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A Recent Systematic Review of Technological Advancements in Art Education Research

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ABSTRACT

This article presents a recent systematic review of technological advancements in art education research, focusing on how technology can enhance teaching and learning in the field. As technology rapidly evolves, it has become a subject of interest in art education due to its potential to foster creativity, critical thinking, and self-expression. The study aims to synthesize a wide range of research, including studies on digital platforms, virtual reality, augmented reality, and online learning tools, to understand how these technologies impact student engagement, motivation, and learning outcomes in art education. To achieve this, the researchers conducted a systematic review following the PRISMA approach, using advanced searching techniques in Scopus and WOS databases on 16th September 2023. They categorized the articles into themes related to technology in art education, environmental and cultural aspects, and interdisciplinary approaches, applying rigorous criteria for selection and analysis. The review's findings reveal the transformative potential of technology in art education. Students have shown a positive attitude towards digital platforms, reporting increased satisfaction when these technologies are integrated into the curriculum. The review also highlights the benefits of technologies like Big Data, 3D printing, and AI-driven interactive learning in art education. Additionally, the study explores how art education contributes to environmental awareness and cultural heritage preservation through technology. In conclusion, this systematic review illuminates the evolving landscape of art education driven by technological innovation and interdisciplinary approaches. While technology offers transformative opportunities, the review emphasizes the importance of balanced integration that deepens students' understanding of artistic concepts and encourages creativity. This work serves as a valuable resource for educators, researchers, and policymakers, offering insights into the potential of technology to enhance art education while advocating for a holistic approach to teaching and learning.

Keywords:

Art education; technology; virtual reality; educational technology; SLR

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1. Introduction

One of the most significant current discussions in Art Education plays a crucial role in fostering creativity, critical thinking, and self-expression among students. As technology continues to advance rapidly, its integration into art education has become an area of growing interest and exploration [1-3]. This article aims to provide an overview of a recent systematic review that examines the impact of technological advancements in art education research. The use of technology in art education has evolved significantly over the past decade, with the advent of digital tools [4-6], software [7-10] and applications that offer new possibilities for artistic creation and learning [11-13]. These advancements have sparked a renewed interest in exploring how technology can enhance art education in various educational settings.

This systematic review comprehensively analyses a range of studies and literature related to the integration of technology in art education. The review aims to synthesize the findings from these studies to provide a comprehensive understanding of the benefits, challenges, and implications of using technology in art education. The review encompasses various aspects of technology integration in art education, including using digital tools for creating and manipulating visual art, incorporating virtual reality and augmented reality in art instruction, and utilizing online platforms for collaborative art projects [14-23]. It also explores the impact of technology on student engagement, motivation, and learning outcomes in art education [24-27].

By examining the existing research on technological advancements in art education, this review seeks to shed light on the current state of knowledge in the field and identify areas for further investigation. The findings of this systematic review will be of great interest to educators, researchers, and policymakers involved in art education, providing valuable insights into the potential of technology to transform the way art is taught and experienced. In the following sections, this article will delve into the key findings and implications of the systematic review, highlighting the significant contributions made by recent research in advancing art education through technology.

2. Literature Review

In the increasingly technology-enriched world of art education, innovative teaching approaches are crucial for enhancing the effectiveness and quality of instruction. Studies have shown that technological advancements significantly impact the education system, emphasizing the need for innovation in teaching and learning. For instance, Ramli and Ekram [88] found that interactive AR textbooks can increase student motivation and create an engaging learning environment. Digital applications, as highlighted by Ismail *et al.*, [89], have proven effective for young learners in the industry 4.0 era, enhancing motivation, understanding, and achievement. Short video techniques and online learning, discussed by Zhipeng and Rahman [85] and Azmi and Wahab [86], also show significant improvements in skills and student engagement. At the higher education level, Chi *et al.*, [90] noted the benefits of multidisciplinary technological approaches in improving education quality, including complex thinking skills and pre-service teacher training.

The integration of advanced digital technologies, such as AI and IoT, is transforming global education landscapes. Sidhu *et al.*, [97] emphasizes the low awareness and readiness of Malaysian Generation Z students regarding IR4.0 technologies, calling for immediate action by educational institutions. Hishamuddin *et al.*, [91] highlights project-based learning (PBL) to develop leadership skills in student teachers within online settings. Habsah *et al.*, [95] found strong student readiness for continued online learning post-COVID-19, underscoring the importance of hybrid learning methods. Mohamed *et al.*, [93] discusses using GeoGebra with van Hiele's model in mathematics,

enhancing STEM education. Nazry Ali *et al.*, [94] addresses ICT challenges in TVET education during the pandemic, while Elmi Sharlina *et al.*, [96] shows significant learning improvements with AR-based Fige Card in chemistry. Zainon and Yaakub [98] presents an innovative teaching aid for network hardware installation, and Lee *et al.*, [92] explores emotional engagement in online elementary learning, advocating for practices that enhance synchronous online education. Collectively, these studies illustrate the transformative potential of technology in creating dynamic and effective learning environments across educational levels.

By incorporating such technologies into art education, it is certain that a more engaging and effective learning experience can be offered [87]. In 2021, Mao and Zhang published a paper describing a three-dimensional (3D) visual communication system based on digital image automatic reconstruction enhancing traditional art education. The system uses a HUI-23 3D image processor, realistic infrared camera hardware, and a 3D image computer expression and reconstruction module. The system achieves 98% 3D image reconstruction accuracy, better image integrity, and stronger performance, offering a new content perspective for digital image art teaching [28]. A research finding by Mao and Zhang [28] also points toward traditional art education models struggle with digital technology. 3D panoramic vision sensing technology is integrated into art education, improving teaching results. This technology reduces error rates from 44% to 11% and allows for realistic teaching situations. The combination of digital image art and visual sensing technology offers a promising future for art education.

More recently, Prykhod'ko *et al.*, [29] conducted research aiming to assess the impact of Big Data and digital platforms on art education quality and efficiency in higher educational institutions across Poland, the Czech Republic, and Ukraine. Their findings revealed a positive student attitude towards digital platforms, highlighting their potential as information sources. The study also presented a model for integrating Big Data into art education and identified future digital system innovation areas. However, it raised concerns about students' lack of awareness regarding Big Data's potential for behavioral planning and forecasting. In a complementary effort, Zhou [30] proposed a Big Data-based evaluation framework for fine arts education, encompassing qualitative and quantitative analyses, hidden evaluation factors identification, and unsupervised learning. The results demonstrated a reliable and accurate evaluation method, contributing to the enhancement of college and university art education.

Besides, Art Education is a crucial component of human development, nurturing creativity and aesthetic appreciation [31]. While multimedia technology has expanded teaching methods in this field, traditional approaches often have limitations due to restricted conditions. To address this, Liu *et al.*, [31] propose an interactive fusion model merging multimedia and virtual technology, creating immersive environments that broaden cognitive horizons, enhance motivation, and provide authentic learning experiences. Simultaneously, VR technology is gaining traction in education, including art and design instruction [32]. A systematic review highlights evolving trends in VR technology use within visual communication design education, revealing a notable gap in the adoption of fully immersive VR methods, signalling an area ripe for further exploration. Furthermore, Dalari [33] investigates integrating Virtual Reality applications into Arts Education for primary school students, aiming to make the subject more engaging and appealing through technology, underscoring the potential for technology to enhance art education across different academic levels.



Fig. 1. Virtual reality painting using tilt brush [19]

Furthermore, several studies collectively investigate the transformative potential of modern computer technology in fine arts education, particularly in China. Wang [34] examines the impact of computer-aided technology on education quality and resource expansion in the digital era. On a similar note, Feng *et al.*, [35] introduce a novel media art education platform employing IoT technology to address issues like real-time output, resource recall, and execution time costs. They employ VXI bus technology for resource acquisition, yielding improved recall and retrieval rates while maintaining relatively low execution time costs. In the context of the 4th Industrial Revolution, Yoo and Lee [36] advocate for a fresh approach to culture and arts education, merging elements from the 3rd Industrial Revolution. Their study assesses the efficacy of existing methods, focusing on the Future Problem-Solving Program (FPSP) centred on sound art to enhance creativity among college freshmen, with positive results indicating potential for future culture and arts education paradigms. These studies collectively emphasize the role of technology in reshaping and revitalizing fine art education.

Technology has opened new opportunities in art education. Utilizing tools such as 3D software, virtual reality platforms, and the Internet of Things (IoT) has transformed how art is taught and understood. Additionally, the integration of Big Data in the analysis and assessment of art education outcomes holds promise for improving teaching quality. However, it is important to remember that alongside technological advancements, there is a need to focus on a deep understanding of artistic concepts and the development of students' creativity rather than solely relying on technology. Therefore, the use of technology in art education should be balanced and well-integrated to achieve the best results.

Besides, the research is lack of comprehensive synthesis and understanding of how recent technological advancements specifically impact art education. While there is growing interest in technology's role in education, there is limited systematic analysis focusing on its effects in the unique context of art education, particularly in terms of enhancing creativity, critical thinking, and self-expression. This study offers several significant contributions with regard to addresses a critical need to understand the evolving role of technology in art

education. As technology rapidly transforms educational practices, it is essential to explore its potential benefits and challenges within the context of art education. The study aims to provide a comprehensive review that not only highlights successful implementations but also offers insights into how these technologies can be effectively integrated to enhance educational outcomes. By doing so, it fills a gap in the existing literature and offers valuable guidance for educators, researchers, and policymakers.

A research questions is formulated and is mentioned below:

- i. How do technological advancements impact teaching and learning in art education?
- ii. What specific technologies are being used in art education?
- iii. What are the thematic areas in which technology influences art education?

3. Methodology

3.1 The Review Protocol

To address the research questions, a systematic review was conducted following the PRISMA approach. Advanced searching techniques were utilized in Scopus and WOS databases on 16th September 2023. This review is structured into three primary sections:

- i. Technology in art education
- ii. Environmental and cultural aspects in art education
- iii. Interdisciplinary approaches in art education.

Furthermore, a specific objective is to delve into the intricate global landscape of advanced technology's utilization in art education. Subsequently, this section systematically reviews and synthesizes pertinent research, employing rigorous criteria for selection and analysis. Finally, the concluding section addresses actionable steps educators can take to ensure the continued integration of technology in the learning process.

3.2 Identification

The systematic review technique comprises three primary steps in choosing diverse suitable papers for this investigation. The first step is to identify keywords and search for similar, comparable phrases utilizing the thesaurus, dictionaries, encyclopaedia, and prior research. As a consequence, after settling on all relevant phrases, search strings for the Scopus and WOS databases (refer to Table 2) were generated. The current study successfully retrieved 1470 publications from both databases in the first phase of the systematic review procedure.

Table 1

The search string

Scopus	TITLE-ABS-KEY ("Art Education" AND technology*) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR, 2023)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English"))
Web of Sciences	"Art Education" AND technology* (Topic) and Preprint Citation Index (Exclude – Database) and 2021 or 2022 or 2023 (Publication Years) and Article (Document Types) and English (Languages)

3.3 Screening

During the screening process, potentially relevant research items are collected for content that aligns with the established research question(s). In the first phase, 180 articles were screened based on a set of inclusion and exclusion criteria developed by researchers. In the second phase, 57 duplicate articles were removed. The primary criterion for literature selection was research articles, as they provide practical information. Other publications such as systematic reviews, reviews, meta-analyses, meta-syntheses, book series, books, chapters, and conference proceedings were excluded from this study. Additionally, only papers written in English were considered. It is important to note that the study was conducted over a three-year period from 2010 to 2023. Ultimately, 1290 publications were excluded based on specific parameters.

3.4 Eligibility

In the eligibility stage, 123 articles were assessed to determine their relevance to the research objectives. Only those articles that met the inclusion criteria were deemed suitable for the study. After thoroughly examining the article titles and key information, 69 papers were excluded as they did not align with the study's objective based on empirical data. The remaining 54 articles were selected for review (refer to Table 2).

Table 2
The selection criterion is searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline	2021 – 2023	< 2021
Literature type	Journal (Article)	Conference, book, review
Publication stage	Final	In Press

3.5 Data Abstraction and Analysis

This study utilized integrative analysis as an assessment strategy to examine and synthesize various research designs, such as quantitative, qualitative, and mixed methods, to identify relevant topics and subtopics. The first step in developing the theme was the stage of data collection. The authors carefully analysed 54 publications to find material relevant to the current study's topics, as shown in Figure 2. They then evaluated significant studies related to technological advancement in Art Education, investigating the methodology used in all studies and the research results. Based on the evidence in this study's context, the authors collaborated with other co-authors to develop themes. They kept a log throughout the data analysis process to record any analyses, viewpoints, riddles, or other thoughts relevant to the data interpretation. Finally, the authors compared the results to ensure consistency in the theme design process. Any disagreements in concepts were discussed amongst themselves. The produced themes were eventually tweaked to ensure consistency. Two experts, one in Art Education and the other in Information Communication Technology (ICT), conducted the analysis selection to validate the problem. The expert review phase ensured each subtheme's clarity, importance, and suitability by establishing the domain validity of the problem.

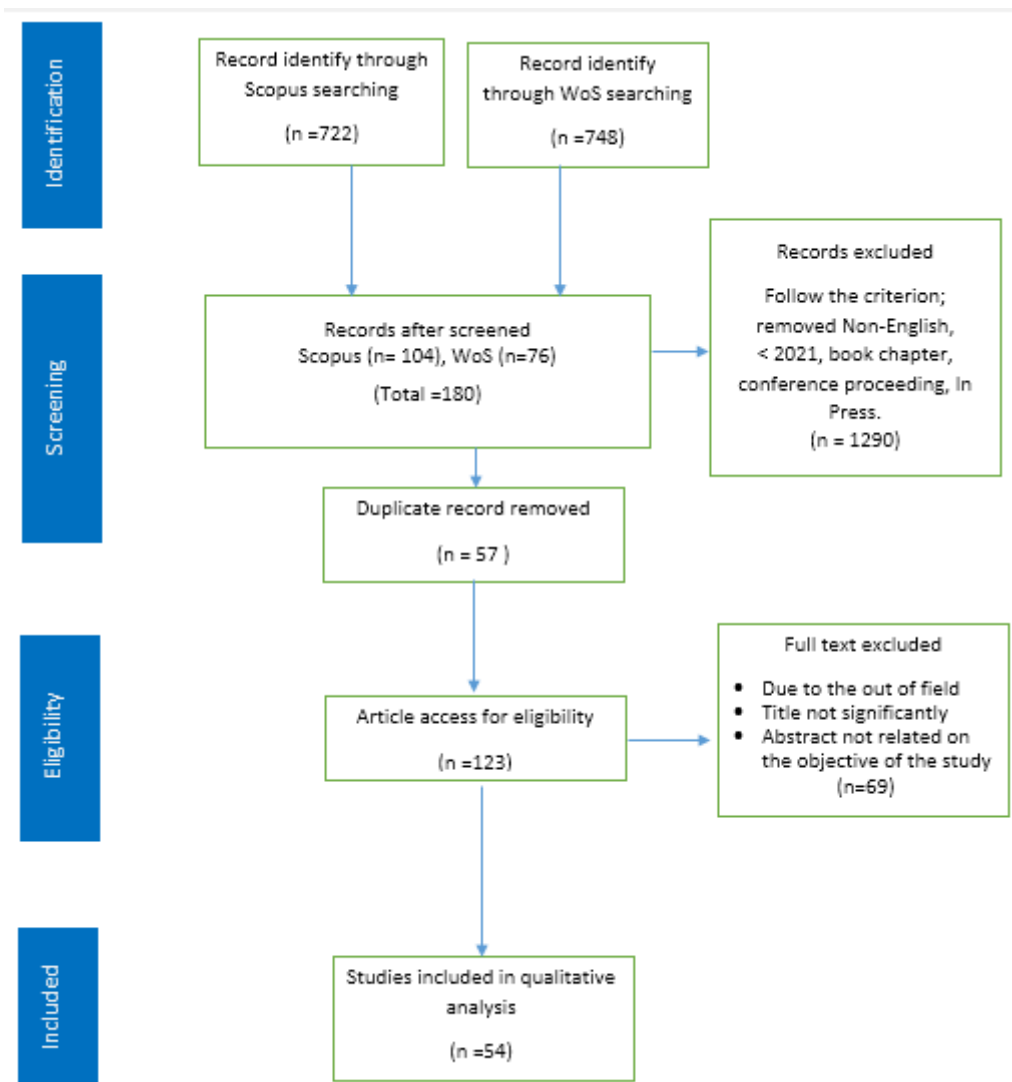


Fig. 2. Prisma flow diagram of the proposed searching study [37]

4. Result and Finding

In this section, the results and findings extracted from this systematic review are explored in depth by shedding light on technological advances that have significantly impacted the field of art education research. The culmination of an extensive systematic review resulted in a comprehensive exploration of the latest technological innovations in the field of art education research, providing insight into the evolving landscape of this dynamic discipline.

Based on searching strategy, 54 articles were analysed and categorized into three main themes, which are Technology in Art Education (18 articles), Environmental Culture Aspects in Art Education (9 articles), and Interdisciplinary Approaches in Art Education (27 articles).

4.1 Technology in Art Education

The study's findings underscore the significant impact of technology on art education, with 70% of students expressing a positive attitude toward digital platforms. These platforms enhance students' knowledge and awareness and are also considered easily accessible by 73% of respondents [29]. One notable revelation from this research is the immense potential of Big Data in the realms of

learning and professional activities. Furthermore, the study identifies substantial opportunities for developing digital systems in art education, highlighting the potential for improved course optimization in colleges and universities. These results collectively emphasize technology's transformational role in enhancing teaching methods, professional development for art educators, and the overall effectiveness of art education.

In addition to the broader impact of technology on art education, the study delves into the specific benefits of using the 'Aurasma' application in the art curriculum [18]. The integration of this technology not only boosts student motivation but also creates a more enjoyable and flexible learning environment. Moreover, it positively contributes to students' academic performance. By achieving a remarkable 92% student satisfaction rate in art education, this technological innovation optimizes art course teaching at the college and university levels [41]. It offers improved teaching practices, allowing educators to engage students more effectively while attaining educational goals in art courses. This successful application of technology showcases the potential for enhanced teaching and learning experiences in art education, ultimately benefiting both students and educators (refer to Table 4).



Fig. 3. Students participating in an experiment involving the application of artificial intelligence (AI) and virtual reality (VR) training [38]

4.2 Environmental and Cultural Aspects in Art Education

Environmental and cultural components of art education have a vital and powerful role in promoting environmental consciousness. This impact is mostly communicated through the merging of Environmental Art education and natural experiences, which provides significant direction for increasing environmental consciousness through education and natural experiences [53]. Furthermore, the need to recognize the revival and worldwide relevance of Local Art Education (LAE) in education is emphasized. This lends credence to LAE's suitability with professional or technical training and advises that LAE features be properly explored. It develops environmental consciousness and suggests that LAE plays a prominent role in Chinese undergraduate curricula [54]. These findings show the transforming power of art education in developing environmentally conscious individuals.

The integration of digital technology in art education has significantly increased self-awareness and connectivity, blurring the boundaries between real and virtual environments [39-55]. This has improved communication, expanded thinking, and fostered collaboration. Art education has also forged connections with non-heritage culture, preserving its essence and enhancing fault diagnosis. The use of ethno-design technologies has positively impacted students' spiritual well-being [58]. Art educators' adaptability to the COVID-19 pandemic challenges has highlighted resilience and potential for future policy adjustments. The integration of 3D printing technologies in teacher education programs is met with enthusiasm, as it concretizes subjects, increases student motivation, and produces effective teaching materials [60]. These outcomes demonstrate the evolving landscape of art education and its far-reaching benefits (refer to Table 5).



(a) Moonshin Art Museum in Roblox



(b) Outdoor of Moonshin Art Museum



(c) Exhibition of Moonshin Art Museum



(d) User in Main Hall of Moonshin Art Museum

Fig. 4. A Roblox avatar of the completed virtual Moonshin Art Museum [39]

4.3 Interdisciplinary Approaches in Art Education

Interdisciplinary approaches in art education have become increasingly vital, particularly in the wake of the COVID-19 pandemic. One notable instance is the implementation of hybrid learning at HKAPA, combining blended learning, flipped classrooms, and outcome-based education for performing arts education. Survey results from teachers and students have yielded invaluable insights into online teaching and learning dynamics within the performing arts domain [61]. This approach addressed the challenges posed by the pandemic and filled a significant research gap in the field.

The comprehensive exploration of interdisciplinary approaches in art education reveals a multifaceted landscape of benefits. These approaches have sparked increased student passion for martial arts and garnered favourable views on VR-assisted education [40]. They

have also shed light on the importance of recognizing aesthetic knowing and its effect across various domains, be it digital or analogue [64]. Moreover, the incorporation of interdisciplinary knowledge in children's realistic figure drawings has showcased improvements in accuracy, educational gaming, and inspiration for children's imaginations [65]. In addition, these approaches have underscored the critical role of visualization technology in enhancing cognitive activity and the need for future educators to master it in mixed digital and traditional education environments. These findings collectively exemplify the transformative potential of interdisciplinary approaches in art education, fostering enhanced learning outcomes and enriched educational experiences across diverse domains (refer to Table 6).

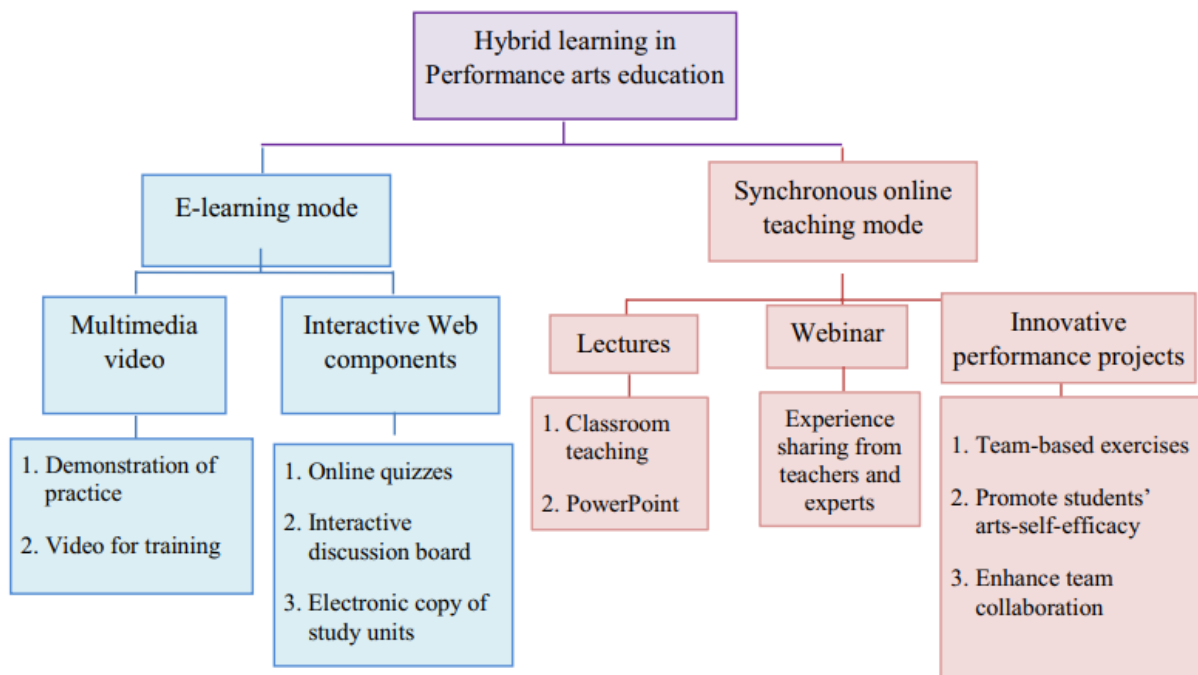


Fig. 5. Framework of the hybrid learning used various technology in performance arts education [61]

Table 4
 Summary of technology in art education

No	Author	Title	Journal	Method	Technology advancement	Result and advantages
1	Prykhod'ko <i>et al.</i> , [29]	Problems and Prospects for the Art Education Development in Higher Educational Institutions Based on Big Data Technologies and Digital Platforms	Journal of Curriculum and Teaching 2022	The study assessed the use of Big Data and digital platforms in art education by analysing their implementation in leading higher education institutions	Big Data and digital platforms	70% of students have a positive attitude towards digital platforms, enhancing their knowledge and awareness. 73% find them easily accessible. The study highlights the potential of Big Data in learning and professional activities, identifying opportunities for digital system development in art education.
2	Miralay [18]	Examination of educational situations related to augmented reality in art education	International Journal of Arts and Technology 2022	The study used a mixed methodology, combining interview forms and mini-questionnaire sets.	Advancements in the use of augmented reality applications in art education (Aurasma).	The study's results demonstrate that the use of the 'Aurasma' application in the art curriculum can boost student motivation, create a fun learning experience, offer a flexible learning environment, and contribute positively to students' academic performance.
3	Wang <i>et al.</i> , [41]	Analysis of the Role of Decision Tree Algorithm in Art Education Based on the Background of the Internet of Things	Mobile Information Systems 2022	Decision three classification and questionnaire surveys of college students.	Application of smart technologies in IOT in the field of education.	92% satisfaction degree of college students with art courses. Experiment successful in arousing students' subjectivity. Optimizing teaching mode in art courses at universities Enhancing teaching effect and achieving teaching goals in art courses

4	Feng and Zhang [42]	Design and Implementation of Computer-Aided Art Teaching System based on Virtual Reality	Computer-Aided Design and Applications 2022	Utilizing computer-aided technology based on virtual reality in art education, combining art theory with computer digital multimedia technology to form a computer-aided art teaching method.	Application of computer-aided technology in art education, focusing on virtual reality.	Integration of computer technology into art education, resulting in improved teaching methods, increased professional development for art educators and learners, and positive achievements in art teaching practices.
5	Jiang and Lu [43]	Information exchange platform for digital art teaching in colleges and universities based on internet of things technology	International Journal of Continuing Engineering Education and Life-Long Learning 2022	Designing a new networking technology for efficient art information exchange, involving layers for information acquisition, transport, access, and service. Utilizing an improved ant colony algorithm to classify information and enhance art education.	Development of a networking technology for art information exchange, addressing efficiency issues.	Enhanced information exchange efficiency and faster response times in the designed platform.
6	Hua <i>et al.</i> , [44]	Application of Support Vector Machine Model Based on Machine Learning in Art Teaching	Wireless Communications and Mobile Computing 2022	Utilizing machine learning-based support vector machine (SVM) for teaching quality evaluation (TQE). The research combines a one-to-one combination method to reduce training time, offering an objective and equitable assessment approach for limited professional sample data.	Application of machine learning and SVM in teaching quality evaluation.	Enhanced and efficient teaching quality evaluation in art education using an SVM-based approach.
7	González-Zamar and Abad-Segura [45]	Digital design in artistic education: An overview of research in the university setting	Education Sciences 2021	Employing bibliometric techniques, the study analysed 1027 Scopus articles on digital design in art education from 2000 to 2020, revealing a significant increase in research interest and establishing connections between education, art, and technology in universities, providing decision-making tools for researchers and promoters.	Utilization of digital technology in higher education and the development of transversal skills in art education.	Identifying trends and key areas of research in digital design in art education offers insights for decision-makers and researchers in the field.

8	Rong <i>et al.</i> , [38]	Research on the Influence of AI and VR Technology on Students' Concentration and Creativity	Frontiers in Psychology 2022	Utilizing VR and AI technology in art education to improve student concentration and creativity. Analysing the impact of different teaching models through questionnaires and demonstrating VR and AI integration.	Virtual reality (VR) and artificial intelligence (AI) are integrated into art education.	Improved student concentration and creativity through the introduction of VR and AI technology in art education, benefiting students' deep learning.
9	Fan and Li [46]	Artificial Intelligence-Driven Interactive Learning Methods for Enhancing Art and Design Education in Higher Institutions	Applied Artificial Intelligence 2023	Utilizing Back Propagation Neural Networks and AI technology for evaluation.	AI technology and interactive learning	Accurate evaluation of art and design instruction, improved practical skills, more engaging learning, and enhanced education quality through the application of AI and interactive learning methods.
10	Wu [47]	Research on the Reform of Art Education and Teaching based on the Background of Big Data	Computer-Aided Design and Applications 2023	Utilizing Experimental methods and big data technology to improve art education by introducing an improved multiband spectral subtraction method for speech enhancement speech by a log-MMSE estimator.	Application of big data and improved spectral subtraction method for speech enhancement	The proposed model effectively enhances art education quality, reduces noise and distortion, and improves teaching interaction in modern art teaching.
11	Yang [48]	Online Art Design Education System Based On 3D Virtual Simulation Technology	Journal of Internet Technology 2021	Development of an online art design education system using 3D virtual simulation technology. Introduction of an SVR-SA model combining support vector machine regression analysis and simulated annealing algorithm for accurate prediction.	Utilization of 3D virtual simulation technology and SVR-SA model in online art design education.	Improved performance and prediction accuracy, meeting art education needs, and potential for continuous optimization in the online art design education system
12	Zhang and Ye [49]	The Application of CAD Technology in the Teaching of Ceramic Art Design	Computer-Aided Design and Applications 2022	Combining computer-aided design (CAD) technology and deep learning algorithms to develop a ceramic art teaching system.	Integration of CAD technology and deep learning algorithms in ceramic art education.	Enhanced student engagement, deepened understanding of ceramic art, and improved teaching efficiency through the computer-aided design teaching mode.

13	Feng <i>et al.</i> , [35]	New media fine art education platform based on Internet of Things technology	International Journal of Internet Protocol Technology 2021	Comparative experiments where there is a build a new media art education platform based on Internet-of-Things (IoT) technology. Designing the IoT platform framework, optimizing functional modules, and using VXI bus technology for resource acquisition.	Utilization of IoT technology in developing a new media art education platform.	Enhanced resource recall performance, higher recall rates (21% and 14% higher), and reduced execution time cost for the new media art education platform compared to alternative methods.
14	Sun <i>et al.</i> , [50]	Effects of multimedia integrated fine arts education on students' learning attitude and learning satisfaction	Frontiers in Psychology 2022	Using a quasi-experimental design on college students.	Utilization of multimedia technology in fine arts education.	Enhanced learning attitude, satisfaction, and competence in fine arts through multimedia-integrated education, contributing to the field of fine arts and humanities.
15	Zhang [51]	Modern Art Design System Based on the Deep Learning Algorithm	Journal of Interconnection Networks 2022	Utilizing Deep Learning Algorithm (DLA) for modern art education, examining its performance through experimental assessment. Implementation of deep learning in drawing, music, literature, and art fields.	Integration of Deep Learning Algorithm (DLA) into modern art education.	Enhanced teaching and learning in the arts, facilitating quicker learning and comprehensive standards and skills development for art teachers.
16	Zhou[30]	Research on Evaluation of Art Education Effect in Colleges and Universities Based on Big Data Technology	Mathematical Problems in Engineering 2022	Using big data technology. Integration of qualitative and quantitative analysis, unsupervised learning, and fuzzy comprehensive evaluation. High fitness level and accuracy in evaluating the effect of art education in universities.	Utilization of big data technology for fine arts education effect evaluation.	Improved automatic evaluation ability of fine arts education effect in colleges and universities, providing accurate and reliable results.
17	Wang [34]	The Application of Modern Computer-Aided Technology in Fine Art Education	Security and Communication Networks 2022	Analyses fine art education in the digital era and studies how computer-aided technology improves quality of education.	Utilization of modern computer technology in fine art education.	Potential for improved quality in fine art education through the integration of computer-aided technology and information devices.

18	Fan and Zhong [52]	Artificial intelligence-based creative thinking skill analysis model using human-computer interaction in art design teaching	Computers and Electrical Engineering 2022	Utilization of network technology and IT in art education to transition to a student-centred approach. Application of pedagogical content knowledge (PCK) and AI-based Creative Thinking Skills Analysis Model (AI-CTSAM) in visual art education. Establishment of an analytical hierarchy process (AHP) and grey clustering-based performance analysis model for enhanced AI effectiveness.	Integration of network technology, IT, and AI in art education.	Improved student learning outcomes, fostering academic enthusiasm and awareness, and enhancing the ability to locate knowledge resources in art education.
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Table 5
 Summary of environmental and cultural aspects in art education

No	Author & year	Title	Journal	Method	Technology advancement	Result and advantages
1	Ding [53]	Environmental art education binding with natural experiences – impacts on students’ environmental awareness	Journal of Environmental Protection and Ecology 2023	Experimental design with 312 primary school students	Utilization of Environmental Art education and natural experiences in environmental awareness.	Significant influence of Environmental Art education and natural experiences on environmental awareness. Provides guidance for raising environmental awareness through education and natural experiences.
2	Cheng and Wei [54]	Boya education in China: Lessons from liberal arts education in the U.S. and Hong Kong	International Journal of Educational Development 2021	Comparative analysis of "boya" education (BYE) in Mainland China and liberal arts education (LAE) in the U.S. and Hong Kong. Examine the importance of BYE and LAE in the information technology (IT) and Artificial Intelligence (AI) era.	Emphasis on the skill sets provided by LAE in the IT-dominated era.	Recognition of the resurgence and significance of LAE in the global context. Advocacy for the compatibility of professional or technical training with BYE and LAE. Suggestion for achieving combined benefits through adopting LAE features. Recommendation for BYE to have a central role in the undergraduate curriculum in China.

3	Song and Lim [55]	Exploring online art education: Multi-institutional perspectives and practices	International Journal of Education Through Art 2022	Collective case study of online undergraduate courses. Qualitative content analysis.	Use of digital technologies and instructional methods in virtual art classes.	Enhanced self-awareness and connectivity in online art education. Blurred boundaries between real and virtual environments. Improved communication through a multilayered structure. Digital technologies expand thinking and expression.
4	Kang <i>et al.</i> , [39]	Learning Cultural Spaces: A Collaborative Creation of a Virtual Art Museum Using Roblox	International Journal of Emerging Technologies in Learning 2022	Creation of a Virtual Art Museum using Roblox Studio.	Utilization of metaverse platform (Roblox Studio).	Improved acquisition of information about art museums. Enhanced collaboration and technical problem-solving. New possibilities for virtual art museums and arts education.
5	Zou [56]	Promoting Environmental Protection through Art: The Feasibility of the Concept of Environmental Protection in Contemporary Painting Art	Journal of Environmental and Public Health 2022	Analysis of the impact of human activity on the environment and the importance of green ecology.	Emphasis on the role of graphic design in promoting environmental awareness and sustainable development.	Advocacy for the use of graphic design to influence society, promote environmental protection, and change thinking patterns towards sustainability.
6	He and Li [57]	Practice and research on non-foreign heritage culture inheritance education in universities based on information fusion technology	Applied Mathematics and Nonlinear Sciences 2023	Integration of ethnic crafts from non-heritage culture into college art education.	Utilization of information fusion-based technology in research and education.	Enhanced connection between college art education and non-heritage culture, preservation of non-heritage culture, and improved fault diagnosis in the context of cultural transmission.
7	Alzhanov <i>et al.</i> , [58]	Formation of a spiritual worldview in students of art education specialties with the help of ethno-design technology	World Journal on Educational Technology: Current Issues 2022	Qualitative research using semi-structured interviews.	Utilization of ethno-design technology in art education.	Art education residency students frequently use ethno-design technologies and find them important. Ethno-design technology positively affects the spiritual well-being of students, suggesting potential benefits in art education.

8	Sabol [59]	Art education during the COVID-19 pandemic: the journey across a changing landscape	Arts Education Policy Review 2022	Qualitative and descriptive analysis	Social media, video conferencing, and digital technology are utilized for virtual instruction.	Art educators adapted to the challenges of virtual instruction during the COVID-19 pandemic by using digital resources and technology. The long-term impact of the pandemic on education and educational policy adjustments are highlighted as areas for future research.
9	Üçgül and Altıok [60]	The perceptions of prospective ICT teachers towards the integration of 3D printing into education and their views on the 3D modelling and printing course	Education and Information Technologies 2023	Case study	Integration of 3D printing in education	Prospective ICT teachers found the 3D printing course satisfactory and felt competent to use 3D printing in teaching, recognizing its benefits in concretizing subjects, increasing student motivation, and producing teaching materials. Recommendations were made for integrating 3D printing technologies into teacher education programs.

Table 6
 Summary of interdisciplinary approaches in art education

No	Author & year	Title	Journal	Method	Technology advancement	Result and advantages
1	Li <i>et al.</i> , [61]	A hybrid learning pedagogy for surmounting the challenges of the COVID-19 pandemic in performing arts education	Education and Information Technologies 2021	Questionnaire survey	Implementation of hybrid learning in arts education	Hybrid learning, combining blended learning, flipped classroom, and outcome-based education, was implemented in response to the COVID-19 pandemic for performing arts education at HKAPA. Survey results from teachers and students provided insights into teaching and learning online in the performing arts domain, filling a research gap.
2	Chen <i>et al.</i> , [62]	The Impact of Digital Technology on the Reform of Art Teaching in the Wireless Network Environment	Wireless Communications and Mobile Computing 2022	Study of teaching methods and strategies in university art design under wireless network teaching mode	Integration of wireless network technology in art education	The introduction of WBRCCS-based formative assessment into inquiry-based teaching significantly improves learning outcomes, enhances student motivation, and enhances understanding of science concepts.

3	Bertling and Moore [63]	The U.S. K–12 Art Education Curricular Landscape: A Nationwide Survey	Studies in Art Education 2021	Large-scale descriptive survey research (N = 742)	Exploration of various educational approaches in K–12 art education	The study reveals a period of plurality in K–12 art education, with emphasis on visual/material culture and multicultural education. The research highlights the need to explore nuances and how each approach is enacted in practice.
4	Hanliang and Lina [40]	Investigation on the Use of Virtual Reality in the Flipped Teaching of Martial Arts Taijiquan Based on Deep Learning and Big Data Analytics	Journal of Sensors 2022	Investigation using virtual reality technology in martial arts education	Application of virtual reality with deep learning algorithm (DBH-CNN)	Positive student reception, increased passion for martial arts, and favourable views on VR-assisted education.
5	Clark-Fookes [64]	Aesthetic Approaches to Digital Pedagogy in Arts Education	International Journal of Education and the Arts 2023	Examination of Digital Arts Learning Context	Proposal of TPAACK model	Recognition of aesthetic knowing and affect in arts learning across domains, digital or analogue.
6	Yu and Li [65]	A study of practical drawing skills and knowledge transferable skills of children based on STEAM education	Frontiers in Psychology 2022	Assessment of children's drawing skills	STEAM education	Evaluation of children's ability to apply interdisciplinary knowledge in realistic figure drawings.
7	Mao and Zhang [66]	The Use of Digital Image Art under Visual Sensing Technology for Art Education	Journal of Sensors 2021	Integration of art with 3D panoramic vision sensing technology	Combining panoramic colour volume structured light generation technology, omnidirectional visual imaging technology, colour correction algorithms	Improved recognition accuracy (from 44% to 11%), realistic teaching situations, inspiration for children's imagination, and educational gaming.
8	Sosnovskaya <i>et al.</i> , [67]	Visualization Practices in Training Pedagogy Students	Webology 2021	Survey of Pedagogy Students	Utilizing visualization technology for teaching	Interest in visual teaching methods; Recognition of visualization's role in enhancing cognitive activity; Need to master visualization technology for future educators in mixed digital and traditional education environments.

9	Chung and Li [68]	Issues-based steam education: A case study in a Hong Kong secondary school	International Journal of Education and the Arts 2021	Exploratory	Integration of issues-based art education into STEM education (STEAM)	Enhanced interdisciplinary learning, real-world application, inquiry-based learning, critical thinking, and engagement in social issues for students.
10	Liston <i>et al.</i> , [69]	Integrating Data Science and the Internet of Things into Science, Technology, Engineering, Arts, and Mathematics Education Through the Use of New and Emerging Technologies	Frontiers in Education 2021	Discussion and lesson demonstration	Integration of art education into STEM (STEAM)	Enhanced authentic learning, interdisciplinary learning, inquiry-based, real-world learning, and critical thinking in students. Engagement in social issues through art education.
11	Wu <i>et al.</i> , [70]	Evaluation of Cultural Value Validity of Digital Media Art Based on Locally Weighted Fitting Algorithm	Advances in Multimedia 2022	Image quality evaluation, local Gaussian weighted fusion, image collocation	Integration of image processing techniques for cultural relics restoration, preservation of precious paintings	Preservation of cultural relics, enhancement of cultural values, and addressing damage issues.
12	Sun and Zhu [71]	Teaching Analysis for Visual Communication Design with the Perspective of Digital Technology	Computational and Mathematical Methods in Medicine 2022	Application of artificial intelligence (AI), adaptive mutation evolutionary method, genetic algorithm, neural network	Integration of AI in teaching quality evaluation (TQE) system for VCD courses	Development of a scientific and reliable TQE model for VCD education, improved convergence speed, and prediction accuracy.
13	Wu, <i>et al.</i> , [72]	Information technology of preschool education reform of fine arts based on fractional differential equation	Applied Mathematics and Nonlinear Sciences 2022	Comparison of fractional Navier-Stokes equations with traditional models through numerical experiments	Integration of information technology in preschool fine arts education	Improved teaching quality and better development for preschool education.
14	Li and Zhu [73]	The Optimal Path of College Art Teaching Based on Embedded Sensor Network	Wireless Communications and Mobile Computing 2022	Experimental research using embedded sensor network	Utilization of ZigBee network, HRPTC, wireless routing protocol, and sensor technology	Enhanced development of the optimization path for college art teaching, improved education methods, and increased student learning enthusiasm by at least 10%.

15	Lim [17]	Expanding Multimodal Artistic Expression and Appreciation Methods through Integrating Augmented Reality	International Journal of Art and Design Education 2022	Integration of AR tools into the art education curriculum	Utilization of AR creation tool (Adobe Aero) and AR education tool (Merge Cube)	Enhanced art expression, representation of artwork in real and virtual spaces, engagement, satisfaction, and understanding of layers and spatial structures among students.
16	Alnasib [74]	Digital Competencies: Are Pre-Service Teachers Qualified for Digital Education?	International Journal of Education in Mathematics, Science and Technology 2023	Examination of pre-service teachers	Assessment of digital competency (DigComp) levels	Identification of differences in DigComp levels and areas of strength and weakness among pre-service teachers in art education and kindergarten. Evaluation of the effectiveness of pre-service teacher programs in preparing future educators for digital education.
17	Knežević and Malone [75]	Equity, inclusion, and feminist pedagogies	Capitale Culturale 2023	Contribution to the DICO Digital project	Focus on ethical teaching in fine art education	Examination of methods to deliver equitable and inclusive career learning in creative arts.
18	Liu [76]	Design of Repository and Search Platform for Art Painting Teaching Resources in Universities Based on the Model of Decision Tree	Computational Intelligence and Neuroscience 2022	Development of a decision tree model-based repository and search platform	Integration of data mining in art education	Improved accuracy of the decision tree model over C4.5, leading to a more effective repository and search platform for school art and painting education resources.
19	Zhang and Zhang [77]	Animation Education Innovation of Big Data in the New Media Environment	Wireless Communications and Mobile Computing 2022	Study of innovation in animation education based on big data	Development of an animation education platform based on big data	High user satisfaction (49.5%) with the platform, indicating its usefulness for learners.
20	Yi [78]	DRIS: Research on Image Classification of Art Education System Based on Deep Learning	International Journal of Cooperative Information Systems 2022	Development of art education picture categorization technique	Utilization of an upgraded deep learning model	Improved classification accuracy (86.49%), 26.29% better than standard models. The DKSE module branch achieved an accuracy of 87.54% with efficient extraction of artistic image information.

21	Zhang <i>et al.</i> , [79]	Modern Art Education and Teaching Based on Artificial Intelligence	Journal of Interconnection Networks 2022	Proposal of Artificial Intelligence Assisted Effective Art Teaching Framework (AIEATF)	Utilization of artificial intelligence in art teaching	Demonstrated potential for improving teaching effectiveness in major art courses, development of an assessment model, a valuable guide for art educators, and positive experimental results in various art disciplines.
22	Surong <i>et al.</i> , [80]	Application and effect simulation of image recognition technology based on machine vision feature parameters in art teaching	Soft Computing 2023	Application of machine vision feature parameters in art teaching and effect simulation	Utilization of image recognition technology in art education	Improved image recognition methods for students, enhanced artistic perception, and balanced development of students.
23	Pattier [81]	Educating in art and culture through YouTube: the impact of edutubers	Komunikacija i Kultura Online 2021	Analysis of 39 successful YouTube educational channels in the Art and Culture area	Use of YouTube as an educational platform	High quantitative impact on informal education, but a negative future projection. Identification of success factors and characteristics of Art and Culture edutubers. Valuable data for researchers and professionals.
24	Liang <i>et al.</i> , [82]	Application of Art Activities in Colleges and Universities Based on BP Neural Network Algorithm	Wireless Communications and Mobile Computing 2022	Incorporation of new media technology in college art education	Integration of multimedia technology, network animation technology, and network advertising design	Impact of online platforms like WeChat on art education. Classification and feature extraction from art works using image processing and machine learning (BP neural network) for artistic style learning.
25	Pulino [83]	Embedding the entrepreneurial mindset at a liberal arts university	Journal of the International Council for Small Business 2022	Development of entrepreneurship education in a liberal arts context	Leveraging an entrepreneurial mindset in a liberal arts environment	Establishment of a thriving entrepreneurial environment in a liberal arts university, overcoming financial constraints, and fostering interdisciplinarity. Tested approach with key success conditions and practical examples for similar institutions.

26	Mao and Zhang [28]	Research on the Application of Visual Sensing Technology in Art Education	Journal of Sensors 2021	Development of visual sensing technology in digital image art	Creation of a 3D image visual communication system	Two schemes for hardware and software development, improving 3D image reconstruction accuracy up to 98%, providing new content perspective for digital image art teaching.
27	Alsuwaida [84]	Designing and evaluating the impact of using a blended art course and web 2.0 tools in Saudi Arabia	Journal of Information Technology Education: Research 2022	Mixed-method approach (qualitative and quantitative), pre-survey, pre-test, post-test, in-depth interviews	Utilization of Web 2.0 tools (e.g., Voki, YouTube, Pinterest, Instagram)	Improved art and design teaching and learning, enhanced 21st-century skills, valuable role of Quality Matters™ Higher Education Rubric (QMHER) in course understanding, and potential for international application of QMHER.

5. Discussion

The discussion of the results begins with the first theme, Technology in Art Education. The integration of digital technologies in art education brings substantial benefits, transforming the traditional learning environment into a more dynamic and interactive space [18,41]. The positive student attitudes towards digital platforms and their accessibility indicate a readiness to embrace technology, which enhances their engagement and learning experience. Big Data's potential in art education allows for more personalized learning experiences and data-driven decision-making, improving both teaching strategies and student outcomes [29]. The 'Aurasma' application, for example, not only increases student motivation but also fosters a more immersive and enjoyable learning atmosphere, which can lead to higher academic performance and satisfaction. Additionally, the use of VR and AI technologies in art education introduces innovative ways to enhance student concentration and creativity, promoting deeper learning and practical skill development [38,46]. For educators, these technologies provide tools for more effective teaching methods and professional growth, enabling them to better evaluate and adapt their instructional approaches. The optimized online art design education systems and multimedia-integrated education platforms streamline the learning process, making it more efficient and engaging for students [41-44]. These advancements reduce the time and effort required for resource recall and knowledge acquisition, allowing students to focus more on creative and critical thinking aspects of art education. Overall, the integration of technology in art education not only improves the quality and effectiveness of teaching and learning but also prepares students and educators to navigate and thrive in an increasingly digital world. This holistic enhancement of the educational experience underscores the transformative potential of digital technologies, making art education more relevant, accessible, and impactful.

The findings also highlight the second theme of Environmental and Cultural Aspects in Art Education. The comprehensive exploration of various aspects of art education, environmental awareness, and technological advancements underscores the multifaceted impact of these factors on contemporary education and society. Environmental art education and natural experiences have emerged as potent catalysts for nurturing environmental consciousness, paving the way for informed ecological stewardship through educational channels. Simultaneously, the resurgence of Liberal Arts Education (LAE) has gained global recognition, advocating for the harmonious coexistence of technical training and liberal arts principles. By embracing LAE features, institutions can maximize the benefits of a well-rounded education. This includes positioning Business and Youth Entrepreneurship (BYE) as a central pillar of the undergraduate curriculum in China, thereby fostering an environment conducive to entrepreneurial growth [54]. In the realm of online art education, digital technologies have not only blurred the boundaries between reality and virtual spaces but have also enriched communication through intricate layers of engagement. Similarly, the integration of graphic design as a powerful tool for societal influence underscores its potential to promote environmental protection and reshape thought patterns toward sustainability [56]. Moreover, the synergy between college art education and non-heritage culture preservation augments the preservation of cultural traditions while facilitating effective fault diagnosis during cultural transmission [57]. Ethno-design technologies have emerged as vital tools, enhancing the well-being of art education residency students and offering promise in the broader art education landscape [58]. Furthermore, the adaptation of art educators to the challenges posed by the COVID-19 pandemic through digital resources and technology reflects their resilience and adaptability [59]. As we move forward, the long-term effects of the pandemic on education and

the subsequent policy adjustments demand sustained research efforts. Lastly, the positive reception of 3D printing courses by prospective ICT teachers highlights the transformative potential of technology in teacher education, offering opportunities to concretize subjects, boost student motivation, and create effective teaching materials. Embracing such innovations in teacher education programs is a promising recommendation for the future [60]. In conclusion, these diverse findings illuminate the evolving landscape of art education, environmental consciousness, and technology's role in shaping education and society, offering a rich tapestry of possibilities and pathways for the future.

The last finding of the third theme in Interdisciplinary Approaches in Art Education also highlights the transformative effects of various educational approaches and technologies across multiple educational domains, including performing arts, science, K-12 art education, martial arts, aesthetic learning, interdisciplinary education, visual teaching, cultural preservation, preparation teachers, career development, image recognition, and higher education [61-84]. These initiatives have collectively demonstrated significant improvements in learning outcomes, student motivation, engagement, critical thinking, and real-world application. They emphasize the role of evolving technologies in education, including virtual reality, image processing, machine learning, and online platforms, in improving teaching effectiveness, expanding educational access, and fostering interdisciplinary learning. Furthermore, they emphasize the importance of preserving cultural heritage, promoting inclusive education, and preparing educators for the digital age. These findings collectively contribute to continued progress and innovation in education, offering valuable insights and practical models for educators, researchers, and institutions seeking to improve teaching and learning in a variety of educational contexts.

This discussion has answered the research questions that have been stated and summarized as shown in the table below:

(RQ1) How do technological advancements impact teaching and learning in art education?	<ul style="list-style-type: none"> • Impact on Student Attitudes and Accessibility • Enhanced Motivation and Learning Environment • Improved Teaching Methods and Professional Development • Enhanced Student Engagement and Learning Outcomes • Broader Educational Impacts
(RQ2): What specific technologies are being used in art education?	<ul style="list-style-type: none"> • Digital Platforms and Big Data • Aurasma Application • Computer Technology • Virtual Reality (VR) and AI Technology • AI-Driven Interactive Learning Method • Multimedia and Computer-Aided Technology • 3D Printing
(RQ3) : What are the thematic areas in which technology influences art education?	<ul style="list-style-type: none"> • Technology in Art Education • Environmental and Cultural Aspects • Interdisciplinary Approaches

6. Conclusion

In summary, this extensive study underlines the transformative potential of digital technology in arts education, as demonstrated by its adoption and highly positive impact on student engagement, motivation, and academic performance. The integration of multimedia, computer-assisted technology, and information devices has enhanced teaching and learning in the arts and highlighted

the continuing potential for improvement in the field. Additionally, this study is part of a broader landscape of educational advancement, spanning multiple domains and technologies, all of which contribute to improved learning outcomes, critical thinking, and real-world applications. Embracing evolving technology and innovative educational approaches positions art educators to improve teaching effectiveness, expand access to education, preserve cultural heritage, and prepare educators for the digital age, ultimately fostering a brighter future for education in general.

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