МЕТОДИЧНІ АСПЕКТИ ВИКОРИСТАННЯ ВІРТУАЛЬНИХ МУЗЕЇВ У ОСВІТНЬОМУ ПРОЦЕСІ ЗАКЛАДУ ЗАГАЛЬНОЇ ОСВІТИ

METHODICAL ASPECTS OF USING VIRTUAL MUSEUMS OF THE EDUCATIONAL PROCESS IN GENERAL EDUCATION INSTITUTIONS

Наталія СОРОКО ✉

Інститут цифровізації освіти
Національної академії педагогічних наук України, Київ, Україна
nvsoroko@gmail.com
https://orcid.org/0000-0002-9189-6564

Nataliia SOROKO ✉

Institute for Digitalisation of Education of the National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine
nvsoroko@gmail.com
https://orcid.org/0000-0002-9189-6564

АНОТАЦІЯ

Широкомасштабна пандемія, спричинена Covid-19, вимушені довготривалі канікули та нестабільність ситуації в країні підняли одну з глобальних проблем освіти – якісний освітній контент.

***Формулювання проблеми.** Світова культура XXI століття існує в динамічному середовищі, яке стрімко розвивається в усіх сферах людської діяльності. Інформаційно-комунікаційні технології мають значний вплив на соціокультурні процеси. У той же час поняття «віртуальність» міцно входить у контекст культури, освіти та бізнесу. Одним із важливих нововведень, які зайняли значне місце в культурному житті, є таке явище, як віртуальний музей.*

***Матеріали і методи.** Для досягнення мети дослідження ми використовували такі методи: систематичний та порівняльний аналіз педагогічних, психологічних, філософських, соціологічних праць, методичної та спеціальної літератури; аналіз педагогічного досвіду використання віртуального музею для навчання в закладах загальної середньої освіти; опитування вчителів про їхній досвід використання віртуального музею у навчальному процесі, виявлення проблем для створення спеціальних вебінарів та курсів з метою розвитку цифрової компетентності вчителя; інтерпретація результатів дослідження.*

***Результати.** Встановлено, що використання віртуальних музеїв у навчальному процесі дає змогу ефективно вирішувати такі основні дидактичні завдання: забезпечення наукового характеру оволодіння студентами науковими знаннями та сприяння формуванню в них демократичного світогляду, що ґрунтується на достовірних наукових фактах і відповідає динаміці розвитку відповідних наукових знань; посилення наочності навчання як принципу дидактики, зумовленого характером процесу пізнання, який починається з чуттєвого сприйняття, переходить до абстрактного мислення, а від нього до практики; розвиток пізнавальних інтересів і здібностей учня як принцип дидактики, що визначає найважливіші мотиви навчання учнів (формування пізнавальних інтересів відбувається двома шляхами: через матеріал, що становить зміст навчання та організацію пізнавальної діяльності учнів); використання віртуальних музеїв може вплинути на зорову та слухову пам'ять учнів; прискорення темпу засвоєння та запам'ятовування навчального матеріалу, що сприяє зміцненню знань, розширенню пізнавальних інтересів учнів; активізація самостійної роботи студентів; зв'язок теорії і практики, що зумовлює необхідність відображення двох нерозривно пов'язаних сторін єдиного процесу навчання; індивідуалізація навчання.*

***Висновки.** Віртуальні музеї дають змогу значно доповнити, розширити та поглибити зміст матеріалу, що вивчається за програмою. Використовуючи віртуальні музеї, вчитель може найкраще підібрати навчальний матеріал. Віртуальні музеї дозволяють найпростішим, доступним і емоційним способом передати навчальний матеріал, значно активізувати розумову діяльність учнів, розширити їх світогляд, викликати особливий інтерес до тієї чи іншої галузі знань. Для того, щоб використання віртуальних музеїв у навчально-виховному процесі сприяло розвитку*

ABSTRACT

The large-scale pandemic caused by Covid-19 forced long vacations and the unstable situation in the country has raised one of the global problems of education - quality educational content.

***Formulation of the problem.** World culture of the XXI century exists in a dynamic environment that is rapidly evolving in all areas of human activity. Information and communication technologies have a significant impact on socio-cultural processes. At the same time, the concept of «virtuality» is firmly in the context of culture, education, and business. One of the important innovations that have taken a significant place in cultural life is a phenomenon such as a virtual museum.*

***Materials and methods.** We used the following methods to achieve the goal of the study: systematic and comparative analysis of pedagogical, psychological, philosophical, sociological works, methodological and specialized literature; analysis of the pedagogical experience of using virtual museums of the education in general secondary education institutions; questioning teachers about their experience of using virtual museum in the educational process, identifying problems for the creation of special webinars and courses to develop digital competence of teacher; interpretation of research results.*

***Results.** The use of virtual museums in the educational process makes it possible to effectively solve the following basic didactic tasks: ensuring the scientific nature for students'education mastery of scientific knowledge and promoting the formation of a democratic worldview in them that based on credible scientific facts and corresponds to the dynamics of of relevant scientific knowledge development; strengthening the clarity of learning as a principle of didactics, due to the nature of the process of cognition, which begins with sensory perception, moves to abstract thinking, and from it to practice; development of student's cognitive interests and abilities as a principle of didactics, which determines the most important motives for student learning (formation of cognitive interests occurs through two ways: through the material that constitutes the content of learning and organization of students cognitive activity); the use of virtual museums can affect students' visual and auditory memory; accelerating the pace of learning and memorizing learning material, which contributes to the strength of knowledge, expanding the cognitive interests of students; the intensification of students' independent work; the connection between theory and practice, which necessitates the reflection of two inextricably linked aspects of a single education process; individualization of learning.*

***Conclusions.** The virtual museum makes it possible to significantly supplement, expand, and deepen the content of the material studied in the curriculum. Using virtual museums, the teacher can best select educational material. Virtual museums allow in the simplest, most intelligible, and emotional way to transfer educational material, significantly enhance the mental activity of students, expand their worldview, and arouse special interest in a particular field of knowledge. For the use of virtual museums in the educational process to promote the development and formation of cognitive interests of students, the teacher must: select information to be presented with the help of virtual museum, by content and compose it in a composition so that it corresponds to the purpose, age, knowledge, and interests of students; the use heuristic methods in teaching educational*

та формуванню пізнавальних інтересів учнів, учителю необхідно: підбирати інформацію у віртуальних музеях за змістом і компонувати її так, щоб вона відповідала меті, віку, знанням та інтересам учнів; використовувати евристичні методи у викладанні навчального матеріалу за допомогою віртуального музею; організувати відповідно до конкретних інтересів учнів різноманітні форми самостійної роботи з використанням віртуального музею (бажано у формі навчальних проектів).

material with the help of virtual museum; to organize by the specific interests of students various forms of independent work with the use of virtual museum (preferably in the form of educational projects).

INTRODUCTION

Formulation of the problem. World culture of the XXI century exists in a dynamic environment that is rapidly evolving in all areas of human activity. Information and communication technologies have a significant impact on socio-cultural processes. At the same time, the concept of «virtuality» is firmly in the context of culture, education, and business. One of the important innovations that have taken a significant place in cultural life is a phenomenon such as a virtual museum (VM).

The research is based on the idea that virtual museums complement education activities on important objects for learning.

This is a fairly new technology in the field of education that requires research in such areas as methods and approaches for its use at different levels of education and in different disciplines, impact on the quality of education, understanding and appropriate use of students in their acquisition of knowledge and skills and teachers to manage the education process.

An analysis of recent research. At the beginning of the XXI century, the development of interactive programs for users, which organize activities in cooperation between educational institutions and museum institutions, taking into account various features of museum-pedagogical activities, is becoming widespread. This is evidenced by many studies of scientists, namely: Karamanov O. V. (2020), Fenenko A. O. (2021), Volynets V.O. (2019), Barroso Osuna J., Gutiérrez-Castillo J.J., Llorente-Cejudo M.D., Valencia Ortiz R. (2019), Daniela L. (2020), Yichen Jia (2020), Schweibenz Werner (2019), Hooper-Greenhill E. (2012), Mukasheva (2022), etc.

The phenomenon of musealization is aimed at preserving the historical potential and creative reserve of human experience, which is realized in collections of objects representing the man experience, communities, nation, and humanity, covering not only traditional institutional activities but also non-institutional practices (Fenenko, 2021; Mukasheva, 2022; Soroko, 2020).

In modern conditions, the Internet is becoming an important virtual space of memory, where, along with disparate memorial events, framework and integrative projects are implemented, including virtual museums, which acquire a certain institutional framework (Volynets, 2019; Soroko et al., 2020).

VM is a type of website optimized for exhibiting museum materials from various fields of science, art, and history (Schweibenz Werner, 2019). Unlike the real, which is static and already formed, the virtual is a kind of problem complex, a node of trends or forces that accompany a situation, event, object, or entity and that motivate the user to solve the problem (Levy, 1998).

In the British Encyclopedia, a virtual museum is a collection of digital objects of cultural value that can be accessed through electronic media (Britannica, 2017).

So, in the mid-90s of the twentieth century, the concept of «virtual museum» came into use. Several thousand virtual museums are currently operating in the Internet space, differing from each other in the form of presentation of the material, the visual solutions used, as well as in the general thematic focus.

It should be noted the project «Virtual museums and social platform on European digital heritage, memory, identity, and cultural interaction» (https://cordis.europa.eu/programme/id/H2020_CULT-COOP-08-2016) that was conducted under the Horizon 2020 Framework Programme from 2015 to 2020. The project's challenge was to give further emphasis on improving access, establishing meaningful narratives for collections and displays, and story-led interpretation by the development of VM. Actions were focused on the development of highly innovative technologies, methods, and ICT tools to significantly improve the 'digital encounter' including the quality of images, sonic narratives, the display, and interactivity with digital objects; social media tools should be integrated into the VM platform to facilitate the exchange of information among users. The project involved: 193 science centers/museums, 19 natural history museums, 28 research bodies, 34 private companies, 9 festivals, 8 professional networks, and 36 other organizations.

«The challenge with developing virtual museums is establishing meaningful user experiences that allow for personal, complex, and emotional encounters with art and cultural heritage», says Anders Sundnes Løvlie, an associate professor at the IT University of Copenhagen and coordinator of the EU-funded GIFT project (https://cordis.europa.eu/article/id/413511-redefining-the-museum-experience-for-the-digital-age-test). The project has had an impact for an audience such as academic researchers, students, creative industries and the public at large. Several prototypes from the project have been deployed to the public in museums in three different countries. Further exploitation of prototypes is being explored with several museum partners. Museums may also benefit from design tools and best practice recommendations offered as part of the framework. In one museum, work with the action research part of GIFT led to the establishment of an internal "digital think tank" which has become a permanent part of the organization offering advice to the museum's management.

Virtual Museums (Fig. 1) can be sorted into the following types (Paliokas et al., 2008):

– Art Collections such as Images, videos, and history of the objects. Those VRMsare about digitalized photos of art effects accompanied by short descriptions, critics, and other information (style, material, and physical sizes). Examples: the Virtual Museum of Japanese Art (http://web-ja-pan.org/museum/menu.html), The Nicholas P. Goulandris Foundation Museum of Cycladic Art (www.cycladic-m.gr).

– Video Tour. Real Museums (with physical presence) are illustrated by panoramic photos of their exhibition rooms.

Examples: the Virtual Museum of Art, Uruguay (http://muva.elpais.com.uy) and the National Gallery of Art, Washington DC (http://www.nga.gov/exhibitions/vgwel.shtm).

‒ Virtual Reality Museums. All architectural elements and the contents of the museum are designed using CAD software (AutoCAD3, 3Dstudio Max1, Maya1c) and played as VRML4files using plugins for web browsers.

‒ Social Interaction Virtual Museums. Virtual Museums with collaborative capabilities offer the visitor the opportunity not only to interact with the three-dimensional world but with the other visitors as well. Examples: a museum of this category visit Tokyo University Digital Museum: MMMUD (http://www.um.u-tokyo.ac.jp/digital/mud.html) Virtual Museum Portals.

‒ Artist's Blogs. A lot of individuals or groups of artists hold personal portfolio presentations using blogs.

The development phase of the VM includes the collection and digitalization of the available material, the design and development of databases for network functionality, and the design of educational activities. Other issues designers confront are the architectural rendering of the virtual scenes, management of 3-D sound, development of communication tools, etc. The case study of this paper is a new type of output files produced by Multimedia Authoring Instruction Tool (MAIT) software (Kekkeris & Paliokas, 2005) earlier developed and intended to offer the Aesthetics and Art History educators a software package to create multimedia presentations. Special care was taken to ensure that the interface design was in line with the age and knowledge of the students, previous experience with virtual reality and other multimedia applications, and familiarity with video games.
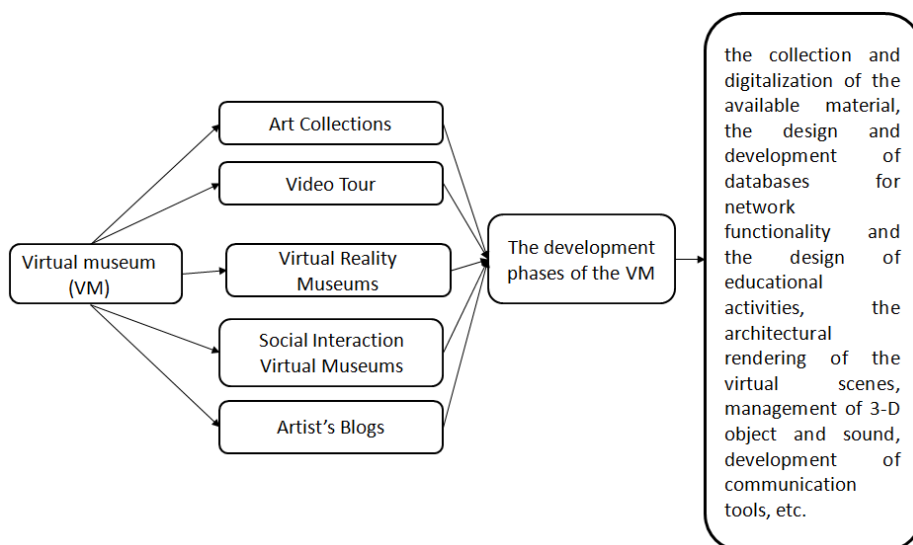

Fig. 1. Classification of virtual museums and their development phase

VM have specific characteristics that support the idea that they can serve as training agents, namely: virtual museums can complement analog reality with digital information; data integration is coordinated in real-time; they make it easy to combine different resources: text, websites, video, audio, and 3D; interactive education materials; tools to create content that requires the participation of the individual (scientist, teacher, and other users) (Barroso Osuna et al., 2019; Daniela, 2020).

The goal of the article is to substantiate and single out methodological aspects of virtual museums in the educational process of general education.

RESEARCH METHODS

We used the following methods to achieve the goal of the study: systematic and comparative analysis of pedagogical, psychological, philosophical, sociological works, methodological and specialized literature; analysis of the pedagogical experience of using VM of the education in general secondary education institutions; questioning teachers about their experience of using VM in the educational process, identifying problems for the creation of special webinars and courses to develop digital competence of teachers; interpretation of research results.

RESEARCH RESULT AND DISCUSSION

We asked teachers to plan and organize a learning project for their students on the use of VM, which would have such a plan: the project topic, the project purpose, which will correspond to the final result to be provided by students, the main project issues, the teaching time, the preparation time, important tasks and students activities, online tools (in particular VM), offline tools, assessment, formative assessments, final assessment, student feedback, teacher feedback.

This should be an integrated lesson plan such as a teacher's detailed description of the course of instruction or «learning trajectory» for a lesson, a guide, and a document that will be continuously improved and updated. It is about developing educational activities that promote deep learning to improve 21st-century skills such as critical thinking, collaboration, communication, creativity, and divergent thinking. Developing a pathway based on methodologies such as problem-based, project-based, and challenge-based learning allows you to incorporate problem-based learning, inquiry, and design into learning activities, taking care of real challenges in the authentic context of our world. Thanks to the multidisciplinary approach, students had to learn to consider the same issue from different points of view, which is an important condition for promoting the development of scientific thinking.

The following VM and tools were proposed:

– to study specific topics (for example, virtual museum: http://www.eskeletons.org/compant, https://www.travelandleisure.com/attractions/museums-galleries/museums-with-virtual-tours; and a directory to virtual museums and museum home pages on the Internet can be found in the World Wide Web Virtual Library: Museums, a service of the International Council of Museums (ICOM) that provides lists of museums by country as well as other categories);

– to create their personal VMs (for example, metaverse, blippar, Google Slides).

One of the interesting projects created by teachers should be noted as «Virtual museum of biology: the musculoskeletal system of man». The goal of the learning project was to teach students the importance of collaboration and division of labor by taking advantage of group experiences on biology, visiting biology museums, understanding virtual museums, and the experience visiting them. The lesson was taught in 3 parts: part 1 was the uncoordinated phase in which individual actions were carried out and subsequently analyzed; part 2 was the planned implementation phase where the division of labor and cooperation was emphasized; part 3 was the consolidation phase where learning discussed and evaluated. The learning objective was the defining what the vertebrate skeleton is.

Most questions of the project were:

– What are the structure and functions of the musculoskeletal system?

– What are the similarities and differences between bone and cartilage?

– What are the characteristics of bone?

– What is the human skeleton?

– What is a virtual museum?

– What exhibits should be placed in the Museum of Biology «The musculoskeletal system of man»?

The result of the learning project «Virtual museum of biology: the musculoskeletal system of man»: students do research and gather information about important figures related to a given topic and then dress up (or use a prop) to create a 'talking wax museum'. A student can take the role of the museum guide or the audience can interview the figures directly.

In the process of conducting research by students, teachers asked them to perform the following tasks using VM with augmented images using any of the platforms such as ARCore Augmented Images (https://codelabs.developers.google.com/codelabs/augimg-intro?utm_source=google-io&utm_medium=organic&utm_campaign=io21-learninglab#0); Blippar (https://blipps.blippar.com/).

To obtain the objectives, our research is focused on teachers from Secondary schools (Semipolkivsky Secondary School of the 1st-3rd Grade (Ukraine), Specialized school № 181 named after I. Kudri with in-depth study of foreign languages (Kyiv, Ukraine)) to determine their attitude to using VM in learning project «Virtual museum of biology: the musculoskeletal system of man». The study involving 27 teachers at the general school was conducted from September to December 2021.

The questionnaire content is aimed to obtain answers to the following questions: Do teachers consider it required to use VM in teaching at school? Could a VM contribute positively to the students learning motivation? How to use VM for quality education in the general school?

Teachers were asked to answer 3 open-ended questions and 1 question with the choice of the answer "Strongly disagree, disagree, Neither agree nor disagree, agree, Strongly agree "

So, teachers were asked to write their opinion on 3 open-ended questions:

– How did you use VM in your teaching activity?

– Which problems had you when proposed for students VM for solving the problem?

– How helped you use VM for displays and support inquiry-based science education?

The question with the choice of the answer "I disagree, I agree, I do not agree at all" was "what is necessary for the successful use of virtual museums to increase the clarity of learning necessary?", to which such answers were offered:

– determine the feasibility of using virtual museums, as well as their integrated use;

– not to overload students with on-screen visual aids;

– draw students' attention to the most important, essential features of objects, phenomena, and processes studied with the help of virtual museums;

– orient students to a comprehensive perception of phenomena;

– enable students to be as active and independent as possible when visiting and creating virtual museums.

Interpretation of open-ended questions.

For the question «How did you use VM in your teaching activity?» the following responses were received:

– «I use VM to submit new material» (75%);

– «I use VM to present objects and processes that are difficult to show in real life» (83%);

– «I use VM for carrying out the brainstorm» (56%);

– «I use VM to increase students' interest in learning material» (27%);

– «VMs help ensure museums visits around the world, regardless of the time and place of the student and teacher» (33%);

– «the material should be selected according to the content in such a way that it stimulates interest in knowledge, brings new knowledge about the world, teaches the ability to see the new, already reveals to students the history of scientific discoveries and practical meaning of knowledge, shows the latest advances in science» (65%).

For the question «Which problems had you when proposed for students VM for solving the problem?» the following responses were received:

– «lack of methodological recommendations» (82%);

– «students' lack of understanding how to use VM, we must to prescribe instructions and plan the excursions and exhibishenes» (63%);

– «the use of VM depends on the availability and quality of the Internet connection» (23%).

For the question «How helped you use VM for displays and supports inquiry-based science education?» the following responses were received:

– «VMs help students learn about complex experiments and subjects that are difficult and expensive to explain. In addition, they provide a realistic environment for the presentation of subjects such as history, art, astronomy, geography, and physical sciences» (78%);

– «VM improves students' real presentation of educational material» (68%);

– «using VMs make learning interesting, thus facilitating the education process of students' interest and motivation» (94%).

Interpretation of the question with the choice of the answer «Strongly disagree, disagree, Neither agree nor disagree, agree, Strongly agree»**.**

The results of the survey on what is necessary for the successful use of virtual museums to increase the clarity of learning necessary are presented in table 1.

Table 1.

The results of the survey on what is necessary for the successful use of virtual museums to increase the clarity of learning necessary

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Determine the feasibility of using virtual museums, as well as their integrated use				15%	85%
Not to overload students with on-screen visual aids	–	48%	24%	18%	10%
Draw students' attention to the most important, essential features of objects, phenomena, and processes studied with the help of virtual museums	–	–	–	100%	–
Orient students to a comprehensive perception of phenomena	–	–	54%	46%	–
Enable students to be as active and independent as possible when visiting and creating virtual museums	6%	16%	35%	38%	5%

The survey results are presented below (Table 1). According to our findings, the teachers are highly interested in using VM in the educational process in general school: «Draw students' attention to the most important, essential features of objects, phenomena and processes studied with the help of virtual museums» – 100% teachers are considered necessary for teaching students.

So, the use of virtual museums in the educational process makes it possible to effectively solve the following basic didactic tasks:

– ensuring the scientific nature of students' education mastery of scientific knowledge and promoting the formation of a democratic worldview in them that is based on credible scientific facts and corresponds to the dynamics of relevant scientific knowledge development;

– strengthening the clarity of learning as a principle of didactics, due to the nature of the process of cognition, which begins with sensory perception, moves to abstract thinking, and from it to practice;

– development of student's cognitive interests and abilities as a principle of didactics, which determines the most important motives for student learning (formation of cognitive interests occurs in two ways: through the material that constitutes the content of learning and organization of students' cognitive activity);

– the use of virtual museums can affect students' visual and auditory memory;

– accelerating the pace of learning and memorizing learning material, which contributes to the strength of knowledge, expanding the cognitive interests of students;

– the intensification of students' independent work;

– the connection between theory and practice, which necessitates the reflection of two inextricably linked aspects of a single education process;

– individualization of learning.

VM give positive results in terms of activating the cognitive activity of students only when they are skillfully and intelligently used in a system of various methods and techniques and combination with other teaching aids.

CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

VMs make it possible to significantly supplement, expand, and deepen the content of the material studied in the curriculum.

Using virtual museums, the teacher can best select educational material. Virtual museums allow in the simplest, most intelligible, and emotional way to transfer educational material, significantly enhance the mental activity of students, expand their worldview, and arouse special interest in a particular field of knowledge.

For the use of VM in the educational process to promote the development and formation of cognitive interests of students, the teacher must:

– select information to be presented with the help of VM, by content and compose it in a composition so that it corresponds to the purpose, age, knowledge, and interests of students;

– the use of heuristic methods in teaching educational material with the help of VM;

– to organize by the specific interests of student's various forms of independent work with the use of VM (preferably in the form of educational projects).

REFERENCES (TRANSLATED AND TRANSLITERATED)

1. Barroso Osuna, J., Gutiérrez-Castillo, J.J., Llorente-Cejudo, M.D., & Valencia Ortiz, R. (2019). *Difficulties in the Incorporation of Augmented Reality in University Education*: Visions from the Experts. J. New Approaches Educ. Res., 8.

2. Britannica (2017). The Editors of Encyclopaedia "virtual museum". Encyclopedia Britannica. https://www.britannica.com/topic/virtual-museum.

3. Daniela, L. (2020). Virtual Museums as Learning Agents. Sustainability. 12(7), 2698. https://doi.org/10.3390/su12072698.

4. Fenenko, A. O. (2021). Virtualna muzealizatsiia yak zasib zberezhennia kulturnoi pamiati [Virtual musealisation as a means of preserving cultural memory]. *Thesis for the academic degree of Candidate of Culturology*. Kharkiv State Academy of Culture, Kharkiv. (in Ukrainian).

5. Karamanov, O. V. (2020). Teoriia i praktyka pedahohichnoi diialnosti muzeiv u suchasnomu osvitnomu prostori Ukrainy [Theory and practice of pedagogical activity of museums in the modern educational space of Ukraine]. *The dissertation for the academic degree of doctor of pedagogical science*. State Establishment "Luhansk National University named after Taras Shevchenko". Starobelsk. (in Ukrainian).

6. Lévy, P. (1998). *Becoming Virtual. Reality in the Digital Age*. Plenum Trade, New York, NY.

7. Mamur, N. & Özsoy, V., & Karagöz, İ. (2020). Digital learning experience in museums: Cultural readings in a virtual environment. *International Journal of Contemporary Educational Research*, 7(2), 335-350. https://doi.org/10.33200/ijcer.799643.

8. Mukasheva, Manargul and Kornilov, Iurii and Beisembayev, Gani and Soroko, Nataliia and Sarsimbayeva, Saule and Omirzakova, Aisara (2022). *Contextual Structure as an Approach to the Study of Virtual Reality Learning Environment*. http://doi.org/10.2139/ssrn.4034173.

9. Paliokas, Ioannis & Kekkeris (2008). Implementation of Virtual Museums for School Use. *The International Journal of the Inclusive Museum*. 1. 11-20. http://doi.org/10.18848/1835-2014/CGP/v01i01/44514.

10. Schweibenz, W., & Wintzerith, S. (2018). The personas method. A tool for communicating data from visitor studies | Metoda modelování postav (personas). *Praktický nástroj získávání informací ze studií návštěvnosti*. Museologica Brunensia, 7(1), 5–18. http://doi.org/10.5817/MuB2018-1-1.

11. Soroko, N.V. (2020). Methodology for teachers' digital competence developing through the use of the STEAM-oriented learning environment. *CEUR Workshop Proceedingsthis link is disabled*, 1260–1271. URL: http://ceur-ws.org/Vol-2732/.

12. Soroko, N.V., Mykhailenko, L.A., Rokoman, O.G., & Zaselskiy, V.I. (2020). Educational electronic platforms for STEAM-oriented learning environment at general education school. *CEUR Workshop Proceedings*, 2643, 462–473. https://doi.org/10.31812/123456789/3884.

13. Volynets, V.O. (2019). Virtualizatsiia kultury v dobu internet-tekhnolohii [Virtualization of culture in the age of Internet technologies]. Abstract of PhD dis. of Cultural Studies: 26.00.01. Kyiv. (in Ukrainian).

14. Yichen, Jia (2020). Constructing Virtual Reality Exhibitions with Multimodal Interactions. *Master of Science in Architecture Studies and Master of Science in Electrical Engineering and Computer Science.* Massachusetts Institute of Technology. URL: https://hdl.handle.net/1721.1/127560.