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Aesthetic issues in the design of multimedia virtual exhibition spaces

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Abstract. The relevance of the study was determined by the digitisation of the museum sector and the growing role of virtual exhibitions in preserving cultural heritage. At the same time, digital technologies create aesthetic challenges that affect the quality of the user experience, making the study of the aesthetics of virtual exhibitions relevant for modern design. The aim of the study was to analyse and identify the main aesthetic problems in the design of digital museum spaces, analyse effective design solutions, and formulate practical recommendations for improving the user experience. The methodological basis of the study was a comparative and visual analysis of various types of virtual exhibition examples, from two-dimensional websites to three-dimensional tours and virtual reality galleries. For an objective analysis, twelve cases of virtual museums were considered, classified according to their presentation format. The results of the study revealed the existence of typical aesthetic problems, such as overloaded or chaotic composition, incorrect use of colours, unadapted typography, mismatched object scales, and ineffective interactivity. These shortcomings lead to a decrease in emotional engagement, cognitive load, and the duration of users' stay in digital spaces. At the same time, the analysis revealed positive design practices based on a logical structure of space, well-thought-out navigation, harmonious colour schemes, adaptive typography, and interactivity, which increase audience engagement and satisfaction. Platforms that combine multimedia elements with personalised viewing routes and the ability to interact with exhibits proved to be particularly effective. The practical value of the article lies in formulating a general vision of the issue, which will help curators, designers, and developers of virtual exhibitions in the aesthetic optimisation of digital space

Keywords: digital exhibitions; visual design; interactive platforms; emotional immersion; user interaction; virtual reality

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INTRODUCTION

In modern conditions of rapid digitalisation of museum affairs, virtual exhibition spaces have become particularly important as an innovative tool for preserving and promoting cultural heritage. They have provided access to museum collections to a wide audience, overcoming geographical, social and physical barriers, which has become particularly relevant in the context of the COVID-19 pandemic and other restrictions. Digital platforms have contributed not only to the preservation of cultural heritage through digital conservation, but also to the expansion of opportunities for museum communication with new audiences (Kotsiuba, 2022; Menezes *et al*., 2023; Zhang, 2023). At the same time, the development of virtual museums has been accompanied by a number of challenges, among which the key issue has been the aesthetics of digital exhibition spaces, which directly affects the quality of the user experience and the effectiveness of communication (Baloian *et al*., 2021).

The issue of aesthetics in virtual exhibition spaces has been increasingly studied in the context of the development of digital technologies, museum studies, and visual design. O.Ya. Melnyk & V.O. Shtec (2020) emphasised the importance of multimedia design for creating aesthetically appealing virtual art environments, stressing that the harmonious combination of sound, image and composition forms a new type of visual perception in digital space. E. Champion *et al.* (2021) and J. Li *et al*. (2023) emphasised that the successful design of virtual exhibitions involved the integration of innovative technologies – such as 3D modelling, virtual reality (VR) and augmented reality (AR) – with classical principles of composition, colour harmony and typography, which formed a coherent aesthetic image and contributed to the deep immersion of users. In particular, the use of game mechanics and layered temporal narratives increased visitor engagement, making virtual exhibitions more interactive and attractive. At the same time, V. Kushnir (2024) noted that digital formats required the adaptation of traditional aesthetic norms, taking into account the peculiarities of virtual space perception, as well as ensuring intuitive navigation and comfortable interaction. The researcher emphasised that the design of virtual museums should take into account the cognitive characteristics of users and create conditions for easy orientation and reduced cognitive load.

Research by G. Mercan *et al*. (2023) showed that the use of augmented and virtual reality significantly improves learning outcomes and emotional perception of exhibitions. They also noted that interactivity and multimedia are key factors that increase user engagement, promote deeper immersion, and shape a positive emotional experience. P. Freixa *et al*. (2022) examined visualisations and narratives in digital media, emphasising the importance of consistency in visual style and structure to create a holistic perception. They stressed that design must combine aesthetic and functional aspects to ensure effective communication and emotional engagement. V. Klivak (2022) explored the design features of virtual exhibitions, paying particular attention to issues of composition, form, colour harmony and typography, which often affect the quality of perception of digital exhibitions. The author emphasised that shortcomings in these aspects can lead to a decline in visitor interest and a deterioration in the overall impression.

Y.I. Kotsiuba (2022) studied the peculiarities of introducing digital technologies in museum tourism, emphasising the importance of adapting museum exhibitions to digital formats while preserving aesthetic and cultural values. The author noted that modern digital platforms should not only be technically advanced, but also aesthetically appealing in order to ensure user comfort and interest. S. Sylaiou & P. Dafiotis (2023) conducted a bibliometric and content analysis of immersive technologies in museum exhibitions, finding that VR and AR technologies significantly improve the quality of visual and emotional perception but require careful design to avoid user overload. S. Woolley *et al*. (2021) examined the role of augmented reality in creating DIY (do it yourself) exhibitions that help engage the public and increase interest in museum collections. They emphasised that innovative multimedia elements should be integrated into the design in such a way as to maintain aesthetic integrity and not distract from the main content.

Thus, an analysis of contemporary research showed that the aesthetics of virtual exhibition spaces was a multidimensional problem that required an interdisciplinary approach. It covered both technical and humanistic aspects, including composition, colour, typography, interactivity, navigation and multimedia. At the same time, there is a need to adapt classical aesthetic principles to the specifics of digital formats, which opens up new horizons for research and practice. The aim of this study was to identify key aesthetic problems in the design of virtual exhibition spaces, analyse successful practices for solving them, and formulate appropriate recommendations for overcoming them.

MATERIALS AND METHODS

In the process of preparing the article, the research was carried out in several consecutive stages. At the first stage, a systematic analysis of contemporary scientific literature devoted to issues of aesthetics, design theory, and the specifics of organising virtual exhibition spaces was conducted. Particular attention was paid to works that reveal the relationship between aesthetic categories and digital forms of presentation of artistic and cultural objects. Next, a content analysis of existing virtual exhibitions (museum, gallery, educational) was carried out, which made it possible to identify the main aesthetic problems typical of modern digital environments. In addition, the study took into account user comments on the Reddit platform (n.d.), which made it possible to

collect empirical feedback from actual visitors to virtual museums and supplement the analysis with insights from the user experience perspective. The final stage was the formation of practical recommendations for improving the quality and effectiveness of the design of virtual exhibition spaces. These were developed on the basis of a systematic analysis of contemporary scientific literature, comparative and content analysis of real virtual exhibitions, and user feedback. The author's approach consisted of combining an interdisciplinary approach, integrating psychological, cognitive and design aspects, and developing a structured methodology for evaluating aesthetic parameters.

The choice of research methods was determined by the interdisciplinary nature of the topic. The main methods were comparative analysis, content analysis, and elements of visual analysis. Comparative analysis allowed for the comparison of different approaches to aesthetics in physical and virtual spaces, while content analysis allows for the identification of typical aesthetic solutions and problems in real examples of virtual exhibitions. Visual analysis was used for a deeper examination of compositional, colouristic, and typographic solutions in digital spaces. The research methodology was designed to ensure that it could be replicated by other researchers in similar conditions. To replicate the study, it is necessary to: (1) create a bibliographic database of scientific sources by keywords ("aesthetics of virtual spaces", "design of virtual exhibitions", "digital aesthetics" etc.); (2) select at least 8-14 active virtual exhibitions of various profiles for content analysis; (3) develop criteria for evaluating aesthetic parameters (composition, colour, typography, interactivity, navigation); (4) conduct a comparative analysis of the data obtained with the theoretical provisions of modern aesthetics and design; (5) review user feedback on social media to identify typical problems of interaction and visual perception. This approach ensures the objectivity, consistency and reproducibility of the research results.

Twelve virtual exhibitions were selected for the study, which can be classified by type of digital presentation: 3D virtual spaces, 2D websites with photographs of exhibits, spherical panoramas, and interactive VR galleries. This selection allowed to cover the diversity of modern technological solutions in virtual museology and design. The first group of 3D virtual spaces included the following examples: VR Space Museum Cosmoria (Virtual Space Program, n.d.), available in VRChat, which offers interactive space exhibitions with the ability to explore the orbit of satellites and other space objects; The Tate Modern's Immersive Experience (Tate Modern, n.d.), which combines traditional art with innovative VR installations; and Cranbrook Art Museum (2025), which offers 3D tours of its exhibitions with the ability to freely view the space. These examples demonstrated a deep level of immersion and interactivity, which is important for aesthetic perception. The second group consists of 2D sites with photographs of exhibits and various navigation options. Among them are the National Museum of Women in the Arts (n.d.), which offers interactive online exhibitions with an emphasis on educational functions; the Smithsonian American Art Museum (n.d.), which provides high-quality online exhibitions with detailed descriptions and the ability to study exhibits; and The Metropolitan Museum of Art (n.d.) with personalised virtual exhibitions based on artificial intelligence (AI). These platforms are designed to provide an in-depth introduction to the exhibits through images and text information (Sylaiou & Dafiotis, 2023).

The third group consists of spherical panoramas, which allow users to view the space around them in 360 degrees. These included virtual tours of museums such as the Vatican Museums (Conroy, 2018), the Louvre (Frick Collection, n.d.) and the Prado Museum (Museo Nacional del Prado, n.d.) with ultra-high 8K resolution. These virtual tours recreate the atmosphere of the physical space, which helps to preserve the aesthetic features of the original exhibitions. The fourth group consisted of VR galleries with a high level of interactivity and the use of augmented reality (AR). Examples included the virtual collection of the Guggenheim Museum (Guggenheim Museum Bilbao, n.d.), which combines VR and AR to create a unique experience, as well as the digital exhibitions of the National Museum of Modern and Contemporary Art (n.d.) with AI-based personalisation, and the interactive AR application of the National Museum "Chernobyl" (Tintul, 2020). These platforms demonstrated current trends in the integration of technologies to enhance aesthetic appeal. The rationale for the selection of cases is based on their diversity in terms of technological approaches, geographical location and subject matter, which allows for a comprehensive exploration of aesthetic issues in different formats of virtual exhibitions. The inclusion of both classic museums with 360° tours and innovative VR galleries provided a comprehensive overview of the current state of digital museum design.

RESULTS AND DISCUSSION

Aesthetics – a philosophical and scientific category that studies the patterns of beauty, the nature of art, and the criteria of artistic value. In practical terms, aesthetics manifests itself as the ability of an object or environment to evoke feelings of harmony, satisfaction, inspiration, or, conversely, discomfort in the viewer. It is important to emphasised that in the context of virtual exhibition spaces, aesthetics is formed not only through visual characteristics, but also through the integration of the cultural context and identity of the digital environment, which enhances perception and creates a unique interactive experience (Yaremchuk, 2020; Polishchuk, 2023). Aesthetic problems are shortcomings in the visual, compositional, colouristic or interactive

organisation of space that prevent the formation of a positive emotional and cognitive experience. Research in the field of digital content perception psychology has confirmed that aesthetic decisions – the choice of colour palette, composition, typography and interactive elements – directly affect the user's emotional state. In particular, adaptive design that takes into account different user psychotypes helps to increase engagement and comfort when interacting with virtual exhibitions, while bright warm colours, harmonious composition and clear navigation can improve mood and evoke feelings of comfort and security, while chaos, excessive complexity, or poor colour combinations can cause fatigue, irritability, or even a decrease in motivation to interact with the exhibition (Klivak, 2022; Kushnir, 2024; Reddit, n.d.).

The cognitive aspect of aesthetics manifests itself in the ability of design to reduce the intellectual load on the user, facilitate the process of perception and processing of information, and promote effective memorisation and comprehension of the presented material. Taking into account the peculiarities of human thinking, such as typical perception errors, as well as the use of interactive game navigation strategies in virtual museums, significantly improves the spatial orientation of visitors and facilitates quick and easy finding of the necessary information. This reduces the number of errors during interaction, increases satisfaction with the experience, and motivates further exploration of the exhibition. Aesthetically appealing, harmoniously organised spaces stimulate positive motivation, while poor design decisions can reduce interest in the exhibition, even if its content is valuable (Yaremchuk, 2020; Kushnir, 2024; Zhang *et al*., 2024). Thus, aesthetics in the design of virtual exhibition spaces is not only a matter of visual appeal, but also a complex tool that combines visual, psychological and cognitive aspects to create a deep, inspiring and effective user experience. Taking psychological patterns into account in the design process allows for the creation of spaces that not only inform but also inspire, promote deeper knowledge acquisition, and shape a positive experience of interacting with digital cultural heritage (Polishchuk, 2023).

Based on the analysis of research, comparison with basic sources and user feedback, typical aesthetic problems of virtual exhibitions that affect the quality of perception of digital museums have been identified. Firstly, in terms of compositional solutions, there was often excessive overload of the visual field or, conversely, excessive simplification, leading to a loss of integrity of the exhibition. In 3D spaces, such as the Cranbrook Art Museum, there is sometimes a lack of clear orientation in space, which complicates navigation and creates a sense of chaos (Fig. 1).

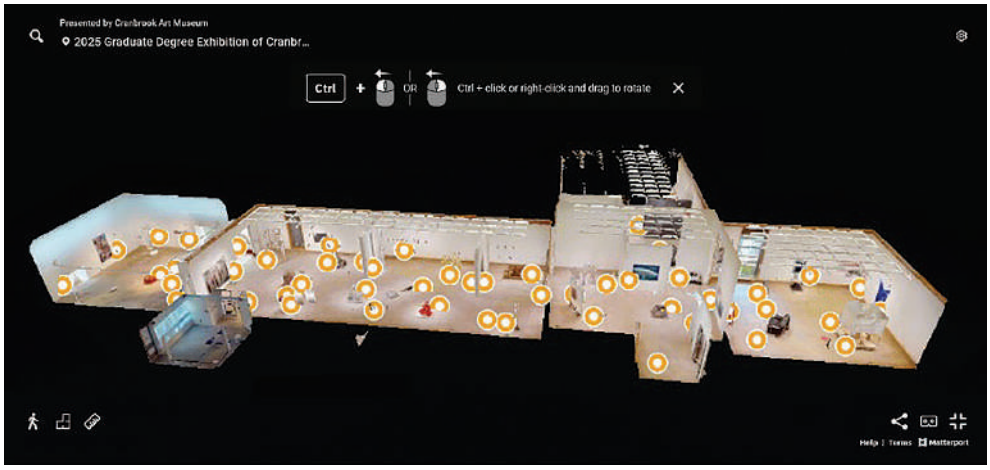

Figure 1. An example of a lack of clear orientation in space
Source: Cranbrook Art Museum (2025)

In 2D websites, such as the Smithsonian American Art Museum or The Metropolitan Museum of Art, the composition sometimes does not take into account the principles of visual hierarchy, which makes it difficult to focus on key exhibits (Fig. 2) (Kotsiuba, 2022; Fomniuk, 2023; Reddit, n.d.). This can lead to a fragmented perception of content. In addition, the lack of accents or insufficient visual structuring negatively affects the user's orientation in space. In terms of colour harmony and typography, many virtual exhibitions have noticeable problems with colour combinations that do not always correspond to the psychological characteristics of visitors' perception. For example, in spherical panoramas of the Louvre or the Vatican Museums, interface elements sometimes use contrasting colours that distract from the main content (Fig. 3). Bright colours against the background of historical objects can upset the balance between the interface design and the objects that are trying to convey a certain context and atmosphere of the museum. In addition, colours that are too bright or saturated can cause eye fatigue, which reduces the overall comfort of use.

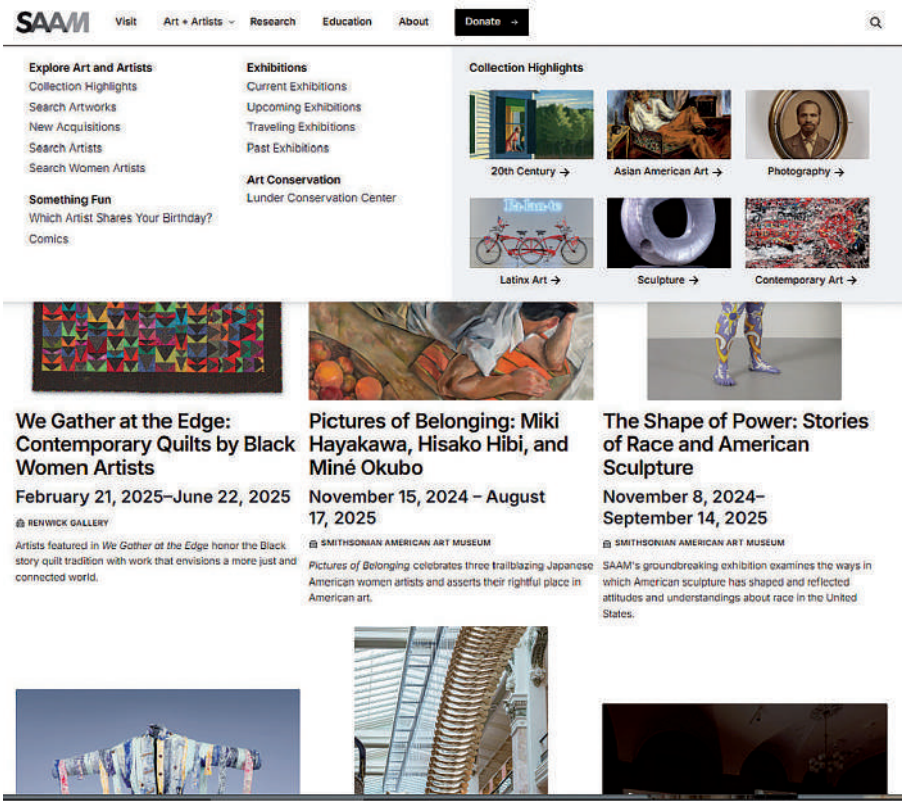

Figure 2. An example of a complex visual hierarchy of elements
Source: Smithsonian American Art Museum (n.d.)

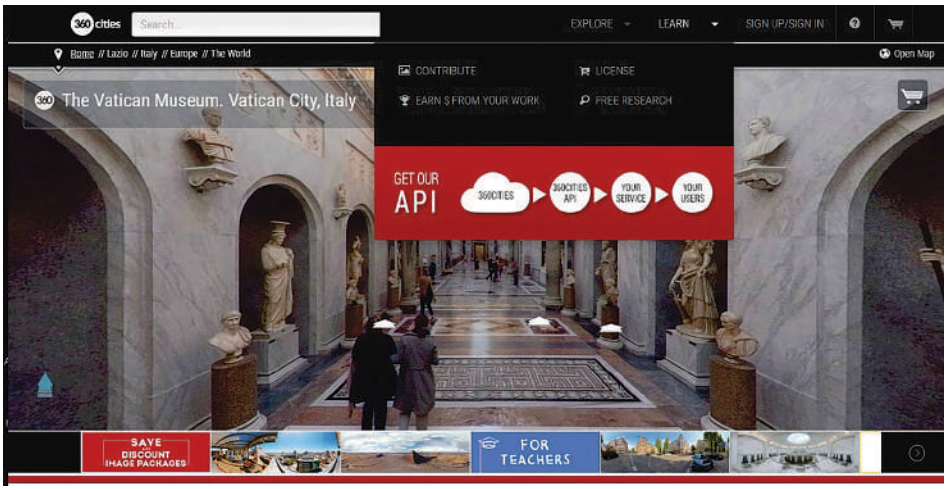

Figure 3. An example of too bright colours in interface elements
Source: B. Conroy (2018)

One of the common issues in digital panoramas is uneven seams between individual parts of the panorama, which can lead to image distortion and object warping (Fig. 4). These seams, which arise when several images or videos are combined into a single whole, may be inconspicuous at first glance, but become significant upon closer inspection, particularly when users focus on details. Typography is often not adapted to the digital format: fonts are either too small or, conversely, too large, which reduces the readability of exhibit descriptions. In VR galleries, such as the Guggenheim Museum, there is sometimes insufficient contrast between the text and navigation elements and the background, making it difficult to perceive the information (Fig. 5) (Baloian *et al.*, 2021; Reddit, n.d.). A lack of contrast can cause important text elements to become invisible, especially when they are placed on complex or changing backgrounds typical of VR environments.

Figure 4. Example of object distortion caused by uneven seams of panorama elements
Source: A. Alhazaa (2018)

Figure 5. An example of insufficient contrast between text and navigation elements
Source: Guggenheim Museum Bilbao (n.d.)

The perception of space and scale also presents certain challenges. In 3D virtual environments, users often experience a mismatch between the real and virtual scale of objects, which disrupts the sense of presence. For example, in the VR Space Museum Cosmoria, some exhibits appear disproportionately large or small, reducing aesthetic authenticity (Fig. 6). In some cases, spherical panoramas lack the option to adjust the viewing scale, limiting the depth of detail perception. Additionally, on many platforms, the ergonomics of navigation are insufficiently considered, making intuitive movement through the space more difficult (Polishchuk, 2023; Fomniuk, 2023; Reddit, n.d.).

Other aesthetic issues include insufficient interactivity or excessive interactivity, which can distract from the main content, as well as the lack of a unified stylistic solution, which makes virtual exhibitions less cohesive. Overall, these issues point to the need for a more comprehensive approach to the design of virtual exhibitions, where aesthetics are combined with functionality and user convenience. On the other hand, this method of analysing selected virtual exhibition spaces has revealed a number of positive aesthetic practices that contribute to improving the quality of the user experience and forming a coherent visual image. In particular, 3D virtual museums such as VR Space Museum Cosmoria and Tate Modern Immersive Experience effectively implement spatial composition, allowing users to intuitively navigate the virtual space thanks to the logical structure of the zones and clear visual accents. The successful combination of realistic graphics with elements of artistic stylisation creates an emotionally rich atmosphere that enhances the aesthetic perception of the exhibition (Fig. 7) (Champion *et al*., 2021; Reddit, n.d.).

Figure 6. An example of an imbalance between object scales
Source: Virtual Space Program (n.d.)

Figure 7. An example of successful navigation organisation across zones in the three-dimensional virtual world Cosmoria
Source: Virtual Space Program (n.d.)

Interactivity and navigation on many platforms are implemented in such a way that users can not only passively view exhibits, but also actively interact with them. For example, on the websites of the Smithsonian American Art Museum and The Metropolitan Museum of Art, museum exhibits can be viewed in detail, additional information can be obtained in the form of multimedia tips, and the viewing route can be personalised (Fig. 8). This increases visitor engagement and makes the experience more immersive and tailored to individual interests (Baloian *et al.*, 2021; Reddit, n.d.).

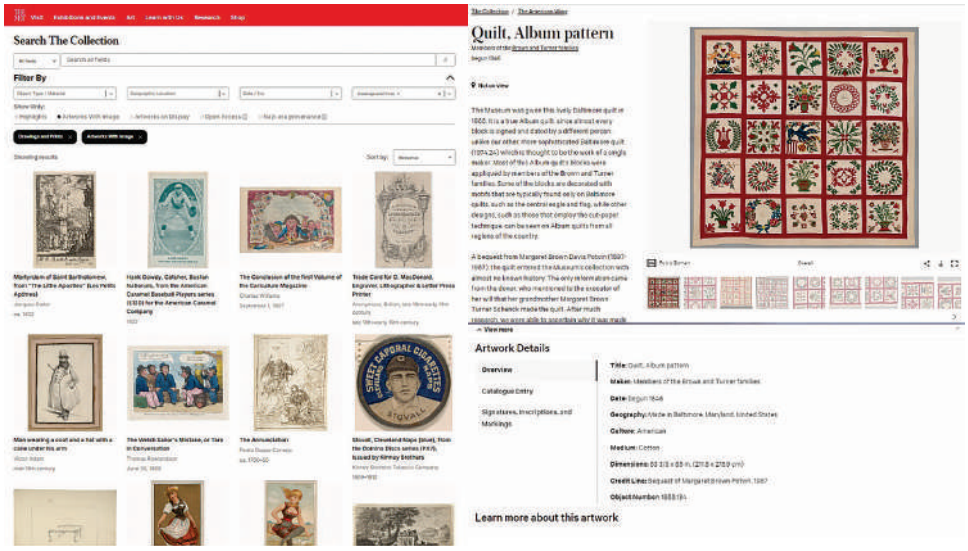

Figure 8. An example of a quick search and detailed description of museum exhibits on a website
Source: The Metropolitan Museum of Art (n.d.)

Innovative approaches to creating visual integrity are evident in the spherical panoramas of the Louvre and Vatican Museums, which use high-quality 8K resolution images to provide maximum detail and a sense of presence (Fig. 9). The successful combination of colour scheme, lighting and textures creates a unified stylistic concept that preserves the atmosphere of the original space (Klivak, 2022). Similarly, the Guggenheim Museum's VR galleries use augmented reality to integrate digital art objects into real space, expanding the boundaries of traditional museum perception (Guggenheim Museum Bilbao, n.d.). The use of multimedia elements and gamification deserves special attention, as in the mobile AR application of the National Museum "Chernobyl", which explains complex scientific concepts through an interactive game (Tintul, 2020; Champion *et al.*, 2021; Zhang *et al.*, 2024). This approach not only increases interest in the exhibition, but also makes the learning process more accessible and engaging. Overall, these positive practices demonstrate that successful virtual exhibition design is based on a harmonious combination of aesthetics, functionality and innovative technologies, which ensures deep immersion and maximum user satisfaction (Li *et al.*, 2023; Reddit, n.d.).

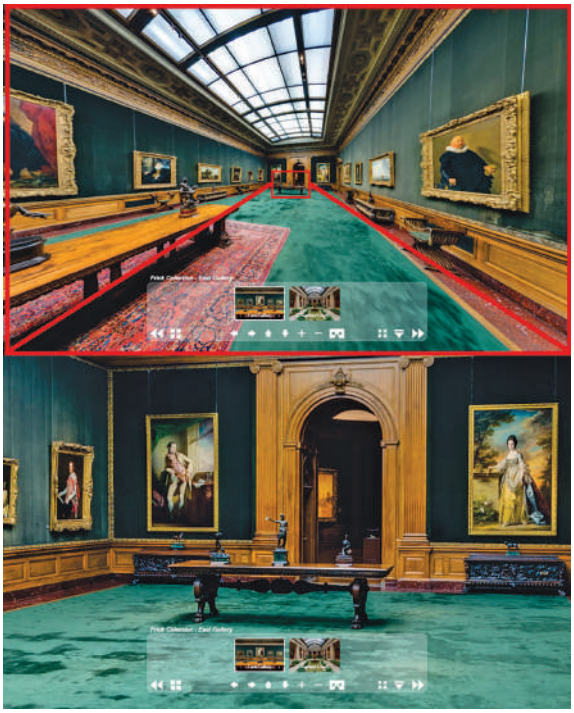

Figure 9. An example of the ability to approach a distant object in a spherical panorama
Source: Frick Collection (n.d.)

A comparison of virtual exhibition spaces with traditional physical exhibitions reveals significant differences in the formation of aesthetic experience and the transformation of classical aesthetic principles in the digital environment. Firstly, physical exhibitions have space limitations, forcing curators to select only part of the collection for display, while virtual spaces allow for the creation of exhibition rooms that are unlimited in size and number, enabling the inclusion of a more complete collection and a more comprehensive presentation of the exhibition's concept. This also facilitates the integration of multimedia and gamified elements that enhance the user's emotional immersion and make the perception of the exhibition more dynamic (Mercan *et al*., 2023; Fomniuk, 2023; Reddit, n.d.). This significantly expands the possibilities for deeper immersion of the visitor in the context of the works, and also allows for the addition of voluminous accompanying materials without overloading the user thanks to interactive elements that can be hidden if necessary. Secondly, classical aesthetic principles such as composition, scale, and colour harmony are transformed in virtual exhibitions due to the peculiarities of the digital format. For example, in a physical museum, the perception of space and scale occurs naturally through physical presence, while in a virtual environment, these parameters are often subject to correction, which can both enhance and distort the aesthetic experience. In particular, the use of adaptive algorithms and artificial intelligence allows for the personalisation of visual perception, adjusting the scale and composition to the individual needs of the user. In spherical panoramas or 3D tours, the scale of objects sometimes does not correspond to their actual dimensions, which affects the sense of presence and authenticity. At the same time, digital platforms make it possible to reproduce works in the environment in which they were created, which is impossible in physical museums, thereby expanding the boundaries of classical aesthetic concepts (Klivak, 2022; Fomniuk, 2023; Lyu, 2024).

Another important aspect is interactivity, which is limited in physical museums but becomes one of the key elements in shaping the aesthetic experience in virtual exhibitions. Virtual spaces allow users not only to view exhibits, but also to interact with them, change perspectives, obtain additional information, and personalise their viewing route, which increases engagement and makes the experience more immersive. The use of augmented and virtual reality technologies opens up new opportunities for tactile and sensory immersion, although it still does not completely replace physical contact. However, it should be noted that virtual exhibitions cannot yet fully replace physical contact with three-dimensional objects, especially sculptures and installations, due to limitations in reproducing real scale and tactile sensations (Kotsiuba, 2022; Li *et al*., 2023).

In general, virtual exhibitions are not simply digital copies of physical museums, but create a new type of aesthetic experience that combines traditional principles with innovative technologies, opening up new opportunities for the presentation, preservation and interpretation of cultural heritage. Table 1 showed that this transformation encompasses various aspects, from spatial constraints and composition to interactivity and emotional immersion, which significantly distinguishes virtual spaces from traditional ones. This process is not a temporary phenomenon, but a gradual evolution of museum practice in the digital age, requiring new approaches to museum PR, education and audience engagement.

Table 1. Comparative analysis of the characteristics of physical and virtual exhibitions

Criterion	Physical exhibitions	Virtual exhibitions
Space	Limited, selective display of collections.	Unlimited, possibility of full presentation.
Composition	Natural perception, classical principles.	Flexible, adaptive, personalised, variable.
Interactivity	Mostly passive, limited by physical contact.	High, multi-level, using VR/AR.
Emotionality	Atmosphere, haptic feedback, authenticity.	Multimedia, gamification, personalisation.

Table 1. Continued

Criterion	Physical exhibitions	Virtual exhibitions
Accessibility	Local, dependent on physical presence.	Global, round-the-clock, location-independent.
Presentation	Limited by physical conditions.	Additional digital materials, context reproduction.
Technology	Traditional exhibition methods.	3D, VR, AR, AI, interactive tools.
Museum practice	Classic approaches to education and PR.	Innovative PR, digital educational models.

Source: developed by the authors of the study

An analysis of selected virtual exhibition spaces has demonstrated the direct impact of aesthetic decisions on the user experience, particularly on visitor engagement and satisfaction. Visual content, graphical user interface, and the organisation of virtual museum space form the first impression, which determines the user's further motivation to continue exploring the exhibition. It is particularly important to take into account the principles of colour harmony, composition, typography and interface ergonomics, which contribute to the intuitive perception of information and reduce the cognitive load on the user. A high-quality interface design that takes these principles into account facilitates quick "scanning" of information, saving the visitor time and effort, which is especially important in the context of fierce competition for user attention in the digital environment (Cranbrook Art Museum, 2025; National Museum of Modern and Contemporary Art, n.d.; Reddit, n.d.).

The patterns identified showed that interactivity and multimedia significantly increase user emotional engagement. Virtual tours with the ability to zoom in, view from different angles, and personalise the viewing route, such as at the Smithsonian American Art Museum or The Metropolitan Museum of Art, create a sense of control and freedom of choice, which positively affects the enjoyment of the virtual visit. In addition, the integration of game elements and navigation strategies enhances spatial cognition and maintains user interest, as confirmed by recent studies by S.V. Polishchuk (2023) and I. Ogirko (2020). The use of multimedia elements such as videos, audio guides, and interactive maps allows for the combination of educational and entertainment aspects, which is in line with current trends in museum marketing and increases the museum's appeal to a wide audience (Tintul, 2020; Smithsonian American Art Museum, n.d.). The wide coverage of different types of virtual exhibitions provided a comprehensive overview of the issue. The patterns identified, in particular the positive impact of interactivity and multimedia on user engagement, confirmed contemporary theoretical approaches to digital aesthetics and design and coincide with the conclusions of other researchers who emphasised the role of immersive technologies and gamification in increasing engagement (Freixa, 2022; Li *et al*., 2023; Zhang *et al*., 2024).

As part of the study, a set of practical recommendations was developed aimed at improving the aesthetic quality and effectiveness of the design of virtual exhibition spaces:

1. Introduction of a structured system for evaluating aesthetic parameters. It is proposed to use clearly defined criteria for evaluating composition, colour harmony, correct display of elements, typography, interactivity and navigation in virtual exhibitions. This will allow for objective analysis and comparison of different platforms, as well as the formulation of recommendations for their improvement.

2. Optimisation of compositional solutions. It is recommended to avoid overloading or chaos in the visual field, to ensure a logical structure of zones, clear visual accents, and a hierarchy of exhibits. Particular attention should be paid to adapting the composition to the specifics of the digital format, taking into account the peculiarities of space perception in three-dimensional and two-dimensional environments.

3. Ensuring the correct display of spherical panoramas. To create spherical panoramas without distortion, it is recommended to use high-quality equipment with a full viewing angle of 360 × 180 degrees. It is important to plan shooting points, avoid overlaps and "dead zones." At the post-processing stage, specialised software should be used to correct geometric distortions. The use of cubic projection helps to minimise distortion and facilitates editing.

4. Harmonisation of color palette and typography. It is advisable to use color combinations that correspond to the psychological characteristics of the target audience and contribute to a more comfortable perception. Typography should be adapted to the digital format: fonts should be legible, contrasting, and consistent with the overall style of the exhibition.

5. Develop intuitive navigation and adaptive interactivity. It is recommended to implement simple, understandable navigation tools that allow users to easily navigate the virtual space. Interactivity should be measured and correspond to the content of the exhibition, without distracting from the main content, but at the same time stimulating research activity and engagement.

6. Use of multimedia and gamified elements. It is worth integrating video, audio, AR/VR technologies, and game mechanics to increase emotional engagement and user motivation. Such elements should be harmoniously integrated into the overall concept of the exhibition and contribute to a deeper understanding of the material.

7. Personalisation of the user experience. It is recommended to implement personalised viewing routes, adaptive interfaces, and the ability to customise visual parameters according to individual user needs.

8. Integration of cultural context and identity. To increase the authenticity and uniqueness of virtual exhibitions, it is recommended to take into account national, historical, and cultural characteristics, as well as to use local narratives and visual codes.

9. Testing and feedback. It is advisable to develop an algorithm for engaging users in testing new exhibitions, followed by analysis of their feedback for the rapid improvement of aesthetic and functional solutions.

This development is a universal methodology that can be adapted to different types of digital museum platforms. The implementation of the proposed recommendations will improve the quality of virtual exhibitions, provide a deeper immersion for users, and contribute to the further development of digital museum design. The results of the study outlined guidelines for improving the aesthetics of digital exhibitions, in particular the need to implement adaptive design solutions that take into account the perceptions of different audiences and ensure a balance between visual appeal, functionality, and technology. Based on an analysis of scientific sources by N. Baloian *et al*. (2021), P. Freixa *et al*. (2022), and V. Klivak (2022), common aesthetic problems were identified: compositional overload, colour disharmony, scale violations, and excessive or weak interactivity. Such shortcomings complicate navigation, reduce emotional engagement and perception quality. On the other hand, logical space organisation, a harmonious colour palette, typography and multimedia elements that promote prolonged stay and deeper immersion in the virtual environment are recognised as effective practices.

In studies by M. Butyrina & V. Ryvlina (2021) and J. Li *et al*. (2023), the impact of aesthetic characteristics on users was considered in the context of spatial orientation, emotional state, motivation to further explore the exhibition, and overall satisfaction with interaction with the digital environment. Conclusions about the effectiveness of certain solutions were based on the generalised results of content analysis of descriptions, analytical reviews, user feedback, and case studies presented in scientific works and practical research. Since qualitative rather than quantitative indicators prevailed in open sources, the conclusions presented were the result of a comprehensive analysis, systematisation, and comparison of various studies. This made it possible to obtain a representative picture of the main trends and problems of the aesthetics of virtual exhibition spaces, as well as to outline directions for future research, in particular regarding the development of new design solutions, the introduction of multi-sensory technologies, and the improvement of the personalisation of the museum experience.

The study by S. Yolthasart *et al*. (2024) focused on the importance of gamification in increasing visitor engagement in virtual museum spaces. The authors proved that the introduction of game mechanics, such as points, achievements, or interactive quests, stimulates research activity and encourages users to stay longer in the digital environment. The study emphasises that the most effective solutions are those that combine game elements with educational tasks, allowing users not only to be entertained but also to delve deeper into the content of the exhibition. This is fully consistent with the case of The Tate Modern's Immersive Experience, where gamified VR installations not only increased the level of emotional engagement but also contributed to better assimilation of information about works of art (Tate Modern, n.d.).

Another important aspect is the evaluation of the user experience in virtual museums using VR technologies, which was revealed in a study by S. Jangra *et al*. (2025). The authors found that ease of navigation, visualisation quality, and the ability to personalise the route are critical to forming a positive perception of the digital exhibition. The researchers noted that even with high-tech solutions such as 3D modelling or AR elements, it is the ergonomics of the interface and its adaptability to different user groups that determine the overall level of visitor satisfaction. These findings were confirmed by an analysis of the Chernobyl AR app case study, where the integration of flexible navigation and multimedia prompts significantly expanded the audience and improved the quality of emotional immersion (Tintul, 2020).

At the same time, the literature has drawn attention to problems of orientation in virtual space, excessive information overload, and imperfect typography, which reduce the quality of the exhibition experience. N. Baloian *et al*. (2021) emphasised the importance of intuitive navigation in virtual museums, while Y. Zhang *et al*. (2024) proposed gaming strategies to improve users' spatial orientation. This indicates that existing challenges require further study and the development of comprehensive design solutions to improve the quality of the virtual museum experience. In addition, M. Butyrina & V. Ryvlina (2021) drew attention to the transformation of cultural narratives in virtual museums, emphasising that the aesthetics of digital exhibitions should take into account not only visual but also semantic aspects that shape new ways of perceiving art and history. This aspect has opened up prospects for further interdisciplinary research combining art history, cultural studies and digital technologies.

Contemporary virtual exhibitions have certain limitations, which, from a scientific point of view, consist in the fact that virtual spaces mainly activate the visual and auditory channels of perception, while tactile, olfactory and other sensory modalities are neglected. The lack of full sensory immersion limits the depth of emotional and cognitive perception of the exhibition, which reduces the level of presence and authenticity of the experience. Z. Wu & M. Oktrova (2024) showed that emotional engagement and the presence effect in a VR

environment are key factors for a deeper understanding of art, especially in the context of interactivity and personalisation of the experience. In addition, there are technical challenges associated with accurately reproducing scale, textures, and spatial orientation, which sometimes leads to distortions and user discomfort. Furthermore, studies have shown that interface ergonomics and adaptability to different user groups are key factors in improving the effectiveness of virtual museums. It is also worth considering that not all potential visitors have access to modern VR/AR devices, which limits the possibilities for full immersion (Melnyk & Shtec, 2020; Butyrina & Ryvlina, 2021; Zhang *et al*., 2024).

The results of a study conducted by Z. Wu & M. Oktrova (2024) deserve special attention, as they found that the use of virtual reality technologies significantly affects the interpretation of contemporary art in virtual exhibitions. The authors argued that VR not only expands the visual and spatial boundaries of digital galleries, but also stimulates the emergence of new strategies for viewer interaction with works of art. One of the most interesting effects recorded by the researchers was the formation of individualised perception, when visitors can change the angle, scale and even colour scheme of a work using interactive tools. This, in turn, enhances the subjectivity of art interpretation, as each viewing can be a unique experience that does not entirely depend on the author's intention. The authors' research also emphasised that such personalisation in digital exhibitions of contemporary art opens up new opportunities for curators to engage audiences, but also calls into question the permanence of the "classical" museum interpretation and hierarchy of meanings of a work.

Thus, aesthetic issues and positive practices in the design of virtual exhibitions remain relevant topics for scientific analysis. The current state of the problem is characterised by significant progress in the digitisation of museum affairs, but at the same time has significant limitations that require further development. Virtual spaces allow for expanding the audience, providing access to hard-to-reach or unique exhibits, and implementing innovative interactive solutions that increase user engagement. In particular, the integration of game navigation strategies in virtual museums has contributed to improving spatial perception and user experience. However, despite these advantages, modern virtual exhibitions are not yet able to provide the full range of sensory perception that is inherent in physical exhibitions.

CONCLUSIONS

The study showed that aesthetics is a decisive factor in shaping a quality user experience in virtual exhibition spaces. An analysis of various types of digital exhibitions revealed a number of typical problems, among which the most prevalent were overloaded or chaotic compositions, unsuccessful colour schemes, unsuitable typography, mismatched scales and curvature of objects, as well as ineffective interactivity. These shortcomings reduced the level of emotional engagement, made it difficult for users to orient themselves in space, and worsened the overall impression of interacting with digital museum platforms. In particular, the VR Space Museum Cosmoria suffered from disorientation due to its chaotic composition, while the Louvre's spherical tours had problems with colour harmony, which made it difficult to perceive details. Similar challenges arose at the Museo Nacional del Prado due to a mismatch in scale, and excessive interactivity at the Smithsonian American Art Museum distracted from the main content.

At the same time, the results of the study pointed to the effectiveness of design practices based on a logical spatial structure, a harmonious combination of colours and fonts, well-thought-out navigation and interactivity adapted to the needs of different audiences. Platforms that integrated multimedia content, personalised visitor routes, and active interaction with exhibits demonstrated the greatest effectiveness. For example, the Tate Modern Immersive Experience provided a high level of orientation thanks to a clear spatial structure, while the National Museum of Women in the Arts improved readability through harmonious typography. The National Museum of Chernobyl's AR app combined gamification with educational content, which significantly increased user engagement. Such solutions contributed to deep immersion and the formation of a positive emotional and cognitive experience. The study confirmed that the modern design of virtual exhibitions should take into account not only visual and compositional aspects, but also the psychological characteristics of digital content perception, ensuring a balance between aesthetics, functionality, and innovation. It is important to implement intuitive navigation, adaptive interactivity, and multimedia elements that do not distract but rather support users' research activity. At the same time, cultural context and national characteristics should be taken into account, allowing for the creation of unique digital spaces with a high level of authenticity. Additionally, it was noted that the wide possibilities for personalising the perception of works of art in virtual reality create a unique individual experience that can differ significantly from classical museum interpretations, opening up new challenges and perspectives for curatorial practice.

Thus, the results of the study not only revealed the main problems and positive practices in the design of virtual exhibitions, but also formed practical recommendations for improving the user experience. The introduction of adaptive navigation systems, harmonious colour palettes, measured interactivity and multimedia elements will contribute to increased comfort, engagement and motivation of users. At the same time, further work should be aimed at overcoming technical

limitations related to the reproduction of sensory modalities, as well as expanding the accessibility of innovative technologies to a wider audience.

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Проблеми естетики в дизайні мультимедійних віртуальних експозиційних просторів

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Анотація. Актуальність дослідження зумовлена цифровізацією музейної сфери та зростанням ролі віртуальних експозицій у збереженні культурної спадщини. Водночас цифрові технології створюють естетичні виклики, що впливають на якість користувацького досвіду, що робить вивчення естетики віртуальних експозицій актуальним для сучасного дизайну. Мета дослідження – проаналізувати та виявити основні естетичні проблеми у дизайні цифрових музейних просторів, провести аналіз ефективних дизайнерських рішень та сформулювати практичні рекомендацій для покращення користувацького досвіду. Методологічну основу дослідження становили порівняльний і візуальний аналізи віртуальних експозиційних прикладів різного типу – від двовимірних сайтів до тривимірних турів і галерей віртуальної реальності. Для об'єктивного аналізу було розглянуто дванадцять кейсів віртуальних музеїв, класифікованих за форматом представлення. Результати дослідження свідчили про існування типових естетичних проблем, таких як перевантаженість або хаотичність композиції, некоректне використання кольорів, неадаптована типографіка, невідповідність масштабів об'єктів та неефективна інтерактивність. Ці недоліки призводять до зниження емоційного залучення, когнітивного навантаження та зменшення тривалості перебування користувачів у цифрових просторах. Водночас аналіз виявив позитивні дизайнерські практики, які ґрунтуються на логічній структурі простору, продуманій навігації, гармонійному колористичному рішенні, адаптивній типографіці та інтерактивності, що підвищує залученість та задоволення аудиторії. Особливо ефективними виявилися платформи, які поєднують мультимедійні елементи з персоналізованими маршрутами огляду й можливістю взаємодії з експонатами. Практична цінність статті полягає у формулюванні загального бачення проблематики, що допоможе кураторам, дизайнерам і розробникам віртуальних експозицій в розробці естетичної оптимізації цифрового простору

Ключові слова: цифрові виставки; візуальний дизайн; інтерактивні платформи; емоційне занурення; користувацька взаємодія; віртуальна реальність