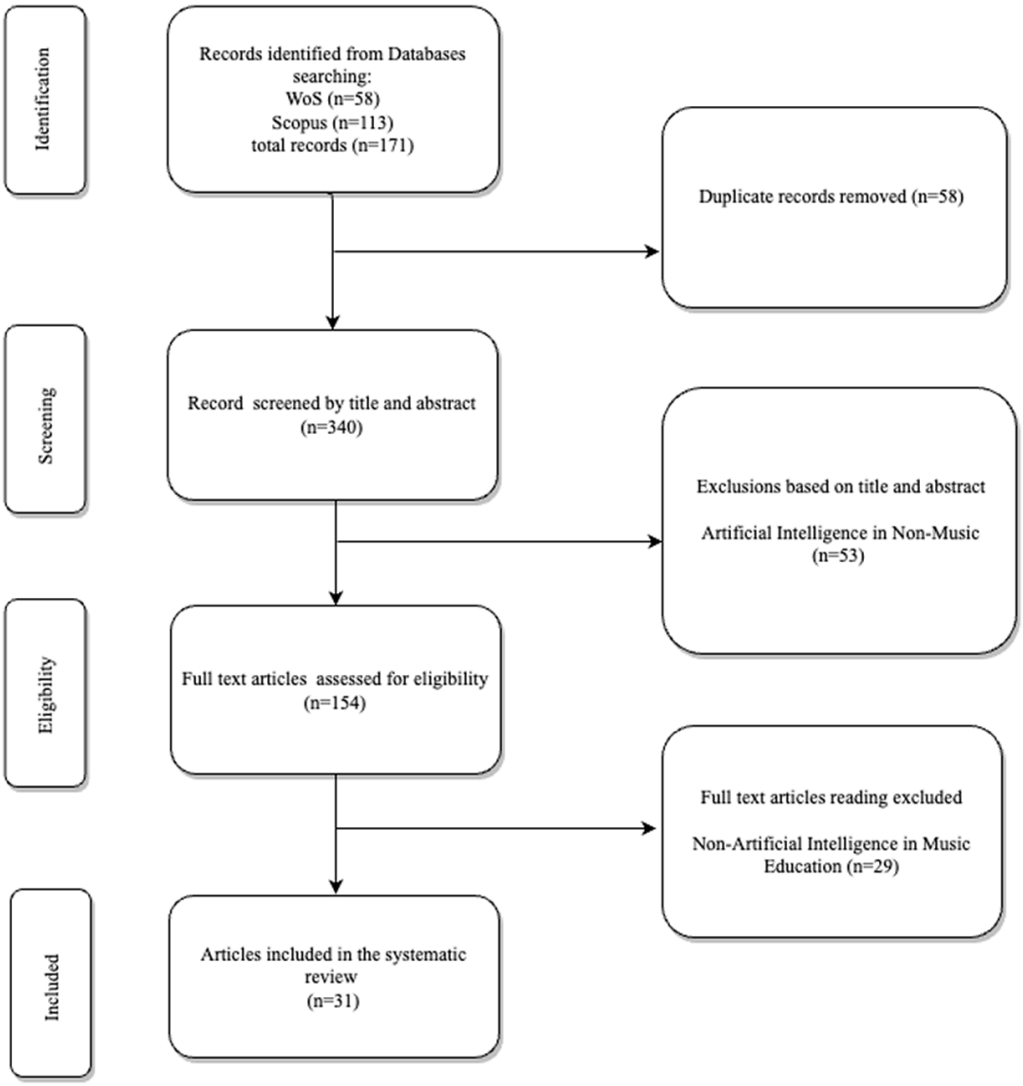

Fig. 1. PRISMA flowchart with the results of the database search

3 RESULTS AND DISCUSSIONS

This study adhered to the PRISMA model and was reported according to the PRISMA checklist. Initially, out of a total of 171 articles, 58 were excluded due to duplicates, 53 due to titles and abstracts not meeting the criteria, 29 due to AI articles that did not deal with music education based on full-text readings, respectively, and unavailable papers that appeared to meet the inclusion criteria were also excluded because it was not possible to obtain full manuscripts. In the end, 31 usable articles were obtained. Table 2 presents a summary of the results of the included articles.

To reduce the potential bias in the results, the study initially utilized two prominent specialized academic databases, SCOPUS and WoS, to conduct the search. Additionally, a 10-year timeframe was chosen to identify possible advancements in AI within the field of music education. Furthermore, due to the scarcity of literature on the intersection of AI and music education, this study comprehensively examined all existing written materials, including conference papers, to ensure that no relevant literature was overlooked during the research process. Ensuring the control of the risk of bias is crucial for maintaining the validity of the findings.

The conclusions of this study will be structured around two main questions, which are described and discussed in the article that follows.

Table 2. Articles included for the study

Authors	Title
Bai, [15]	Convolutional neural network and recommendation algorithm for the new model of college music education
Bai, [14]	Design of the Artificial Intelligence Vocal System for Music Education by Using Speech Recognition Simulation
Cui, [17]	The Influence of Music Appreciation Courses on The Formation of College Students' ideological Quality under The Environment of Big Data
Huang, [18]	Research on the Application of Artificial Intelligence in Music Listening Learning -- Taking Intelligent Hearing Training as an Example
Knapp et al., [19]	Soundtrap usage during COVID-19: A machine-learning approach to assess the effects of the pandemic on online music learning
Liang Zhang, [20]	Fusion Artificial Intelligence Technology in Music Education Teaching
Liu, [21]	The Auxiliary Role of College Music in Teaching in View of Artificial Intelligence
Nijs, [8]	Dalcroze meets technology: integrating music, movement and visuals with the Music Paint Machine
Peng and Wang, [22]	Online Education of a Music Flipped Classroom Based on Artificial Intelligence and Wireless Network
Qian, [23]	Research on Human-centered Design in College Music Education to Improve Student Experience of Artificial Intelligence-based Information Systems
Qiusi, [6]	Research on the Improvement Method of Music Education Level under the Background of AI Technology
Shi, [24]	Research on the Innovation Path of Music Education in Higher Vocational Colleges and Universities in the Context of the New Era
Wan, [25]	Research on Diversified Teaching Strategies for Music Courses in Colleges and Universities under the Background of Artificial Intelligence
Xu and Xia, [26]	Development of speech recognition system for remote vocal music teaching based on Markov model
Ye, [27]	A Study on Music Education Based on Artificial Intelligence
Yu et al., [28]	Developments and Applications of Artificial Intelligence in Music Education
Yuan, [29]	Application and Study of Musical Artificial Intelligence in Music Education Field
Yuan, [30]	Influencing Factors and Modeling Methods of Vocal Music Teaching Quality Supported by Artificial Intelligence Technology
Zhang and Yang, [31]	Research on Music Assisted Teaching System Based on Artificial Intelligence Technology
Zhang and Song, [32]	Design of an online interactive teaching platform for rural music education based on artificial intelligence
Yuan, [33]	Does AI-assisted creation of polyphonic music increase academic motivation? The DeepBach graphical model and its use in music education
Dai, [34]	Artificial Intelligence Technology Assisted Music Teaching Design
Guan and Ren, [35]	Application of Artificial Intelligence and Wireless Networks to Music Teaching
Li, [36]	Analysis of Piano Performance Characteristics by Deep Learning and Artificial Intelligence and Its Application in Piano Teaching
Yan and Xia, [37]	Interactive Audio-Visual Course Teaching of Music Education Based on VR and AI Support
Wei et al., [38]	College music education and teaching based on AI techniques
Lv, [7]	Innovative music education: Using an AI-based flipped classroom
Li and Wang, [39]	Artificial Intelligence in Music Education
Hong Yun et al., [40]	A decision-support system for assessing the function of machine learning and artificial intelligence in music education for network games
Cui, [16]	Artificial intelligence and creativity: piano teaching with augmented reality applications
Liu et al., [41]	National Ballad Creation Education Under Artificial Intelligence and Big Data

3.1 Artificial intelligence in music education

This study was enhanced by bibliometric tools such as RStudio, which facilitated the visualization of key concepts and their interconnections and provided a user-friendly command editing interface [42]. Table 3 provides a concise summary of the key details of the data used in the research, covering the period from 2018 to 2024. A total of 31 papers were obtained from 21 distinct sources, including journals, books, and other publications. Based on an annual growth rate of 34.8% and an average age of papers of 3.74 years, this suggests that most of the studies have been conducted recently. The papers contain a mean of 5.935 citations per document, with a cumulative total of 848 references referenced throughout all the sources. The paper contains 221 Keywords Plus (ID) and 85 Author's Keywords (DE), indicating a wide variety of subjects addressed in the research. According to the authors' information, there are a total of 56 writers, out of whom 31 documents were created by a single author. The authors' cooperation shows an average of 1.81 co-authors per document, with 9.677% of the partnerships being of an international nature. The research mostly consists of articles (26), with just five conference papers included.

Table 3. Main information of records included

Description	Results
Timespan	2017–2024
Sources (journals, books, etc.)	21
Documents	31
Annual growth rate %	34.8
Document average age	1.77
Average citations per doc	5.935
References	848
Keywords plus (ID)	221
Author's keywords (DE)	85
Authors	56
Authors of single-authored docs	19
Co-Authors per doc	1.81
International co-authorships %	9.677
Article	26
Conference paper	5

Additionally, Figure 2 depicts the yearly number of published papers from 2015 to 2024. Prior to 2020, there was limited scholarly attention given to the advancement of AI in the realm of music education, as depicted in the figure. Only one single article on the subject emerged in 2017, with no preceding studies of similar kind having been conducted. However, from 2018 to 2019, there was a complete halt in research related to the study of AI in music teaching and learning, with no new findings obtained. Following a period of two years with no progress, the utilization and investigation of AI technology in music education experienced a sudden emergence and consistent growth. The number of articles on this topic increased from three in 2020 to four in 2021. In 2022, there will be a significant exponential increase in the number of publications, with a total of nine papers being published. In 2023,

there is a slight decrease in the number of published papers, but overall, it still contributes significantly to the ongoing research in the relevant field. As of early 2024, when the authors carried out a search of this literature, six articles had appeared, suggesting that the interest and research effort in this topic continue.

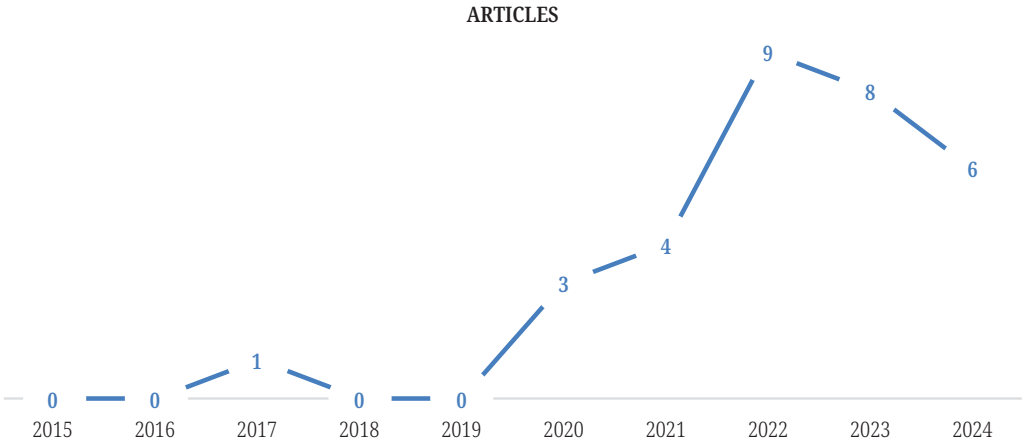

Fig. 2. List of publications from 2015–2024

Furthermore, Table 4 presents comprehensive annual citation data for research papers in the field of music education. The table precisely shows the average number of citations for each article, the total count of articles (N), the average number per year, and the citation years from 2015 to 2024. According to a single research paper published in 2017, the mean number of citations was 15. Therefore, over a span of 2.14 years, there were an average of 7 citable years. Statistics for 2018 and 2019 were not recorded due to the absence of articles during those years. But 2020 saw a new increase, averaging 5.67 citations per item across three papers. This averages 1.13 citations per year across five years of citable papers. The subsequent years exhibit diverse counts of article citations. These changes exemplify the fluid reception and impact of music education publications during this period.

Table 4. Annual total citation per year

Year	Mean TC Per Art	N	Mean TC Per Year	Citable Years
2017	15	1.00	2.14	7
2020	5.67	3.00	1.13	5
2021	9.75	4.00	2.44	4
2022	7.75	9.00	2.58	3
2023	5.67	8.00	2.84	2
2024	0	6.00	0.00	0

Trends and cluster. On the other hand, Figure 3 presents the main themes discussed in areas related to music education and AI in the form of a word cloud. In word cloud analysis, the frequency of a specific textual word in the collected information about articles directly corresponds to its importance and the size of its representation in the image [43]. Figure 3 demonstrates the significance of the topics "Music Education" and "Artificial Intelligence" based on their prominence, indicating their research importance. The term "students" being prominent suggests that AI research in the field of music education primarily focuses on students. Furthermore, the rise of

'engineering education' and 'educational computing' highlights the importance of considering interdisciplinary research when incorporating AI into music education. Dai [34] contends that AI encompasses the examination of both the social sciences and the natural sciences. The presence of the terms "teaching modes," "learning system," "deep learning," and "machine learning" in the word cloud indicates an emphasis on different teaching methods in the field of music education. The phrase emphasizes the integration of AI and technology into the field of music education, specifically drawing from technology and AI-related terms such as "big data" and "analytic hierarchy process." It is important to highlight that the terms "curricula" and "vocal music" indicate that music curricula are also impacting AI research in the realm of music education.

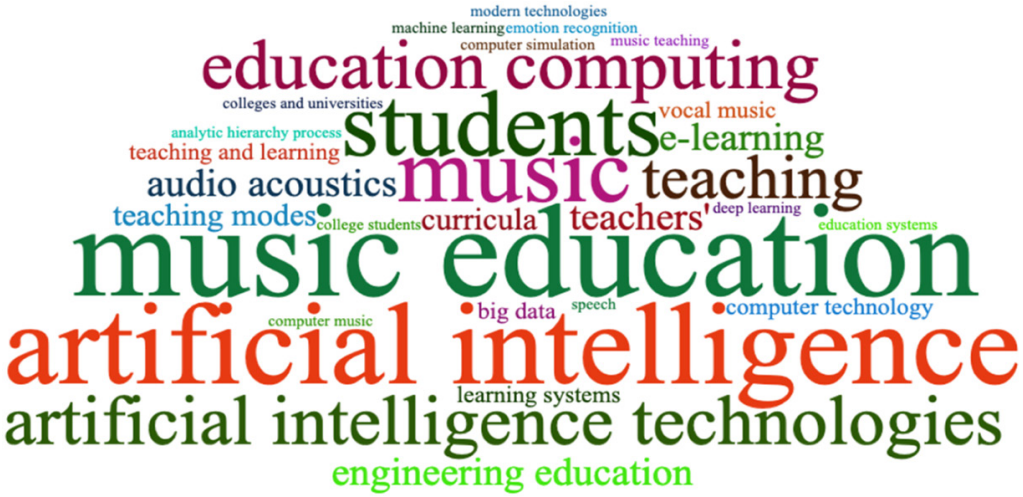

Fig. 3. Most frequent words

However, according to the data shown in Table 5, the network analysis identifies four primary clusters associated with music education and AI: "music education," "computer technology," "college students," and "college and university." The cluster labeled "music education" is seen to be the most central and widespread, as it has the greatest Callon Centrality value of 3.847 and a Cluster Frequency of 125. These metrics suggest that the "music education" cluster holds significant relevance within the network. The "music education" cluster also has the greatest Callon density (76.179) and rank centrality, indicating a significant concentration of connections inside the cluster. This can be attributed to the interrelatedness of the themes within music education. Furthermore, it is crucial to emphasize the significance of establishing connections with other clusters and the potential influence this can have on the overall configuration of the network. The clusters labeled "computer technology," "college students," and "colleges and universities" exhibit substantial presence and interconnection throughout the network, as shown by their moderate to high metric values.

Table 5. The base clusters identification

Cluster	Callon Centrality	Callon Density	Rank Centrality	Rank Density	Cluster Frequency
Music education	3.84658030	76.1785845	4	4	125
Computer technology	0.97222222	61.1111111	3	2	10
College students	0.25	62.5	1	3	4
Colleges and universities	0.5	50	2	1	2

Furthermore, the topic of research was chosen as the keyword plus during the building of the thematic map and examination of its progression [44]. To achieve the best results, the word count was limited to 50 to 300, allowing for thorough research [45] and [46]. Figure 4 shows the progress on the topic of AI in music education. These themes are categorized based on their usefulness and growth within the study area. The diagram is partitioned into four quadrants:

1. Motor themes (upper-right quadrant): This quadrant includes the most advanced and relevant subjects.
2. Basic themes (lower-right quadrant): The themes in this quadrant have strong connections to other clusters but a relatively low density of internal links. These issues are maturing, and their importance to the area has been demonstrated by their degree of centrality.
3. Niche themes (upper-left quadrant): The strength of the internal connections of the themes in this quadrant is such that the researcher sees them as corresponding to the study of research problems that have been well developed. They may be clusters that were at the center in the early days, with a gradual decline in the researcher's interest in their themes.
4. Emerging themes (lower-left quadrant): The themes emerging from this quadrant are peripheral and underdeveloped.

According to Figure 4 of the thematic progression, "music education" is the dominant and well-established topic in the study area, while "computer technology" is a significant but less developed theme. The topic of "college students" is perceived as either growing or declining, while "colleges and universities" are considered specialized subjects with less significance and progress. This study provides valuable insights into the current state and potential future directions of research on pedagogy in music education.

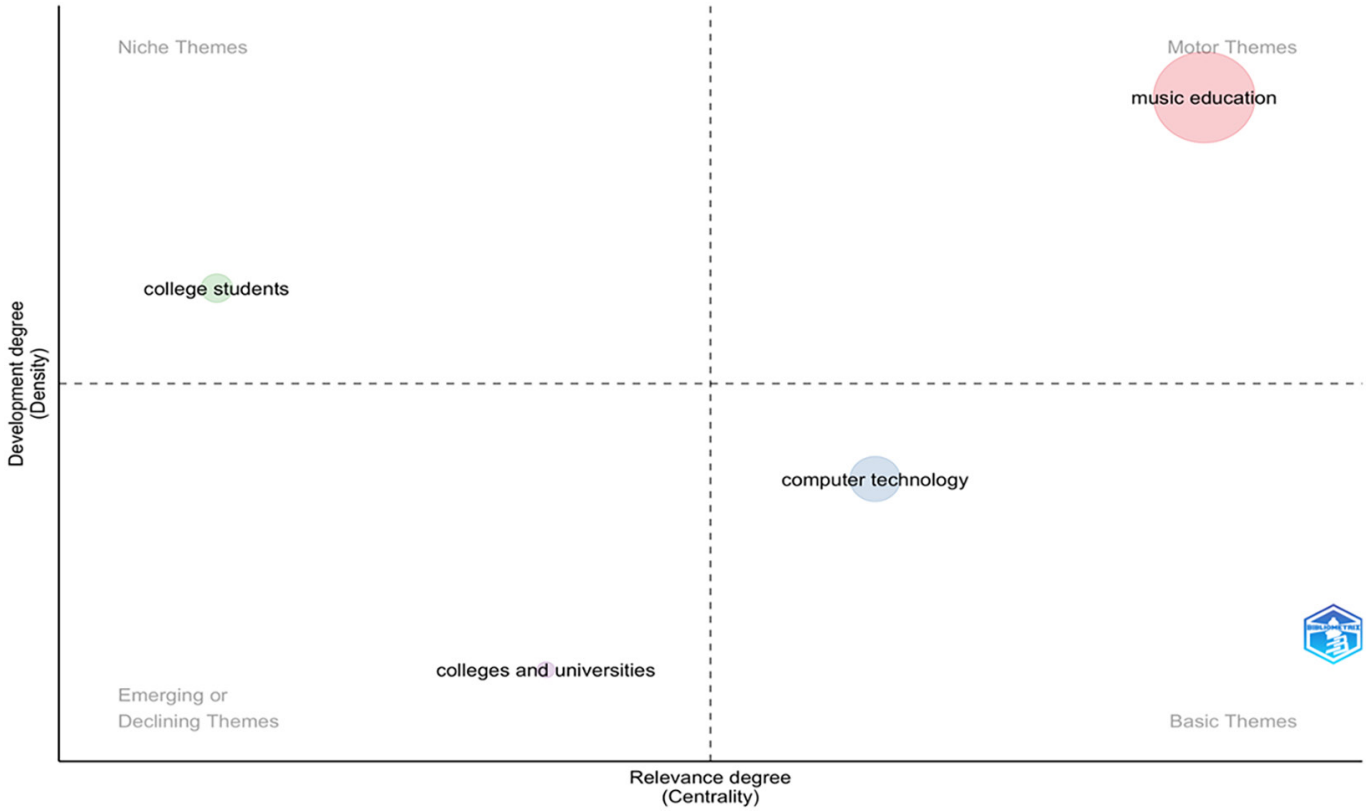

Fig. 4. Thematic evolution of music education pedagogy

3.2 Innovation pedagogy in music education

Traditional methods of music education struggle to motivate students to learn; therefore, AI-driven technologies may require more innovative teaching techniques to captivate students [19]. This section will use a textual analysis of the literature to gain insights into the current AI technologies used in teaching and learning music. Moreover, this text delves into the influence of AI on progress in music education.

AI teaching in music. Table 6 provides insight into the current utilization of AI techniques in the field of music education. Based on the analyses of the articles in this study, it is evident that not all the studies have provided a comprehensive description of the methodology used for integrating AI technology in music education. Nevertheless, it is essential to acknowledge that we can still gain knowledge from the approaches to AI utilization described in certain literature, which demonstrate that the AI techniques employed to facilitate music teaching and learning differ. Machine learning-based AI techniques are commonly used to assist in music education. Multiple studies have determined that machine learning has been employed to evaluate the effectiveness of music education through the utilization of cross-platform digital audio workstations [19] and [34]. However, there are differences in the computational techniques used for machine learning. Liang Zhang [20] recommended using deep learning algorithms in machine learning to enhance the optimization of music education and offer a tailored experience for music instruction and learning. Shi [24] integrates LSTM and JobSemantic modeling methods to enhance music course recommendations, ensuring a more accurate alignment between students' music proficiency and courses, and enhancing the pertinence and flexibility of teaching. While Wan's [25] study also employed machine learning techniques to attain accuracy in recommending music courses and constructing a music education resource platform, this study utilized ID3 algorithms in data mining and machine learning approaches to analyze music course resource data. Yuan [30] employed ARM and SA algorithms to analyze student singing performance data to offer more precise and tailored instruction and feedback in the field of AI in music voice teaching.

Furthermore, the utilization of a convolutional neural network in conjunction with a recommendation algorithm is a commonly employed AI technology tool in the field of music education. Studies have demonstrated that the utilization of convolutional neural networks and recommendation algorithms in music instruction can offer personalized assistance and direction to students. By analyzing their performance, these AI techniques can provide appropriate guidance and feedback tailored to their skill level and individual requirements. Furthermore, they enhance the overall effectiveness and quality of music education [15], [22], and [36]. Furthermore, the utilization of AI through neural network methods has been employed to enhance students' comprehension of sound characteristics in music education, optimize the process of teaching and learning, and increase the effectiveness of music learning [21], [26], and [31]. The less commonly employed AI methodology for music instruction involves utilizing Deep Bach modeling to generate polyphony and examine its effect on the academic motivation of undergraduate music students [33]. The utilization of conversational AI techniques specifically aims to enhance the efficacy of music instruction in Dolcroze [8]. Guan and Ren [35] utilize the intelligent network platform to implement an intelligent music teaching model.

Table 6. Types of artificial intelligence usage

AI Using Methods in Music Teaching and Learning	Research Frequency
Convolutional neural network & recommendation algorithm	3
Deep Bach	1
Machine learning	6
Neural networks	3
Conversational AI	1
Intelligence network	1
No details	15

Table 7 reveals that AI teaching models are predominantly utilized in university music courses, with a limited number of instances in preschool and K-12 level music instruction. As some scholars have deemed, music classrooms that incorporate AI instruction necessitate greater proficiency in information technology and computer skills. They also require active student participation and collaboration. Furthermore, AI technology is more easily integrated into university learning environments and is well-received by university students [21, 23].

Additionally, when considering the curriculum, it becomes evident that AI-based music courses encompass a wide range of subjects, including piano, vocal training, music composition, music theory, and music education. This demonstrates that AI-based teaching is not restricted by the content of music instruction. Moreover, AI teaching transcends the constraints of the music learning environment. From the literature, it is evident that AI-powered music education can provide support for distance learning, blended learning, and physical learning environments. Knapp et al. [19] state that AI provides more opportunities for music education and enriches the methods of teaching and learning music.

Table 7. AI teaching in different music programs

Authors	Music Programmes	Grades	Teaching and Learning Setting
Bai, 2024 [15]	Music theory	University	Face to face (F2F)
Bai, 2022 [14]	Vocal	University	F2F
Cui, 2020 [17]	Music appreciation	University	F2F
Huang, 2021 [18]	Music Listening Training		F2F
Knapp et al., 2023 [19]	Arranging and Composition	K-12	F2F
Liang Zhang, 2024 [20]	Music education and performance	University	F2F
Liu, 2022 [21]	Music education	University	F2F
Nijs, 2017 [8]	Dalcroze Music pedagogy		F2F
Peng and Wang, 2022 [22]	Online music education	Secondary school	Blended learning
Qian, 2023 [23]	Music education	University	F2F
Qiusi, 2022 [6]	Music education		F2F

(Continued)

Table 7. AI teaching in different music programs *(Continued)*

Authors	Music Programmes	Grades	Teaching and Learning Setting
Shi, 2024 [24]	Music education	University	F2F
Wan, 2024 [25]	Music education	University	F2F
Xu and Xia, 2023 [26]	Vocal		Remote online learning
Ye, 2020 [27]			
Yu et al., 2023 [28]	Piano		F2F
Yuan, 2020 [29]			
Yuan, 2024 [30]	Vocal		
Zhang and Yang, 2021 [31]	Music education	University	F2F
Zhang & Song, 2023 [32]	Music education		Remote online learning
Yuan, 2024 [33]			
Dai, 2021 [34]	Music education	University	
Guan and Ren, 2021 [35]	Music	Secondary school	
Li, 2022 [36]	Piano	Pre-school	F2F
Yan and Xia, 2023 [37]			F2F
Wei et al., 2022 [38]	Music performance	University	
Lv, 2023 [7]	Piano	University	
Li and Wang, 2023 [39]	Piano		
Hong Yun et al., 2022 [40]			
Cui, 2022 [16]	Piano	University	
Liu et al., 2022 [41]	Music Ballad Composition		

Innovations in music pedagogy. To achieve improved outcomes in the process of learning music, AI-assisted music teaching and learning endeavors to revolutionize and advance pedagogical approaches in music education. Hence, based on the study, the authors categorize the present advanced manifestation of AI technology in music education into four domains: facilitating individualized music instruction and learning, acquiring immediate input from music students, improving the interactive learning encounter, and offering organized digital teaching materials.

The most remarkable innovation in AI technology support for music pedagogy is the provision of a personalized learning experience. According to Knapp et al. [19], personalized learning experiences refer to the delivery of customized learning materials and instruction tailored to the specific learning requirements and proficiency level of each student. This approach aims to assist students in honing their musical abilities and fostering their motivation to learn. This novel methodology empowers students to customize their learning experience based on their individual proficiency and preferences, thereby facilitating the optimal cultivation of their musical aptitude [14], [15], [17], and [18].

Cui [17] proposes that the benefits of AI technology and big data enable real-time feedback, which is essential for personalized learning. The implementation of immediate feedback in music instruction is also an indication of innovative approaches in music pedagogy. Bai [14], showed that providing prompt feedback using voice input techniques can effectively help students correct pitch and rhythm issues, thereby improving the music learning experience. Utilizing real-time feedback from students can enable teachers to promptly modify the design of course content and the organization and management of teaching [24], [25], and [31]. In the context of vocal instruction and learning, Xu and Xia [26] demonstrated that AI-powered speech recognition systems can effectively detect and analyze voice signals using advanced deep neural network technology. This enables teachers to gain a comprehensive understanding of students' vocal performances, offer prompt feedback, and facilitate the enhancement of vocal skills.

In the conventional approach to music education, which prioritizes the teacher's delivery of information and practical examples, there is often a lack of emphasis on interactive teaching methods. AI-supported advancements in music education prioritize the interaction between music teachers and learners [33, 34]. Music resources and tools enhance students' interactive learning experience in music by providing platforms for interactive practice and recommending music [16], [7], [21], and [40].

Teaching and learning music present challenges due to its intangible nature, relying on auditory perception, vocalization, and instrumental performance for expression. Thus, Zhang and Yang [31] argue that AI technologies enable students to acquire music knowledge systematically by providing structured information and digital teaching resources. This in turn enhances learners' understanding of musical skills and facilitates learning performance. Qian [23] states that AI technology has the potential to aid in music visual and auditory training, enabling learners to better grasp intricate learning processes, enhance learning outcomes, and deepen their comprehension of music. Huang [18] demonstrated that the utilization of AI techniques in music listening training can enhance the process of analyzing and recognizing music.

Although AI has a significant influence on innovative music education, it also presents difficulties for teaching and learning music. Teachers will face a growing technological burden. Bai [15] notes that teachers may need to spend extra time and effort to master AI techniques such as convolutional neural networks and recommendation algorithms. Moreover, the implementation of AI resources in novel music pedagogies may present privacy and data security concerns. This is since it will entail the gathering and examination of students' personal data. Consequently, learners may harbor apprehensions regarding privacy and the security of their personal data. It is important to consider the potential threat of information leakage or misuse. Certain scholars argue that the music teaching process must consider the conveyance of emotions and moods. They believe that AI struggles to accurately capture and replicate human emotions and personalized moods. Consequently, the accuracy and reliability of AI algorithms significantly influence the quality of teaching and learning. Enhancing the algorithmic model and improving its accuracy pose an ongoing challenge [18, 19].

4 CONCLUSION

The objective of this study was to employ a systematic review methodology to comprehend the progression of AI in research on music education. Additionally, the

study aimed to investigate the potential alterations in conventional music teaching and learning that can be facilitated by innovative pedagogical approaches utilizing AI technology. The systematic review conducted in this study employed the PRISMA 2020 guidelines to analyze relevant literature published between 2015 and 2024. To identify pertinent academic research, comprehensive searches were performed on two widely recognized platforms, namely the WoS and Scopus. Despite an extensive search, the survey yielded a limited number of scholarly articles on AI support for music teaching and learning. The identified articles exhibit restrictions in terms of both chronology and geography. The findings of the study suggest that the terms "music education," "artificial intelligence," "teaching modes," "e-learning," "students," and "teachers" are commonly used in this study area. These terms highlight different aspects of the field, such as pedagogical approaches, teaching and learning approaches, and technical considerations. In summary, the examination of common terms indicates that music education research conducted during the chosen time covered a diverse array of subjects and fields of study.

The findings provide an overview of the progress made in AI technology research within the realm of music education. Recent literature indicates that AI has been incorporated into music education, but there is a dearth of research on AI technology in music pedagogy. This means that there is a lack of effective and systematic methods to facilitate AI-assisted teaching and learning of music. Regarding the development of literature, a significant study on the transformation of the music teaching and learning process through AI was conducted in 2017. The genuine focus of scholars and practical implementation is to be measured starting from 2020 onwards. This phenomenon is undeniably linked to the profound influence that the 2020 pandemic had on the field of education. After that, sudden alterations in the music education landscape have necessitated a more rigorous reliance on advanced technology for the facilitation of music instruction. It has led scholars to turn their research perspectives to the expansion and innovation of AI technology for music teaching and learning. AI is gaining traction in the field of music education and is becoming increasingly popular. However, our findings indicate that there is a greater amount of AI research on music education emerging in China compared to other regions. This can be attributed to the Chinese Ministry of Education's proactive efforts to promote the integration of AI into education since 2018, along with the implementation of various guiding documents [4], [47], and [48].

Furthermore, AI technology has revolutionized traditional music teaching methods by offering customized learning experiences, interactive teaching interactions, and comprehensive digital teaching resources. However, the authors acknowledge that AI still has a considerable distance to cover in transforming music education, as there is ample potential for further advancements in this field. The field of music education in AI research is still in its early stages, and further research is needed to explore effective innovations in music teaching methods.

In the future, it is crucial that we acknowledge and address the numerous challenges that AI presents in the field of music education. This necessitates the involvement of additional experts and scholars to effectively tackle issues such as technological implementation difficulties and disparities in educational resources. The investigation of learner acceptance intention, privacy and data security, algorithm accuracy, and credibility are also pressing matters. Further endeavors are required to consistently enhance AI to advance the development of music pedagogy and enhance teaching efficacy.

5 REFERENCES

[1] Y. Liu, "Revitalizing music education for new generations: Navigating the path of popular music pedagogy through comparative analysis of Dalcroze, Orff, and Kodály methodologies and their implications," *Educational Administration: Theory and Practice*, vol. 29, no. 4, pp. 345–357, 2023. https://doi.org/10.52152/kuey.v29i4.961

[2] J. Olvera-Fernández, R. Montes-Rodríguez, and A. Ocaña-Fernández, "Innovative and disruptive pedagogies in music education: A systematic review of the literature," *International Journal of Music Education*, vol. 41, no. 1, pp. 3–19, 2022. https://doi.org/10.1177/02557614221093709

[3] Ministry of Education of China, "Digital education: Application, sharing, and innovation," *World Digital Education Conference*, 2024. http://www.moe.gov.cn/jyb_xwfb/xw_zt/moe_357/2024/2024_zt02/pxhy/pxhy_znll/pxhy_znll_mtbd/202402/t20240201_1113848.html

[4] Ministry of Education of China, "The Ministry of Education released four actions to boost AI-enabled education," 2024. http://www.moe.gov.cn/jyb_xwfb/xw_zt/moe_357/2024/2024_zt05/mtbd/202403/t20240329_1123025.html

[5] W. Xu and F. Ouyang, "The application of AI technologies in STEM education: A systematic review from 2011 to 2021," *International Journal of STEM Education*, vol. 9, 2022. https://doi.org/10.1186/s40594-022-00377-5

[6] M. Qiusi, "Research on the improvement method of music education level under the background of AI technology," *Mobile Information Systems*, vol. 2022, no. 1, pp. 1–8, 2022. https://doi.org/10.1155/2022/7616619

[7] H. Z. Lv, "Innovative music education: Using an AI-based flipped classroom," *Education and Information Technologies*, vol. 28, pp. 15301–15316, 2023. https://doi.org/10.1007/s10639-023-11835-0

[8] L. Nijs, "Dalcroze meets technology: Integrating music, movement and visuals with the music paint machine," *Music Education Research*, vol. 20, no. 2, pp. 163–183, 2017. https://doi.org/10.1080/14613808.2017.1312323

[9] C. K. Lam, "Technology-enhanced creativity in K-12 music education: A scoping review," *International Journal of Music Education*, 2023. https://doi.org/10.1177/02557614231194073

[10] M. J. Page *et al.*, "The PRISMA 2020 statement: An updated guideline for reporting systematic reviews," *BMJ*, vol. 372, p. n71, 2021. https://doi.org/10.1136/bmj.n71

[11] C. Okoli, "A guide to conducting a standalone systematic literature review," *Communications of the Association for Information Systems*, vol. 37, 2015. https://doi.org/10.17705/1CAIS.03743

[12] A. F. Mena-Guacas, M. F. Chacón, A. P. Munar, M. Ospina, and M. Agudelo, "Evolution of teaching in short-term courses: A systematic review," *Heliyon*, vol. 9, no. 6, 2023. https://doi.org/10.1016/j.heliyon.2023.e16933

[13] C. Keh-Nie Lim and M. Zhang, "Chinese national music platformisation: A systematic review," *Heliyon*, vol. 9, no. 11, p. e22304, 2023. https://doi.org/10.1016/j.heliyon.2023.e22304

[14] J. Bai, "Design of the artificial intelligence vocal system for music education by using speech recognition simulation," *Computational Intelligence and Neuroscience*, vol. 2022, no. 1, pp. 1–9, 2022. https://doi.org/10.1155/2022/5066004

[15] H. Bai, "Convolutional neural network and recommendation algorithm for the new model of college music education," *Entertainment Computing*, vol. 48, p. 100612, 2024. https://doi.org/10.1016/j.entcom.2023.100612

[16] K. Cui, "Artificial intelligence and creativity: Piano teaching with augmented reality applications," *Interactive Learning Environments*, vol. 31, no. 10, pp. 7017–7028, 2022. https://doi.org/10.1080/10494820.2022.2059520

[17] Y. Cui, "The influence of music appreciation courses on the formation of college students' ideological quality under the environment of big data," *Journal of Physics: Conference Series*, vol. 1533, 2020. https://doi.org/10.1088/1742-6596/1533/4/042074

[18] Y. Huang, "Research on the application of artificial intelligence in music listening learning – Taking intelligent hearing training as an example," *Journal of Physics: Conference Series*, vol. 1915, p. 042085, 2021. https://doi.org/10.1088/1742-6596/1915/4/042085

[19] D. H. Knapp, B. Powell, G. D. Smith, J. C. Coggiola, and M. Kelsey, "Soundtrap usage during COVID-19: A machine-learning approach to assess the effects of the pandemic on online music learning," *Research Studies in Music Education*, vol. 45, no. 3, pp. 571–584, 2023. https://doi.org/10.1177/1321103X221149374

[20] L. Z. Liang Zhang, "Fusion artificial intelligence technology in music education teaching," *Journal of Electrical Systems*, vol. 19, no. 4, pp. 178–195. 2024. https://doi.org/10.52783/jes.631

[21] J. Liu, "The auxiliary role of college music in teaching in view of artificial intelligence," *Mobile Information Systems*, vol. 2022, pp. 1–11. 2022. https://doi.org/10.1155/2022/2693199

[22] Y. Peng and X. Wang, "Online education of a music flipped classroom based on artificial intelligence and wireless network," *Wireless Communications and Mobile Computing*, vol. 2022, no. 1, pp. 1–9. 2022. https://doi.org/10.1155/2022/9809296

[23] C. Qian, "Research on human-centered design in college music education to improve student experience of artificial intelligence-based information systems," *Journal of Information Systems Engineering and Management*, vol. 8, no. 3, p. 23761, 2023. https://doi.org/10.55267/iadt.07.13854

[24] S. Shi, "Research on the innovation path of music education in Higher Vocational Colleges and Universities in the context of the New Era," *Applied Mathematics and Nonlinear Sciences*, vol. 9, no. 1, pp. 1–18, 2024. https://doi.org/10.2478/amns-2024-0727

[25] L. Wan, "Research on diversified teaching strategies for music courses in colleges and universities under the background of artificial intelligence," *Applied Mathematics and Nonlinear Sciences*, vol. 9, no. 1, pp. 1–17, 2024. https://doi.org/10.2478/amns-2024-0212

[26] F. Xu and Y. Xia, "Development of speech recognition system for remote vocal music teaching based on Markov model," *Soft Computing*, vol. 27, pp. 10237–10248. 2023. https://doi.org/10.1007/s00500-023-08277-8

[27] F. Ye, "A study on music education based on artificial intelligence," *IOP Conference Series: Materials Science and Engineering*, vol. 750, no. 1, pp. 1–9, 2020. https://doi.org/10.1088/1757-899X/750/1/012115

[28] X. Yu, N. Ma, L. Zheng, and K. Wang, "Developments and applications of artificial intelligence in music education," *Technologies*, vol. 11, no. 2, p. 42, 2023. https://doi.org/10.3390/technologies11020042

[29] S. Yuan, "Application and study of musical artificial intelligence in music education field," *Journal of Physics: Conference Series*, vol. 1533, no. 3, p. 032033, 2020. https://doi.org/10.1088/1742-6596/1533/3/032033

[30] Y. Yuan, "Influencing factors and modeling methods of vocal music teaching quality supported by artificial intelligence technology," *International Journal of Web-Based Learning and Teaching Technologies*, vol. 19, no. 1, pp. 1–16. 2024. https://doi.org/10.4018/IJWLTT.340030

[31] X. Zhang and D. Yang, "Research on music assisted teaching system based on artificial intelligence technology," *Journal of Physics: Conference Series*, vol. 1852, pp. 1–8, 2021. https://doi.org/10.1088/1742-6596/1852/2/022032

[32] Y. Zhang and W. Song, "Design of an online interactive teaching platform for rural music education based on artificial intelligence," *Applied Mathematics and Nonlinear Sciences*, vol. 9, no. 1, 2023. https://doi.org/10.2478/amns.2023.2.00944

[33] N. Yuan, "Does AI-assisted creation of polyphonic music increase academic motivation? The deepbach graphical model and its use in music education," *Journal of Computer Assisted Learning*, vol. 40, no. 4, pp. 1365–1372, 2024. https://doi.org/10.1111/jcal.12957

[34] D. D. Dai, "Artificial intelligence technology assisted music teaching design," *Scientific Programming*, vol. 2021, pp. 1–10. 2021. https://doi.org/10.1155/2021/9141339

[35] Y. Guan and F. Ren, "Application of artificial intelligence and wireless networks to music teaching," *Wireless Communications and Mobile Computing*, vol. 2021, no. 1, pp. 1–16, 2021. https://doi.org/10.1155/2021/8028658

[36] W. Li, "Analysis of piano performance characteristics by deep learning and artificial intelligence and its application in piano teaching," *Frontiers in Psychology*, vol. 12, 2022. https://doi.org/10.3389/fpsyg.2021.751406

[37] J. Yan and X. Xia, "Interactive audio-visual course teaching of music education based on VR and AI support," *International Journal of Human–Computer Interaction*, vol. 40, no. 13, pp. 3552–3559, 2023. https://doi.org/10.1080/10447318.2023.2190668

[38] J. Wei, M. Karuppiah, and A. Prathik, "College music education and teaching based on AI techniques," *Computers and Electrical Engineering*, vol. 100, p. 107851, 2022. https://doi.org/10.1016/j.compeleceng.2022.107851

[39] P. P. Li and B. Wang, "Artificial intelligence in music education," *International Journal of Human–Computer Interaction*, vol. 40, no. 16, pp. 4183–4192, 2023. https://doi.org/10.1080/10447318.2023.2209984

[40] Z. Hong Yun, Y. Alshehri, N. Alnazzawi, I. Ullah, S. Noor, and N. Gohar, "A decision-support system for assessing the function of machine learning and artificial intelligence in music education for network games," *Soft Computing*, vol. 26, pp. 11063–11075, 2022. https://doi.org/10.1007/s00500-022-07401-4

[41] X. Liu, X. Han, X. Lin, and J. H. Yang, "National ballad creation education under artificial intelligence and big data," *Frontiers in Psychology*, vol. 13, 2022. https://doi.org/10.3389/fpsyg.2022.883096

[42] J. Stander and L. Dalla Valle, "On enthusing students about big data and social media visualization and analysis using R, RStudio, and RMarkdown," *Journal of Statistics Education*, vol. 25, no. 2, pp. 60–67, 2017. https://doi.org/10.1080/10691898.2017.1322474

[43] M. A. Hearst, E. Pedersen, L. Patil, E. Lee, P. Laskowski, and S. Franconeri, "An evaluation of semantically grouped word cloud designs," *IEEE Transactions on Visualization and Computer Graphics*, vol. 26, no. 9, pp. 2748–2761, 2020. https://doi.org/10.1109/TVCG.2019.2904683

[44] M. J. Cobo, A. G. López-Herrera, E. Herrera-Viedma, and F. Herrera, "An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field," *Journal of Informetrics*, vol. 5, no. 1, pp. 146–166, 2011. https://doi.org/10.1016/j.joi.2010.10.002

[45] X. Chen, Y. Lun, J. Yan, T. Hao, and H. Weng, "Discovering thematic change and evolution of utilizing social media for healthcare research," *BMC Medical Informatics and Decision Making*, vol. 19, no. 2, pp. 39–53, 2019. https://doi.org/10.1186/s12911-019-0757-4

[46] S. Sengupta and A. A. Vaish, "A study on social media and higher education during the COVID-19 pandemic," *Universal Access in the Information Society*, vol. 23, pp. 1249–1271, 2023. https://doi.org/10.1007/s10209-023-00988-x

[47] Ministry of Education of China, "Action plan for artificial intelligence innovation in higher education," 2018. http://www.moe.gov.cn/srcsite/A16/s7062/201804/t20180410_332722.html

[48] Ministry of Education of China, "Creating 'Golden Expertise' and 'Golden Courses', forging China's 'Golden Masters'," 2022. http://www.moe.gov.cn/jyb_xwfb/s5147/202208/t20220808_651488.html

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