

Virtual Reality and Art Education: A Literature Review

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Abstract: Despite its application in art classrooms, virtual reality is becoming one of the significant tools in terms of the pedagogical shift. This systematic review compiles findings from 14 peer-reviewed studies retrieved from Scopus. Interdisciplinary studies addressing pedagogical potentials, technological limitations and curricular implications of VR emerged from keyword searches of “virtual reality” and “art education”. The analysis highlights the potential for VR to enhance art. VR facilitates creativity, engagement, with three dimensional virtual spaces, digital art world, and the world of museums. Studies emphasise its function in democratising access by granting them remote access to cultural resources and experimental techniques. Generic methodologies that underpin both analog and digital practices are facilitated by VR. But there are important barriers that prevent equitable adoption. Technical barriers like expensive hardware, complex software, and a need for specialized training limit accessibility, and worsen resource disparities. Pedagogical issues include patchy curricular integration, an absence of evidence-based guidelines, and possible cognitive overload with navigating immersive interfaces. Critics additionally wonder if VR gives worthwhile contributions to skill learning, or if it serves as an interesting toy over its becoming a potentially vital facet of artistic evolution, citing reduced tactile interaction and lack of long-term creativity manifestations. The potential of VR to revolutionise art education is exciting but any such implementation will need to overcome technological, pedagogical and socioeconomic hurdles. Longitudinal studies should be prioritised to measure skill retention, whilst the development of standard pedagogic guideline and investigation of cost-effective solutions for marginalised institutions would each be beneficial for future planned research. Educators, technologists and policymakers must work together to ensure that VR is used ethically and equitably. By overcoming these barriers, VR can transition from an auxiliary resource to a central pillar of inclusive, international art education, allowing varied learners to interact with art in meaningful ways.

Keywords: Virtual reality; Art education; Literature review

Introduction

More than ever before, researchers have been interested in the overlap between virtual reality (VR) and art education. It is because technology is so promising for the evolution of artistic learning and future creative processes. VR has been praised for the immersive, interactive and engaging environments it provides. Moreover, it offers students experiences where they can create and interact with art that can go beyond traditional educational boundaries (Wu et al., 2023). Such an integration has been seen as a revolutionary change. It opens up classrooms and allows students to access art-related resources outside the bricks and mortars of classrooms (Ursu et al., 2024). Although the adoption of VR in education has been on the rise, there are still important unanswered questions about the effectiveness and pedagogy of VR, as well as the long-term impacts of such virtual engagement on art education. While there are still many uncertainties within VR, this emphasises the necessity of exploring the ways in which VR had transformed artistic learning, and if its potential has been fully realised.

This current review is warranted due to both the potential and pitfalls of VR as it relates to art education. However, its ability to create real-life situations as well as access to virtual museums, interactive installations and collaborative curator-artistic experiences offer new opportunities for creativity and engagement (Hamad & Jia, 2022). With this new trend, students became able to manipulate three-dimensional digital spaces, experiment with artistic techniques and explore virtual galleries within platforms that were previously unattainable in a True-To-Real classroom. Yet, the real utility of VR technology in improving learning outcomes, developing artistic skill and pedagogical effectiveness has been disputed (Pellas et al., 2021). Some studies have pointed out the possibility of promoting creativity and access, while others have expressed doubts about the practicality and educational value.

Pedagogical readiness of educators and institutions has long been the biggest barrier preventing widespread VR use in art education. While some educators consider VR an emerging technology to enhance teaching and learning, many remain sceptical with regards to technological limitations, budget constraints and cognitive demands (Waller et al., 2022). The gap in the understanding of the institutions at the time often did not meet the demands of providing sufficient hardware, software and access to help keep pace in VR

development which compounded concerns about the digital divide and the unequal access to VR resources particularly for art educators who often have been lacking the technical knowledge base to integrate VR into their programs (Turnbull et al., 2021). Furthermore, the immersive nature of VR has presented both opportunities and challenges. Though it has created more intimate contact and new creative experiences, it has also led to complaints about sensory-saturation-stimulation-supernova-inducing, disengagement from tactile materials and dependence on software and pre-designed virtual spaces. It restricts students' artistic freedom. These tensions remind us of the necessity of returning to a critical lens of what VR means in the context of art education and how it pushes, adheres or challenges what we hold as values in our teaching and learning.

To provide a comprehensive analysis, this literature review is guided by the following key research questions:

1. What are the research focuses of past studies on VR in art education?
2. What insights have been gained from previous studies on the effectiveness of VR in art education?

Literature Review

VR is an emerging digital platform that has ultimately captured its role in most domains ranging from medicine to architecture, gaming and education to simply provide immersive and engaged experience for users. It dynamically simulates real-world environments or builds new digital spaces. VR has been widely touted in the education sphere for not only facilitating experiential learning but immersing students into learning content using innovative means (Goi, 2024). But, even as VR has proved its enormous potential to revolutionise conventional modes of teaching, including those in educational traditions of art, its use in art education remains relatively neglected and under-explored. Hence, it deserves closer and in-depth scrutiny. This current review aims to synthesise work undertaken to date examining the research focus and insights drawn.

VR in art education has emerged from its potential to offer immersive artistic experiences beyond the confines of the conventional classroom. This provides students tools to create, manipulate and interact with digital art in three-dimensional spaces through VR, allowing new forms of artistic expression and experimentation (Ali Kadry, 2023). Advocates have claimed that VR fuels creativity, providing applications like sculpting, storytelling and modelling that allows students to engage with creative methods that are too difficult or perhaps not possible to do within a physical environment (Lüders et al., 2022). Moreover, the immersive nature of VR enables learners to enter virtual gallery halls, museums or completely imaginary worlds, providing a multi-sensory learning process which enhances their connection to art (Cecotti et al., 2024). This low threshold has been especially revolutionary for students in underserved areas because virtual reality can democratise specific arts education (Li, 2024) by promoting access to remote experiences of resources like virtual museums and galleries. In addition, VR has encouraged interdisciplinary collaboration between coding, design and digital art, allowing interactive installations and innovative projects to emerge.

Although these advantages are quite revealing, some huge challenges loom in the art discipline to adopt VR. Technical limitations have been among the most significant barriers to VR implementation, such as the high cost of equipment and software, as well as the specialised technical training required (Tan et al., 2022). In fact, pedagogical questions of whether or not VR imparts fundamental artistic principles that matter or simply a new way of doing things that is a trumped up gimmick, continue to pop up. Additionally, the absence of a standardised VR-based art curriculum has added to the challenges surrounding its incorporation, resulting in inconsistencies between teaching methodologies and emphasising the need for clear structures and integrity within VR-enhanced art education (Kong & Feng, 2024). Moreover, the cognitive requirement to navigate through VR interfaces is also an issue, which may overtax students so that they cannot pay their attention to learning arts and presenting creativity within VR environments.

This review of the literature so far points out gaps that have prevented a comprehensive understanding of VR's function in the art educational experiences. First, while numerous studies have highlighted VR's potential to foster student engagement, there has been little empirical evidence related to learning outcomes and even less to be found related to artistic skill development and conceptual understanding. The previous works primarily focused on short-term benefits, creating a gap that warrants exploration into longitudinal studies that delve into the long-term impact of VR on artistic development. Moreover, there has been little focus on the development of pedagogical frameworks for the effective integration of VR into art curricula, which has left educators with few clear best practices or strategies for leveraging the potential of VR. A second underexplored area has been the cultural and ethical dimensions of VR-based art education. Questions surrounding the accessibility issues of VR, how people with varying degrees of mobility can interact with VR, and how people from different cultures react to things in VR, and ethical issues of create digital art, concerning vibrant issues like authorship, intellectual property, and the tendency of cultural homogenisation of virtual spaces. These gaps must be explored for a fuller understanding of VR in art education and to promote equity in the introduction of such technology and pedagogical soundness in its implementation and use.

Therefore, this conclusion highlights the potential of VR to transform art education, and the challenges which the technology faces in trying to establish itself as an influential teaching method. Lack of technical know-how, pedagogical ambiguity and absence of standardised curricula point to the necessity of introducing a more critical and systematic understanding of how VR can enter art education. Future studies need to focus on empirical evaluations of VR's effect on learning outcomes, longitudinal studies of artistic development, and robust frameworks for implementing pedagogy that integrates VR in service of the core goals of the art education curriculum. Moreover, more consideration should be devoted to the cultural and ethical ramifications of VR to guarantee that when integrated into the world around us, it does so in a way that encourages accessibility for all and does not transgress the diverse spectrum of artistic traditions. By tackling these limitations, educationists and scholars have the opportunity to harness the full capabilities of VR, steering it towards meaningful application in art education that not only enhances creativity and engagement but also maintains the richness and profundity inherent in artistic learning.

Methodology

The study used a systematic method to analyse the literature about VR application in arts education. As a primary source to find relevant studies, Scopus, which covers a very large number of high-indexed journals, was used. Predictably, a structured keyword search was performed using the terms 'VR' and 'art and design' to ensure comprehensive coverage of the subject matter.

In order to maintain the novelty and rigor of the review, the studies were restricted to only those published in the last four years (from 2020-2024). Articles were also filtered by citation count, prioritising highlighted articles with significant scholarly impact and acknowledgment. Thus, articles with the highest citation were chosen for extreme investigation, about fourteen of them. Such a methodological consideration allowed for the consideration of relatively recent, yet influential bodies of research on the application of VR technology for art education.

Results

Initially, Qiao and Bei (2024) implemented an end-to-end stereo parallax estimation algorithm via deep learning to devise a mechanism simulating human ocular perception within a VR milieu. By integrating a hierarchical detail processing algorithm akin to human vision, the duo successfully reconstructed VR scenes to mirror the verisimilitude observed through human eyes more closely. This technological innovation found extensive application in artistic ventures, offering audiences an enveloping experience. In its practical deployment, the VR opera "The Drunken Princess" garnered accolades across various metrics, securing an average audience appraisal exceeding 4 points across all evaluated aspects. Notably, the production quality was particularly esteemed, attaining a 4.438 point rating. Regarding narrative immersion, the VR opera outperformed traditional opera formats, scoring 4.393 against 4.1445, respectively. This underscores the VR technology's capacity to augment narrative delivery. Furthermore, a sectoral survey on VR painting awareness disclosed a higher recognition within the art and design domains, at 54% and 43%, respectively, compared to a mere 22.1% in education and 36.2% across other industries, illustrating VR painting's prominence primarily within artistic and design circles. Public engagement with VR painting exhibitions, facilitated through QR code scanning, also recorded a favourable satisfaction index of 47.9167. The findings advocated for VR art experiences as a means to captivate and cater to a broader audience spectrum through accessible platforms.

Subsequently, Yao et al. (2023) delineated the burgeoning application of object digitization across multifarious domains including VR, artistic design, and the medical and biological sciences. To realize comprehensive three-dimensional digitization of objects amidst intricate environments, they proposed a facile, efficacious, and steadfast panoramic three-dimensional optical digitization system. Incorporating a laser-based optical measurement setup and a bi-mirror configuration, the system facilitated omnidirectional illumination of objects via a singular laser projection during scanning. Additionally, the primary imaging device captured multi-angled three-dimensional object data. The rotational scanning technique amplified the method's efficiency and versatility, permitting large-scale object surface data acquisition. Through laser triangulation and mirror reflection transformation, three-dimensional object data from various perspectives were integrated, yielding complete surface data within a global coordinate framework. The proposed methodology underwent rigorous precision and validity testing across samples with varying surface textures and dimensions, affirmatively demonstrating its proficiency in accurate full-surface three-dimensional digitization within complex settings.

Moreover, Wang and Mokmin (2023) posited that VR (VR) has emerged as a predominant form of alternate reality extensively cultivated for educational purposes over recent decades. Educators across various disciplines have been trialling the integration of this technology into their pedagogical strategies, aiming to forge an interactive learning environment to bolster student engagement and interest. Specifically, the application of VR technology within immersive learning settings has been rigorously explored and refined,

particularly in the context of art education and beyond, yielding favourable outcomes. This investigation zeroes in on art college students, delineating the evolution of immersive learning via VR technology within the realms of art and design education. Art, being a discipline that necessitates a multifaceted artistic interaction throughout the educational journey, was scrutinized through a systematic review spanning the last five years. This review sought to elucidate the progression of VR technology in art instruction, the array of VR technologies employed, and the learner demographics benefitting from such technological interventions. The findings reveal a notable absence of fully immersive VR technology application in visual communication design education, highlighting a prime opportunity for future academic and research endeavors to enhance this domain.

Furthermore, Guerra-Tamez (2023) elaborated on a theoretical framework assessing the efficacy of VR technology-facilitated learning among bachelor-level art and design students. Implementing surveys among 200 undergraduate students within these fields, the collected data were subjected to analysis via multivariate partial least squares (PLS) structural equation modelling. The analytical outcomes suggested that immersive VR experiences positively influence the flow experience among learners. Additionally, the data underscored a mediating role of flow experience on the learning experience, articulated through factors such as motivation, curiosity, cognitive gains, reflective thinking, and value perception. These insights afford academic institutions specializing in art and design a viable means to amplify classroom learning through VR technology. Moreover, they present a foundation for replicating the proposed model across diverse educational spectrum, potentially broadening the application scope of VR in pedagogical contexts.

On the other hand, Wang and Zhang (2023) concurred that the incorporation of generative artificial intelligence within the art and design sector has markedly benefited designers and adjacent industries. Their research sought to investigate and appraise the determinants and individual characteristics propelling Generation Z's adoption of generative artificial intelligence-aided design. The analytical framework of the study was rooted in the Unified Theory of Acceptance and Use of Technology 2, supplemented by the Technology Readiness Index and the notion of trait curiosity. An empirical assessment was executed leveraging data garnered from 326 respondents situated in the southeast of the Chinese Mainland. Structural equation modelling yielded several insights: firstly, Unified Theory of Acceptance and Use of Technology 2's constructs like effort expectancy, price value, and hedonic motivation were found to positively affect generative artificial intelligence utilization intentions, whereas performance expectancy did not exhibit a significant impact. Secondly, attributes such as optimism and innovativeness were instrumental in enhancing factors including performance expectancy, effort expectancy, price value, and hedonic motivation. Thirdly, trait curiosity was observed to significantly bolster optimism and the propensity towards generative artificial intelligence utilization. These outcomes underscore the imperative for generative artificial intelligence platforms to refine their construction and operational modalities, offering actionable strategies to augment Generation Z's engagement with such technologies.

Subsequently, Sun and Li (2023) delineated the advancements in computer simulation technology, highlighting the evolution of various simulation platforms anchored in VR technology. Despite the proliferation of hardware devices from numerous vendors, a standardized mode of interaction remains elusive, with many VR products persisting in employing two-dimensional interface design methodologies, detrimentally affecting user experiences. The necessity for further investigation into VR environment interaction design methods was emphasized. In response, this study introduced computer-aided design technology into a VR-based art and design interactive platform, aiming to elevate user-platform interaction. Findings indicated the platform's proficiency in extracting and recognizing mural color features, accurately identifying user gestures, and facilitating 3D image modelling through VR technology. This provided robust technical and data support for the platform's interaction modules. User interaction data analysis affirmed that the computer-aided design platform's design, operation, and layout satisfactorily met the majority of users' cognitive, perceptual, and interactive requirements, invigorating their interest and enhancing their experiential quality. The study not only corroborated the virtual command system's usability test results but also validated the effectiveness of the user experience, fostering an improvement in user feedback mechanisms.

Zheng and An (2023) elucidated that digital media art, as a nascent form of media and mass expression, has decisively outpaced conventional artistic modalities such as painting, dance, and film, attributing this shift to its advanced technical capacities and intermedia characteristics. The escalation of computer information technology in recent years, particularly the augmented expressive power of graphics and images alongside diversifying processing techniques, has substantially broadened the expressive potential for digital media art creations. The synergistic application of graphic art computer-aided design and multimedia technologies, notably VR, heralds the advent of genuinely immersive art forms. This discourse is devoted to examining digital media art design and innovation under the aegis of VR technology. A quintessential attribute of VR creations is not merely furnishing the audience with an interactive experience with "real" artworks but also leveraging technological advancements to accentuate the gender and emotional resonances of the artistic endeavors, thereby magnifying their allure to the intended audience. This paradigm seeks to ameliorate the limitations

inherent in traditional presentation methods by integrating virtual digital elements—such as the Great Wall 3D model—and multimedia into actual scenes, coupled with interactive functionalities. By kindling interest, this approach not only amplifies the dissemination of China's rich historical culture but also endows cultural relics with a voice, narrating the annals of historical wisdom.

In parallel, Zhao and Cai (2023) posited that the brisk evolution of digital and computer technologies has substantially redefined the creative domain, influencing art product design and its applicability across industries. This inquiry aims to delineate the impacts of these technological advancements on contemporary art product design and to identify prevailing trends that catalyse industry growth. Employing a mixed-methods research framework, the study scrutinizes the amalgamation of cutting-edge software, hardware, and innovative methodologies within the art and design continuum. The results underscore that technologies such as digital fabrication, 3D printing, virtual and augmented reality, and artificial intelligence have revolutionized the design paradigm, empowering artists to forge complex, multidimensional, and interactive artifacts. Moreover, the assimilation of technological innovations has paved new pathways for resource sharing and global interconnectedness, fundamentally transforming the industry's conventional demarcations. The conclusion posits the imperative of adopting digital and computer technologies for sustaining innovation within the creative sector and underscores potential future advancements that could further refine art product design and its industry-wide applications.

Furthermore, Fouad et al. (2023) have illuminated the burgeoning application of VR (VR) technologies across diverse sectors, including its pivotal role in the art and design arena for tasks such as modelling, prototyping, and testing. Despite the widespread adoption, a significant limitation of most VR headsets is their focus solely on visual and auditory stimuli, neglecting the engagement of additional senses. This study was propelled by dual objectives: firstly, to explore the potential of a physical prop in enhancing the immersive experience within a VR context, and secondly, to elucidate the correlation between the employment of a physical prop and the enhancement of memory retention pertaining to the virtual encounter. To this end, two distinct VR roller-coaster scenarios were devised: one entailing the participant sitting on a chair, and the other incorporating the use of a harness for added physical engagement. The research methodology encompassed a blend of qualitative and quantitative data gathering methods, including physiological metrics (heart rate, breathing rate, skin conductance, and brain activity measurement via biosensors), observational studies, and self-reported feedback through surveys. Preliminary findings indicate a positive, albeit variable, association between the integration of physical props within a VR experience and the subsequent augmentation in both immersion and memory retention of said experience.

Following that, Arrigoni and McKim (2022) checked into contemporary strategies for the acquisition of born-digital artifacts within the context of art and design museums, through the lens of two case studies focusing on the procurement of a VR artwork and a mobile application, respectively. The authors underscore the non-traditional preservation demands and the unique nature of these objects to champion an experimental approach towards museum collections. These case studies serve as a catalyst for reevaluating the role of experimentation in collection practices, particularly in engaging with creators and users who may be less acquainted with traditional museum collection protocols. The authors argue for the necessity of adapting experimental boundaries within the confines of existing institutional policies, structures, and practices, taking into consideration the diverse interests and expectations of various stakeholders. In conclusion, Arrigoni and McKim (2022) advocated for museums and collecting institutions to prioritize the development of competencies and comprehension of the needs associated with this emerging category of objects, encouraging an embrace of uncertainty and flexibility over a stringent adherence to conventional long-term preservation paradigms.

Referring to Ruan (2022), the swift advancement of both the economy and society has necessitated the integration of disciplines, presenting a significant challenge across societal domains. The emergence of rapidly evolving technological innovations and theoretical frameworks characteristic of the digital age has introduced unprecedented challenges, particularly within the sphere of art and design education. Simultaneously, the ongoing enhancement of computer hardware and the advent of various simulation technologies have unveiled new prospects for art and design endeavors. Art and design education, envisaged as a comprehensive project, mandates the employment of advanced pedagogical approaches underpinned by scientific theories. This study probes the interconnectedness inherent in the design teaching process, alongside elucidating the challenges and requisites of both students and educators. Through meticulous analysis and research, the aim is to uncover effective strategies and methodologies to address these issues and requisites, thereby optimizing the educational outcome. The traditional modalities, technologies, and methods of art and design education are increasingly proving inadequate in fulfilling the societal demand for holistic design and art talents. Leveraging VR technology and targeting the art and design educational framework, this paper explores the deployment of immersive VR technology within design teaching practices. Building upon traditional teaching modes, an integrated three-dimensional design teaching approach is proposed and validated. This method seeks to

stimulate students' creative faculties in design education and encourage their immersion in learning and three-dimensional practice, thereby fostering the expansion of creative thinking.

Following on, Wu and Chen (2021) elaborated that digital painting entails the use of a graphics program to create artworks on a computer, employing virtual tools such as brushes, colours, and other digital paintbox supplies. This definition encompasses the primary digital painting (as a computer file) and its subsequent physical manifestation through non-manual processes (e.g., printing on paper, acrylic glass, aluminum, canvas, etc.). Digital technology, encompassing computers (tools, techniques, and digitally encoded content) as the mediums and materials of creation, is thus categorized as a prevailing technology. Despite the widespread use of web applications within the digital painting community, certain technical challenges persist, such as the need for efficient visualization of paintings amidst browser plugin requirements. With the ascendancy of Hypertext Markup Language 5 in conjunction with virtual imaging technology, its application in digital painting design has gradually intensified. High-tech devices employing virtual imaging technology predicated on Hypertext Markup Language 5 artificial environments are posited to enhance the digital painting system and its efficacy through interactive, virtualised technologies. VR technology, grounded in Hypertext Markup Language 5, is posited to augment virtual aesthetics and address challenges associated with VR digital painting, art, and design.

To continue, Chen (2021) highlighted the application of VR (VR) in gaming, enabling players to delve into immersive game environments. The development of VR content encompasses an array of domains including hardware, programming, and art and design expertise. utilization of Google Cardboard for VR gaming presents an economical and accessible option, albeit compromised by subpar display performance and latency issues due to mobile phone hardware limitations. To mitigate visual discomfort for users, developers amalgamate 2D and 3D art to fabricate 3D models with a reduced polygon count, concurrently deploying advanced computer graphics techniques to alleviate hardware strain and enhance visual output. Nevertheless, the device's operational constraints circumscribe gameplay, thereby imposing restrictions on game design. The research introduced a game development tool comprising basic templates and adaptable modules, designed to ease the programming burden for novices and seasoned students alike in Cardboard game creation, ultimately aiming to elevate the calibre of student-produced games.

Lastly, Nimkulrat (2020) embarked on an inquiry into the utilization and acquisition of craft knowledge through the handcrafting process, employing digital tools and fabrication methods. This investigation pursued understanding how craft-making and handcrafted objects could be transfigured via digital technologies, addressing two pivotal questions: (1) What are the evolving forms of knowledge and meaning-making in a craftsperson working with digital media? (2) How does material manipulation in computer-aided design (CAD) through VR (VR) inform analogue material practice and experimentation? Conducted through the author's craft practice, starting with a hand-knotted artefact, the study transitioned this analogue creation into a digital format using various techniques. This exploration served both as an assessment of digital fabrication capabilities and a means to probe into new cognitive frameworks facilitated by this burgeoning form of practice. The research expanded the comprehension of the craftsman's role amidst the digital tools' possibilities and constraints. Through documenting and reflecting on several iterations of digitally fabricated objects, this emergent craft practice stimulated the convergence and interaction of established disciplines within art and design. Findings of the study encompass the delineation of new workflows and the translation of gestures between digital and analogue material practices. Furthermore, reflections on the materials and methods employed in digital fabrication revealed their potential to enrich the semantic layers attached to created objects. These insights demonstrate not merely the craftsperson's application of pre-existing knowledge within a novel digital context but also the acquisition of new hands-on knowledge through the translation of analogue practices into digital realms.

The past studies under review offered a comprehensive examination of the amalgamation and ramifications of VR and digital technologies within a variety of domains, specifically in the realms of art and design education, game development, and the crafting process. Each piece of research contributes towards a nuanced comprehension of how these technologies are redefining conventional methodologies, proffering innovative solutions, and posing novel challenges. A table was presented below.

Table 2.1
 Information of Past Studies Reviewed

Authors	Year	Focus	Key Insights
Qiao and Bei	2024	Deep learning-based stereo parallax estimation in VR	Enhanced narrative immersion and broader audience engagement in art through VR.
Yao et al.	2023	Panoramic three-dimensional optical digitization system	Advanced precision in digitising objects for various applications, including VR and artistic design.
Wang and Mokmin	2023	VR's role in art and design education	Opportunity for leveraging VR to foster creativity and engagement among art college students.
Guerra-Tamez	2023	Efficacy of VR-facilitated learning in art and design	Positive influence of immersive VR experiences on learning through enhanced flow states.
Wang and Zhang	2023	Adoption of GenAI in art and design	Need for GenAI platforms to evolve with the needs of younger generations in the creative industries.
Sun and Li	2023	Challenges in VR interaction design	The necessity for more intuitive and immersive interaction methodologies within VR environments.
Zheng and An	2023	trans-formative impact of digital media art	Potential of VR and digital technologies to transcend traditional art forms.
Zhao and Cai	2023	Digital and computer tech in art product design	Revolutionary role of digital fabrication and VR in creating complex, interactive artworks.
Fouad et al.	2023	Role of physical props in VR experiences	Tangible elements significantly augment immersion and memory retention in VR.
Arrigoni and McKim	2022	Collecting born-digital artifacts in art and design museums	Challenges and experimental approaches in the collection strategies of digital artifacts.
Ruan	2022	Integration of disciplines in art and design education	Innovative pedagogical approaches leveraging VR technology to enhance creative thinking and engagement.
Wu and Chen	2021	Digital painting using HTML5 and virtual imaging technologies	Potential of HTML5 and virtual imaging to enhance digital art creation, merging digital and analogue practices.
Chen	2021	Use of VR in gaming, specifically with Google Cardboard	Challenges and innovations in using VR for gaming, including hardware limitations and development tools.
Nimkulrat	2020	Craft knowledge and digital fabrication	Insights into how digital tools can augment traditional crafting processes and translate handcrafted objects.

The collection of studies presented looked into the integration and impact of VR and digital technologies across various domains, notably art and design education, game development, and the crafting process. Each study contributes to a nuanced understanding of how these technologies are redefining traditional practices, offering innovative solutions, and presenting new challenges. First of all, Qiao and Bei (2024) introduced a deep learning-based stereo parallax estimation algorithm to simulate human ocular perception within VR environments, notably applied in the artistic domain through the VR opera "The Drunken Princess." The study not only demonstrated VR's potential to enhance narrative immersion but also its effectiveness in engaging a broader audience through accessible and immersive art experiences. This work underscored the trans-formative potential of VR in the art domain, suggesting a paradigm shift towards more interactive and immersive artistic creations.

Next, Yao et al. (2023) focused on the application of a panoramic three-dimensional optical digitization system, offering a novel approach to the comprehensive digitization of objects in complex environments. This methodology, leveraging laser-based optical measurement and a bi-mirror configuration, signified a leap forward in the precision and efficiency of digitising real-world objects for various applications, including VR, artistic design, and medical sciences. The study exemplified the broad applicative potential of advanced digitization techniques in enhancing the fidelity and interaction of digital representations within VR

environments. Following that, Wang and Mokmin (2023) explored VR's role in art and design education, highlighting its capacity to facilitate immersive learning experiences. The absence of fully immersive VR technology in visual communication design education pointed to a significant opportunity for innovation and development. This gap in the application of VR technologies suggested a pivotal area for future research and development, aimed at harnessing VR's full potential in educational contexts to foster creativity and engagement among art college students.

Later, Guerra-Tamez (2023) provided a theoretical framework to assess the effectiveness of VR-facilitated learning among art and design students, revealing that immersive VR experiences positively influence the learning experience through enhanced flow states. This study not only affirmed the pedagogical benefits of VR technology but also encourages its broader adoption in education, advocating for a shift towards more engaging and interactive learning environments. Then, Wang and Zhang (2023) examined the adoption of generative artificial intelligence in art and design, identifying key factors that influence Generation Z's engagement with generative artificial intelligence-assisted design. Their findings highlighted the necessity for generative artificial intelligence platforms to continually evolve and adapt to meet the changing needs and expectations of younger generations, suggesting a dynamic landscape for technology adoption within creative industries.

In addition, Sun and Li (2023) addressed challenges in VR interaction design, particularly in the context of art and design platforms. Their study pointed to the need for more intuitive and immersive interaction methodologies within VR environments, marking a critical area for ongoing research and development to enhance user experience and engagement. However, Zheng and An (2023) discussed the trans-formative impact of digital media art, propelled by advances in computer information technology and VR. Their analysis reflected on the potential of VR and digital technologies to transcend traditional art forms, offering novel ways of experiencing and interacting with artistic works.

Besides, Zhao and Cai (2023) explored the influence of digital and computer technologies on art product design, underscoring the revolutionary role of digital fabrication and VR in creating complex, interactive artworks. Their work highlighted the ongoing evolution of the creative landscape, driven by technological innovation. To continue, Fouad et al. (2023) investigated the role of physical props in enhancing VR experiences, suggesting that tangible elements can significantly augment immersion and memory retention. This study shed light on the importance of multi-sensory engagement in VR, indicating avenues for enriching VR experiences beyond visual and auditory stimuli.

Moreover, Arrigoni and McKim (2022) explored the challenges of collecting born-digital artifacts in art and design museums, advocating for an experimental approach to collection strategies. Their work reflected on the evolving nature of art in the digital age, emphasizing the need for museums to adapt to the unique requirements of digital artifacts. Next, Ruan (2022) addressed the challenges and opportunities presented by the integration of disciplines in art and design education, emphasizing the need for innovative pedagogical approaches that leverage VR technology. This study called for a reevaluation of traditional teaching methods in light of digital advancements, aiming to foster creative thinking and engagement among students.

Wu and Chen (2021) examined the realm of digital painting, highlighting the potential of HTML5 and virtual imaging technologies to enhance digital art creation. Their analysis underscored the ongoing interplay between technological advancement and artistic expression, pointing to a future where digital and analogue practices merge seamlessly. Similarly, Chen (2021) explored the integration of VR (VR) in gaming, addressing the immersive potential and development complexities of VR content, and highlighting the cost-effective yet limited Google Cardboard as a platform. The study presents strategies to mitigate visual discomfort and hardware limitations through the use of low-polygon 3D models and advanced graphics techniques. Additionally, Chen introduces a developmental tool designed to simplify the creation process for student developers, aiming to enhance the quality and accessibility of VR gaming experiences in educational contexts. Finally, Nimkulrat (2020) examined the intersection of craft knowledge and digital fabrication, offering insights into how digital tools can augment traditional crafting processes. This exploration into the digital translation of handcrafted objects opened new perspectives on the role of technology in preserving and evolving craft traditions.

Collectively, these studies illuminated the multifaceted impacts of VR and digital technologies across art, design, education, and digital fabrication. They highlighted a trans-formative period where traditional practices are being reimagined through the lens of technology, fostering innovation while also presenting new challenges. The critical integration of these technologies suggested a future where artistic expression, educational methodologies, and design practices were increasingly interwoven with digital advancements, heralding a new era of creativity and interaction.

Discussion

VR technology has had a profound impact on art education and has transformed the pedagogical methods, artistic practices and audience engagement in the field. But its execution offers both transformational promise and persistent obstacles. Prior research has coalesced into three interrelated themes: technology, pedagogy, and experience.

Technically, based on Qiao and Bei (2024), a deep learning algorithm for stereo parallax estimation have improved the realism of VR worlds. Projects such as *The Drunken Princess* VR opera reported similar results with anecdotal improvements in narrative engagement and audience involvement. Similarly, Yao et al. (2023) demonstrated how VR offered the ability to digitise physical artefacts with remarkable accuracy and facilitate artists to interact with virtual replicas. However, Sun and Li (2023) point to a fundamental limitation. Interaction design is an ongoing challenge as clunky user interfaces can break that immersive experience. This highlights the demand for more straightforward and accessible VR experiences.

Pedagogically, VR has significant potential, but it has been adopted inconsistently. According to Guerra-Tamez (2023), highly engaging immersive VR environments are as effective as simulation-based education in improving student motivation, cognitive development and reflective thinking via experiential learning. This is in line with Ruan's (2022) call for interdisciplinary curricula that utilize VR to foster creativity. Yet, the systematic review conducted by Wang and Mokmin (2023) highlights an ongoing gap, namely visual communication design education continues to underuse VR. These findings imply that educational institutions should emphasise on the reform of courses and training of faculty members in order to fully capitalise on the potential of VR for teaching and creative work.

VR is changing the way of artistic expression and the way we interact with the audience. Zheng and An (2023) highlight its ability to go beyond traditional art forms, allowing exploratory, creative and interactive digital media installations. In a similar vein, Zhao and Cai (2023) showcase VR's potential as a medium of multidimensional artworks that blend digital intricacy with haptic comprehension. Fouad et al. (2023) serve as an example of the use of physical props as a means of readers immersion. But such innovations lay bare systemic challenges. As Arrigoni and McKim (2022) observe, institutions are averse to acquiring VR-based works in particular, and argue that experimental preservation approaches should be implemented for born-digital pieces.

This synthesis yields several important insights. VR facilitates narrative immersion and closes the gap between analog and digital that allows for iteration between both, a feature evident in Wu and Chen's (2021) VR-supported painting workflows and Nimkulrat's (2020) digitisation of craft as a preservation attempt. Yet, serious barriers remain. Interaction design features limit accessibility while institutional inertia blocks curricular inclusion. Confronting these hurdles will require a joint effort for designing better VR interfaces, restructuring pedagogical frameworks and cultivating cross sector partnerships. As such tools continue to develop, its capacity to democratise creative expression and education is likely to increase, but only if those invested in these spaces address such matters thoughtfully and creatively. Ultimately, the future of VR in art education will depend on tempering innovation with inclusivity, so that its tools facilitate rather than exclude the next generation of artists and audiences.

Conclusion

One of such blend is integration of VR into art education, which brings a paradigm shift in teaching, creating, and experiencing art, enabling opportunities to break the traditional barriers. VR allows educators and artists to transform the way we express ourselves because it encourages narrative immersion, promotes interaction and collaboration, and integrates digital and physical modes of art. Yet its transformatory potential is limited by systemic barriers, from underdeveloped interaction design, through fragmented institutional uptake to lack of overarching strategies for preserving and exhibiting born-digital works.

The dual focus is key to fully realising the potential of VR for stakeholders. Educational institutions should continue to invest aggressively in curricular innovation, but when they do so they should embed VR as not just an add-on tool but rather as a component of the pedagogical practice that complements traditional techniques. This necessitates faculty training, investment in infrastructure, and interdisciplinary collaboration to match VR's capabilities with educational goals. Museum culture also needs to transform through experimental acquisition models and hybrid exhibition formats that embrace digital and analogue artistry alike. At the same time, technologists and designers need to tackle the barriers to accessibility by building standardized, intuitive interfaces and adaptable environments that accommodate a broad spectrum of learners and artists.

Future research required engaging with the ethical, cultural, and pedagogical aspects of VR in art education beyond technical experimentation. This raises a bunch of questions: How is VR democratising access to art education across socioeconomic divides? How can we leverage frameworks to ensure fair access to immersive technologies? Digital innovation would create this tactile, craft-based practice, but how do we live

together like a synthesis? By discussing these issues, we hope to procure a more lucid view of VR's place in fostering inclusive and future-ready artistic ecosystems.

As VR technology evolves, it may well have its most profound influence in breaking down the imaginary divide between "traditional" and "digital" art, bringing them together as part of a vibrant, interrelated creative continuum. Through this synergy, the art world can nurture a new generation of artists and audiences fluent as much in its physical form as in its virtual, ready not just to navigate but also to shape the path of technological change. The path forward will require bold collaborations, but the potential, a retooled, freer arena of art education, is an undertaking worth the effort.

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