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Postgraduate education system as an environment for the development of digital competence of an art teacher

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Abstract. The article analyzes scientific approaches to interpreting the concepts of "digital competence" and "digital competence of an art teacher". It examines the core characteristics of digital competence as defined in domestic regulatory documents and explores various researchers' perspectives. Based on this analysis, the study identifies and describes the key components of a modern art teacher's digital competence: cognitive, operational-activity, and value-motivational. Digital competence is defined as a dynamic combination of knowledge, skills, and value orientations that enable teachers to effectively and critically utilize digital technologies in their professional artistic-pedagogical activities. The paper focuses on the primary areas of digital competence implementation based on the DigCompEdu framework and describes the experience of training art teachers through formal, non-formal, and informal education. Special attention is paid to the challenges art teachers face in developing digital competence, including infrastructure limitations, age-related barriers, and the impact of wartime conditions on Ukrainian education. The study analyzes the role of postgraduate education in developing art teachers' digital competence and establishes that the postgraduate educational environment facilitates continuous professional growth and fosters readiness to integrate digital technologies into artistic-pedagogical activities. The article discusses the implications of recent developments in artificial intelligence tools for art education and identifies directions for future research in the context of post-pandemic digital transformation and ongoing educational challenges in Ukraine.

Keywords: postgraduate education system, advanced training, digital technologies, digital competence, art teacher, DigCompEdu, professional development

1. Introduction

Education systems worldwide are undergoing digital transformation. Postgraduate teacher education has emerged as a critical site for professional development, where teachers develop competencies needed for contemporary practice. The postgraduate education system supports continuous professional growth for pedagogical workers. Research shows that teacher preparation quality for implementing digital innovations depends on both professional development levels and digital competence [6, 13].

Art teachers require specialized preparation that differs from other subject areas. Teaching visual arts involves studio practice, material exploration, and aesthetic judgment – dimensions that digital transformation affects uniquely. Developing digital competence for art teachers thus presents distinct challenges that warrant focused investigation.

Since February 2022, Ukraine's education system has faced unprecedented challenges due to Russia's full-scale invasion. Over 2,000 educational institutions have been damaged or destroyed, and millions of students and teachers displaced [23]. Distance and hybrid learning became necessities rather than choices, accelerating digital transformation while exposing gaps in infrastructure and teacher preparedness [2]. Art teachers faced additional challenges: practical subjects requiring hands-on instruction needed reimagining for online delivery, and access to specialized equipment

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and materials became limited.

Understanding digital competence development in postgraduate education is crucial for several reasons: it directly impacts the quality of art education; it affects teachers' ability to adapt to changing educational environments; it influences students' digital literacy development; and it contributes to the broader digital transformation of education in Ukraine.

The potential of postgraduate education for developing digital competence remains underutilized. This study examines how art teachers' digital competence can be developed through postgraduate education, addressing a gap in both Ukrainian and international literature.

This study addresses the following *research questions*:

1. How is the concept of "digital competence of an art teacher" defined in the scientific literature and regulatory documents?
2. What are the main components of digital competence for modern art teachers?
3. What effective forms of training exist for developing art teachers' digital competence in postgraduate education?
4. What challenges do art teachers face in developing digital competence, particularly in the current Ukrainian context?

2. Literature review

2.1. Digital competence frameworks and art education

The concept of "digital competence" has become a defining characteristic of teachers' professional development in the digital era. Research distinguishes multiple dimensions: cognitive (knowledge and understanding), operational (skills and practices), and attitudinal (values and dispositions) [7, 36]. The European Framework for the Digital Competence of Educators (DigCompEdu) provides a comprehensive model encompassing six competence areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence [6, 13]. Recent scholarship emphasizes that digital competence is not merely technical proficiency but encompasses complex motivational, attitudinal, and value-based components [15, 32].

However, applying general competence frameworks to art education requires critical adaptation. Art teachers' digital competence differs fundamentally from other disciplines in several respects. First, art education involves visual literacy – the ability to interpret, negotiate, and make meaning from visual content – which digital technologies transform significantly [3]. Second, artistic practice centers on material engagement and embodied knowing; digital competence must bridge traditional craft skills with digital production methods [29]. Third, aesthetic judgment in digital contexts raises unique questions: How do teachers assess student work when AI contributes to visual output? What constitutes originality in AI-assisted art? [37]. These art-specific dimensions – visual literacy, material practice, aesthetic judgment, and creative process – remain underexplored in the digital competence literature, which predominantly addresses general education contexts.

Ukrainian scholarship has contributed significantly to understanding digital competence development in postgraduate education [20, 24, 31]. This body of work highlights conditions for developing digital skills through continuous professional development, emphasizing the role of postgraduate institutions in supporting teacher growth.

2.2. Post-pandemic and wartime education context

The COVID-19 pandemic accelerated teacher digital competence development globally, exposing significant gaps in preparedness and infrastructure. Research demonstrates that teachers with higher digital competence adapted more successfully to remote teaching, while those with limited digital skills struggled with basic technological requirements [8]. Post-pandemic, attention shifted

from emergency remote teaching to sustainable digital pedagogy integration [16]. For art education specifically, the transition required reconceptualizing studio-based pedagogy for virtual environments – challenges that persist as hybrid models become normalized.

Ukraine's wartime context since February 2022 has created conditions of educational resilience that are instructive for understanding digital competence development under crisis. Art teachers faced compounded challenges: practical subjects requiring hands-on instruction needed reimagining for online delivery, while access to specialized equipment and materials became severely limited [2]. The Ukrainian experience highlights particular dimensions of digital competence development under crisis conditions: infrastructure instability necessitates asynchronous and offline-capable solutions; psychological trauma affects technology adoption patterns; and professional development must address both technical skills and psychological resilience [33]. These contextual factors differentiate Ukrainian art education digital transformation from parallel processes in more stable settings.

2.3. Generative AI in art education

The emergence of generative AI tools since late 2022 has introduced unprecedented challenges for art teacher digital competence. Unlike general educational applications, AI in art education directly engages creative production – generating images from text prompts, enhancing artistic workflows, and enabling new forms of digital expression [30]. This raises fundamental questions about authorship, originality, and creative skill development that do not arise in other disciplines.

For art teachers, AI competence encompasses both technical proficiency (understanding prompt engineering, AI tool capabilities and limitations) and critical ethical reasoning (assessing when AI assistance undermines skill development, navigating attribution and authorship questions, evaluating AI-generated content for artistic quality). Recent frameworks distinguish between AI literacy (understanding how AI works) and AI fluency (effectively integrating AI into professional practice) [22]. Art teachers require both, plus an additional dimension: aesthetic judgment about AI's role in creative practice.

The pedagogical implications remain contested. Some argue AI tools democratize creative production, enabling students without traditional drawing skills to create visually compelling work [25]. Others contend that AI-mediated creation undermines foundational skill development and aesthetic judgment. Art teachers must navigate these tensions, developing frameworks for appropriate AI use that preserve artistic learning goals while preparing students for technologically-mediated creative practice [27]. Professional development programs increasingly address these challenges, though research on effective AI integration strategies for art education is still developing [12].

2.4. Theoretical framework: Art-TPACK

The integration of digital competence frameworks with art education theory requires bridging general educational technology models with discipline-specific epistemology. We propose an Art-TPACK framework that extends Mishra and Koehler's Technological Pedagogical Content Knowledge model [19] for art education contexts. This framework informs the three-component model of digital competence developed in section 4.1.

The Art-TPACK framework reconceptualizes the three foundational knowledge domains:

1. *Technological Art Knowledge (TAK)* encompasses understanding digital tools specific to artistic creation – drawing tablets, design software, generative AI platforms, 3D modeling applications – and their affordances for creative practice. Unlike general technological knowledge, TAK requires understanding how digital tools interact with artistic media: the difference between vector and raster imaging for illustration, the implications of AI-generated imagery for creative authorship, the material qualities of digital vs. traditional media.

2. *Pedagogical Art Knowledge (PAK)* involves methods for teaching visual literacy, facilitating critique, and supporting creative process in digital environments. This includes portfolio

pedagogy, studio critique formats adapted for online contexts, and formative assessment approaches for process-oriented creative work. Art pedagogy centers on the "studio habit of mind" [14] – observing, reflecting, exploring, expressing – which requires adaptation for digital contexts.

3. *Content Art Knowledge (CAK)* covers art history, aesthetic theory, contemporary practice, and visual culture studies in relation to digital media. This includes understanding how digital technologies have transformed artistic practice, from digital painting to generative art to NFT markets. Critical content knowledge enables teachers to contextualize digital tools within broader artistic traditions and contemporary discourse.

The intersection of these domains generates art-specific digital competencies that differ qualitatively from general educational technology integration. Eisner [10] argues that art education involves not merely skill acquisition but development of aesthetic judgment, visual literacy, and material intelligence. Digital competence in art education must therefore encompass critical engagement with digital media as artistic medium, not merely as pedagogical tool. Specifically, the cognitive component of digital competence (section 4.1) develops from TAK and CAK; the operational-activity component develops from the intersection of PAK and TAK; and the value-motivational component addresses the ethical and aesthetic questions raised by digital art practice.

3. Methodology

This study employs a conceptual framework development approach to address the research questions. The methodology integrates integrative literature review with policy document analysis and framework synthesis, following established approaches for developing theory-informed conceptual models in educational research [6]. Two illustrative cases from professional development practice are examined to ground the framework in observed implementation experience.

A literature search was conducted across Scopus, Web of Science, and ERIC databases for the period 2019–2025. Search terms included: "digital competence" AND ("art education" OR "art teacher" OR "visual arts"), "teacher digital competence" AND "professional development", "DigCompEdu" AND "subject-specific", and "generative AI" AND "art education". Sources were selected based on relevance to the research questions, with particular attention to empirical studies on teacher digital competence, framework analyses, and policy documents from governmental and international bodies. Reference lists of key sources were hand-searched to identify additional relevant works.

Ukrainian regulatory documents were analyzed: Professional Standard for Teachers of General Secondary Education [17], Concept of Digital Competence Development [18], and New Ukrainian School Concept [5]. European framework documents (DigComp 2.2 [35], DigCompEdu [26]) were examined using thematic content analysis to identify competence components relevant to art education.

The conceptual framework was developed through iterative synthesis: identifying general digital competence components from DigCompEdu; mapping these against art education literature; identifying gaps requiring art-specific adaptation; and proposing the Art-TPACK extension with art-specific dimensions. The framework was refined through iterative comparison with empirical findings from the literature.

The two illustrative cases presented in section 4.4 draw on the author's direct observation of professional development programs at the Institute for Digitalisation of Education and are intended to ground the conceptual framework in practice rather than to constitute independent empirical claims.

4. Results

The postgraduate education system in Ukraine has traditionally performed three functions: compensatory (eliminating gaps in basic pedagogical education), adaptive (operational reorientation

to changes in education and society), and developmental (enhancing general cultural development and satisfying professional needs of educators) [9]. Today, postgraduate education is viewed as a dynamic educational environment that ensures continuous professional development, promotes key competency formation – including digital competencies – and responds to digital transformation challenges [4]. For art teachers, this system provides the primary institutional pathway for developing digital competence, addressing the unique epistemological requirements of visual arts pedagogy through formal courses, non-formal programs, and informal professional networks.

4.1. Components of digital competence for art teachers

Based on the analysis of researchers' views and considering the characteristics and specifics of artistic-pedagogical activity, digital competence of an art teacher is understood as a dynamic combination of knowledge, skills, and value orientations that ensure the teacher's ability to effectively and critically use digital technologies in professional artistic-pedagogical activity. As outlined in the Art-TPACK framework (section 2.4), these components are grounded in the intersecting knowledge domains of TAK, PAK, and CAK.

Figure 1 presents the main components of modern art teachers' digital competence.

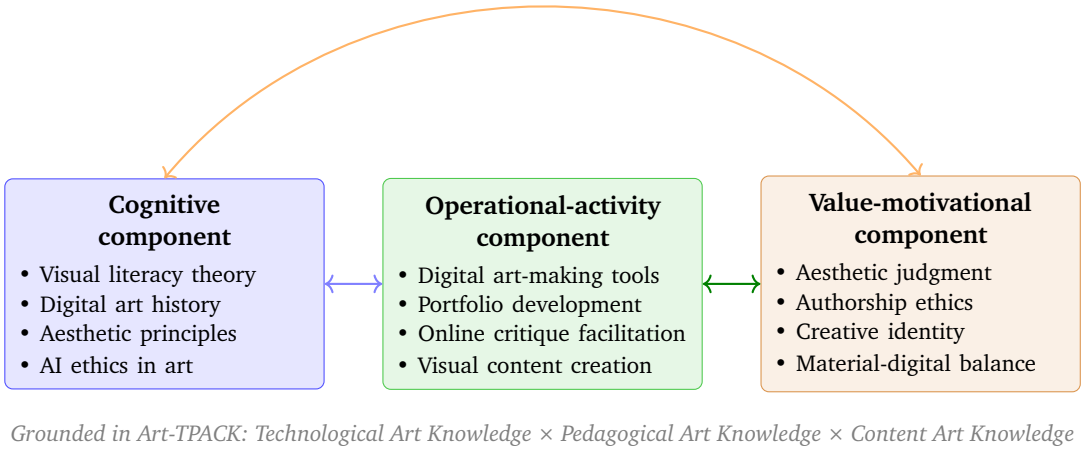

Figure 1: Art-specific digital competence framework integrating cognitive, operational, and value dimensions with Art-TPACK grounding.

The *cognitive component* comprises theoretical knowledge essential for art education in digital contexts: visual literacy theory, digital art history, aesthetic principles for evaluating digital work, and ethical considerations specific to AI in art. Grounded in TAK and CAK, this component forms the intellectual foundation for art teachers' activity in the digital environment, enabling informed decisions about when and how to integrate technology into artistic practice.

The *operational-activity component* encompasses digital skills specific to art education: proficiency with digital art-making tools (drawing tablets, design software, 3D applications), portfolio development and digital curation, facilitation of online critique sessions, and creation of visual educational content. Arising from the intersection of PAK and TAK, these competencies require understanding how digital tools interact with artistic media and creative process, rather than generic tool proficiency.

The *value-motivational component* addresses attitudes and dispositions specific to art education: aesthetic judgment in evaluating digital and AI-generated work, ethical reasoning about authorship and appropriation, creative identity in relation to technology, and orientation toward balancing material and digital artistic practice. Rooted in the ethical and aesthetic questions raised by digital art practice, this component guides teachers' decisions about when technology enhances versus undermines artistic development.

4.2. Directions and conditions for implementation

For art teachers, the application of DigCompEdu requires significant adaptation to address the unique epistemology of artistic practice. While the framework provides general guidance across six competence areas, art teachers need specialized digital capabilities that engage with visual literacy, material practice, aesthetic judgment, and creative process [10, 14]. Table 1 presents art-specific digital competence dimensions that extend the DigCompEdu framework.

Table 1
Art-specific digital competence dimensions.

Dimension	Art-specific competencies
Visual literacy	Critical analysis of digital images; understanding visual rhetoric; evaluation of image authenticity and manipulation
Material practice	Integration of traditional and digital media; understanding materiality in digital art; bridging tactile and digital experience
Aesthetic judgment	Evaluating AI-generated vs. human-created art; establishing digital aesthetics criteria; portfolio curation and critique
Creative process	Supporting iterative digital creation; managing digital creative workflows; documenting artistic process digitally
Critical making	Understanding authorship and originality in remix culture; navigating digital appropriation and attribution; developing ethical frameworks for student use of found and AI-generated imagery

These art-specific dimensions extend the six DigCompEdu competence areas [21, 26] with discipline-specific knowledge and skills. Professional engagement in art education includes participating in digital artist communities and navigating online gallery platforms. Digital resources encompasses creating and curating visual content, managing digital image archives, and evaluating source credibility for visual materials. Teaching and learning involves facilitating studio critique in online environments, demonstrating digital art-making techniques, and supporting students' development of digital portfolios. Assessment includes evaluating creative process documentation, providing formative feedback on digital works-in-progress, and developing criteria for AI-assisted creative work. Empowering learners addresses supporting diverse creative voices, providing accessible digital art tools, and fostering critical engagement with visual culture. Facilitating learners' digital competence means developing students' visual literacy, ethical image use practices, and critical evaluation of AI-generated content.

Implementation of these competencies in postgraduate education requires specific conditions [28, 34]: digitalization of education with supporting regulatory documents; institutional readiness of postgraduate education to ensure digital competence formation; adequate IT infrastructure; and high-quality instructor preparation for professional development courses. These conditions enable the translation of competence frameworks into practical training programs.

4.3. Forms of professional development

Postgraduate education acts as a specific environment that allows gradual development of art teachers' digital competence. Figure 2 presents the structural elements of the specialized educational environment in postgraduate education that supports this development.

In formal education, practical forms include professional development courses at postgraduate education institutes, special courses, and short-term thematic training oriented toward teachers' use of digital tools. In non-formal education, effective forms include distance and online learning, Massive Open Online Courses (MOOCs) on platforms such as Prometheus, EdEra, and Coursera. In informal education, innovative and gamified forms have become widespread, such as digital camps (EdCamps), informal conferences, and hackathons for educators aimed at creating educational IT projects within limited time.

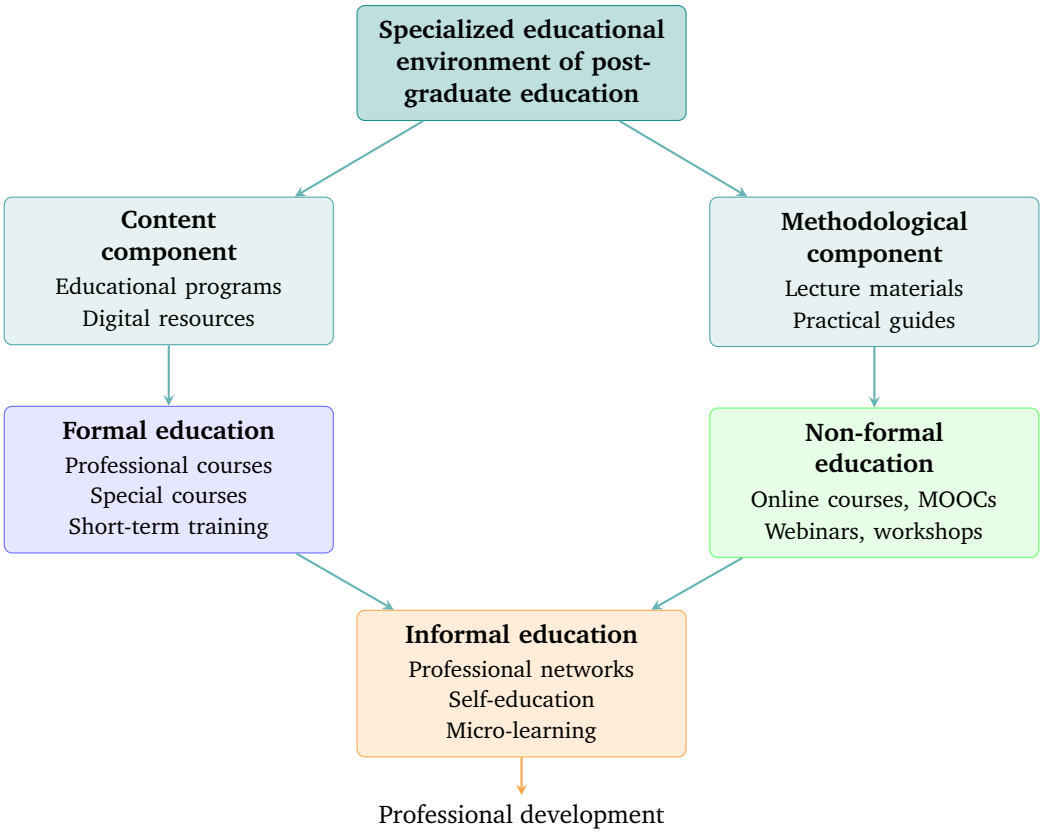

Figure 2: Structural elements of the educational environment of postgraduate education for developing digital competence.

Professional communities provide critical infrastructure for informal learning. Facebook communities such as the UNESCO project "Community of Modern Teachers and Psychologists" facilitate peer knowledge exchange, while Viber and Telegram channels enable rapid sharing of methodological resources. These informal networks have proven particularly valuable during wartime disruptions, when formal professional development may be interrupted.

4.4. Case studies: professional development approaches

Two illustrative cases, drawn from the author's observation of professional development programs at the Institute for Digitalisation of Education, demonstrate the implementation of digital competence development for art teachers in the Ukrainian context. They highlight both opportunities and challenges encountered in practice.

Case study 1: GenAI integration in art teacher professional development. A professional development course at the Institute for Digitalisation of Education introduced art teachers to generative AI tools for creative practice. Observation of implementation revealed key challenges: teacher resistance to AI-assisted creativity, with participants questioning whether AI use constituted "real" art; difficulty assessing student work when AI contributed to visual output; and the need for ethical frameworks to guide appropriate AI use. Participant questions included: "How do we distinguish student creativity from AI generation?" and "What constitutes original work in AI-assisted art?" The course demonstrated that art teachers require not only technical AI literacy but also philosophical frameworks for authorship and assessment.

Case study 2: All-Ukrainian digital skills webinars. Annual webinars reaching art teachers across Ukrainian regions demonstrated practical digital tool integration for artistic practice. Observation

revealed differentiated needs: rural teachers face infrastructure barriers limiting tool adoption; urban teachers seek advanced applications and specialized software; experienced teachers prefer workshop formats over lecture presentations. Analysis suggests that effective professional development must account for regional infrastructure disparities and experience-based preferences in learning format. The webinars illustrated how informal professional development can scale reach while maintaining relevance across diverse contexts (figure 3).

Figure 3: All-Ukrainian webinars for art teachers: practical digital tool integration.

5. Challenges and barriers

While postgraduate education offers numerous opportunities for digital competence development, art teachers face significant challenges across several interconnected dimensions. The wartime context since February 2022 has intensified all of these, and several adaptive strategies have emerged in response.

5.1. Infrastructure, resources, and wartime adaptation

Rural schools often lack adequate internet connectivity, hardware, and software necessary for implementing digital tools in art education, a divide exacerbated by wartime infrastructure damage. Art education requires specialized tools beyond general educational technology – digital drawing tablets, design software licenses, and discipline-specific applications – and budget limitations often prevent their acquisition. In response, art teachers have adopted free, open-source alternatives such as Krita and Inkscape when commercial licenses become unaffordable, and developed low-bandwidth or offline-capable resources and portable creative workflows. Mobile-first approaches allow students to continue work during infrastructure interruptions. Some institutions have established distributed backup systems, with course materials hosted on multiple platforms to ensure continuity during attacks on infrastructure.

Displacement of teachers and students – both internally and internationally – creates additional challenges for accessing Ukrainian-language professional development. Digital communities have become crucial for maintaining pedagogical continuity: the Facebook community “Community of Modern Teachers and Psychologists” has reported increased participation from displaced educators seeking connection and resources, and cross-border collaboration has emerged as Ukrainian teachers in diaspora share strategies with those remaining in-country.

Economic hardship and supply chain disruptions compound resource scarcity. Constraints-driven innovation in this context may inform post-war resource planning and offers lessons for resource-limited contexts more broadly. An unexpected pedagogical development has also emerged: students have begun using digital tools to document cultural heritage under threat, creating new contexts for digital competence that connect technical skill with cultural preservation.

5.2. Age and experience gaps

Research indicates that older teachers and those with longer teaching experience often exhibit lower levels of digital competence and greater resistance to technology adoption [1]. Some experienced teachers view new technologies as an additional burden rather than an enhancement to pedagogical practice. Addressing these gaps requires differentiated professional development approaches that account for varying starting points and learning preferences, including workshop formats preferred by more experienced practitioners.

5.3. Psychological dimensions

Trauma affects technology adoption patterns. Research indicates that educators under stress may resist complex new systems while accepting simple, immediately useful tools [2]. Professional development programs have incorporated psychological support components alongside technical training. The relationship between digital competence and psychological resilience warrants further investigation: digital competence may support resilience by expanding available pedagogical options, while resilience in turn may enable more adventurous digital adaptation.

5.4. AI integration challenges

The rapid emergence of generative AI tools presents particular challenges for art education. Unlike other disciplines where AI may assist with problem-solving or writing, art education centers on creative production and aesthetic judgment. When AI generates images from text prompts, the traditional relationship between student skill development and creative output becomes disrupted: students may produce visually compelling works without developing foundational drawing, composition, or color theory skills.

Teachers face assessment dilemmas: How should work be evaluated when students contribute curatorial decisions rather than manual execution? What criteria distinguish AI-assisted work from AI-generated work? How do teachers assess student creative intention when the algorithm mediates visual output? These questions require reconceptualizing art assessment frameworks [25]. Professional development must address not only technical AI literacy – understanding how generative models work, their limitations, and potential applications – but also ethical reasoning about authorship, attribution, and creative integrity [27]. Art teachers need pedagogical strategies that integrate AI tools while preserving skill development and fostering critical judgment about AI-generated content.

6. Discussion

6.1. Interpretation of findings

This study addressed four research questions concerning the definition, components, training forms, and challenges of art teachers' digital competence development through postgraduate education.

Regarding **definition** (RQ1), the literature reveals that digital competence for art teachers encompasses discipline-specific dimensions – visual literacy in digital contexts, material practice bridging traditional and digital media, aesthetic judgment of AI-generated content, and critical making navigating authorship and attribution – that are not captured by applying general teacher digital competence frameworks directly to an art context. The Art-TPACK framework proposed in section 2.4 provides a theoretical grounding for these competencies by integrating technological art knowledge, pedagogical art knowledge, and content art knowledge.

Regarding **components** (RQ2), the three-component model integrates with Art-TPACK to address the unique epistemology of artistic practice, as elaborated in section 4.1. Each component maps to distinct knowledge domains: the cognitive component to TAK and CAK; the operational-activity

component to the PAK–TAK intersection; and the value-motivational component to the ethical and aesthetic questions raised by digital art practice.

Regarding **training forms** (RQ3), formal, non-formal, and informal education serve distinct and complementary purposes. Formal education provides structured, accredited learning; non-formal education offers flexibility and accessibility; informal education supports peer knowledge exchange and just-in-time learning. The Ukrainian case demonstrates that effective professional development requires integration across these three pathways, particularly under crisis conditions where formal programs may be disrupted.

Regarding **challenges** (RQ4), art teachers face infrastructure limitations, age and experience gaps, psychological barriers, resource constraints, and AI integration challenges. The wartime context exacerbates all of these: infrastructure instability requires asynchronous and offline solutions; psychological trauma affects technology adoption; displacement disrupts professional networks. These findings suggest that digital competence development programs must account for contextual barriers alongside technical skill development, and that psychological support should be embedded in professional development design.

6.2. International and comparative context

International research on teacher digital competence consistently identifies professional development as a critical factor [6, 13]. The Ukrainian approach aligns with European DigCompEdu frameworks while facing contextual challenges unique to the post-Soviet educational space and wartime conditions.

Compared to other European countries, Ukraine has made significant progress in developing digital competence frameworks and integrating them into teacher professional standards. The Concept of Digital Competence Development [18] and updated Professional Standards [17] demonstrate policy alignment with European frameworks. However, implementation remains uneven: urban centers benefit from better infrastructure and more professional development opportunities, while rural areas lag significantly. This urban-rural digital divide mirrors patterns observed in other Eastern European countries [11].

The Ukrainian experience offers lessons for understanding digital competence development under crisis conditions that may inform other post-conflict or crisis-affected educational systems. Countries facing infrastructure disruption, teacher displacement, or resource scarcity may benefit from the adaptive strategies documented here: asynchronous learning solutions, mobile-first approaches, distributed backup systems, and psychological support integration. International comparative research examining Ukraine alongside other post-conflict contexts would illuminate which adaptations generalize and which remain context-specific.

6.3. Framework limitations for art education

While DigCompEdu provides a comprehensive framework, its application to art education requires adaptation. Art teachers need additional competencies related to digital art-making tools and techniques; virtual gallery and exhibition creation; digital portfolio development; integration of traditional and digital artistic practices; critical evaluation of AI-generated art; and digital preservation of artistic works. The art-specific dimensions in Table 1 and the Art-TPACK framework address these gaps, but empirical validation of this extended framework remains a priority for future research.

6.4. Implications for practice

The findings suggest several practical recommendations:

1. Postgraduate education programs should offer differentiated tracks based on teachers' initial digital competence levels.

2. Art-specific digital competence modules should be developed within broader professional development programs.
3. Informal learning networks should be supported and institutionalized.
4. Infrastructure investment should prioritize underserved schools and regions.
5. Professional development should address psychological barriers to technology adoption alongside technical skills.

6.5. Limitations and future directions

This study has several limitations to be addressed in future research.

Methodological limitations. The study employs a conceptual framework development approach with illustrative rather than systematic empirical validation. The three-component model and Art-TPACK framework require testing through surveys, case studies, or intervention research to assess their validity and utility for art teacher professional development.

Geographic scope. The focus on Ukrainian postgraduate education, while providing valuable contextual depth, limits generalizability to other national contexts. The Ukrainian case reflects specific institutional arrangements, resource constraints, and wartime conditions that may not transfer directly to other settings. International comparative research examining digital competence development in postgraduate education systems across countries would strengthen the framework's applicability.

Temporal scope. The rapid evolution of AI tools means that findings regarding AI integration in art education may require revision as technologies develop. Longitudinal studies tracking art teachers' digital competence development over time would capture this evolution and identify sustainable professional development strategies.

Population focus. Art teachers represent one subject area; the framework may require adaptation for other creative disciplines (music, drama, design). Future research should examine whether the art-specific dimensions identified here – visual literacy, aesthetic judgment, material practice – generalize to adjacent fields or remain distinctive to visual arts education.

Data limitations. The study does not include systematic empirical data on competence levels, training effectiveness, or teacher perceptions. Future research should incorporate mixed-methods designs including teacher surveys, program evaluations, and qualitative interviews to validate the framework and assess professional development impact.

7. Conclusions

The analysis reveals that art teachers' digital competence requires a discipline-specific framework extending beyond general teacher digital competence. The proposed three-component model – cognitive, operational-activity, and value-motivational – is grounded in the Art-TPACK framework to address the unique epistemology of artistic practice. Art-specific dimensions include visual literacy, material practice, aesthetic judgment, creative process, and critical making.

Among training forms, professional development courses, special courses, and short-term thematic training have been identified as most effective within formal education. Distance and online learning formats and MOOCs are prominent in non-formal education. Informal education draws on networking in professional communities, thematic groups, Viber and Telegram channels, and self-directed microlearning.

The role of postgraduate education in developing art teachers' digital competence lies in creating conditions for continuous professional improvement across formal, non-formal, and informal education pathways. A specialized educational environment in postgraduate education promotes art teachers' digital competence and readiness to integrate digital technologies into artistic-pedagogical

activity, while also providing the flexibility to respond to crisis conditions such as those created by the ongoing war in Ukraine.

7.1. Future research directions

Further research will focus on describing learning technologies for art teachers within postgraduate education aimed at increasing digital competence levels based on New Ukrainian School principles and new priority directions of digital transformation of education. Priority areas include:

- Empirical assessment of art teachers' digital competence levels across Ukrainian regions
- Development and validation of art-specific digital competence assessment instruments
- Investigation of generative AI integration in art teacher professional development
- Analysis of wartime educational challenges and adaptive strategies
- Comparative studies of digital competence development in postgraduate education systems across countries

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Data availability statement

No new data were created or analyzed in this study. Data sharing is not applicable.

Conflicts of interest

The author declares no conflict of interest.

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