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Integrated Use of Various Software Environments for Increasing the Level of Visualization and Perception of Information

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Abstract

Implementation of various software tools in the educational process affects formation of students' professional competencies. This influence should be taken into account in scientific and methodological support of the modern education system. The purpose of the article is to develop a technology for creating educational VR content that provides immersion into a virtual thematic space using a variety of different software environments and improves the effectiveness of teaching. In this article, the technology of creating an electronic course using a complex of specialized software tools is considered. The initial stage of such technology is to develop a course description that includes data and knowledge about the object or phenomenon under study. Three-dimensional models of virtual objects created in SketchUp, Blender. Solidworks, Compass-3D, etc. are used for technical objects. Then 3D models of objects and landscape are used for creating a virtual space in the Twinmotion software package. Then photorealistic panoramas, images and videos are imported from Twinmotion into 3DVista Virtual Tour Pro to create a virtual tour. At the final stage, the virtual tour is integrated into the LMS Moodle learning management system. The implementation of the technology of integrated use of specialized software tools was tested in the creation of educational content that provides immersion into a virtual thematic space on the example of the course "History of the Tambov Region", which is included in many educational programs at Tambov educational institutions. High efficiency of developed educational content is confirmed by the survey results of several groups of students and its further analysis using Importance-Performance Analysis (IPA) methodology; as well as by checking learning achievements based on testing two groups of students of 12 people each. The first test group studied the discipline using the proposed electronic content, and the second one without it. The test results showed that the proportion of correct answers to test questions in the first group was 17% higher than for the students of the second group. Thus, the authors proposed the technology for development of educational content, which includes a number of specialized software tools, as well as the organization of the educational process using innovative educational means. Moreover, the use of the proposed technology allows students to develop teamwork and interpersonal communication skills by interactive lectures and group discussions.

Keywords: e-learning; learning management system; software environments; technology for creating thematic virtual space; effectiveness of educational content.

1. Introduction

Learning Management System (LMS) is a specialized software platform that allows to organize and automate most of the teaching processes. In Russia, LMS systems are also often referred to as distance learning systems.

The main functions of learning management systems include: creation and storage of educational content in various formats (video, audio, presentations, etc.); registration of students; administration of access rights to educational materials; control of the learning process; communication between teachers and students; evaluation of learning outcomes; formation of analytics, etc.

Modern learning management systems are quite flexible and allow to organize blended learning, combining face-to-face classes with a lectures and e-classes with an ability to asses knowledge in the form of tests and other educational tools. All these functions are available online via the Internet [20, 14].

Learning management systems can be compared to a virtual classroom where students or employees, who are physically located anywhere in the world, can study.

To date, a large number of different LMS have been developed [5], including Canvas, Diskurs, Dokeos, Docebo, eFront, Flora, iSpring Learn LMS, Learn Amp, LMS Moodle, Open edX, RedClass, Stepik, TalentLMS, TeachBase, Udemy, etc. A number of systems belong to the server LMSs installed on the company's server (for example, Moodle, RedClass). Some are available by subscription in the format of a cloud web service and do not require any specialized software on the company's own server (for example, iSpring online, TeachBase, Learn Amp). Some are integrated into modern Content Management Systems (CMS), such as Drupal, Joomla, Wordpress, Wix with expanded capabilities in the field of training.

Learning using Virtual Reality (VR) and Augmented Reality (AR) technologies is becoming more and more relevant. However, the development of such applications requires a lot of money and time. Among the LMS that allow integrating VR/AR technologies into the educational process it is possible to single out the commercial ISP platform (Immersive Simulations Platform) [https://modumlab.com /]. ISP is used for staff training by such large companies as Gazprom, Sberbank, VTB, Severstal, Polyus.

Among the most popular LMSs Moodle (Modular Object-Oriented Dynamic Learning Environment) can be pointed out. Moodle is an open-source server solution including a cloud service Moodle Cloud [http://moodlecloud.com]. Many schools and universities have developed a large number of courses using Moodle, and in this paper the authors present a solution to the problem of integrating VR content into this platform.

The creation of VR content is based on the use of 3D Vista Virtual Tour Pro software. Since 2020, a large number of functions related to e-learning have been added to this software product such as creation of quizzes and tests with evaluation of results, as well as integration with LMS including Moodle. These new features made it possible to use virtual tours, which are interconnected panoramas in 360° format as a basis for game-based and interactive learning [19, 21]. When developing such virtual tours, various specialized software tools can be used.

This work is devoted to the issues of integrated use of various software tools for the development of virtual tours in order to use them in the educational process.

2. Materials and methods

When organizing the teaching process using VR and AR technologies, it is necessary to create a thematic virtual space associated with the course being studied, which will allow students and schoolchildren to fully immerse themselves into the content of the course. The

technology of creating educational content using a variety of different software environments can be presented as follows.

The initial stage of the technology is development of a course description that includes data and knowledge about the object or phenomenon being studied [10]. In particular, a model of a historically significant territory, frames that describe the structure of the territory and models, properties and values that characterize the entire territory [18, 17, 10, 7, 8, 2, 3].

At the stage of 3D modeling, objects are geographically linked to the district plan using such resources as Google.Maps or Yandex.Maps. With the help of a quadcopter, detailed images of all fragments of objects that are partially lost as well as of their location are taken. As a result, a plan of the territory in zenith isometry is obtained.

The next stage is creation of three-dimensional models of all required objects (for example, buildings, structures, infrastructure elements, etc.) in SketchUp, Blender programs, and for technical objects in Solidworks, Compass-3D, etc. [13, 12]. The created three-dimensional models of objects and landscape are imported into the final virtual scene using Twinmotion software package [22, 15]. Twinmotion allows using high-quality rendering to obtain visualizations of architectural objects, in particular interiors, exteriors, etc. Further, photorealistic panoramas, images and videos are imported from Twinmotion into 3DVista Virtual Tour Pro environment to create a virtual tour [23, 9], which will allow students to move between panoramas.

The use of special programs such as 3DVista Stitcher 4 and Live-Guided Tours allows to "stitch" a set of photos into a 360° panorama, create live guides, conduct guided tours in real time, have video and audio communication within a virtual tour. Mobile versions of such tours are also available.

The tour leader (guide, teacher, tour guide) can point out specific areas of interest within the virtual space, discuss certain aspects of the discipline with students. At the same time, students have opportunities to study the territory with a live guide, independently inspect the territory or perform the role of a guide with the permission of the tour leader. All this makes it possible not just to passively study the material, but also to ask questions, discuss certain elements and details of the virtual space being studied [9].

When creating a virtual tour in 3DVista Virtual Tour Pro, it is necessary to specify the compatibility of the virtual tour with the standard for distance education systems SCORM (Sharable Content Object Reference Model – a model of links to shared objects). This will allow to transfer final results (scores, grades, time, etc.) to the LMS Moodle, which supports SCORM, for storage and analysis after the completion of the tour. To integrate a virtual tour with e-learning elements into the Moodle system, it is necessary to add it to the corresponding course in the form of a SCORM package (see Fig. 1).

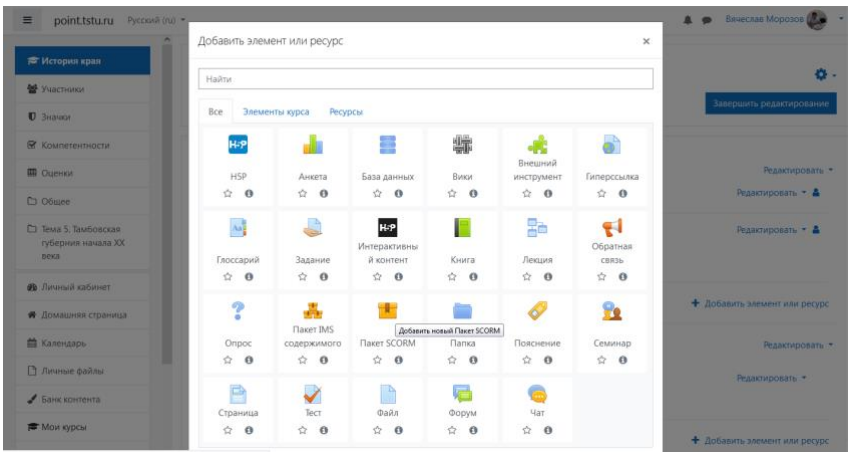


Fig. 1. Visualization of the LMS Moodle window during the connection of a virtual tour created in 3DVista Virtual Tour Pro

3. Research results

The implementation of the technology of integrated use of various software environments has been tested when creating educational content that provides immersion into a virtual thematic space on the example of the course "History of the Tambov Region", which is included in many educational programs at Tambov educational institutions. Figure 2 shows a fragment of the content of the discipline.

As an example, let us consider a fragment of a thematic virtual space associated with the production activities of the Nobel brothers in Tambov region.

To create a virtual space, historical sources related to the activities of Nobel Brothers Oil Production Partnership on the territory of Tambov province were used, in particular, plans for oil products warehouses located near the stations of Platonovka, Lipetsk and Usman. Figure 3 shows the plan of the warehouse of Nobel Brothers Oil Production Partnership at Platonovka railway station. A fragment of a virtual model of an oil warehouse created with the sequential use of such software environments as SketchUp, Solidworks, Twinmotion, 3DVista Virtual Tour Pro and LMS Moodle, is shown in Fig. 4.

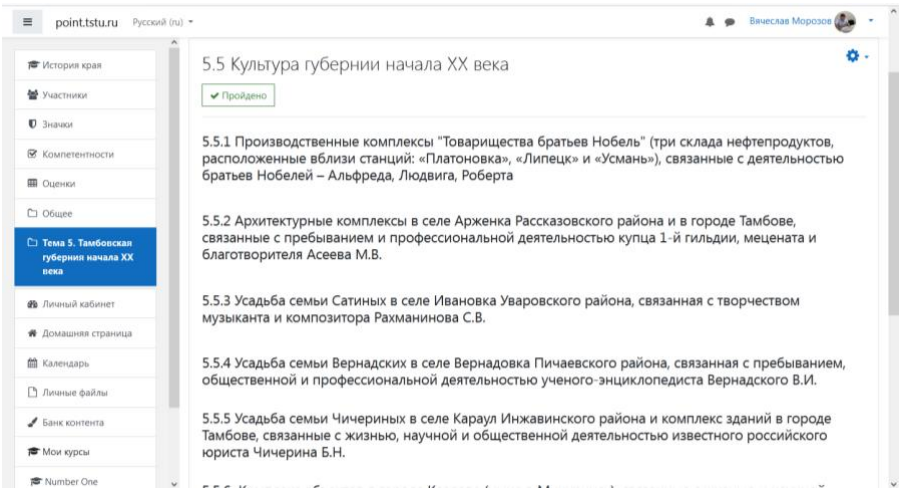


Fig. 2. A fragment of the content of the course "History of the Tambov region"

Fig. 3. A schematic diagram of the warehouse plan of Nobel Brothers Oil Production Partnership near Platonovka station

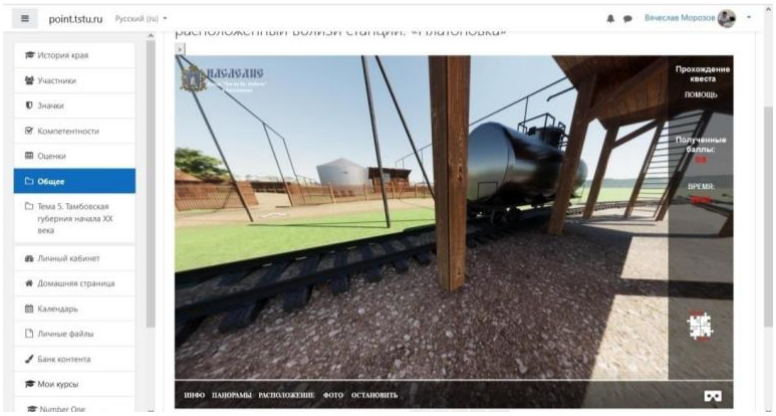


Fig. 4. A fragment of a virtual model of Nobel Brothers Oil Production Partnership warehouse near Platonovka station

Verification of the acquired knowledge was carried out by taking virtual educational quests using LMS Moodle [24, 1, 6]. As an example, Figure 5 shows visualization of intermediate test results.

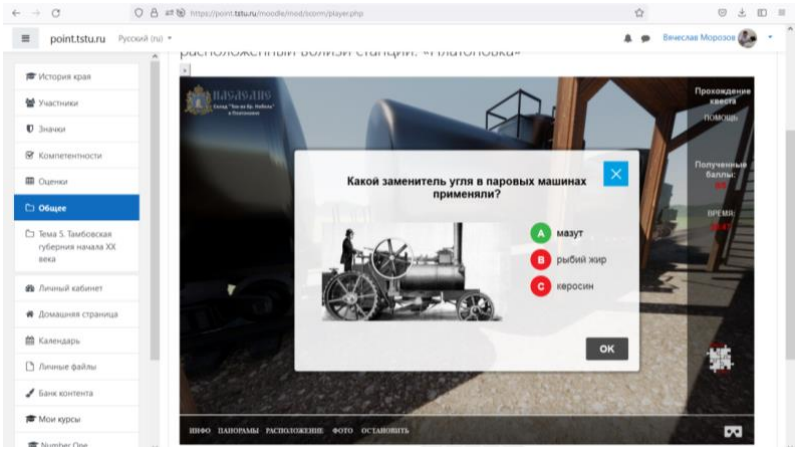


Fig. 5. Visualization of intermediate quest results

The final grades after completion of the course "History of the Tambov Region" using LMS Moodle are shown in Fig. 6.

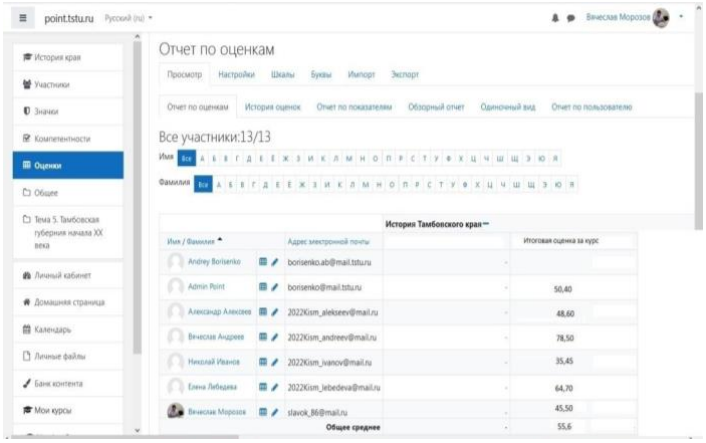


Fig. 6. Visualization of final results after completion of the course "History of the Tambov region" using LMS Moodle

To assess the effectiveness of educational content that includes various software environments, a survey of several groups of students and schoolchildren was conducted. To identify important characteristics (attributes) with low satisfaction indicators, analysis methodology Importance-Performance Analysis – IPA is widely used [16].

The importance of obtaining knowledge in this way and satisfaction with the content, i.e. the quality of implementation, was assessed by students and schoolchildren on a five-point scale.

The survey was conducted online via the electronic form using the survey tool Google Forms [4]. This solution is on the one hand free, and on the other hand easy to learn and use. A fragment of the form used for the survey is shown in Fig. 7 [11].

Table 1 shows average score values for each of the characteristics by importance and performance categories obtained from the survey results.

On the graph (see Fig. 8) average values of characteristics are plotted, vertically – the importance of characteristics, horizontally – satisfaction with the implementation of characteristics.

The graph is divided into 4 quadrants (quarters). Quadrant 1 (first quarter – high importance, high performance) includes characteristics that do not require improvement. Both importance and performance fully satisfy the user. Quadrant 2 (second quarter – high importance, low performance) includes characteristics that are of high importance to the user, but the quality of their implementation is too low and requires improvement. The implementation of these characteristics requires the closest attention. Quadrant 3 (third quarter – low importance, low performance) corresponds to characteristics that do not matter to the user. These characteristics do not require any attention. Quadrant 4 (fourth quarter – low importance, high performance) includes characteristics that are not important to the user, but at the same time are implemented at a high level. This means that too much attention is paid to the characteristics that present no interest to the user. Fig. 9(a, b) presents histograms of frequency ratings of characteristics (1) and (13), where the height of the bars corresponds to the scores.

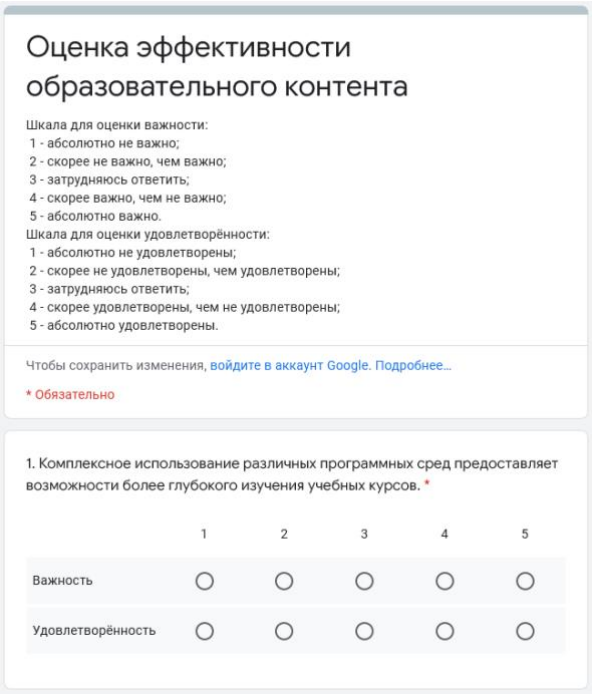


Fig. 7. A fragment of the form for questioning students in order to assess the quality of educational content

Table 1. Characteristics of educational content

Characteristic (attribute)	Numerical notation	Importance	Performance
1. The integrated use of various software environments provides opportunities for deeper study of the courses.	1	3,96	3,85
2. Multiplatform implementation (Windows, Android, iOS, *nix) of educational content.	2	3,74	3,82
3. The possibility of integrating educational content into the Management System-LMS.	3	3,19	3,85
4. High-quality visualization of objects for various purposes allows to better perceive the processes or phenomena of the subject area.	4	3,82	3,89
5. Is the scale of the virtual space sufficient to hold student's attention and motivate him/her to study the process or phenomenon to the end?	5	3,0	2,81
6. Easy navigation in the virtual space. Users can easily find transition points for all routes in the virtual space.	6	3,81	3,95
7. Immersion into virtual space using special VR glasses or a VR helmet (Oculus, Vive, Gear VR equipment, etc.).	7	4,04	3,77
8. Interesting educational content motivates the student to fully explore the object or process in the virtual space.	8	4,04	3,81
9. Implementation of e-learning elements in the form of quests inside the virtual space.	9	3,73	3,89
10. Obtaining knowledge in an accessible and attractive form of a game (gamification of learning).	10	3,85	4,15
11. Connecting a guide and other participants to the tour. Conducting an online tour in a thematic virtual space.	11	3,96	4,12
12. The possibility of group work in a virtual space.	12	3,39	3,23
13. Acquisition of new competencies in the subject area to which the educational content is devoted.	13	4,19	4,04

The results of the study confirm high quality of simulation of professional activity in an immersive virtual environment for obtaining applied competencies and skills within the framework of the studied material.

The effectiveness of integrated use of various software products in a virtual environment was tested on by two groups of students of 12 people each, who enrolled on the course "History of the Tambov Region". One group studied the discipline in the traditional way, and the second one using an immersive educational environment. Test results showed that the proportion of correct answers among students who studied in the traditional way is 17% lower than in the second group.

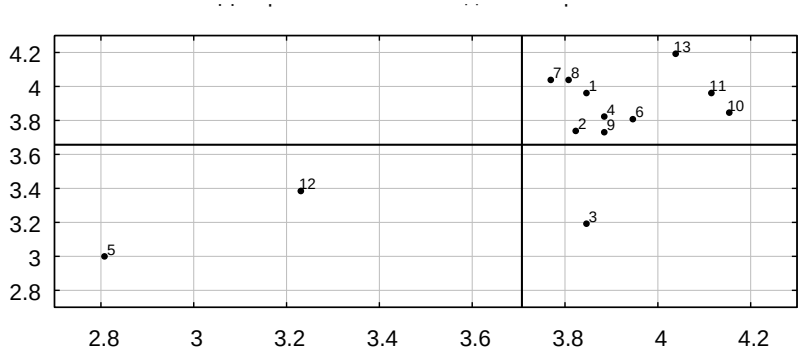
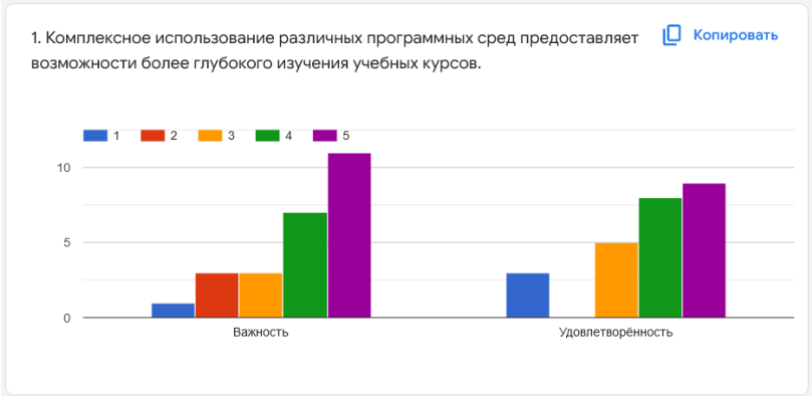
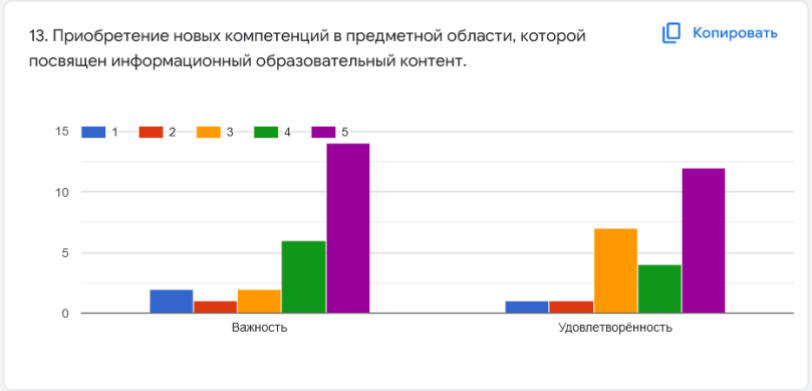


Figure 8. Importance-Performance Diagram



(a)



(b)

Fig. 9 (a, b). Histograms of scores for characteristics 1 and 13

4. Conclusion

The expediency of using the technology of creating educational VR content that provides immersion into a virtual thematic space using a variety of different software environments is confirmed by the test results. The approbation was carried out on the example of the course "History of the Tambov Region", which is included in many educational programs at Tambov educational institutions. The use of such an environment helps to ensure the achievement of the planned learning outcomes, which correlate with the indicators of professional competencies being formed.

Also, the use of the proposed technology allows students to develop teamwork and interpersonal communication skills through interactive lectures and group discussions, which ensure better mastering of new academic material.

References

1. Eremenko Yu.A, Zalata O.A. (2020) Psyhophysiological Approaches to Instructional Design for Immersive Environments. *Educational Studies Moscow*, no. 4, pp. 207–231. DOI: 10.17323/1814-9545-2020-4-207-231 (In Russ., abstract in Eng.)
2. Krasnyanskiy M.N., Popov A.I., Obukhov A.D. (2017) Mathematical modeling of adaptive management system of vocational education. *Transactions of the Tambov State Technical University*, vol. 23, no. 2, pp. 196–208. DOI: 10.17277/vestnik.2017.02.pp.196-208 (In Russ., abstract in Eng.)
3. Nemtinov V.A., Manayenkov I.M., Nemtinova Yu.V. (2020) Creation of a virtual technological laboratory and organization of training for highly qualified personnel. *Higher Education in Russia*, vol. 29, no. 2, pp. 159–168. DOI: 10.31992/0869-3617-2020-29-2-159-168 (In Russ., abstract in Eng.)
4. Assessment of the quality of an informational educational resource (2022) [Electronic resource]. URL: https://forms.gle/buDHWnZnG8WZMRKaA
5. Overview of 10 distance learning systems (2022) [Electronic resource]. URL: https://lala.lanbook.com/obzor-10-sistem-distancionnogo-obucheniya
6. Tsarapkina Y.M., Yakubova E.Y. (2018) Web-quest technology usage in professional self-determination. *RUDN Journal of Informatization in Education*, vol. 15, no. 4, pp. 373–381. DOI: 10.22363/2312-8631-2018-15-4-373-381 (In Russ., abstract in Eng.)
7. Sheinbaum, V.S. (2017) Interdisciplinary activity training in the virtual environment of professional activity-state, prospects. *Higher Education in Russia*, no. 11, pp. 61–68. (In Russ., abstract in Eng.)
8. Sheinbaum V.S. (2018) Competence “ability to work in a team” and its development using technology of interdisciplinary training in a virtual environment of professional activity. *Higher Education in Russia*, no. 2, pp. 2–8. DOI: 10.25586/RNU.HET.18.02.P.02 (In Russ., abstract in Eng.)
9. 3DVista – Virtual Tours, 360° video and VR software (2021) [Electronic resource]. https://www.3dvista.com/
10. Gorelov I.A., Nemtinov V.A. (2019) Information analysis of the dynamics of development of historically significant territory "Market square" of Tambov. *Voprosy Istorii*, no. 11, pp. 33-44. DOI: 10.31166/VoprosyIstorii201911Statyi05
11. Google. Google Forms: Create your own online surveys for free (2022) [Electronic resource]. URL: https://www.google.ru/intl/ru/forms/about/
12. Duda J., Oleszek S. (2021) Concept of PLM Application Integration with VR and AR Techniques. *Advances in Production Management Systems*, 592 IFIP P. 91-99
13. Karpushkin S.V., Krasnyanskiy M.N., Malygin E.N., Mokrozub V.G. (2020) Determination of maximum productivity the technological system of multi-product chemical plant. *IOP Conference Series: Materials Science and Engineering* Vol. 971, 032056. DOI: 10.1088/1757-899X/971/3/032056
14. Kersten T., Tschirschwitz F., Deggim S., Lindstaedt M., (2018) Virtual Reality for Cultural Heritage Monuments – from 3D Data Recording to Immersive Visualisation. *Euro-Mediterranean Conference*, pp. 74–83. DOI: 10.1007/978-3-030-01765-1_9
15. Introduction to Twinmotion. (2021) [Electronic resource]. URL: https://www.unrealengine.com/en-US/onlinelearning-courses/introduction-to-twinmotion
16. Hidayah N.A., Subiyakto A., Setyaningsih F. (2019) Combining Webqual and Importance Performance Analysis for Assessing A Government Website. *7th International Conference on Cyber and IT Service Managemen*t (CITSM). IEEE, pp. 1–6.
17. Nemtinov V.A., Manaenkov I.M., Nemtinova Y.V. (2020) Virtual training and research laboratory of technological processes of chemical-technological systems. *Scientific Visualization*, vol. 12, no. 1, pp. 10–21. DOI: 10.26583/sv.12.1.02

18. Nemtinov V.A., Borisenko A.B., Nemtinova Y.V., Gorelov A.A., Tryufilkin S.V. (2018) Implementation of technology for creating virtual spatial-temporal models of urban development history. *Scientific Visualization*, vol. 10, no. 3, pp. s99–107. DOI: 10.26583/sv.10.3.07

19. Nishanbaev I., Champion E., McMeekin D.A. (2019) A Survey of Geospatial Semantic Web for Cultural Heritage. *Heritage*, vol. 2, no. 2, pp. 1471–1498. DOI: 10.3390/heritage2020093

20. Popovski F., Nedelkovski I., Mijakovska S., Nalevska G. P. (2016) Interactive Scientific Visualization in 3D Virtual Reality Model. *TEM J*. vol. 5, no. 4. pp. 435–440. DOI:10.18421/TEM54-04

21. Pozdneev B., Tolok A., Ovchinnikov P., Kupriyanenko I., Levchenko A., Sharovatov V. (2019) Digital transformation of learning processes and the development of competencies in the virtual machine-building enterprise environment. *Journal of Physics: Conference Series*. vol. 1278, 012008. DOI: 10.1088/1742-6596/1278/1/012008

22. Twinmotion. Real-time immersive 3D architectural visualization. (2022) [Electronic resource]. https://www.unrealengine.com/en-US/twinmotion

23. Virtual Tours in E-Learning, Training & Quizzing. (2022) [Electronic resource]. https://blog.3dvista.com/2020/04/27/virtual-tours-in-e-learning-training-quizzing/

24. Zakirova F.M., Qarshieva D.U. (2020) Quest for pedagogical technology and its use in education systems. *International Journal on Integrated Education*, vol. 3, no. 5, pp. 12–16. DOI: 10.31149/ijie.v3i5.369