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ORIGINAL

Application of Virtual Reality Platforms in Teaching Art Disciplines as a Factor of Creative Development

Aplicación de Plataformas de Realidad Virtual en la Enseñanza de Disciplinas Artísticas como Factor de Desarrollo Creativo

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ABSTRACT

Introduction: the article examines the importance and effectiveness of applying VR tools in teaching design and music. It emphasizes the positive influence of VR on the development of creative thinking, visualization ability, and an experimental approach among students in the Ukrainian specialty B2 «Design» and students in music programs.
Method: a cross-group experimental design was employed to monitor changes in students' creative abilities under varying learning conditions.
Results: fndings from a survey of 60 students across two academic groups are presented; most expressed a positive attitude toward VR as a tool for developing professional skills. The key advantages of introducing VR into art education are outlined, including increased motivation, individualized learning, and the ability to create complex creative environments. At the same time, ethical, technical, and social issues related to the use of VR and artificial intelligence are acknowledged.
Conclusions: the study concludes that modern digital technologies should be integrated with traditional forms of creativity to build a purposeful and balanced learning environment.

Keywords: Art Education; Musical Art; Artificial Intelligence; Creativity; Student Activity.

RESUMEN

Introducción: el artículo examinó la importancia y la eficacia de aplicar herramientas de realidad virtual (RV) en la enseñanza del diseño y la música. Se enfatizó la influencia positiva de la RV en el desarrollo del pensamiento creativo, la capacidad de visualización y el enfoque experimental entre estudiantes de la especialidad ucraniana B2 «Diseño» y de programas de educación musical.
Método: se empleó un diseño experimental entre grupos para monitorear los cambios en las capacidades creativas del estudiantado bajo condiciones de aprendizaje diferenciadas.
Resultados: se presentaron los hallazgos de una encuesta a 60 estudiantes de dos grupos académicos; la mayoría manifestó una actitud positiva hacia la RV como herramienta para el desarrollo de competencias profesionales. Se delinearon ventajas clave de la incorporación de la RV en la educación artística, como el aumento de la motivación, el aprendizaje individualizado y la posibilidad de crear entornos creativos

complejos. Al mismo tiempo, se reconocieron cuestiones éticas, técnicas y sociales relacionadas con el uso de la RV y de la inteligencia artificial.
Conclusiones: el estudio concluyó que las tecnologías digitales modernas debían integrarse con las formas tradicionales de creatividad para construir un entorno de aprendizaje intencional y equilibrado.

Palabras clave: Educación Artística; Educación Musical; Inteligencia Artificial; Creatividad; Actividad Estudiantil.

INTRODUCTION

In the modern world, digital technologies are radically changing the way people live, work, and learn. These changes are especially noticeable in the field of art education, where new tools not only modernize teaching methods, but also form innovative approaches to the development of creativity and aesthetic thinking of students.

The traditional model of higher art education focused on the formation of artistic taste, emotional perception, and professional skills. However, in the digital era, these approaches are increasingly limited: they do not meet the needs of students who expect interactivity, involvement, and new formats for mastering art.

This is where virtual and augmented reality technologies become promising. They create learning environments where students can immerse themselves in artistic and cultural contexts, receiving a unique sensory and visual experience. VR can not only diversify the learning process, but also increase motivation, reveal creative potential, and turn knowledge acquisition into a full-fledged creative journey.

However, the integration of VR into art education remains insufficiently systematized. The theoretical basis needs clarification, empirical studies on the impact of VR on the development of specific artistic skills and critical thinking are lacking, as well as comparative analyses of traditional and digital teaching methods.

This study aims to consider VR as a tool for the development of creativity in higher art education, to assess its capabilities through the prism of modern experimental learning, and to determine its contribution to the formation of new educational strategies.

The Mykhailo Boychuk Kyiv State Academy of Decorative and Applied Arts and Design has deep historical roots and is among the leading centers of higher art education in Ukraine. Its origins date to the early 20th century, a period of active development of the national system of professional art training. The Academy was established as a distinctive institution that integrates traditions of Ukrainian decorative art with modern design practices. Its mission is to harmonize classical artistic principles with innovative approaches to creativity.

Responding to rapid changes in art and culture, the Academy focuses on training qualified specialists in decorative and applied arts, design, monumental painting, artistic textiles, ceramics, graphics, and related fields. From its earliest years, the institution emphasized preserving national artistic traditions and implementing an individualized approach to learning, which has fostered students' creative thinking, refined aesthetic judgment, and the formation of a personal artistic style.

Over time, the Academy has built substantial scholarly, methodological, and organizational capacity, establishing an extensive system of training studios led by renowned artists and designers. Its educational concept rests on close collaboration among specialties, the systematic development of practical skills with practicing instructors, and a balanced combination of lectures, individual tutorials, and master classes. Students actively participate in exhibitions, competitions, cultural projects, and open-air classes, enabling them to realize their creative ideas at a professional level.

During the Soviet period, the Academy, like most Ukrainian art universities, was influenced by a centralized system of educational management, strict ideological control, and standardized teaching methods primarily developed in Moscow. These constraints hindered the development of innovative approaches and limited instructors' pedagogical autonomy. Nevertheless, due to the high qualifications of the faculty and a sustained commitment to nurturing students' creative potential, the Academy maintained a high level of professional training.

After Ukraine gained independence in the 1990s, the art education system underwent significant change. The Academy acquired greater autonomy in curriculum development, broadened its disciplinary offerings, and began actively implementing contemporary pedagogical concepts. A student-centered approach, research-based learning, project-based methods, and interactive technologies became integral to the educational process.

Problem Importance

In the context of rapid digital transformation and evolving educational environments, integrating VR platforms into the teaching of art disciplines has become especially pertinent. Although some empirical studies

address the use of VR in the natural and technical sciences, this topic remains insufficiently examined within art pedagogy. Several theoretical questions are unresolved, particularly how VR affects the development of creative thinking, aesthetic sensitivity, and students' emotional and figurative perception of art.

The need for further investigation is both theoretical and practical. On the theoretical side, it is important to synthesize and analyze the mixed findings of prior research, where VR is viewed either as a promising instructional tool or as a source of risks such as digital addiction, cognitive overload, or reduced face-to-face social interaction. On the practical side, the problem involves modernizing art education through adaptive and personalized digital solutions that ensure equitable access to high-quality learning across diverse sociocultural contexts.

The social value of this topic lies in the requirement that contemporary art education meet the challenges of the twenty-first century, preparing creative professionals who can work effectively in virtual environments, generate new cultural products, and use digital tools for self-expression. The key task is to balance technological progress with the humanistic essence of art education within a framework of digital humanism, which centers on the student's identity, values and affective domain, and creative freedom.

This study aims to identify the potential of VR platforms in teaching art disciplines as a driver of students' innovative thinking and to develop recommendations for the effective implementation of virtual reality in the educational process.

The objectives are to synthesize existing theoretical approaches, systematize available practical evidence, and make an original scholarly contribution to the creation of a digital strategy for advancing art education in higher education institutions.

Relevant Scholarship Description

In recent years, there has been growing interest in the potential of digital technologies in art education, especially in the use of VR platforms as tools that can transform the educational process. Researchers emphasize that digitalization opens up new pedagogical opportunities, but at the same time leaves a number of unresolved questions regarding its impact on the development of creativity and aesthetic thinking of students.

A number of scholars focus on methodological approaches to the integration of digital technologies into education. For example, Gonzalez-Zamarand Abad-Segura[1] investigated methodologies for the use of AI in art education, while Su et al.[2] presented a model of its integration in primary school with potential for higher education. In the post-Soviet space, Efimov[3] analyzed the methodology for using AR in school, and Kryvonos et al.[4] summarized the principles of creating an immersive educational space. More recent works also emphasize the competency aspect of digitalization: Rizahodzhaeva and colleagues[5] showed how ICTs contribute to the development of 21st century skills; Aida et al.[6] examined the formation of professional competencies of future teachers in distance education; Bondar[7] et al. described innovative approaches of universities during the pandemic.

The impact of VR and AR on learning motivation is confirmed by numerous empirical works. In particular, Familoni and Oyebuchi[8] showed that VR/AR in the USA increases student engagement and improves learning outcomes. Marougkas[9] and colleagues drew attention to the personalization of educational experience, which is crucial for the development of creativity. In the Ukrainian material, Martynenko emphasized the role of AR in increasing learning motivation, and Slupska and Shkurenko[11] identified key benefits of VR – from visualization of complex concepts to modeling of creative processes. The study of Sipi, Kurtyak et al.[12] complements this corpus, showing the effectiveness of virtual laboratories in increasing accessibility and motivation in natural disciplines, which creates parallels for art education.

A separate block of works is devoted to the use of VR for teaching art history. It is worth mentioning here studies that demonstrate how VR deepens the interpretation of visual material[13,14], as well as how VR technologies diversify approaches to understanding artistic heritage. In the field of design and visual communications, West and Burbano[15] have investigated the impact of electronic resources on artistic practices, and Martynenko and colleagues have emphasized the role of VR in the development of emotional branding and visual identity.

Another direction is related to the technical integration of VR. Makhkamova et al.[16] have proposed a systematic classification of VR solutions for education, while Liu and co-authors[17] have analyzed the relationship between multimedia technologies and VR in art education. These works emphasize that successful integration requires not only pedagogical innovations, but also infrastructural solutions. In the same vein, Mulyarevych[18] and co-authors consider digital learning centers as a component of the information and digital environment that can ensure the sustainable development of VR technologies in education.

Some authors, such as Ruschemeier[19], emphasize the role of generative AI (for example, Midjourney) in stimulating creativity and developing new forms of visual culture. This opens up prospects for combining VR and AI in shaping the artistic practices of the future.

In general, existing research outlines various aspects of implementing VR and other digital technologies in art education: from the formation of competencies and the development of motivation to the teaching of art

history and the technical implementation of VR solutions. However, the body of literature remains fragmented. There is no coherent model that would systematically describe how VR affects creative thinking, aesthetic sensitivity, and the personalization of the educational process. There is also a lack of comparative studies of traditional and VR approaches and empirical data on the long-term effect of VR in art education.

Hypothesis Statement and Research Design

Given the identified research gap and the fragmentation of existing studies, the primary aim of this article is to determine whether the use of virtual reality platforms in teaching art disciplines affects the development of students' creative thinking, as well as how this influence manifests at the cognitive, emotional, and behavioral levels.The hypothesis is that applying virtual reality platforms in teaching art disciplines leads to a statistically significant increase in students' creative thinking compared with traditional teaching methods. This hypothesis is based on constructivist learning theory (Piaget, Vygotsky) and research on immersive experience, according to which active interaction with the learning environment promotes deeper information processing, increased motivation, and stimulation of creative processes. VR platforms provide multichannel perception, immersion in artistic contexts, and the ability to experiment without physical constraints, creating optimal conditions for the development of creativity.

METHOD

The study had a quasi-experimental design with between-group comparison (experimental and control groups). The educational intervention lasted four weeks (three 90-minute classes per week). The venue was the Mykhailo Boychuk Kyiv State Academy of Decorative and Applied Arts and Design.

Participants. The sample included 60 second- and third-year students (30 women, 30 men), aged 18 to 25, who had at least one year of study in the art field. The sample was formed purposively: invitations were distributed via Moodle, Google Classroom, and the department's social networks. Of the 82 invited students, 60 students (73,1 %) agreed. All participants provided written informed consent and were informed of the right to withdraw at any stage. The exclusion criteria were severe mental or sensory impairments, as well as the lack of basic digital skills.

Students were randomly assigned to two equal groups:

- Experimental group (n=30): learning using VR platforms.
- Control group (n=30): learning in a traditional format without VR.

Intervention. The experimental group worked with the VR platforms Tilt Brush and Open Brush (to create 3D visualizations) and Artsteps (to organize a virtual exhibition). Equipment: Meta Quest 2 headsets connected to a PC with the appropriate software. Tilt Brush/Open Brush was chosen due to its intuitive interface and the ability to create spatial artistic compositions, while Artsteps provided an environment for collective presentation of works.

The control group performed the same tasks (acquaintance with styles, creation of individual and group projects, presentation), but in the format of lectures, printed materials, digital presentations (PowerPoint) and regular classroom discussions. This design allowed us to clearly isolate VR as an independent variable, reducing the impact of the "novelty effect".

The following measures were used to measure the results:

- Creativity: Torrance Tests (TTCT; subscales of flexibility, originality, detail, abstractness; Cronbach's α = 0,84 for the Ukrainian adaptation).
- Motivation: Academic Motivation Scale (AMS).
- Emotional Engagement: Student Engagement Scale.
- Previous digital experience: a short survey to control for this factor.

The study was conducted in three stages:

- Pre-testing (before the intervention).
- Four-week training in VR or traditional format.
- Post-testing using the same instruments.

After the intervention, semi-structured interviews were conducted with 10 participants of the experimental group for a qualitative analysis of the VR experience.

Sample size was determined using G*Power (expected mean effect d=0,6; α=0,05; power 0,80). The actual number of participants (30 per group) provided sufficient statistical power.

The following were used for data analysis:

- Mixed analysis of variance (ANOVA) to compare changes in creativity, motivation, and engagement between groups (factor "group × time").

- Independent samples t-tests to assess post-test differences.
- Thematic analysis of interviews to identify qualitative patterns of VR experiences.

The study was conducted in accordance with the ethical principles of voluntariness, confidentiality, and anonymity. Data were stored in encrypted form with access only to the research team.

While efforts were made to standardize instruction, the risk of bias from instructors who may have interacted differently with students in the VR group could not be completely eliminated. Participants could not be blinded to their status, a typical limitation of educational experiments.

RESULTS

Today, the Mykhailo Boychuk Academy actively employs digital technologies in instruction, including media tools, 3D modeling, graphics software, and elements of virtual reality. Considerable attention is devoted to developing educational and research programs that support the cultivation of students' creative skills in a digital environment. A modern material and technical base ensures high-quality delivery of both theoretical and practical classes. By combining Ukrainian artistic traditions with cutting-edge technologies, the Academy continues to prepare generations of artists and designers capable of representing the country on the international stage. At the same time, like other historic art schools in Ukraine, the institution faces new challenges associated with the modernization of education.

The development of tailored educational programs that address the unique needs of each learner emphasizes self-directed study, solution-oriented learning, and the integration of practical experience with theoretical understanding. This approach is a key development priority for the Academy. The institution's educational model combines individual and studio-based classes with lecture courses, creating conditions that foster continuous professional and personal growth. A modern material and technical base plays an essential role, enabling a wide range of classes and the delivery of master's programs.

The Academy offers a variety of mandatory and elective disciplines that provide solid theoretical knowledge and practical skills. Within contemporary Ukrainian art education, new academic and professional programs are emerging that require the active implementation of digital technologies. Accordingly, curricula reflect ongoing technological transformation, and instructors adopt and apply the latest tools in their teaching.

Specifically, the Department of Design consistently incorporates contemporary visualization tools, advanced software, digital graphics, 3D modeling, and artificial intelligence into its teaching practices, effectively responding to current demands. The Academy's experience and methodology can serve as a reference point for the broader adoption of innovative technologies in art education.At present, the Mykhailo Boychuk Kyiv State Academy of Decorative and Applied Arts and Design demonstrates a readiness to adapt to technological change. The use of VR in the educational process reflects a commitment to combining academic traditions with innovative approaches, creating a flexible and forward-looking environment for preparing future specialists in the field of art and design. A prominent feature of the updated programs is the introduction of VR as a tool for developing creative thinking, spatial imagination, and digital competencies.

VR technology enables students to model complex art objects, visualize three-dimensional spaces, evaluate projects at the concept stage, and organize virtual exhibitions. This approach expands the methodological foundation of the educational process, rethinking the student's role: the student is not only a recipient of knowledge but also an active creator who interacts with their project in a virtual environment.

Today, VR is becoming an integral tool in art education, changing the way designers form concepts and develop creative ideas.[20] As a computer-generated immersive environment, VR is rapidly gaining popularity across artistic fields, opening new horizons for design education and artistic practice. This technology makes it possible to create and edit three-dimensional models, virtual objects, environmental elements, mechanisms, and structures, significantly expanding students' creative possibilities.

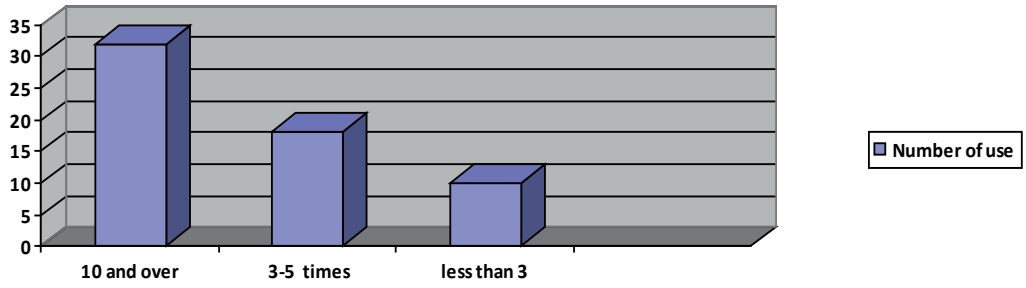

Figure 1. Diagram of the VR use

An additional survey conducted among 60 art students at the Mykhailo Boychuk Kyiv State Academy of Decorative and Applied Arts and Design showed varying levels of VR use in everyday learning and creative activities. In particular, 32 participants reported using VR up to 10 times a month, 18 – on average 3–4 times a week, and another 10 – several times a month (figure 1). On average, this amounted to about 6–7 VR sessions per student, and in total, about 684 sessions were recorded per month.

These results indicate that virtual reality is gradually becoming a common practice in the education of future designers and artists. VR opens up opportunities for experiments with materials and techniques in a safe environment, allows editing 3D models before the start of physical production, and also creates virtual exhibitions. This is especially true during pandemics or wartime, when access to offline events is limited, and digital platforms give students a chance to present their work to a wide audience.

Based on a mixed analysis of variance (ANOVA), a significant interaction between the factors Group (VR/control) and Time (before/after intervention) was recorded on the Torrance test creativity scores. The experimental group demonstrated a significant increase in the mean values on all subscales (flexibility, originality, detail, abstractness), while in the control group the improvement was insignificant and statistically insignificant.

As a result, the VR group outperformed the control group on all post-test scores, confirming the main hypothesis of the study. The largest effect was found in the subscale «originality», which indicates a positive impact of the VR environment on the generation of new ideas.

Table 1. Means (M), standard deviations (SD) and mixed ANOVA results for TTCT

TTCT Subscale	Group	Pretest M (SD)	Pretest M (SD)	F (1,58)	p	η^2
Flexibility	VR	45,2 (6,3)	58,7 (6,8)	24,6	<0,001	0,30
	Control	44,9 (6,1)	47,1 (6,4)			
Originality	VR	42,8 (7,2)	61,4 (8,1)	31,8	<0,001	0,35
	Control	43,1 (7,5)	46,0 (7,9)			
Details	VR	39,6 (5,8)	52,3 (6,4)	19,2	<0,001	0,25
	Control	39,1 (6,0)	41,2 (6,3)			
Abstractness	VR	41,0 (6,7)	55,1 (7,0)	27,5	<0,001	0,32
	Control	40,7 (6,5)	42,0 (6,8)			

The results of the analysis indicate a significant increase in intrinsic academic motivation in the VR group. The indicators increased by an average of 15 points ($p < 0,001$), while in the control group the increase was minimal and statistically insignificant. Extrinsic motivation remained at approximately the same level in both groups, and amotivation indicators decreased only in the VR group. This indicates that VR platforms are able not only to stimulate creativity, but also to increase intrinsic interest in learning.

Table 2. Dynamics of academic motivation (AMS)

Indicator	Group	Pretest M (SD)	Pretest M (SD)	t (28)	p	d
Intrinsic Motivation	VR	52,4 (8,1)	67,5 (8,5)	6,1	<0,001	1,12
	Control	51,9 (7,8)	54,2 (8,0)	1,2	0,24	0,20
Extrinsic Motivation	VR	47,8 (7,0)	48,3 (7,2)	0,5	0,61	0,09
	Control	47,1 (7,1)	47,4 (7,0)	0,4	0,68	0,07
Motivation	VR	18,6 (5,4)	12,3 (4,9)	-4,8	<0,001	0,88
	Control	18,2 (5,6)	17,7 (5,5)	-0,7	0,49	0,13

The data indicate a significant increase in the level of emotional engagement of students in the experimental group. The VR environment contributed to an increase in interest, joy and a sense of involvement in the learning process. In the control group, the indicators changed insignificantly.

Table 3. Level of emotional engagement of students

Group	Pretest M (SD)	Pretest M (SD)	t (28)	p	d
VR	40,2 (6,5)	56,8 (7,1)	8,4	<0,001	1,53
Control	39,9 (6,2)	42,5 (6,6)	1,6	0,12	0,29

Within art education, VR supports new formats of collaboration: virtual environments reduce the distance between the designer and the finished product and provide convenient ways to present works to clients in a more interactive form. At the Mykhailo Boychuk Kyiv Academy of Decorative and Applied Arts and Design, VR is regarded not only as an auxiliary tool but also as a key driver of the transformation of art education and the development of new approaches to design practice.

Today, the use of specialized digital programs is an essential component of training future musicians and designers. For designers working on logos, illustrations, album covers, or stage design, Adobe Illustrator is an indispensable vector-graphics tool. Work with layers, palettes, effects, and design elements stimulates creativity and fosters a professional visual style.

Musicians actively use the digital audio workstations Ableton Live and FL Studio, which allow experimentation with rhythm, melodies, harmonies, and electronic effects, deepening understanding of musical structure and advancing sound design skills. The integration of VR into these environments, for example through AliveInVR, enables control of musical parameters with gestures in virtual space.

Students in visual design benefit from the free raster-graphics program Krita, which supports the creation of concept art, stage design, and graphics for music videos. With VR, artists can immerse themselves in a «digital canvas,» create three-dimensional illustrations, and achieve a new level of expressiveness.

For stage and performance designers, TouchDesigner is a critical platform that enables the creation of interactive multimedia visuals for live productions. It integrates coding, animation, and audio effects, allowing the development of full-scale multimedia installations.Cinema 4D and Unreal Engine are widely used for 3D modeling of sets, scenes, and music videos. With these tools, performances and environments can be recreated in virtual space, producing realistic, navigable worlds. In combination with VR, musicians and designers gain the ability to work with visual content at real scale, which strengthens spatial thinking.

For musicians who integrate visual effects into their performances, Resolume Arena is a key platform for video mapping and live visualization. It enables real-time synchronization of video with music, creating a distinctive concert atmosphere.

When creating 3D models for sound visualizations, key stages include importing audio and transforming it into visual structures, ranging from simple meshes to complex 3D performances. These approaches deepen artistic impact and create a synesthetic experience in which sound and image interact. For example, Notch-based workflows allow music, lighting, and visual effects to be combined in VR in real time.

Selected student works created with VR technologies are illustrated in figures 2, 3, and 4.

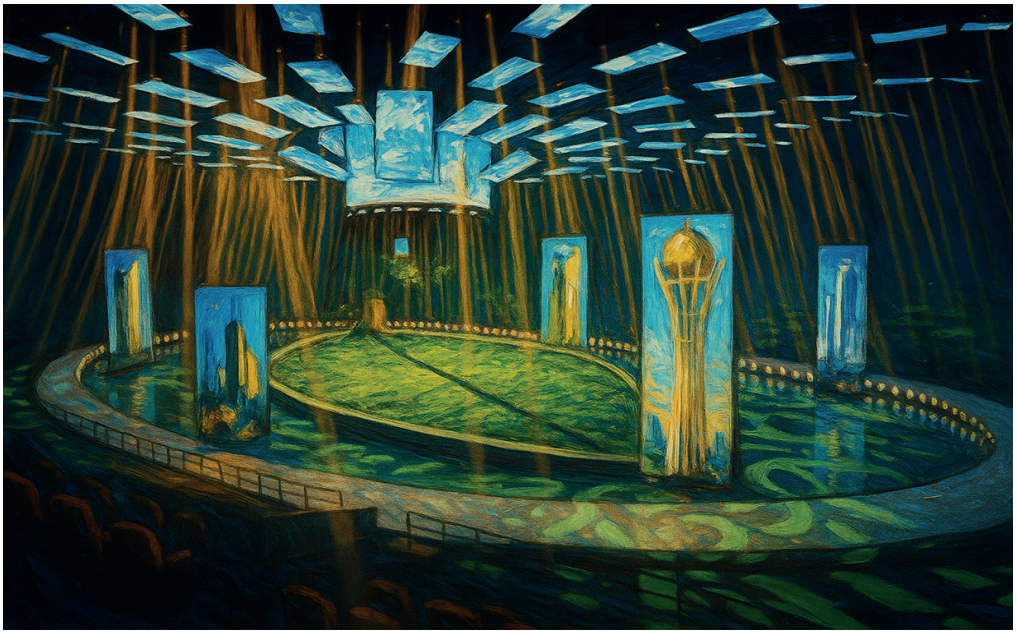

Figure 2. Design of a concert hall

Figure 2 presents a stage environment modeled in a virtual setting, featuring naturalistic lighting and a daytime landscape backdrop. This configuration exemplifies digital scenography for public events or art installations. For design students, it demonstrates principles of spatial composition by integrating visual components, 3D forms, media objects, and lighting effects. For music students, it illustrates how the visual environment can enhance the perception of a musical work or concert performance, creating a cohesive and immersive event atmosphere.

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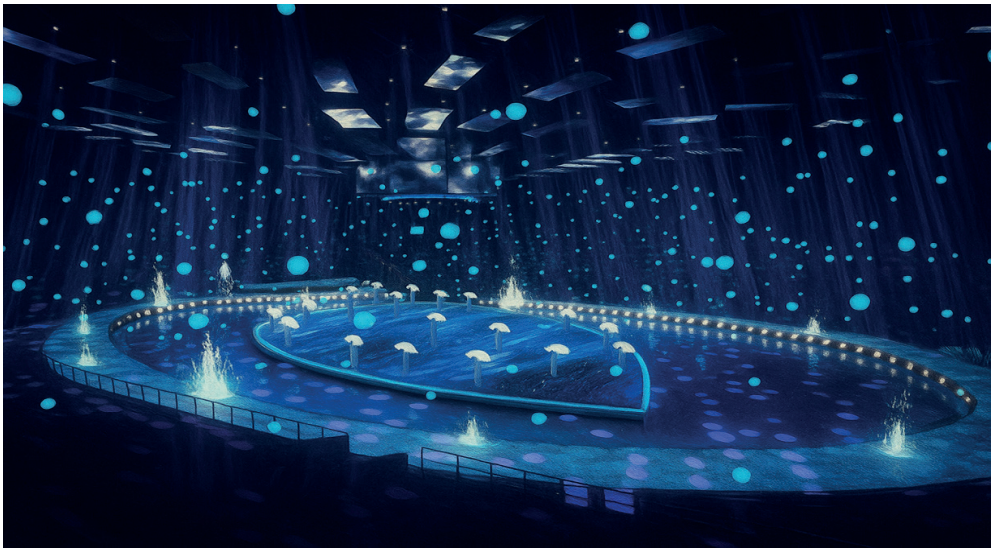

Figure 3. Design of a concert hall

Figure 3 depicts the same space in a nighttime atmosphere created through dynamic lighting effects and visual elements that resemble light particles or droplets. This scenography engages the emotional perception of space and rhythm, serving as a visual analog of a musical composition. Design students can examine how interactive lighting, rhythmic structures, and color palettes shape an overarching concept, while music students can analyze how visual effects accompany music to create a synesthetic or performative experience.

Figure 4. Design of a concert hall

Figure 4 shows a modern concert stage equipped with large LED screens for projecting visual imagery and a star-shaped podium. This example demonstrates high-tech stage design commonly used in pop and electronic music. For design students, such a stage serves as a model for developing visual identity, configuring lighting, and integrating graphics within the performance space. For music students, it illustrates how stage architecture and design influence concert perception, interaction between performers and the audience, and the formation of an overall audio-visual narrative.

Consequently, virtual reality serves as an influential tool in students' professional preparation, offering opportunities to explore and experiment with multiple facets of their field while refining practical skills in a digital setting. Immersive virtual environments enable learners to engage with simulated scenarios, devise effective solutions, and address challenges that mirror those encountered in future careers. This learning format fosters creativity, cultivates critical thinking, and builds readiness to operate in innovative domains of art and design.

As part of the study, which included 60 students from two academic groups specializing in "Design" and "Musical Art," participants were asked, "How do you evaluate the influence of VR on your creative process?" The survey findings are summarized in table 4.

Table 4. Survey results on the VR impact on the creative process

Impact assessment	Number of people	%
Excellent	22	36,7 %
Positive	28	46,6 %
Neutral	7	11,7 %
Negative	3	5 %

The study found that 83,3 % of students reported a positive influence of VR tools on their creative process. Many participants also noted that engagement with VR environments supports the development of conceptual design skills and enhances their visual thinking.

Table 5. Generalization of the assessment of students' attitudes towards virtual reality

Response category	Number of people	%
Positive impact	50	83,3 %
It is difficult to answer	7	11,7 %
Negative impact	3	5 %

VR offers extensive opportunities for interactive learning and creative self-expression among students. Contemporary art increasingly integrates postmodern practices, such as craft, cultural borrowing, and the actualization of art, with digital technologies and engagement with artificial intelligence. The use of neural networks, including Leonardo AI and Midjourney, facilitates the creation of visual content that spans fictional worlds and images of authors and their design works. This convergence significantly broadens the creative horizons of artists and designers in the digital age.

The obtained data confirm the hypothesis of positive influence of VR on development of creative thinking, motivation and emotional involvement of students. The effects were most pronounced for indicators of originality, intrinsic motivation and emotional involvement. Additional qualitative analysis demonstrates that VR contributes not only to improvement of cognitive results, but also forms a new level of educational experience that complements individual creativity and collective cooperation.

DISCUSSION

Statistically significant improvement in Torrance Creative Thinking Test (TTCT) scores in the VR-platform group. This improvement was also accompanied by a noticeable increase in intrinsic academic motivation (AMS) and emotional engagement, which together form a comprehensive picture of the positive impact of VR on the learning process in art education. This set of results confirms the main hypothesis that the integration of VR can stimulate both cognitive and affective components of creative learning.

Our data are consistent with a number of international studies that link immersion in virtual environments with deeper learning and increased accessibility of educational materials.[22] Similar conclusions about increased motivation and engagement are drawn from studies that record increased educational outcomes after the implementation of AR/VR in the USA and highlight the role of personalization of the VR environment in stimulating creativity. Our observation of a stronger effect on the originality subscale also resonates with work describing the generative potential of visual immersive environments for generating new ideas.[10]

Mechanistically, our results can be explained by several interrelated factors indicated in the literature. First, the immersive nature of VR creates an "experience environment" in which the student can experiment with form, color, and space without risk of material loss, which facilitates freer idea generation and reduces the fear of making mistakes.[29] Second, the possibility of visualizing 3D compositions and rapid prototyping (using Tilt Brush/Open Brush) accelerates the iterative process of creativity, an aspect that has been addressed in both theoretical and empirical works.[19,31] Third, using Artsteps to organize a virtual exhibition activates the social component of the creative process, brings students closer to real gallery practices, and thereby strengthens the identity of the creator and professional motivation - this is confirmed by the qualitative responses of the participants and reviews in the literature.[11,15]

At the same time, the results should be interpreted taking into account the existing reservations in the scientific community. First, some researchers emphasize that technology is not a universal "recipe" for creativity: the emotional and subtle aspects of artistic practice are still difficult to reproduce exclusively by

digital means.[35] Our data on the increase in emotional engagement indicate the opposite trend, but do not answer the question of whether the same aesthetic judgments are formed as in traditional practical experience. Second, ethical and legal issues related to the use of content and algorithms remain a critical limitation for the widespread implementation of VR and AI in education.[36] Third, technological dependency and the risk of weakening traditional craft skills are real concerns that have been warned about by a number of authors;[37] this requires a balanced approach, where VR complements rather than replaces hands-on exercises.

Our study also confirms the concerns highlighted in the review: the need to train teachers to work with immersive tools[39,40] and the risk of reducing live social interaction if the virtual environment is over-reliant.[38] The potential "novelty effect" was mitigated by standardizing activities in the control group (interactive mini-sessions, peer review); however, it cannot be completely eliminated, which represents a common challenge in educational experiments.

The practical implications of our results arise from the combination of empirical support for the effectiveness of VR and acknowledged limitations. First, courses for future artists and designers would benefit from a hybrid architecture, where VR is integrated into existing learning trajectories for modeling, prototyping, and presentations, while maintaining traditional workshops for developing manual skills.[41] Second, it is necessary to implement systems of continuous professional development of teachers with practical training on specific platforms (Tilt Brush, Open Brush, Artsteps), as well as standardized methods for assessing creative projects in VR. Third, policies on the ethical use of content and copyright should be implemented, and the technical and financial accessibility of the tools should be ensured for all students.

Despite reliable statistical results, the study has several limitations that should be taken into account in future work. First, the short-term nature of the intervention (four weeks) does not allow for assessing the long-term effect and the transfer of the acquired skills to professional practices; therefore, longitudinal studies are needed. Second, the sample size (N=60) is sufficient to detect a medium effect, but given the heterogeneity of arts programs, replications with larger and more diverse cohorts are needed to increase external validity. Third, although the TTCT is a recognized tool for measuring creativity, it should be complemented with objective tools for product evaluation (e.g., expert ratings of works in real and virtual spaces) and metrics of long-term career success. Future research should also examine the mechanisms in more detail: which elements of VR (immersion, simulation tools, collective exhibition) are most strongly correlated with increased TTCT, and to what extent the combination of VR with generative AI enhances or attenuates these effects.[10,14]

Our study brings empirical clarity to the debate about the role of VR in art education, demonstrating statistically significant improvements in creativity (TTCT) indicators along with increased intrinsic motivation and emotional engagement. The findings are consistent with international research that highlights the potential of VR to personalize learning experiences and model creative practices[4,12,19,22], but also highlight the need for careful, ethically informed, and pedagogically sound implementation of these technologies.[35,36,37,38,39,40,41] Future research should focus on the long-term effects, mechanisms of influence, and conditions that maximize the benefits of VR without sacrificing the values of traditional artistic practice.

CONCLUSIONS

Thus, the answer to the research question — how does the integration of VR platforms into art courses affect the development of students' creative thinking — is positive: experimental data showed a statistically significant improvement in creativity indicators (TTCT) in the group that worked with VR, accompanied by an increase in intrinsic motivation and emotional involvement. This indicates that immersive environments not only facilitate the process of mastering techniques and forms, but also stimulate the generation of new ideas and activate individual creative strategies.

The practical significance of the work lies in the fact that VR can become an effective tool in the curriculum for art and design specialties: it should be used for modeling, prototyping, simultaneous visualization and virtual presentation of projects. However, effective implementation requires pedagogically motivated course design, teacher training, technical accessibility and attention to ethical and legal aspects of the use of digital content.

Theoretically, the study deepens the understanding of the mechanisms through which digital technologies influence creative thinking: immersiveness and rapid iteration of projects reduce barriers to experimentation, and collective virtual exhibitions strengthen professional identity and motivation. At the same time, the results highlight the need to maintain a balance between innovation and traditional practice, so that VR complements, rather than replaces, the development of manual and craft skills.

Three key areas of action for educational policy and practice are: the implementation of hybrid learning models, investment in teacher training, and the creation of ethical/legal standards for digital content. This will maximize the benefits of VR for the development of students' creative potential while minimizing the associated risks.

Finally, although the current study confirmed a short-term positive effect, further longitudinal and replication

studies are needed to assess the sustainability of the effect, its transferability to professional practice, and the optimal conditions for the application of VR in different artistic disciplines.

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