Interdisciplinary Studies of Complex Systems
No. 27 (2025) 87–99

https://doi.org/10.31392/iscs.2025.27.087 UDC 792.028:004.896

Strategies for implementing immersive technologies in creative project-based learning

Tetiana Andrushchenko[1], *Tetiana Sovhyra*[2,3], *Valeriia Kuznietsova*[2,4], *Inna Shevel*[5], *Volodymyr Zabora*[2,6], *Oleksandr Kabanets*[2,7]

Abstract. The article presents the results of a research conducted among students of the Kyiv National University of Culture and Arts as part of a project using augmented reality tools (development of the REMS application in a VR studio). The relevance of the research is determined by the need to adapt the educational process to the conditions of rapid technological progress, which, in turn, requires the development of digital competencies in students. The main objective of the study is to investigate the generative role of augmented reality (AR) in the creation of creative content and to identify priority approaches to the organisation of interactive and simulation practices. The presence of creative elements in virtual content developed as part of project-based learning confirms the important formative role of augmented reality in creating original content for immersive educational practices. The results of the study highlight the adaptability of augmented reality in promoting inclusiveness and enhancing the creative potential of educational trajectories. It has been established that participants in the educational process are capable of creating creative visual models by simulating real spaces and objects, resulting in an original interactive form of learning that embodies the characteristics of the artistic and cultural creative process. The creation of a shared virtual learning environment contributes to an increase in the level of interpersonal interaction between participants.

Keywords: augmented reality (AR), immersive technologies, project-based learning, culture-creating process, virtual content

Introduction

The digital transformation of the educational process, caused by restrictions resulting from the global COVID-19 pandemic and ongoing military aggression against Ukraine, has led to significant changes in the organisation of cultural practices. On the other hand, the introduction of digital technologies

[1] Ukrainian National Tchaikovsky Academy of Music. Kyiv. Ukraine. t.i.andrushchenko@udu.edu.ua, https://0000-0002-0381-171X
[2] Kyiv National University of Culture and Arts, Kyiv University of Culture
[3] STIsovgyra@gmail.com, https://orcid.org/0000-0002-7023-5361
[4] LK.Ler4ik1010@gmail.com, https://orcid.org/0000-0001-9252-7480
[5] Kyiv Economic University named after Vadym Hetman, Kyiv, Ukraine. shevelinna@ukr.net
[6] Vladimause@ukr.net, https://orcid.org/0000-0001-6273-5430
[7] kabanets.flo@gmail.com, https://orcid.org/0000-0003-1272-6725

in educational practices has helped to create conditions for the development of individual trajectories in accordance with the needs and capabilities of each student. One of the key aspects of the digitalisation of modern education is the formation of interactive learning environments. In particular, the use of augmented reality (AR) technology has expanded the possibilities of immersive learning and contributed to the development of students' creative thinking. An analysis of the achievements and prospects of using innovative technologies in artistic and educational practices is relevant because it will help identify the main obstacles and point to new opportunities for their use in implementing effective learning.

The technological features of AR-practices have been studied in numerous scientific studies, starting with the *reality-virtuality continuum* presentation by P. Milgram and F. Kishino [23, p. 1321–1329], according to which augmented reality is characterised by the ability to superimpose virtual elements onto the real environment. Contemporary experience in organising the creative process using augmented reality is explored in numerous researches by

C. Flavian, S. Ibáñez-Sánchez and C. Orus (2019) [9, p. 547–560], Y. Chen, Q. Wang, H. Chen, X. Song, H. Tang, and M. Tian (2019) [3], N. Horri and M. Pietraszko (2022) [13, p. 486–510], as well as J. Tan, Y. Chen, and S. Jiao (2023) [34], T. V. Sumithra, L. Ragha, A. Vaidhya, and R. Desai (2024) [33, p. 26–35]. They emphasise the significant potential of augmented reality in organising creative and educational processes, promoting inclusion and encouraging active student participation.

Augmented reality is seen as a technology that integrates virtual information with the real world [24, p. 250–260; 3, p. 5], as an active cultural and educational tool for interaction [2, p. 1–21; 16, p. 3], as a visual means of exploring concepts that not realised in the physical world [4, p. 272–309; 20, p. 199–208], as a means of conveying important information to the user [11, p. 232–237; 25, p. 533–544], and as a source of entertainment and distraction rather than meaningful learning [1, p. 153–170; 27, p. 309–327].

However, researchers disagree on how digital tools and virtual content are perceived by participants in educational and artistic practices. R. Salar, F. Arici, S. Caliklar, and R. Yilmaz emphasise the potential of immersive technologies in creating unique learning experiences that provide the opportunity to learn anytime, anywhere [29, p. 257–271]. M. A. Kuhail, A. ElSayary, S. Farooq, and A. Alghamdi note that immersive technologies improve learning, encourage active student participation, and promote the development of digital skills and creativity [18, p. 75]. Similarly, D. Verbivskyi, S. Zhukovskyi, O. Usata, O. Fonariuk, and V. Humeniuk point out the importance of introducing digital technologies into pedagogical practice [35, p. 2587–2599]. However, according to T. Mao and X. Jiang, the digitisation of art is limited by technological problems in reproducing analogue sensory images in a virtual environment [21]. D. Hamilton, J. McKechnie, E. Edgerton, and C. Wilson argue that the future development of such technologies largely depends on stable financial investments [12, p. 1–32]. This view is shared by M. Pears, M. Yiasemidou, M. A. Ismail, D. Veneziano, and C. S. Biyani, who emphasise the importance of funding the use of immersive technologies in education and healthcare [26, p. 112–119].

Scientific research raises the question not only of reviewing the technological aspects of augmented reality, but also of cognitive characteristics and the effect of immersion on recipients [5, p. 1057–1080; 32, p. 44–49]. In the context of this study, which focuses on project activities using augmented reality, the theory of situational cognition explains that the feeling of presence arises when users interact with virtual products, leading to a situational feeling of "presence" in the virtual environment [22, p. 18]. According to the theory of contextual immersion proposed by J. Lee and M. Kim, the effectiveness of augmented reality in organising the creative process depends on the contextual relevance of virtual models, which can be structured around: 1) time and place; 2) object (related to object recognition); 3) user, which promotes personalisation, interactivity and various forms of user communication [20, P. 199–208]. This study also emphasises the need to use immersive methods when evaluating augmented reality experiences [10, p. 24–37; 32, p. 44–49; 15, p. 70–79].

S. LaValle notes that neurons in the human brain respond to virtual stimuli in the same way as they respond to stimuli in the real world, meaning that people perceive virtual environments and respond to them in the same way as they do to reality. Based on the above, it can be concluded that virtual content affects users in the same way as physical content [19, p. 13]. However, G. Ryan, S. Callaghan, A. Rafferty, M. Higgins, E. Mangina, and F. McAuliffe argue that the sense of presence in augmented reality can sometimes negatively affect concentration [28] A similar concern is expressed by V. Volynets, who notes that immersive technologies "gradually reduce the proportion of direct communication between teacher and student" [36, P. 44].

With the growth in the number of AR applications, there is a growing need to analyse user experience [7, p. 49–50; 30, p. 40–44] and stimulate their creativity [6, p. 34–48]. The results of these studies confirm the conclusion that augmented reality can be used to create artistic content that embodies the most ambitious ideas of developers, as well as to promote interactive forms of artistic activity.

L. Hrynevych, N. Morze, and M. Boiko emphasise that the digital transformation of education requires the development and effective use of appropriate electronic educational resources, tools, and services, as well as the improvement of the digital competence of students, teachers, educators, and parents [14, p. 2]. Therefore, there is a growing need to review educational programmes in line with modern technological achievements and pedagogical approaches.

Despite the noticeable enthusiasm of researchers and technologists for augmented reality, scientists mostly consider AR as an auxiliary tool in the creative process. In contrast, this study focuses on reviewing culture-creating practices in educational activities, through which participants in the educational process can create aesthetic (creative) results, namely works of art, by applying augmented reality. To evaluate this hypothesis, the study analyses the results of project activities using augmented reality carried out at the Kyiv National University of Culture and Arts.

The purpose of the article is to analyse the experience of implementing immersive technologies in art education practices carried out as part of the project activities of students at the Kyiv National University of Culture and Arts.

Presentation of the main research material

The potential of augmented reality technologies is particularly evident in the context of artistic practices, which involve the creation of virtual content based on images of real objects (markers) [31, p. 111–121]. VR and AR technologies are effectively used to create virtual tours of inaccessible places and to design virtual laboratories for research in various scientific disciplines [35, P. 2592]. Interactive classes can be conducted in the form of virtual lectures and seminars on platforms such as *Rumii, EngageVR, Anyland, NeosVR, High Fidelity*, and *Bigscreen*. The *Altspace* and *vTime* platforms offer significant opportunities, especially for practising foreign language skills. The key advantage of these platforms is their ability to support interactive and collaborative learning. For example, *My Way VR* provides access to over fifty high-quality video resources that can be downloaded. Within these platforms, virtual learning environments are created in real time, allowing participants to simultaneously immerse themselves in VR scenarios of the educational process.

In the context of this study, virtual and augmented reality are conceptualised as interactive information modelling technologies implemented using high-performance computing systems that influence users through visual, auditory and other sensory channels. Such practices not only contribute to the acquisition of theoretical knowledge, but also facilitate its practical application, allowing information to be conveyed and experience to be gained in a fully immersive format. The use of AR in educational environments contributes to the individualisation of the learning process, thereby promoting the emergence of new models of interaction between teachers and students. A clear example of this approach is an educational practice that took place in 2018: two groups of anthropology students – from Harvard University (Cambridge, Massachusetts) and Zhejiang University (China) – collaborated in the form of their animated avatars in a virtual classroom using the Rumii social VR platform (Doghead Simulations).

The students studied ancient Egyptian symbols found in a tomb on the Giza Plateau in North Africa together. This method of learning allowed Chinese and American students to engage in real-time dialogue and use a graphic widget to reproduce the hieroglyphs they had studied. Each student was equipped with a VR headset, and the teacher launched Rumii and downloaded three-dimensional models of the Sphinx and one of the tombs, allowing students to move around and explore the virtual space. Additional Rumii features included high-definition video streaming and screen sharing [36, p. 42]. This example illustrates not only the vast possibilities of interactive transnational academic collaboration, but also the immersive nature of simulation-based learning. Users located more than 7,000 miles apart were able to have a communicative experience and create a creative educational practice within a shared virtual environment.

The use of Video 360° footage is one of the most accessible approaches for educators seeking to implement immersive technologies in the learning process. This content is recorded using special cameras that simultaneously capture the surroundings from all angles. When viewed through virtual reality headsets, such videos create a sense of presence and spatial immersion. In contrast, inter-

active applications are more autonomous and complex developments designed for practical use in VR laboratories. One example is the group project discussed, in which students create virtual content as part of the learning process.

This form of immersing students in a virtual environment is currently being implemented in the educational system of the Kyiv National University of Culture and Arts. Teachers have the opportunity to use immersive technologies (VR and AR) to develop virtual projects, allowing students to interact directly with the learning material. Participants in the educational process work with specialised software development environments (e.g., Visual Studio Code in the CS1 programming course), database management systems (e.g., MySQL or PostgreSQL) [8, p. 184–187] and modelling platforms (e.g. MATLAB for signal processing or Simulink for system modelling) [17, p. 61–66].

In order to study the level of technological awareness among teachers and students, as well as to analyse the results of using augmented reality applications, an open seminar on the practical application of immersive technologies (VR and AR) was held on 16 May 2023 as part of the annual *Digital Weeks* event at the Kyiv National University of Culture and Arts. During the seminar, students worked in the Meta Workrooms virtual learning environment using Oculus VR virtual reality headsets (Fig. 1).

Students visited virtual museums, including St. Sophia Cathedral and Kyiv Fortress, and toured university buildings during a 3D virtual tour (Fig. 2).

Fig. 1. Open seminar on the practical application of immersive technologies (VR and AR) in education (KNUKiM, Kyiv, 2023)

Fig. 2. VR model of St. Sophia Cathedral (KNUKiM, Kyiv, 2023)

Simulating real-life scenarios using such tools allowed students to gain practical experience, thereby improving their understanding and retention of the course content.

In addition, the creation of shared virtual learning environments promotes interpersonal interaction, which in turn contributes to the development of teamwork and communication skills – competencies necessary for future professional practice [13, p. 486–510].

A research survey was conducted based on the results. Fifty-six people participated in the study, including 50 master's students and six practising teachers who conducted the seminar sessions. All respondents participated on a voluntary basis. A targeted sampling strategy was used to identify individuals or groups who had previous experience using AR tools to create artistic content. The student sample included equal representation from different academic disciplines, with 10 participants from each of the following specialisations: journalism, audiovisual arts and production, design, performing arts, cultural studies, and museum studies. During the interviews, participants shared their impressions of creating AR-based installations, as well as their experiences of collaborating with colleagues and teachers in developing artistic works, answering six research questions:

RQ1: Have you had any previous experience with augmented reality in a creative context?

RQ2: What are your impressions of participating in the study?

RQ3: Were you able to realise your creative concepts using augmented reality tools?

RQ4: Were you able to effectively integrate virtual content with representatives of the real environment?

RQ5: Did the virtual content seem realistic to you?

RQ6: Was the Unity platform functionality accessible and easy to learn?

This approach allowed the workshop facilitators to improve the design of the creative process and structure the collaboration between project participants more effectively.

Research interviews with respondents allowed us to analyse creative approaches to the application of augmented reality technology in artistic and cultural practices.

Table 1. Analytical results of the survey

Research Question	**Positive (%)**	**Negative (%)**	**Conclusion**
RQ1: Prior experience with AR	89% – had no prior experience with AR	11% –had limited experience	Most participants had no previous experience with AR.
RQ2: Impressions of participating in the study	89% – reported fascination	11% – expressed disappointed due to limited tool functionality	Participants were generally fascinated; some noted tool limitations.
RQ3: Realisation of creative ideas using AR tools	71% – were able to partially or fully realise their ideas	29% – encountered technical or conceptual difficulties	High creative potential; further technical training is advisable.
RQ4: Integration of virtual content with real-world environments	71% – believed they achieved a realistic effect	29% – reported limitations in visualization and model detail	Effective integration is possible but remains a key challenge.
RQ5: Realism of virtual imagery	89% – created convincing visuals	11% –lacked skills in textures, lighting, and rendering.	Visual quality can be improved through targeted training.
RQ6: Mastering Unity platform functionality	89% –mastered basic functions without major difficulties	11% –noted interface complexity and required teacher support	Introductory training and mentor support are recommended.

RQ1: 89% (50/56) of participants reported that they had never worked with augmented reality before. 11% (6/56) had limited experience, primarily through participation in educational projects or independent experimentation. Conclusion: for most participants, working with AR was a new experience.

RQ2: 89% (50/56) of students expressed enthusiasm about the new possibilities for creative expression enable by. 8% (4/56) reported disappointment due to the limited functionality of certain tools. 3% (4/56) expressed mixed feelings owing to technical difficulties. Conclusion: the vast majority of participants responded positively to AR, however, the need for improved technical support is evident.

RQ3: 71% (40/56) of participants were able to partially or fully realise their creative ideas. 29% (26/56) encountered technical or conceptual challenges, including limited visualization and insufficient model detail). Conclusion: AR demonstrates high creative potential but requires foundational technical skills for effective implementation.

RQ4: 71% (40/56) of participants believed they had achieved a realistic effect. 8% (4/56) reported challenges with adapting lighting and perspective,

while 21% (12/56) noted difficulties in combining virtual and real images due to software or hardware limitations. Conclusion: additional training is required to enhace the visual quality and realism of AR content.

RQ5: 89% (50/56) of participants succesfully created convincing visuals. 11% (6/56) indicated a lack of skills in handling textures, lighting, and rendering. Conclusion: realistic integration remains one of the key technical challenges in AR content development.

RQ6: 89% (50/56) of participants reported that they mastered the basic functions of the Unity platform without serious difficulty. 11% (6/56) highlighted the complexity of the interface and the need for teacher assistance. Conclusion: effective use of Unity requires introductory training or mentoring support.

These creative practices encourage students to actively participate in the learning process, allowing them to apply theoretical knowledge in virtual but realistic conditions. In particular, augmented reality contributes to a unique learning experience by supporting experiments with different pedagogical approaches. The implementation of such specialised software tools allows for the development of interactive courses in computer science and creative project management, the creation of virtual laboratories, and the construction of interactive simulations that support the study of various technical concepts.

Another example of project activity was the development of the REMS AR application, carried out by the teaching and student staff of the Kyiv National University of Culture and Arts. This application was created using Unity AR, a cross-platform development environment (Unity Technologies, USA). The project used marker scanning technology to recognise specific images. The goal was to create virtual content based on an advertising brochure for the Kyiv National University of Culture and Arts (Department of Stage and Mass Events Direction — hence the abbreviation REMS). As part of the project, participants — teachers and students — developed virtual sketches of 3D graphic models, which were projected onto each page of the printed brochure.

The third page of the brochure contains information about the academic disciplines taught at the department. Accordingly, the project participants proposed to visualise the learning process by creating virtual graphic models of students demonstrating the practical skills acquired while studying the subjects listed in the brochure. These virtual models are three-dimensional (3D) and animated, which allows for dynamic visualisation of learning outcomes.

These scenes appear automatically when the camera lens scans a programmed page of the booklet. If the position of the marker changes, the corresponding 3D model adjusts its position. Similarly, changing the viewing angle causes the model to expand or shift visually. When the user turns or closes the page, the 3D model disappears.

On the sixth page of the booklet, dedicated to the specifics of the students' stage work, the project participants created a graphic text model called "REMS is space" and placed several planets in visual perspective. Each subsequent planet appears smaller in size, creating the illusion of spatial depth and significant distance between focal points. In this way, the participants in the creative process tried to show the unlimited possibilities of the department in the implementation of the educational and creative process and at the same

time provide students with practical experience in creating a scenographic solution for spatial composition [31, p. 11–121].

This example of an AR installation demonstrates that the virtual composition created is conceptually different from the real image on the corresponding page of the booklet. This feature confirms the fact that augmented reality technology can be used not only to illustrate the content of a real image, but also to reinterpret the artist's idea by synthesising different meanings.

The introduction of immersive technologies allows students to experiment with different concepts, try out creative approaches, and develop their own strategies. For example, students can use interactive simulations to explore complex mathematical models or software processes by adjusting parameters and observing the results. In addition, the use of group activities or online competitions stimulates a sense of engagement and a spirit of competition.

In the context of creative project work, students collaborate effectively with each other and with the teacher. The results of this study highlight the relevance of augmented reality technology in modern education and highlight its potential to promote innovation in teaching and learning.

Fig. 3. REMS AR App (KNUCA, Kyiv, 2020). The result of the joint work of students and teachers is the visualisation of virtual scenes in the REMS AR application

Conclusions

To prove the hypothesis about the formative role of immersive technologies in the organisation of project-based creative learning, an open seminar was organised using VR technologies and a creative project presentation (REMS AR) of the educational process of the Department of Directing at the Kyiv National University of Culture and Arts was implemented. A survey of participants in this project activity showed that most respondents positively assessed their first experience of using AR tools to implement creative ideas. In particular, 71% reported that they were able to partially or fully implement their creative concepts, and 89% successfully mastered the basic functions of the technology without any particular difficulties. Creative project-based learning (a synthesis of the creative, culture-building and educational processes) stimulated students' interest and motivation, improved their overall learning experience and academic results. The creative experience revealed in AR installations illustrates the formative generative feature of immersive technologies in the realisation of artistic meanings and creative ideas. However, it is important to emphasise the interdependence between virtual and physical models in the development of creative projects. AR allows participants in the educational process to design simulated environments by modelling elements of the virtual world. A significant proportion of respondents (89%) confirmed that they were able to create visually convincing images that closely resemble their real-life counterparts.

Analysis of the REMS AR App project shows that virtual models are not autonomous in their application. Separated from the physical context, such as the layout of a printed brochure for the directing department, they lose their specific authorial meaning. The use of AR for modelling educational scenarios contributed to the development of teamwork skills. Thanks to the use of augmented reality, participants were able to virtualise the information presented in the printed brochure through the prism of their own interpretation, using allegory, metaphor, spatial perspective and other visual techniques. Thus, graphic virtual content became an additional creative tool that improved the perception and understanding of theoretical material. The results of this thematic study highlight the adaptability of AR in promoting educational inclusion and improving user experience, emphasising the importance of further implementing immersive technologies as a means of stimulating creativity, increasing student engagement, and promoting innovation in educational and artistic spaces. The creation of shared virtual environments for learning and collaboration improves interpersonal interaction between participants. Therefore, this study recommends that educators and students actively implement and integrate digital technologies into their teaching and learning methodologies in line with current educational and technological trends.

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