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A Systematic Review of Augmented Reality Technology in Fine Arts Education (2015 - 2024)

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ABSTRACT

Purpose: This study is a systematic review of Augmented Reality (AR) technology in the field of art education over the past decade all over the world, with the aim of integrating, evaluating, and disseminating empirical evidence that can inform AR-based teaching theories and practices. **Method:** Employing the PRISMA framework with predefined search strings and dual-phase screening, 90 qualifying publications were selected from three premier databases: Scopus, Web of Science and ERIC (EBSCO). The literature analysis focused on five core dimensions: (1) specific application areas, including sub-domains of fine art education such as drawing, visual arts, and design; (2) educational setting, covering diverse scenarios from formal classrooms to informal learning environments; (3) technical implementation, involving the operating devices and development platforms; (4) integration with educational pedagogy, exploring how AR technology can be combined with pedagogical theories; and (5) research methods and findings, analyzing the methodologies used to assess the effectiveness of AR technology and their key discoveries. **Finds:** The results of this study reveal the literatures in terms of development trends and publication patterns, and shed light on the distribution of AR technology, the use of devices, the characteristics of research methods, as well as the findings and outcomes of AR adoption in fine art education. **Implications for research and practice:** the study discusses the practical significance of AR technology in fine art teaching and proposes key directions for future research.

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Introduction

Augmented reality (AR) is a technology that combines real and virtual elements in real-time and registers them in different dimensions. This definition is based on the works of Caudell and Mizell (1992), Azuma (1997), and Dreimane and Zālīte-Supe (2022). AR refers to an interactive technology that superimposes computer-generated perceptual information (including text, video, images, audio, infographics, and 2D/3D models) onto physical environments through precise spatial registration, maintaining real-time alignment between virtual and real objects (Billinghurst & Duenser, 2012; Tekedere & Göke, 2016).

Given the exponential growth of research reports in the field of educational technology, evidence-based reviews have become increasingly important. They provide insights into contemporary technological implementations, identify key directions for future research, and offer valuable guidance for practitioners (Reeves & Lin, 2020). Against this backdrop, this study aims to delve into the application and development trends of AR in fine art education. By offering references and recommendations for fine art educators, we hope to promote the broader application and development of AR technology within this domain. In other words, despite the growing body of literature on AR, there remains a notable gap in up-to-date systematic reviews that specifically focus on AR implementation in fine art education. To address this research gap, this study examines AR in fine art education environments over a 10-year period (2015–2024) all over the world.

Through a systematic analysis of AR technology in specific fine art domains, educational setting, technical support, educational pedagogy, and research methodologies over the past decade, this study seeks to fill the existing void in the literature. More specifically, the review is guided by the following research questions (RQ):

RQ1: In which disciplinary subfields of fine art education, such as sketching, visual arts, and design, is AR technology mainly applied?
RQ2: In what educational setting is AR technology applied?
RQ3: On which devices do the AR technology for fine art education run, and on which platforms are it developed?
RQ4: How does the AR technology integrate specific educational pedagogy to contribute to fine art education?
RQ5: What research methods are adopted to evaluate the application effectiveness of AR technology in fine art education, and what are the main research findings?

The review will extract and compare the following variables across studies: disciplinary subfield, educational setting, AR device type, pedagogical strategy, and research design and findings.

Literature Review

Augmented Reality Technology in Education

In educational contexts, AR systems typically employ mobile devices or head-mounted displays to deliver multimodal content that enhances learners' perception of reality. With the rapid advancement of technology, which has transformed the field of education in many ways, AR provides educators with a novel and potentially transformative teaching tool (Dunleavy & Dede, 2013; Kesim & Ozarslan, 2012). The most important power of integrating AR into education is that AR provides opportunities for interaction, facilitates ubiquitous learning,

makes information easier to understand by enriching reality, promotes self-directed learning, increases levels of engagement, and is applicable to a wide range of disciplines and educational levels (Ghobadi et al., 2022). The use of AR as a pedagogical method in the learning process can have a positive impact on teaching, learning outcomes and interaction (Alkhattabi, 2017; Huang et al., 2015). It can also contribute more effectively to students' learning skills and knowledge acquisition (Bacca-Acosta et al., 2021; Mariscal Vivas et al., 2020).

Extensive literature reviews have documented AR's educational applications in multiple domains, including general education (Chen et al., 2016; Radu, 2014; Saidin et al., 2015), specialized learning environments (Garzón et al., 2019), STEM education (Arici et al., 2019; Hidayat & Wardat, 2023; Yu et al., 2022), science education (Kalemkuş & Kalemkuş, 2022), health sciences (Rodríguez-Abad et al., 2021), special education (Yenioglu et al., 2021), and language acquisition (Khoshnevisan & Le, 2018). Furthermore, researchers have examined AR's usability in educational settings (Law & Heintz, 2021), its cognitive and performance impacts (Buchner et al., 2021), and the practical strengths and challenges of its implementation (Akçayır & Akçayır, 2017). Particularly noteworthy are AR's remarkable achievements in engineering education, where over twenty studies have specifically focused on its application in engineering drawing and teaching effectiveness evaluation. However, despite this extensive research across various educational fields, a significant gap remains in the systematic investigation of AR's applications in art education, as existing reviews have not specifically addressed this domain.

Fine Art Education with AR Technology

Fine art education, as an important way to cultivate students' aesthetic ability and creativity, has always faced the challenge of how to better integrate theory and practice (Rintoul, 2014). Traditional fine art education mainly relies on textbooks, pictures and teachers' explanations, and students' learning experience is relatively one-dimensional. These methods often focus on theoretical explanations and the appreciation of static works, making it difficult to fully stimulate students' imagination and creativity (Chaobin, 2019; Jie & Meimei, 2019). However, with the rapid development of digital devices and the Internet, the learning environment and learning styles of students have changed dramatically (Haleem et al., 2022). Traditional fine art textbooks and teaching methods have gradually become difficult to meet students' needs, and students have higher expectations for more vivid, interesting and interactive learning experiences (Yanan et al., 2024).

AR technology has emerged as a transformative tool in fine arts education due to its ability to bridge physical and digital creative spaces, enhance learner engagement, and support experiential learning approaches. Alkhabra et al. (2023) proposed a significant pedagogical shift from conventional lecture-based instruction to active learning approaches utilizing AR technology. This transition not only fosters the development of students' technical and artistic abilities but also serves as a powerful tool for cultivating essential 21st century skills. As demonstrated by Yang (2022), AR technology offers versatile applications in art education, enabling the presentation of various art materials through photo and video resources, as well as graphic models.

At present, the application of AR in art education has achieved certain results in several aspects. In terms of art appreciation, many museums and art organizations have developed AR guided tour applications, which allow visitors to obtain more information about the artworks, such as the background of the creation of the works, and the artist's life story through their cell phones or other devices (tom Dieck et al., 2016), which improves the user's concentration on the

exhibitions and their ability to appreciate the art, as well as arouses new interest in the artworks (Tabone, 2020), and also brings more positive experiences and learning outcomes (Aitamurto et al., 2018; Ma, 2021). In drawing and design teaching, AR technology can provide real-time guidance and feedback to students. In basic drawing instruction, AR technology can help students better master drawing skills through real-time feedback and virtual aids (Liao & Kuo, 2020; Shima & Soga, 2019). Despite various learning advantages and positive findings about AR-based instruction, art education has so far failed to witness its sustained implementation on a large scale.

Unlike STEM subjects where AR is often used to visualize invisible phenomena, fine-arts education deals with tacit, procedural, and spatial knowledge, such as drawing, colour mixing, and 3-D composition, that traditionally require physical ateliers and prolonged master-apprentice feedback. AR offers just-in-time guidance, risk-free iteration, and multi-perspective viewing that are impossible with physical media alone, thus aligning with constructivist and embodied cognition pedagogies in which learning is situated, multimodal, and student-generated (Kolb & Kolb, 2017). Beyond its pedagogical affordances, the integration of AR in fine-arts education responds to current global policy directions. UNESCO's Framework for Culture and Arts Education (Unesco, 2024a) urge Member States to harness technological advances to enhance creativity, initiative, and responsible digital use in the arts. It further calls for embedding culture and arts into educational policies, curricula, and teacher qualification systems to support lifelong and life-wide learning, while promoting equitable access to digital tools and professional development for educators (Unesco, 2024b). Despite these global priorities, many fine-arts curricula remain traditional, and educators often lack the training and resources to apply AR effectively. This review, therefore, aims to synthesize global evidence on AR's role in bridging these pedagogical and policy gaps.

Philosophizing the integration of AR in fine arts education carries pedagogical significance because it reframes technology not merely as an instructional tool but as an epistemic medium through which learners construct artistic understanding. While previous studies on AR often emphasize performance outcomes or usability, the pedagogical essence of AR lies in its ability to extend perception, embodiment, and reflection, which core principles in experiential and constructivist learning theories (Dewey, 1938; Kolb & Kolb, 2017). From a philosophical standpoint, AR mediates between the tangible and the imagined, enabling students to externalize abstract artistic concepts into interactive visual forms. This aligns with the idea of learning as becoming, where learners do not just acquire skills but reshape their artistic identity through immersive experience (Biesta, 2013). Thus, philosophizing this issue highlights the deeper educational meaning of AR in nurturing creative cognition, reflective practice, and embodied knowledge that transcend instrumental or technical uses.

The current literature review searched on art education is the book chapter *Augmented Reality in Arts Education* by Panciroli et al. (2023). This offers a theoretical framework for AR in art education but has limitations. It relies on literature review/theoretical analysis (lacking empirical support, limiting practical validation), focuses on European/international organization policies (insufficient coverage of other regions, reducing global applicability), skimps on AR technical details (e.g., development processes, platforms), and includes narrowly representative case studies. These gaps weaken its value for educators/developers, requiring future research to address.

Methodology

Research design

This study utilized Systematic Literature Review (SLR) methodology to gain insight into the use of AR technology in fine art education. Data retrieval and selection was implemented under the data screening framework of the PRISMA 2020 guidelines (Page et al., 2021). For research retrieval and selection, relevant evidence that meets pre-specified eligibility criteria and is able to answer a specific research question needs to be organized according to the following steps. Any relevant evidence that meets the pre-specified eligibility criteria and can answer a specific research question needs to be collated according to the following specific steps (Moher et al., 2009; Page et al., 2021). This study located, selected, and analyzed AR technology literature related to fine art education published between January 1, 2015, and August 27, 2024, with the goal of answering the research questions posed in this study. The systematic review consisted of three main phases-initial literature search, manual screening, and analytic coding-detailed below.

Initial Literature Search

To achieve the initial screening, manual search of peer-reviewed international journal articles was performed. For this review, screening was done in Scopus, Web of Science, ERIC (EBSCO). Scopus is a large database of abstracts and citations, includes numerous journals on educational technology and arts education, offering powerful search tools for interdisciplinary research. Web of Science, a high-quality scholarly database, indexes high-impact journals, particularly in educational technology, and covers disciplines like computer science, pedagogy, and the arts. ERIC, sponsored by the U.S. Department of Education, focuses on educational research, including literature on educational technology and arts education.

The search terms (keywords) for this study were drawn from any search term related to AR, as well as several search terms that could be described in terms of fine arts education. Combining the definitions of fine arts from the Oxford Dictionary of Fine Arts, the category of fine arts encompasses what is usually used to cover painting, sculpture and architecture (although architecture is clearly a 'useful' art) (Chilvers, 2015). Art created primarily for aesthetic reasons and not for functional use (see applied art). Examples of the fine arts are painting, drawing, sculpture, and printmaking (Clarke, 2010).

Taken together, the search string is a combination of three key phrases. The first group consisted of only two items, “augmented reality” and its acronym “AR”; the second group included markers for educational backgrounds, and the third group was about fine arts. In this research, a preliminary search was carried out in August 2024, making use of Boolean logic ("augmented reality" OR AR) AND (education* OR learning OR teaching OR instruction) AND (art OR painting OR drawing OR "visual art*" OR "fine art*" OR sculpture OR crafts OR architecture OR calligraphy OR design OR "new media art" OR photography). The study spanned a comprehensive time period from January 1, 2015, to August 27, 2024. During this period, a total of 14,099 articles were identified across three major databases: 5,994 articles from Web of Science (WOS), 7,596 from Scopus, and 509 from ERIC. After removing duplicates, 9,883 unique articles remained for further screening. The final literature search was completed on August 27, 2024.

Manual Screening

At this stage, the researcher conducted the PRISMA review process (Figure 1). In this paper, the following inclusion and exclusion criteria are established (Table 1). Subsequently, each paper was carefully reviewed to ascertain its eligibility for analysis. Overall, several aspects were considered here, such as the language, topic and content of the paper. This study was conducted on Rayyan (https://www.rayyan.ai/) (Ouzzani et al., 2016) where the entire manual screening process including identification, screening, eligibility and analysis was conducted. The manual screening process lasted for about five months and involved five researchers. The first, fourth, and fifth authors led the initial screening, and the second and third authors oversaw the entire process.

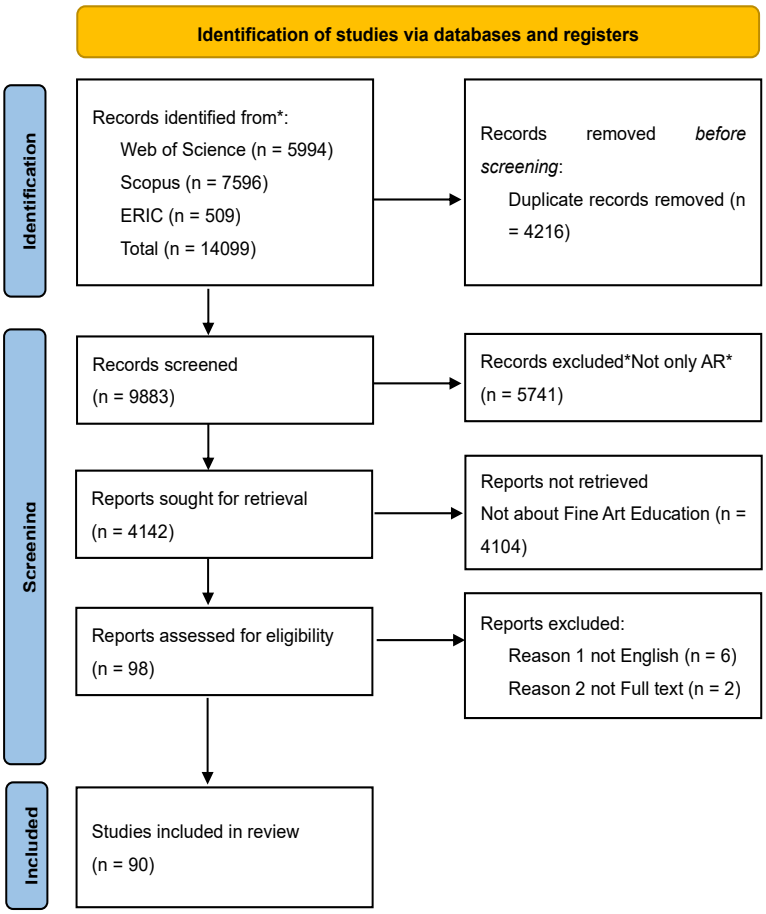

Figure 1: PRISMA Flow Diagram

Disputes about inclusion and exclusion results were resolved during biweekly progress meetings. After manual screening, a total of 90 articles (Table 2) were deemed to meet all criteria and were included in the main pool for further analysis. Figure 1 illustrates this process through the PRISMA Flow Diagram.

Table 1

Inclusion and exclusion criteria

Inclusion Criteria	Exclusion criteria
•Peer-reviewed article.	Review or meta-review articles.
•In English language.	Languages other than English
•Appropriate title and met the requirements of the study	Unrelated title and did not meet the requirements of the study
•Available in full-text	Abstract-only studies available
•Related to AR	VR or Mix reality or AI
•Fine art education	Studies that mentioned AR and learning, but were about learning other topics such as science or history rather than fine art education.

Table 2

List of articles after inclusion and exclusion criteria

ID	Author	Paper Title	Educational Setting	Specific Area
ID 1	Zhao et al. (2017)	Texturing Of Augmented Reality Character Based On Colored Drawing	Pre-school Education	Color
ID 2	Wibawa et al. (2017)	Augmented Reality: Studio Lighting Photography Simulator Ver.1.0	Vocational Education	Photography
ID 3	Wei et al. (2015)	Teaching Based On Augmented Reality For A Technical Creative Design Course	Secondary Education	Technical Creative Design
ID 4	Trice and Hokanson (2019)	Using Augmented Reality In A Beginning Drawing Course For Design Students	Higher Education	Basic Drawing
ID 5	tom Dieck et al. (2016)	Enhancing Art Gallery Visitors' Learning Experience Using Wearable Augmented Reality: Generic Learning Outcomes Perspective	Informal Learning Environment	Art Appreciation
ID 6	Hart (2020)	The Romantic App: Augmented Reality In Fine Art Education	Higher Education	Art Appreciation
ID 7	Aitamurto et al. (2018)	The Impact Of Augmented Reality On Art Engagement: Liking, Impression Of Learning, And Distraction	Informal Learning Environment	Art Appreciation

ID	Author	Paper Title	Educational Setting	Specific Area
ID 8	Hermawan and Arifin (2015)	The Development And Analysis Of Quality Of "Batik Detector" As A Learning Media For Indonesian Batik Motifs Android Based In Indonesian School Of Singapore	Higher Education	Crafts
ID 9	Ihamäki and Heljakka (2019)	The Internet Of Art As A Site For Learning And Fun – Playful Experiences Through Augmented Geocaching	Pre-school Education	Public Art
ID 10	Siek et al. (2022)	The Exploration Of Emotions From Print Design Course Using Augmented Reality	Higher Education	Print Design
ID 11	Ye et al. (2024)	The Effect Of Augmented Reality-Based Serious Game On Traditional Pattern Learning	Higher Education	Traditional Pattern
ID 12	Chang (2021)	Applying The ARCS Motivation Theory For The Assessment Of AR Digital Media Design Learning Effectiveness	Higher Education	Digital Media Design
ID 13	Sun et al. (2019)	Hololens-Based Visualization Teaching System For Algorithms Of Computer Animation	Higher Education	Computer Animation
ID 14	Son (2021)	The Application Of Web-3d And Augmented Reality In E-Learning To Improve The Effectiveness Of Arts Teaching In Vietnam	Informal Learning Environment	Not Mentioned
ID 15	Sobandi et al. (2021)	Batik AR Ver.1.0: Augmented Reality Application As Gamification Of Batik Design Using Waterfall Method	Primary Education	Crafts
ID 16	Shima and Soga (2019)	Development Of An Interactive Training Support System For Drawing And Painting Skill On A 3D Object With AR And Haptic Interface	Higher Education	3D Drawing
ID 17	Schwelling and Yoo (2018)	Automatic 3D Modeling Of Artwork And Visualizing Audio In An Augmented Reality Environment	Informal Learning Environment	Art Appreciation
ID 18	Chang et al. (2019)	Applying Mobile Augmented Reality (AR) To Teach Interior Design Students In Layout Plans: Evaluation Of Learning Effectiveness Based On The ARCS Model Of Learning Motivation Theory	Higher Education	Interior Design
ID 19	Alp et al. (2023)	Augmented Reality Experience In An Architectural Design Studio	Higher Education	Architectural Design
ID 20	Rossi (2019)	SAR For Kids: Spatial Augmented Reality As Tool For Art Education	Primary Education	Visual Arts
ID 21	Ma (2021)	Research On The Design Of Mobile Guiding In Art Museum Based On Augmented Reality	Higher Education	Art Appreciation
ID 22	Ozenen (2022)	Enhancing Engagement And Learning Outcomes In Architectural Computing Design Education: A Study On The Implementation Of Augmented Reality	Higher Education	Architectural Design

ID	Author	Paper Title	Educational Setting	Specific Area
ID 23	Pollalis et al. (2018)	Artlens: Enhancing Museum Visitors' Engagement With African Art	Informal Learning Environment	Art Appreciation
ID 24	Gürçınar and Esen (2018)	The Application Of Augmented Reality In Interior Design Education	Higher Education	Interior Design
ID 25	Nanthanasit and Wongta (2018)	Approach Augmented Reality Real-Time Rendering For Understanding Light And Shade In Art Education	Art beginners and Intermediate Art Students	Light and Shade
ID 26	Kurniawan et al. (2019)	Artrace: Augmented Reality For Student's Fine Motor Learning	Pre-school Education	Early Arts Education
ID 27	Kaliyaperumal and Vijayakumar (2020)	Learners' Feedback On The Effectiveness Of Replacing An Instructional MOOC Video With Augmented Reality In A Practice-Based Course	Higher Education	Photography
ID 28	Rudenko and Haahr (2023)	Synaesthesia Gallery AR: Journey Through The Senses – Using Augmented Reality For Education	Informal Learning Environment	Cross-Modal Perception of Art and Music
ID 29	Ayu et al. (2023)	Is It Practical Digital Learning Application For Learning 3d Graphic Design Based On Augmented Reality?	Vocational Education	3D Graphic Design
ID 30	Ihamäki and Heljakka (2020)	Internet Of Art: Exploring Mobility, AR And Connectedness Through A Collaborative Art Experience	Pre-school Education	Art Appreciation
ID 31	David (2019)	Immersive Learning Experiences: Technology Enhanced Instruction, Adaptive Learning, Augmented Reality, And M-Learning In Informal Learning Environments	Informal Learning Environment	Art Appreciation
ID 32	Iqbal Maulana et al. (2023)	FunAR-Furniture Augmented Reality Application To Support Practical Laboratory Experiments In Interior Design Education	Higher Education	Interior Design
ID 33	Damala et al. (2016)	The Loupe: Tangible Augmented Reality For Learning To Look At Ancient Greek Art	Informal Learning Environment	Art Appreciation
ID 34	Davis et al. (2021)	Using Design Of Location-Based Augmented Reality Experiences To Engage Art-Oriented Girls In Technology And Science	Secondary Education	Interdisciplinary Art
ID 35	Liu and Zhang (2024)	Design Of Children's Artistic Creation Products Integrating AR And Tangible Interactions	Primary Education	Artistic Creativity
ID 36	Mokmin et al. (2023)	Impact Of An AR-Based Learning Approach On The Learning Achievement, Motivation, And Cognitive Load Of Students On A Design Course	Higher Education	2D Design

ID	Author	Paper Title	Educational Setting	Specific Area
ID 37	Hafizah et al. (2023)	Exploring The Intersection Of Technology And Art Education: (Archi3d) A Conception Development Of Facade Design Elements At Colonial Buildings Through Augmented Reality (AR)	Informal Learning Environment	Architectural design
ID 38	Lim (2022)	Expanding Multimodal Artistic Expression And Appreciation Methods Through Integrating Augmented Reality	Higher Education	Art Appreciation
ID 39	Techasarntikul et al. (2019)	Evaluation Of Pointing Interfaces With An AR Agent For Multi-Section Information Guidance	Informal Learning Environment	Art Appreciation
ID 40	Sanabria and Arámburo-Lizárraga (2017)	Enhancing 21st Century Skills With AR: Using The Gradual Immersion Method To Develop Collaborative Creativity	Secondary Education	Art History and Theory
ID 41	Jimenez Vicario et al. (2016)	Augmented Reality And Generative Design. A Tour Through Print Media For Designing And Representing Architecture	Pre-school Education & Primary Education & Secondary Education	Architectural Design
ID 42	Chen et al. (2021)	Continuance Intention Of Augmented Reality Textbooks In Basic Design Course	Higher Education	Basic Design
ID 43	Huang et al. (2017)	Discovery Augmented Reality Mobile Gaming Scheme For Understanding Color Fundamentals	Secondary Education	Color
ID 44	Gong et al. (2022)	Augmented Reality (AR) As A Tool For Engaging Museum Experience: A Case Study On Chinese Art Pieces	Informal Learning Environment	Art Appreciation
ID 45	Elfeky and Elbyaly (2018)	Developing Skills Of Fashion Design By Augmented Reality Technology In Higher Education	Higher Education	Fashion Design
ID 46	Huang et al. (2015)	Using Augmented Reality In Early Art Education: A Case Study In Hong Kong Kindergarten	Pre-school Education	Early Arts Education
ID 47	Chu et al. (2021)	Artist: Interactive Augmented Reality For Curating Children's Artworks	Primary Education	Artistic Creativity
ID 48	Chu et al. (2017)	Effects Of Formative Assessment In An Augmented Reality Approach To Conducting Ubiquitous Learning Activities For Architecture Courses	Higher Education	Architectural Design
ID 49	Lee et al. (2022)	Cards: Comprehensive AR Docent System	Informal Learning Environment	Art Appreciation
ID 50	Bebar et al. (2022)	An Augmented Reality Application For Depicting Space Using The Principles Of Linear Perspective	Higher Education	Linear Perspective

ID	Author	Paper Title	Educational Setting	Specific Area
ID 51	Huda et al. (2021)	Augmented Reality Technology As A Complement On Graphic Design To Face Revolution Industry 4.0 Learning And Competence: The Development And Validity	Higher Education	Graphic Design
ID 52	Sanna et al. (2022)	An Integrated Framework To Support Bachelor Design Students In 3-D Modeling	Higher Education	3-D Modeling
ID 53	Liao and Kuo (2020)	An Analysis For Motivating Sketching Practice With Augmented Reality In Da Vinci Eye	Higher Education	Sketching
ID 54	Yoon and Chandrasekera (2015)	Adopting Augmented Reality In Design Communication: Focusing On Improving Spatial Abilities	Higher Education	Architectural Design
ID 55	Kuriya and Ishida (2023)	Development Of An AR Application For Learning Traditional Patterns	Not mentioned	Traditional Pattern
ID 56	Martínez Díaz et al. (2024)	Graphic Thinking, Communication And Motivation: A Teaching Experience With Augmented Reality	Higher Education	Architectural Design
ID 57	Xie (2017)	Transboundary Educational Reform Of The Traditional Graphic Design Major Under The Influence Of AR Technology	Higher Education	Graphic Design
ID 58	Pyakurel et al. (2023)	Cogcues: Shifting Perception Through Interactive Projected Cues In Still Life Drawing	Art beginners and Intermediate Art Students	Basic Drawing
ID 59	Kang et al. (2019)	PrototypAR: Prototyping And Simulating Complex Systems With Paper Craft And Augmented Reality	Primary Education	Crafts
ID 60	Ishihara and Makino (2020)	AR Based Self Learning System Of Japanese Calligraphy Skills	Primary Education & Secondary Education	Calligraphy
ID 61	Fahrezi and Hermawan (2024)	Learning Media Introduction Of Magetan Batik Handicraft Products Using Augmented Reality	Primary Education	Crafts
ID 62	Fonseca Escudero et al. (2017)	Educating Urban Designers Using Augmented Reality And Mobile Learning Technologies	Higher Education	Architectural Design
ID 63	Gheorghiu et al. (2022)	Rhythms In Stone: Revealing And Augmenting The Human Presence In Mesolithic Rock Art	Informal Learning Environment	Art History and Theory
ID 64	Panciroli et al. (2023)	Augmented Reality In Arts Education	Formal & Informal Learning Environment	Art History and Theory
ID 65	Tan et al. (2018)	An AR System For Artistic Creativity Education	Secondary Education	Artistic Creativity

ID	Author	Paper Title	Educational Setting	Specific Area
ID 66	Karyono et al. (2024)	Augmented Reality (AR) Technology To Stimulate Creativity In A Zero-Waste Lifestyle In Converting Plastic Waste To Art Products To Support Sustainable Development Goals (SDGS)	Not mentioned	Artistic Creativity
ID 67	Okubo and Mizuno (2018)	Influence Of Interactive Learning Support System Using Augmented Reality On 3D Object Drawing	Higher Education	3D Drawing
ID 68	Hussein (2022)	Integrating Augmented Reality Technologies Into Architectural Education: Application To The Course Of Landscape Design At Port Said University	Higher Education	Landscape Design
ID 69	Mokhtar et al. (2018)	Development Of Mobile-Based Augmented Reality Colouring For Preschool Learning	Pre-school Education	Color
ID 70	Chen and Mokmin (2024)	Enhancing Primary School Students' Performance, Flow State, And Cognitive Load In Visual Arts Education Through The Integration Of Augmented Reality Technology In A Card Game	Primary Education	Visual Arts
ID 71	Tabone (2020)	The Effectiveness Of An Augmented Reality Guiding System In An Art Museum	Informal Learning Environment	Art Appreciation
ID 72	Inatome and Soga (2018)	Development Of An AR Drawing System With Point Cloud Data Suitable For Real-Time Gripping Movement By Using Kinect	Not mentioned	Sketching
ID 73	Arámburo-Lizárraga and Sanabria (2015)	An Application For The Study Of Art Movements	Higher Education	Artistic Creativity
ID 74	Iwasako and Soga (2015)	Proposition And Design Of A Skill Learning Environment For Drawing Onto 3D Objects Using AR	Higher Education	Crafts
ID 75	Yoo and Foster (2019)	Interactive Visualization Of Painting Data With Augmented Reality	Informal Learning Environment	Art Appreciation
ID 76	Barakari and Skamagkis (2022)	ARtales: AR Mobile Application Using Transformative Learning Through Aesthetic Experience – First Evaluation	Informal Learning Environment	Art Appreciation
ID 77	Kim et al. (2019)	The OTC (Object To Camera) Approach To Visualize Behind Stories Of Museum Exhibits	Informal Learning Environment	Art Appreciation
ID 78	Zhou and Tai (2024)	Implementation Of An Augmented Reality Guide: Auto-Presenting Suitable Content To Adults And Young Children About Chen Cheng-Po's Oil Paintings	Informal Learning Environment	Art Appreciation
ID 79	Zulkilfi Che et al.	Augmented Reality As Learning Tool In Education Of Sculpture Arts	Higher Education	Sculpture Arts

ID	Author	Paper Title	Educational Setting	Specific Area
	(2019)			
ID 80	Miralay (2022)	Examination Of Educational Situations Related To Augmented Reality In Art Education	Primary Education	Art Appreciation
ID 81	Squires (2019)	Instructional Designs And Educational Technologies Within Augmented Reality Transmedia Storytelling: IDET ARTS	Informal Learning Environment	Art Appreciation
ID 82	Dam et al. (2024)	Audio Augmented Reality Using Sonification To Enhance Visual Art Experiences: Lessons Learned	Informal Learning Environment	Art Appreciation
ID 83	Ha et al. (2024)	Implementation Of Augmented Reality In Landscape Architectural Education: Enhancing Understanding Of Three-Dimensional Space	Higher Education	Landscape Architectural Design
ID 84	Widiaty et al. (2016)	A Preliminary Study On Augmented Reality For Learning Local Wisdom Of Indonesian Batik In Vocational Schools	Vocational Education	Crafts
ID 85	Golembovska et al. (2020)	Assessing The Perception Of Abstract Paintings With Elements Of Augmented Reality	Informal Learning Environment	Art Appreciation
ID 86	Velaora et al. (2020)	ARtect, An Augmented Reality Educational Prototype For Architectural Design	Higher Education	Architectural Design
ID 87	Lichty (2020)	Making Inside The Augment: Augmented Reality And Art/Design Education	Higher Education	Art/Design
ID 88	Maniello (2019)	Art Upon Art: The Spatial Augmented Reality As New Value For Contemporary Art And Educational Tool For Art History	Informal Learning Environment	Contemporary Art
ID 89	Sun (2021)	Innovative Design Of Immersion Teaching Aids For Children's Art Based On Augmented Reality Technology	Pre-school Education	Early Arts Education
ID 90	Zhao et al. (2022)	An Augmented Reality Based Mobile Photography Application To Improve Learning Gain, Decrease Cognitive Load, And Achieve Better Emotional State	Higher Education	Photography

Analytic Coding

After finalizing the master repository, we investigated the content of the selected articles and collected detailed information in the following five categories: article metadata, specific area in fine art education, educational setting, technical support, educational pedagogy, and research methodology details. Table 3 illustrates the coding scheme for this study and lists the codes for each category with a brief description. The metadata provided key information such as the year and type of publication of the article and enabled easy documentation, selection and categorization of the articles. The other five categories correspond to five research questions: (i)the domain code indicated a specific area of specialization of AR technology in fine art education; (ii) the context code revealed the educational setting of AR technology in fine art education; (iii) the technology code consisted of AR devices, and development platforms; (iv) the theory code revealed the educational theories of AR technology in fine art education; and (v) the research code pertained to the methodologies employed to evaluate the efficacy of AR technology in fine art education, along with the principal findings unearthed by these studies.

Table 3

Lists of codes for the analysis of selected articles

Category	Code	Description
Metadata	Title	Full title of the article
	Authors	Complete list of author names
	Year	Publication year
	Source	Information about the journal/book/URL
	Author's institution affiliated country	The country where the author's institution is located
	Article Type	Journal articles/conference proceedings/Chapter book/ dissertation
Domain	Specific fields	Arts and Crafts/ Design/ Drawing and Sketching/ Artistic Creation and Expression/ Art Education and Appreciation/ Interdisciplinary Art/ Photography/ Other
Context	Educational Setting	Preschool education/ primary education/ secondary education/ vocational training/ higher education/ informal learning settings
Technology	Equipment	Mobile Device/ Head-Mounted Display Device/ Multi-Platform Device/ Other/ Not Mentioned
	Development Platform	Unity 3D and Vuforia/ Unity 3D- Other Platforms Co/ Only Unity 3D/ Aurasma/ Vuforia AR SDK/ OpenCV/ Other/ Not mentioned
Theory	Educational Pedagogy	Situated Learning Theory/ ARCS Motivation Theory/ Constructivist Learning Theory/ Play-based Learning/ Immersive Learning/ Gradual Immersion Method/ Flow Experience Theory/ Technology-Enhanced Learning/ Interactive Learning/ Mobile Learning/ Collaborative Learning/ Learner-Centered Pedagogy/ Not Mentioned
Research	Research Type	Empirical/theoretical/synthesis
	Methodology	Quantitative/ Qualitative/Mixed
	Sample Size	Number of total participants
	Research Method	Test/survey/interviews/field notes/other
	Data Analysis	Difference Analysis/ Associational Analysis/ Descriptive Statistical Analysis/ Qualitative Descriptive Analysis/ Content Analysis/ Thematic Analysis/ Case Analysis

Results

Publishing Trends

A total of 90 papers were included in this paper for review to analyze the publication trends of AR research in the field of art education between 2015 and 2024, to observe the changes in the number of studies and to understand the heat and dynamics of research in this field. Between 2015 and 2024, there are 90 articles, including 45 conference papers, 40 journal papers, and 5 book chapters. As shown in Figure 2, from 2015 to 2024, research on augmented reality in the field of art education shows a significant growth trend, but the growth process is not linear but accompanied by certain fluctuations.

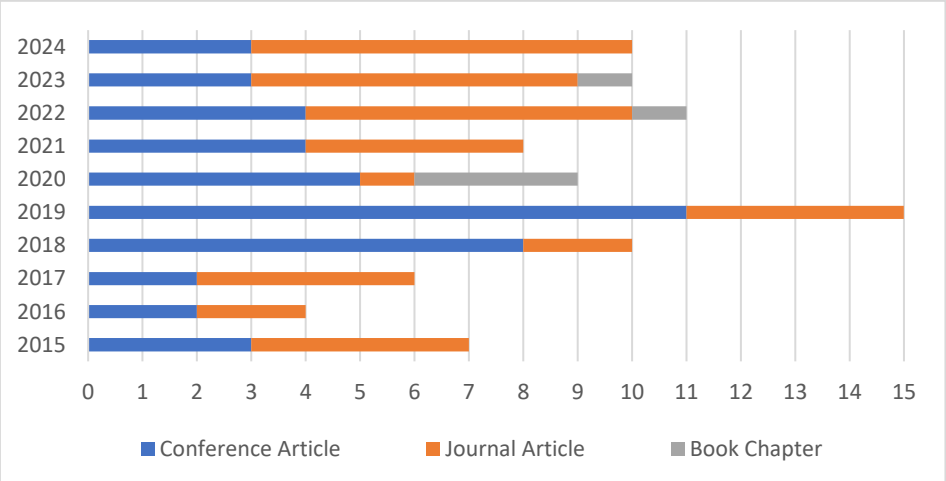

Figure 2: Number of published papers per year.

AR in fine art education research showed fluctuating publication trends 2015–2024. 2015 had 7 articles (3 conference, 4 journal); 2016 saw a decline, with recovery in 2017 as research deepened into AR-art education integration. 2018–2019 were peaks (10, 15 articles respectively), with more conference papers showing growing attention. 2020 had fewer literatures but included book chapters (ID6,71,87), signaling a shift to systematic theory-building. 2021–2023 stayed stable (8–10 articles yearly). 2024 had around 10 articles, with total cumulative literatures reaching 90, indicating scaled, long-term development. This sustained progress is hypothesized to stem from post-epidemic class format shifts: large-scale online teaching spurred ed-tech innovation, and AR's strengths (enhancing learning experiences, knowledge visualization) opened broad application space in art education.

Figure 3 shows 24 countries/regions have published on AR in fine-art education. China (18) and the U.S. (17) dominate, covering both technical and pedagogical issues. Indonesia (10) follows, with four studies on batik (IDs 8, 15, 61, 84). Japan (7) and Malaysia (6) are next; Spain, Turkey and the U.K. contribute ≥3 papers each, often on architectural or interior-design education (e.g., IDs 19, 22, 24, 41, 56, 62). Smaller outputs elsewhere signal emerging global interest. Overall, East–Southeast Asia and North America lead; diversified, locality-driven research is spreading worldwide.

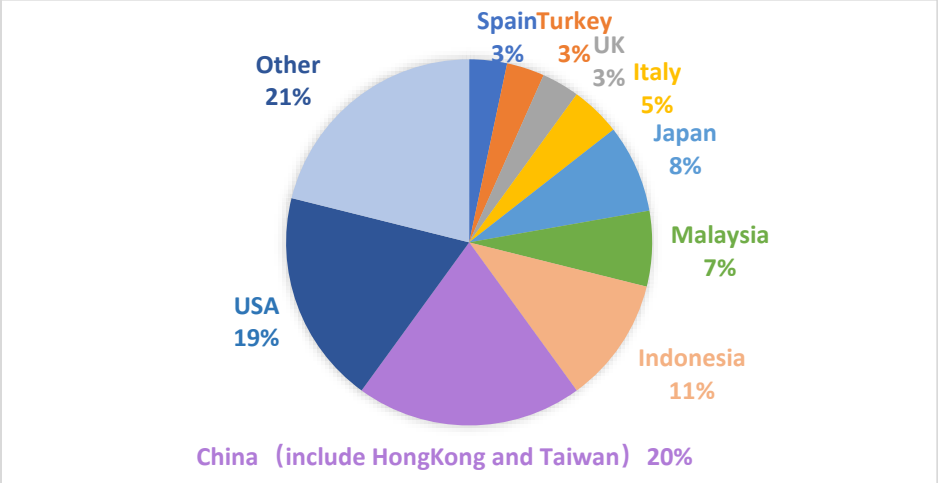

Figure 3: Number of published papers per country.

Disciplinary Subfields of Fine Art Education

According to the *Oxford Dictionary*, fine arts encompass painting, drawing, sculpture, printmaking, and architecture. Within fine arts education, subfields such as art appreciation, design, and painting have increasingly integrated augmented reality, transforming it from a novel medium into a pedagogically significant technology. A synthesis of 90 representative studies reveals distinct trends and disciplinary emphases (see Figure 4).

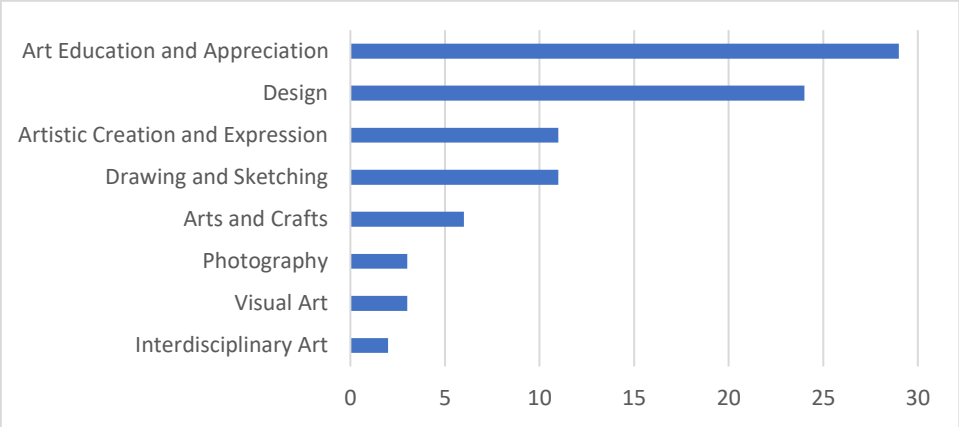

Figure 4: Number of published papers per specify area of fine art.

Research in art education and appreciation (32.22%, 29 studies) highlights AR's capacity to enhance learner engagement in museum and gallery contexts, facilitate art historical understanding, and foster creative expression among young learners, despite challenges related to user fatigue and technological dependence. In design education (26.67%, 24

studies), AR supports comprehension of complex spatial and structural concepts through interactive tools, mobile applications, and on-site visualization. Particularly in architecture and landscape design, embedding 3D models into real environments strengthens spatial awareness and design competence.

In drawing and sketching (12.22%, 11 studies), AR merges virtual and real contexts to improve perspective, color, and light-shadow learning, providing real-time feedback and enhancing learner motivation. However, current studies primarily focus on early education levels.

Research on artistic creation and expression (12.22%, 11 studies) demonstrates AR's potential to enhance interactivity, reduce cognitive load, and provide virtual practice environments for calligraphy and sculpture. In arts and crafts (6.67%, 6 studies), AR facilitates traditional craft transmission through virtual simulations and audiovisual feedback. Other applications (8.89%) in photography, animation, and interdisciplinary art further underscore AR's role in enriching creativity and experiential learning within fine arts education.

Educational Settings

The use of AR technology in fine art education has been widely covered across multiple educational settings through the analysis of 90 related academic papers (Figure 5), including preschool (7.78%), primary (8.89%), secondary (5.56%), higher education (41.1%), hybrid education (3.33%), vocational (3.33%), and informal learning environments (24.44%), as well as a special classification of art beginners and intermediate art students (2.22%). stage (3.33%) vocational education stage (3.33%), and informal learning environments (24.44%), as well as a special categorization art beginner and intermediate fine art student stage (2.22%).(Figure 5)

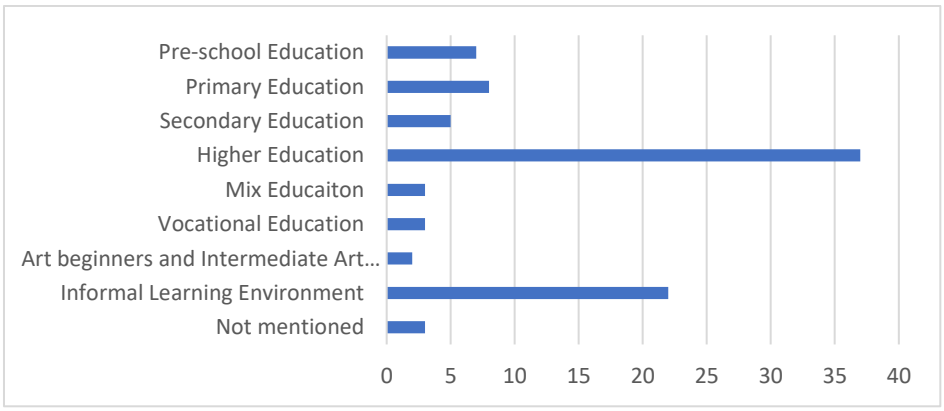

Figure 5: Number of published papers per education environment.

At the higher education level, 37 papers highlight AR's wide application in fine art education across subfields like architectural, landscape, interior design (ID18,19, etc.), painting, graphic design (ID4,12, etc.), etc. It enhances spatial perception, learning interest, and teaching effectiveness (e.g., 3D manipulation in design, improved

photography/art appreciation (ID6,13, etc.), reduces cognitive load (ID11), and boosts student outcomes (ID12,18, etc.), supporting higher art education's digital transformation. In informal settings, 22 studies show AR enriches art learning via contextual info and interactivity (ID5,7, etc.) but faces challenges like user fatigue, with outcomes not always surpassing traditional methods (ID7). Primary (8 papers) and preschool (7 papers) education use AR to stimulate interest/creativity, with preschool studies noting AR color education enhances children's creativity. Other phases have below 5 papers: secondary education (5 papers) emphasizes art-tech interdisciplinary integration; mixed education (ID41,60,64) focuses on cross-stage AR application; vocational education (ID2,29,84) uses AR for crafts/photography/design skill enhancement; beginner/intermediate studies (ID25,58) target AR-aided drawing. Future research should expand AR's cross-stage application to optimize art teaching.

Devices and Development Platforms

AR technology has been increasingly applied in fine art education, with various devices and development platforms utilized to enhance the learning experience. According to the comprehensive analysis of these 90 articles, the distribution of AR devices is shown in Figure 6. Among them, mobile devices accounted for the largest share of 59%; head-mounted display devices accounted for 12%; multi-platform devices accounted for 7%; customized devices accounted for 3%; and other devices accounted for 7%; in addition, 12% of the articles did not specify the type of AR devices used. In addition, 12% of the articles did not specify the type of AR device used. The usage of AR development platforms is shown in Figure 7. There are 16 articles using Unity 3D and Vuforia; 9 articles using Unity 3D - Other Platforms Co; 6 articles using only Unity 3D; 2 articles using Aurasma, Vuforia AR SDK and OpenCV; and 25 articles using other platforms; There are also 28 articles that do not specify the development platform (Figure 6).

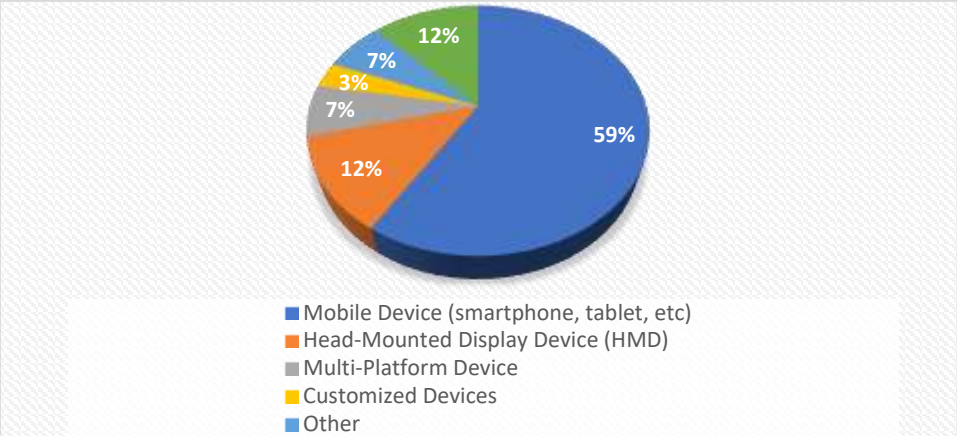

Figure 6: AR Devices

Mobile devices (smartphones/tablets) are the most common AR hardware in art education, used in 53 studies for their portability, accessibility, and low cost, which reducing financial burdens in experimental validation and boosting feasibility. Head-

mounted displays (HMDs, e.g., Microsoft HoloLens) were reported in 11 studies, offering immersive, hands-free experiences to interact with virtual elements (ID35,60,74) and enhancing art gallery learning (ID5,23,71). Multi-platform devices (6 studies, ID19,37,41,52,77,90) provide OS flexibility; customized devices (3 studies, ID3,33,58, e.g., "AR Creative-Classroom") meet specific needs. Other devices (touch screens, eye-trackers, 6 studies, ID16,20,54,72,82,87) add unique interactions. 11 studies lacked device specifications, focusing on methods/outcomes over hardware, hindering reproducibility. Future research should detail AR equipment to advance standardization in the field.

There are various AR development platforms (Figure7), with Unity3D and Vuforia being the most commonly used, appearing in 16 papers (17.78%) combined. These platforms offer powerful tools for creating immersive and interactive AR experiences. For instance, ID2 utilized Unity3D and Vuforia to develop a photography studio simulation app where students interacted with virtual lights and objects. Similarly, ID11 created an AR-based game using Unity and Vuforia to enhance students' understanding and memorization of complex patterns. A total of 31 papers involved Unity3D, with 9 combining it with other platforms, 6 using only Unity3D, and 31 overall highlighting its convenience for AR development. Additionally, studies used Aurasma (ID45,80), Vuforia AR SDK (ID33,69), and OpenCV (ID50,58), reflecting developers' choices of suitable tools based on specific educational needs and goals to implement effective AR applications (Figure 7).

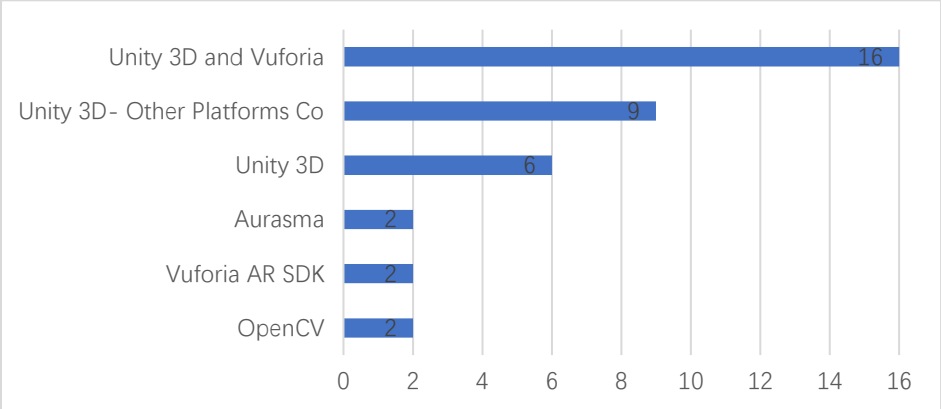

Figure 7: Major platforms for AR development

Educational Pedagogy

In our in-depth analysis of the collected literature, we found that the use of AR technology in fine art education is supported by multiple educational pedagogy theories. Forty-six of the articles do not explicitly mention the educational theories on which they are based. It is worth noting that some of the articles do not rely on a single theory, but integrate multiple theories. After sorting, these theories can be broadly categorized as follows (Figure 8). In addition, the theories involved in 18 articles were diversified, which are not listed separately here due to their dispersed nature and lack of obvious commonality and categorization value.

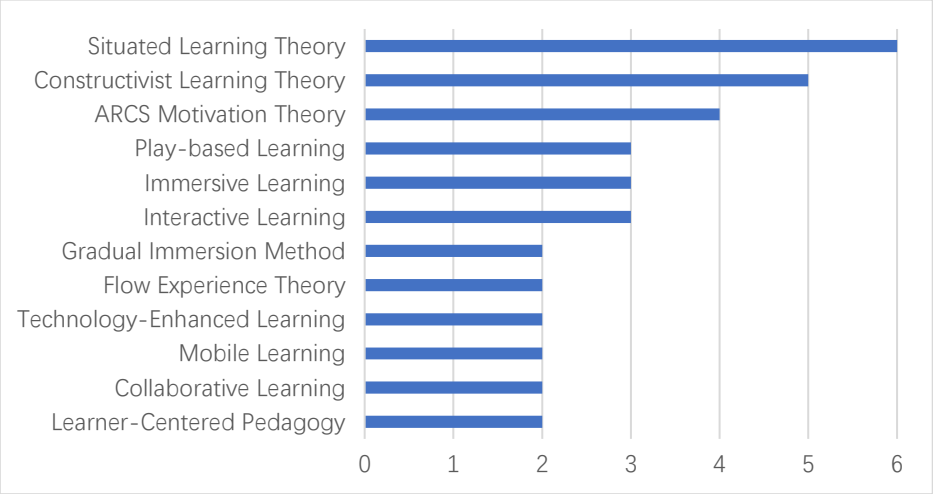

Figure 8: Educational Pedagogy.

In the practice of AR technology applied to fine art education, a variety of educational pedagogy are interrelated and mutually supportive, and together they construct a systematic theoretical framework that provides a comprehensive theoretical basis for the effective use of AR technology. According to Figure 8, the relative importance and application frequency of these theories in the application of AR technology to art education varies, with Situated Learning Theory occupying the most prominent position with the highest number of applications (ID2,45,62,64,70,81), which suggests that Situated Learning Theory has a significant role in the use of AR technology to provide significant advantages in authentic learning contexts, which can effectively promote students' application of art knowledge in real-world environments and enhance their practical abilities (ID 63).

Constructivist Learning Theory (ID 2, 45, 59, 64 79) followed, which emphasizes the construction of knowledge through practice and exploration. Based on the constructivist theory, AR technology was used to simulate real-life situations, such as a photography studio (ID2) and a fashion design scene (ID45), so that students could actively explore and learn in practice, thus deepening their understanding and mastery of art knowledge. ARCS Motivation Theory (ARCS) was applied the third most times, indicating significant results in motivating students to learn by eliciting attention, increasing content relevance, and enhancing self-confidence and satisfaction. This provides important motivational support for subsequent learning activities. ID3, 12, 18, and 36 have used ARCS motivation theory to design and evaluate AR applications.

Other educational pedagogies are also distinctive and offer different support for the use of AR technology in fine art education. But there are also 46 articles that do not explicitly mention specific educational theories. Although these literatures do not explicitly mention specific educational theories, their research contents and methods provide rich practical experiences and references for the application of AR technology in art education. Future studies can further explore the educational theories behind these practices to better guide the application of AR technology in fine art education.

Literature Review Pattern

In this literature review, a total of 90 related literatures were sorted out, and their research paradigms were mainly categorized into Empirical (Empirical) and Theoretical/Synthesis (Theoretical/Synthesis) (see Figure 9). Among them, the Empirical research paradigm is the most widely used and accounts for the highest proportion, involving a total of 82 pieces of literature. These studies quantitatively or qualitatively assessed the effects of AR technology in fine art education through experimentation, observation, and data analysis. In contrast, the theory/synthesis research paradigm covers a total of 8 documents (ID 14, 25, 57, 64, 65, 73, 84, 87), which mainly focuses on the in-depth analysis of the existing literature as well as the construction of the theoretical framework, providing solid theoretical support and a clear development direction for the application of AR technology in fine art education.

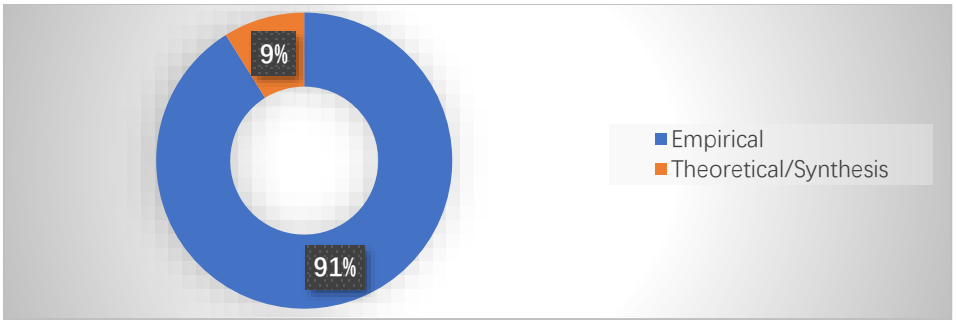

Figure 9: Research categories.

In this study, 82 empirical research papers were systematically reviewed, analyzed and summarized. At the methodological level, these empirical studies cover four types: quantitative research (n=24), qualitative research (n=22), mixed methods research (n=26), and research and development (n=10) (see Figure 10). Of these, the methodology of research and development is noteworthy. Unlike traditional research methods, the research and development methodology are similar to the development process in the computer science discipline, which is less common in the liberal arts. This phenomenon suggests that interdisciplinary research is emerging and its number is growing.

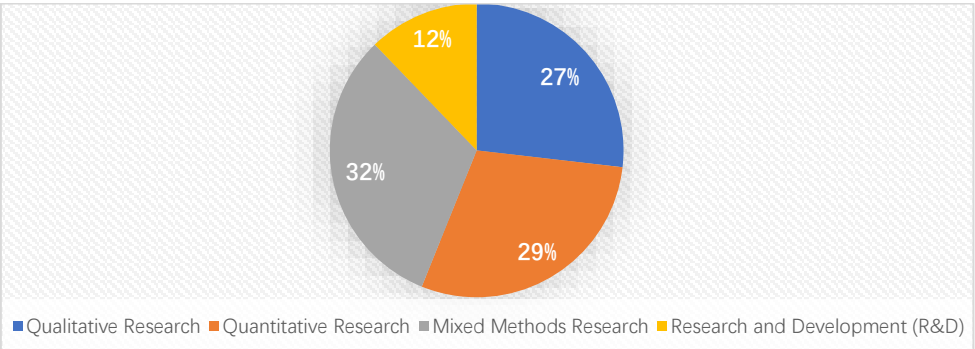

Figure 10: Types of studies

This study systematically analyzed 82 empirical literatures on AR in fine art education. Quantitative research (24 articles, 29.2%) mainly used experimental design (n=20, e.g., pre-posttests to assess learning outcome enhancement; ID18,27,48) and questionnaires (n=17) to measure AR's effects on learning effectiveness, motivation, and cognitive load (ID70). Qualitative research (22 articles, 26.8%) explored AR application experiences via case studies (n=10), interviews (n=9), observations (n=14), and group discussions (n=6). Mixed methods research (26 articles, 31.7%) combined both approaches, using questionnaires (n=17), experiments (n=15), etc., to assess outcomes (quantitative) and explore experiences (qualitative), e.g., ID3 (control group experiments and observations) found AR boosted attention, while ID33 (teacher questionnaires) noted equipment/ training gaps. Research and development approach focused studies (10 articles, 12.2%) emphasized system development, using questionnaires (n=7), experiments (n=3), etc., for AR application development and validation.

This study categorized sample sizes of 82 empirical AR in fine art education literatures (Figure 11). 22 papers (e.g., ID1,4,13) omitted specific sample sizes, focusing on tech development or qualitative user experience rather than quantitative assessment. 32 articles had samples less than 30 (e.g., ID8,9,10), mostly preliminary/pilot studies that, despite limitations, laid groundwork for large-scale research. Nineteen papers (e.g., ID2,3,5) had samples of 30–100, enabling reliable statistical analysis of AR's effects on motivation, performance, and cognitive load. Seven literatures (e.g., ID11,21,31) had samples more than 100, verifying AR's advantages via rigorous design, aiding policy and practice.

Sample size distribution

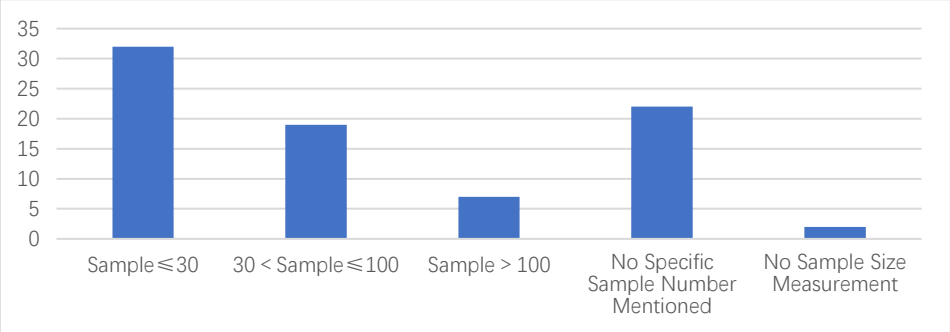

Figure 11: Sample of Studies

Data collection and analysis methods

In this study, the selection of data collection tools varied depending on the research methodology. In order to comprehensively sort out these tools and their applications, this study summarizes all the data collection tools and summarizes the analysis methods used. As shown in Figure 12, these tools are mainly classified into the following categories: questionnaires, tests, observations, interviews, records of group discussions, and other more decentralized tools, the latter of which will not be listed one by one because they are too widely distributed.

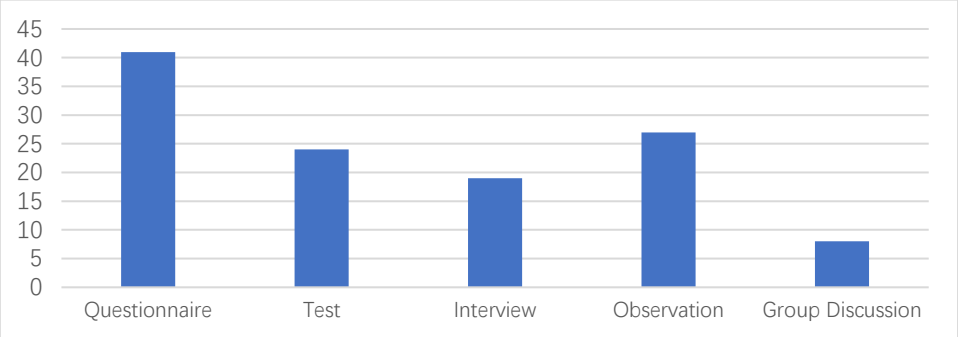

Figure 12: Data Collection

Questionnaires, as the most common method of collecting self-reported data from learners (Luo et al., 2021), featured prominently in the 82 empirical papers, with 41 using this method. These studies focused on collecting student feedback through questionnaires to assess the impact of AR technology in different areas. In addition, test/quiz methods were applied in 24 literatures, including art skill tests and knowledge tests, etc. These tests were mainly used to quantitatively assess the improvement of students' abilities after receiving AR art instruction, as well as the impact of AR technology on students' learning outcomes.

The interview method is also widely used in qualitative, mixed, and R&D studies, with a total of 19 papers employing this method. These studies collected students' feedback through interview guides to assess in-depth the experience of applying AR technology, and found that AR technology can effectively increase students' learning interest and engagement. Meanwhile, the observation record method was used in 27 pieces of literature, and these studies assessed the application effect of AR technology through observation records, especially observing students' behavioral performance in the AR art classroom. Finally, group discussion records are reflected in 8 literatures, which are mainly used to obtain the feedback, feelings and opinions of the samples, so as to understand the application effect of AR technology more comprehensively.

In terms of data analysis, this study includes both quantitative and qualitative analysis, and the specific statistical methods are shown in Figure 13. In quantitative statistics, descriptive statistical analysis (n=31) and difference test (n=34) are the most commonly used methods, which can help researchers to understand the data distribution and differences between groups initially. In addition, correlation statistics (n=5) can provide more in-depth analysis results. Among the tests of variance, common methods include t-test (n=18), analysis of variance (ANOVA) (n=12), and analysis of covariance (ANCOVA) (n=4). These methods provide researchers with diverse analytical tools to reveal the impact of AR technology on student learning outcomes. Correlation statistics, on the other hand, included correlation analysis (n=2) and regression analysis (n=3), which further revealed the relationship between variables. In qualitative data analysis, the main methods include qualitative descriptive analysis (n=7), content analysis (n=7), thematic analysis (n=6), and case study analysis (n=5). These methods can help the researcher dig deeper into the meaning behind the data and reveal the experience and effect of AR technology in art

education. Through these qualitative analysis methods, the researcher was able to gain a more comprehensive understanding of students' acceptance and experience of using AR technology.

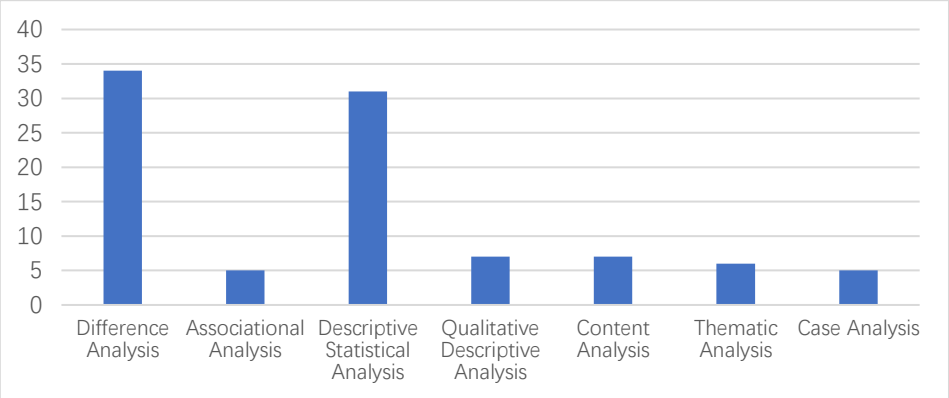

Figure 13: Data Analysis Methods

Research findings and results

The findings were summarized through a systematic analysis of 82 empirical papers. As shown in Figure 14, the main findings of AR technology in art education were categorized into the following five categories.

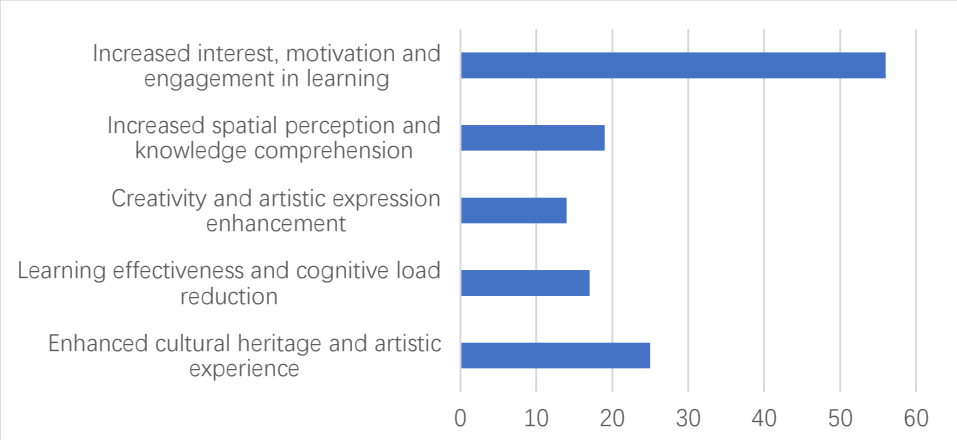

Figure 14: Research Finds and Results

56 studies indicate AR boosts students' learning interest, motivation, and engagement via immersive, interactive experiences. For example, stimulating interest and satisfaction in design, photography, and architecture through real-time feedback (ID3,12,18,22,27,36,42,45,70). 19 papers highlight AR's strength in enhancing spatial perception, aiding understanding of 3D spatial/perspective principles via real-time 3D model display (ID4,16,24,50,54,56,83). 14 studies show AR fosters creativity and artistic

expression through virtual-real integration, such as virtual model superimposition (ID3,6,35,66,89) or transforming plastic waste into art (ID66). 17 articles confirm AR improves learning effectiveness and reduces cognitive load, with AR serious games outperforming traditional methods (ID36) and EEG data validating emotional state improvement (ID90). 25 papers note AR enhances cultural heritage/artistic experiences, e.g., aiding batik learning (ID8,15,61,84), deepening engagement with Qingming Shanghe Tu (ID44), and enabling immersive prehistoric rock art experiences (ID63).

Discussion

This systematic review examined 90 empirical studies on the application of augmented reality in fine arts education from 2015 to 2024 worldwide. The findings reveal several key patterns and gaps that hold pedagogical significance and practical relevance.

Practical implications of AR in fine arts education

AR technology has demonstrated strong potential to enhance teaching and learning across various subfields of fine arts, particularly in art appreciation (32.22%), design (26.67%), and drawing (12.22%). Its ability to visualize abstract concepts, simulate artistic processes, and foster immersive engagement aligns well with constructivist and experiential learning theories. For example, Back et al. (2019) showed that AR-supported art appreciation enabled learners to interact with historical artworks in context-rich environments, enhancing both comprehension and emotional connection.

Moreover, AR applications have proven effective in developing students' spatial perception, creativity, and technical skills, especially in domains such as architectural design, photography, and 3D modeling. These outcomes are consistent with studies in other disciplines (e.g., Chu et al. (2021) suggesting that AR's motivational and cognitive benefits are transferable across educational contexts.

Importantly, AR has been adopted across all educational stages, from preschool to higher education and informal learning environments. The relatively high adoption rate in informal settings (24.44%), such as museums and galleries, which highlights AR's role in extending learning beyond traditional classrooms. In early childhood and primary education, AR's gamified and interactive features have been shown to significantly boost learner engagement (Chen & Mokmin, 2024).

Technological Trends and Challenges

Mobile devices (used in 53 studies) remain the dominant hardware for AR delivery due to their accessibility and affordability. Unity 3D and Vuforia are the most common development platforms, offering robust tools for AR content creation. However, technical limitations persist. Studies (e.g., ID7, ID71) report issues such as motion sickness from head-mounted displays (HMDs), user distraction, and interface complexity. These findings underscore the need for user-centered design and cost-effective solutions tailored to educational contexts. Notably, 26 studies did not specify their development platforms, and 11 omitted device details, which raising concerns about reproducibility and transparency. Future research should prioritize clearer reporting standards and explore cross-platform

compatibility to enhance scalability.

Gaps in Educational Theory Integration

While some studies grounded their AR interventions in theories such as contextual learning (6 studies), constructivism (5), and ARCS motivation theory (4), nearly half (46 studies) lacked explicit pedagogical frameworks. This absence may reflect a disconnect between technical development and instructional design. As Masalimova et al. (2023) and Cabero-Almenara et al. (2022) argue, theory-driven approaches are essential for meaningful integration of technology into learning environments. Future research should emphasize interdisciplinary collaboration to bridge this gap and develop AR applications informed by robust educational models.

Methodological Insights and Limitations

Experimental designs and mixed-methods approach dominate the reviewed literature, with questionnaires (41 studies), tests (24), and observations (27) as common data collection tools. However, sample sizes tend to be small ($n \leq 30$ in 32 studies), and 22 studies did not report sample sizes at all, which limiting generalizability. Longitudinal studies and larger, more diverse samples are needed to assess sustained impact and contextual variability.

The research and development (R&D) paradigm, though less common (12%), offers a promising framework for iterative design and evaluation of AR tools. Its structured approach mirrors software development cycles and could facilitate more effective integration of AR into fine arts curricula.

Research gap and recommendation for future

Despite the breadth of research analyzed, several significant gaps remain. The present review adopts a global scope without applying country-specific inclusion criteria, enabling a comprehensive mapping of augmented reality (AR) applications in fine-arts education worldwide. Geographically, research output is unevenly distributed: Central Asia, Africa, and Latin America collectively represent less than 1% of studies, indicating a strong regional imbalance. This disparity highlights a need for more inclusive global participation and cross-cultural examination of AR's pedagogical potential. The contextual absence of these regions limits our understanding of how sociocultural, infrastructural, and policy differences mediate AR adoption in arts education.

The second major gap concerns the lack of explicit theoretical integration. Nearly half of the studies reviewed did not reference any learning theory, which restricts their generalizability and theoretical coherence. Strengthening theory-driven design will enable researchers to explore not only whether AR works but how and why it transforms artistic learning. Future studies should combine educational theories, which constructivism, experiential learning, embodied cognition, and motivation theory, to articulate multidimensional models of AR-supported art education.

A third gap lies in methodological and temporal limitations. A considerable proportion of studies employed small sample sizes ($n \leq 30$ in 32 studies) or omitted this information entirely (22 studies), constraining the robustness and reproducibility of findings. Future

research should adopt larger, more diverse samples and longitudinal designs to examine sustained impacts on creativity, critical thinking, and artistic identity. Moreover, follow-up evaluations and iterative feedback loops between development and pedagogy are essential to ensure that AR applications evolve through authentic classroom use rather than remaining experimental prototypes.

The early appearance of co-applied Artificial Intelligence (AI) and AR systems (Cheng, 2023; Hai-Jew, 2024; Miralay, 2024; Wang, 2024) indicates a new direction for fine arts education. The fusion of AI's adaptive intelligence with AR's immersive visualization offers possibilities for personalized learning, real-time feedback, and automated art critique. This integration could enable students to explore not only aesthetic form but also algorithmic creativity, which bridging human artistry and computational generation. However, such progress demands interdisciplinary collaboration between technologists, artists, and educators, as well as ethical awareness regarding authorship and creative agency.

The future of AR in fine arts education will depend on the co-development of layered, customizable AR tools that teachers can adapt to different artistic disciplines and student needs. This aligns with Unesco (2024b) call for integrating technology into arts curricula, strengthening teacher training, and ensuring equitable digital access. The convergence of AR and AI technologies thus holds the potential to transform art education into a more inclusive, dynamic, and reflective learning ecosystem, where technology serves creativity rather than dictates it.

This study also has its limitations. For example, the reviews were very selective and we only selected journal articles from three reputable databases just to ensure quality in order to focus and tighten the papers. A more comprehensive review is aimed at in the future, possibly expanding the scope and focusing on groundbreaking developments in future technologies and devices for AR technology.

Conclusion

This systematic review synthesized a decade of empirical research on the application of augmented reality in fine arts education, encompassing 90 studies across diverse educational settings, technological platforms, pedagogical frameworks, and methodological approaches. The findings confirm that AR has become an increasingly influential tool in fine arts instruction, particularly in art appreciation, design, and drawing, with mobile devices and Unity-based platforms serving as the dominant technological enablers. Despite its growing adoption, the review reveals several critical gaps. Nearly half of the studies lacked explicit pedagogical grounding, and many relied on small or unreported sample sizes, limiting the generalizability of their findings.

Furthermore, long-term evaluations and cross-cultural implementations remain underexplored, especially in underrepresented regions such as Central Asia, Africa, and Latin America. To advance the field, future research should prioritize theory-driven design, larger and more diverse samples, and longitudinal studies that assess sustained impact. The integration of AR with emerging technologies such as artificial intelligence also presents promising avenues for personalized and immersive learning experiences. Practically, educators and developers must collaborate more closely to ensure that AR tools

are not only technically robust but also pedagogically meaningful and adaptable to varied educational contexts.

In conclusion, AR technology holds significant promise for transforming fine arts education. By addressing current limitations and embracing interdisciplinary innovation, future efforts can unlock its full potential to enrich artistic learning and expand access to creative expression worldwide.

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