Integration of Digital Technologies in Modeling the Educational Environment of a Bachelor in the Conditions of Martial Law

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Keywords: Virtual Math Education Space, WordPress Content Management System, WordPress Plugins.

Abstract: The article reveals the features of the integration of digital technologies in the modeling of the educational environment of a higher education student, which can significantly improve the quality of education and preparation of students for real life, help in providing a qualified workforce and increasing the innovative potential of the state. The purpose of the article is to model and develop a virtual educational environment that will help to effectively form general and professional competencies of students, as well as develop cooperation and communication skills, in particular, in the conditions of the state of war. We used research methods: theoretical; empirical and mathematical-statistical; methods of developing a virtual mathematical educational environment. The potential of modeling a virtual mathematical educational environment on the example of a website has been studied, and it has been determined which tools and technologies can be used to create it. The possibility of obtaining free access to educational materials and a testing platform for consolidating acquired knowledge has been developed, which is quite relevant in the conditions of the state of war. The content management system (CMS) WordPress was chosen as the platform for creating the website. The article analyzes the results of a survey of applicants regarding the effectiveness of using a virtual educational environment in the process of studying mathematical disciplines and the degree of their familiarity with the use of digital technologies in modeling such an environment. The practical significance of the research results lies in the modeling and development of a virtual mathematical educational environment for a student of higher education, which, according to the authors of the article, will help students better understand complex mathematical concepts and principles, as well as develop cooperation and communication skills.

1 INTRODUCTION

The need for innovations and their effective transfer to the economy of Ukraine is extremely urgent today. This is primarily related to the need to transform the raw material-oriented low-tech economy of Ukraine into an economy focused on innovation and high technologies.

In these conditions, innovations can be an effective means of restoring and modernizing production and transitioning the Ukrainian economy to a higher technological level. First of all, this can be ensured by the transformation of Industry 4.0 technologies (Internet of Things, artificial intelligence, big data analytics, robotics, cloud computing, virtual and augmented reality, etc.), which fundamentally change the technical processes of production of goods and services, marketing and the institutional structure of society [1].

To evaluate the innovative capacity of Ukraine, we will use international comprehensive ratings and evaluations.

Table 1 shows the ranking of Ukraine according to the Global Innovation Index (GII) for the last three years (2020-2022). The Global Innovation Index ranks world economies according to their innovation potential. It consists of approximately 80 indicators grouped into innovative contributions and results. The GII aims to capture the multidimensional aspects of innovation. The table below shows the ratings of Ukraine for the last three years, noting that data availability and changes in the structure of the GII model affect the annual comparison of GII ratings. The statistical confidence interval for the ranking of Ukraine in GII 2022 is between 48 and 59 places.

According to the data provided in Table 1, in 2022, Ukraine shows better indicators of innovative results than innovative contributions. In 2022,

Ukraine ranked 75th in terms of innovative power, which is higher than in 2021, but lower than in 2020. Ukraine ranks 48th in the volume of innovative results. This position is lower for both 2021 and 2020. Ukraine ranks 4th among 36 countries with incomes below the average and ranks 34th among 39 European economies [2].

Table 1: Ranking of Ukraine according to the Global Innovation Index (GII) for 2020-2022 [2].

Reporting period	Ranking according to the GII	Subindex "Innovation Input"	Subindex "Innovation Output"
2020	45	71	37
2021	49	76	37
2022	57	75	48

In 2022, Ukraine ranked 75th in terms of innovative power, which is higher than in 2021, but lower than in 2020. Ukraine ranks 48th in the volume of innovative results. This position is lower for both 2021 and 2020. Ukraine ranks 4th among 36 countries with incomes below the average and ranks 34th among 39 European economies [2].

According to the GII indicator, innovation capacity is based on knowledge and technology (human capital and research, as well as the results of knowledge and technology), while indicators of infrastructure development, institutions, and market complexity have a negative impact on innovation capacity (Table 2).

Table 2: Rating of Ukraine by components of the Global Innovation Index (GII) for 2020-2022 [2].

Reporting period	GII	Institution	Human capital and research	Infrastructure	Market complexity	Business complexity	Results of knowledge and technologies	Creative results
2020	45	93	39	94	99	54	25	44
2021	49	91	44	94	88	53	33	48
2022	57	97	49	82	102	48	36	63

Note that according to the rating, one of the best developed drivers in Ukraine is human capital and research, as well as the results of knowledge and technology.

Considering the consequences of the aggressive war of the Russian Federation against Ukraine and the general decline of the world economy as a whole, which will negatively affect the innovative potential of Ukraine, it is necessary to concentrate efforts on preserving and strengthening the strengths - the development of secondary and higher education and digital technologies.

The purpose of the article is to model and develop a virtual educational environment that will help to effectively form general and professional competencies of students, as well as develop cooperation and communication skills, in particular, in the conditions of the state of war.

2 ANALYSIS OF CURRENT RESEARCH

The evolution of educational technologies led the scientific community of mathematics education researchers to the conclusion that the use of digital technologies performs two main functions: (a) as a support for the organization of the teacher's work and (b) as support for new ways of working and presenting mathematics [3]. In today's environment, the use of technology for mathematics teachers has begun to have a third function: as a reinforcement of communication, interaction in communities, communication and sharing of materials. In [4] added a fourth function, commercial-industrial, which consists in supporting more independent work of students and is focused on practicing and evaluating previously taught mathematical knowledge and skills in various online formats.

Digital and non-digital tools in teaching mathematics were investigated by Monaghan et al. [5]. Digital technologies for assessment are discussed in detail in the journal "Mathematics Education in the Digital Era", in papers [6-8].

The authors [9] investigated the innovativeness of vocational education and described the architecture of digital technologies in the educational environment of the teacher [10] as the transfer of innovations to the economic space of the state.

Lipeikiene in his scientific work [11] defines the main requirements for a virtual educational environment: access control; creation of professional training material of the course and mastering the skills of managing it; ensure the use of all types of multimedia content; links to digital libraries and other important information on the Internet; automatic glossaries, indexes, search systems; communication tools; connection to the software necessary for training (if available); a personal space for students to share and store materials; tools for automatic assessment and self-assessment; monitoring of students' success, systematization of their grades,

statistical information about the educational process for the teacher.

The authors [12] investigated the issue of foresight modeling of the synergistic educational space of obtaining higher education and described the architecture of digital technologies in the educational environment of the teacher [13] as the transfer of innovations to the economic space of the state.

3 DEVELOPMENT OF VIRTUAL MATHEMATICS EDUCATIONAL SPACE IN LMS WORDPRESS

The use of modern digital technologies in education has led to the emergence of a virtual educational environment, within which continuous self-realization, self-development of an active and creative personality is possible under the conditions of the organization and functioning of educational systems with realized openness, integrability and adaptability through educational websites.

In the conditions of a pandemic and wartime, the use of the latest technologies and the global Internet network in the educational process is the main need of today. Web technologies are developing rapidly, and developed websites contain more and more modern features, becoming convenient for users both in professional use and in everyday life. The ability to design and develop dynamic, functional and convenient educational websites is an important component of the teacher's professionalism. After all, the success of his students depends on how he will be able to implement an educational web project in the digital educational Internet space.

Some teachers are inclined to think that only a specialist programmer can create a website. But this is not the case, as there are a large number of simple digital tools with ready-made templates for managing content and presenting educational material in the form of an author's website, with the help of which a teacher can independently, without outside help, create his own website.

In the article, we consider the development of a virtual mathematical educational space using the popular open source content management system WordPress [14]. This content management system allows you to develop a powerful educational website, where registered users get access to various mathematics courses and a platform for testing the acquired knowledge.

Installing the MasterStudy LMS plugin [15] for WordPress enables the teacher to create and customize a personalized learning process by building a separate educational trajectory for the individual user profiles that registered students have access to. It offers an easy-to-use interface that simplifies the management of the site's resources with educational materials. Administrators can create an unlimited number of courses and lessons, organize them by category and set prerequisites for course enrolment.

MasterStudy LMS offers a built-in grading system that allows for easy grading and feedback.

The virtual mathematical educational space, created by the WordPress content management system with the MasterStudy LMS plugin, involves the registration of users who can access various mathematical courses and a testing platform to consolidate knowledge. Website developers add educational videos and lecture texts, create tests, combine them into different courses, receive feedback and course evaluations from registered users.

The main page of the educational site contains brief information about the purpose of the website, the “Join for free” button to view the list of courses and topics, user login and registration, information about popular courses, information about the teacher and the courses published by him.

Useful for site developers is a page editor with a visual interface, Elementor, which allows you to create and edit WordPress pages without using programming code [16]. Among its main advantages is a set of ready-made templates that can be used to create different types of pages; a large number of widgets; adding animation effects to elements; creating and configuring forms for collecting data or applications; providing the ability to view the page in real time while editing it, which allows you to visually evaluate the results, etc.

The optional WP Mail SMTP plugin [17] improves email inflow by reconfiguring WordPress to require a proper SMTP provider for sending emails. WP Mail SMTP Pro plugin features email logging, advanced email reports and statistics, connection backup, email alerts, smart conditional routing, and more.

To add video materials to the courses, we created a YouTube channel on which we created several playlists and uploaded the corresponding video lectures (Figure 1). This YouTube channel will act as a server for the site's video materials, thus removing the extra load from the site's server by transferring the

processing and playback of video materials to the YouTube service.

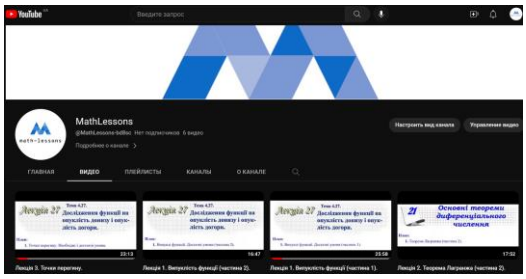

Figure 1: Created YouTube channel for hosting video materials.

In the page settings section on the mathematical educational website, we specify the type of lesson "Video" and add a link to the video material posted on the YouTube channel (Figure 2).

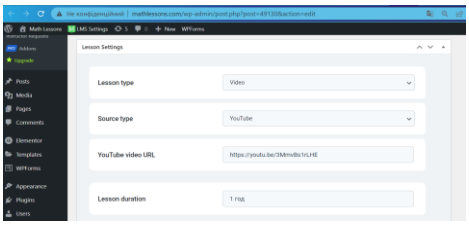

Figure 2: Adding video material from a YouTube channel to a lesson.

You can create, edit and delete courses as an administrator from the site control panel (Figure 3).

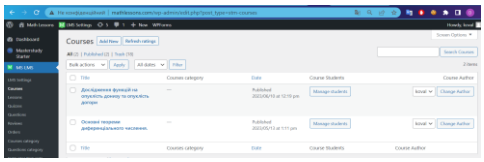

Figure 3: Courses control panel.

An unregistered student can only familiarize himself with the list of educational materials placed in the chosen course. To gain access to educational materials, the student must register on the site using the “Login / Registration” command on the main page. Next, he fills in the fields name, e-mail address of the mailbox, password and confirms the registration. At the specified address, a letter with account activation will automatically arrive in the mailbox by going to the site with a unique vocation.

After activating the account, the management page will open, where the student can change the name and surname, the password of the account and get information about the courses and tests for which he is registered. The site administrator will receive information about the new registered student in the website control panel menu and has the ability to manage this student (edit or remove name, photo, password, etc.) (Figure 4).

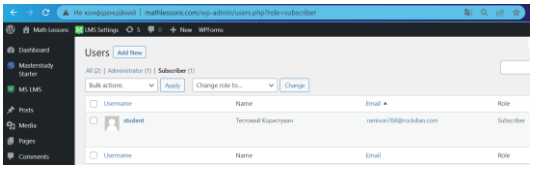

Figure 4: New user information in the website control panel.

After the student has registered on the site, he starts studying, for example, on the course “Basic Theorems of Differential Calculus” (Figure 5).

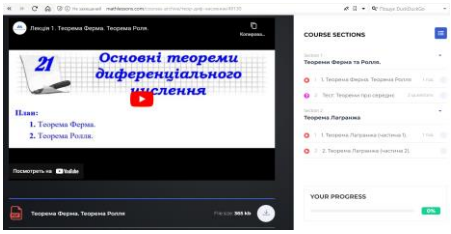

Figure 5: Course materials “Basic Theorems of Differential Calculus”.

The course progress is tracked in the window “Your progress”.

The site administrator will receive a question in the “Comments” menu of the site control panel (Figure 6) and will send an answer to the user (Figure 7).

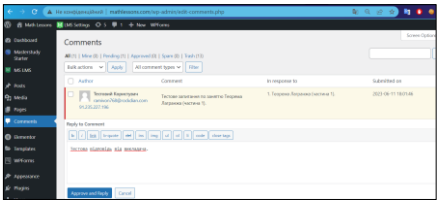

Figure 6: User question in the site control panel.

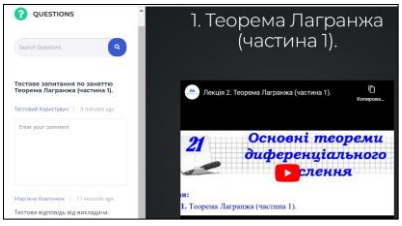

Figure 7: Provided response from the teacher to the user.

After completing the course, the student has the opportunity to leave his evaluation and comments on

this course. The administrator will receive an assessment for the developed course (Figure 8).

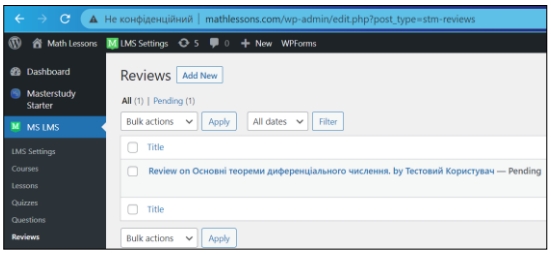

Figure 8: Received rating from the user for the course.

4 DISCUSSION

To test the relevance of developing a virtual mathematical educational space for bachelor's degree and master's degree students of the Faculty of Mathematics, Physics and Computer Sciences of the Mykhailo Kotsiubynskyi Vinnytsia State Pedagogical University, we will use the correlation coefficients of Chuprov K and Pearson C to assess the relationship in a situation where a quality feature consists of more than two groups [18]. The Chuprov coefficient K (1) is used in case of an unequal number of rows and columns of the conjugation table ($k_1 \neq k_2$):

$$K = \sqrt{\frac{\varphi^2}{\sqrt{(k_1-1)(k_2-1)}}}, \qquad (1)$$

where k_1 і k_2 are the number of groups of the first and second characteristics (parameters X і Y).

Pearson correlation coefficient C (2) is used when the number of rows and the number of columns in the conjugation table are the same ($k_1 = k_2$):

$$C = \sqrt{\frac{\varphi^2}{1+\varphi^2}}, \quad \varphi^2 = \sum_{y=1}^{k_1}\left(\frac{\sum_{x=1}^{k_2}\left(\frac{n_{xy}^2}{n_x}\right)}{n_y}\right) - 1. \qquad (2)$$

The values of the Chuprov K and Pearson C coefficients vary from 0 to 1.

Enter the emp irical data in Table 3-4 and perform the calculations.

Let's write the expression φ^2 in more detail (3), based on the conditions $k_1 = 3$ і $k_2 = 5$:

$$\varphi^2 = \sum_{y=1}^{k_1}\left(\frac{\sum_{x=1}^{k_2}\left(\frac{n_{xy}^2}{n_x}\right)}{n_y}\right) - 1 == \frac{\sum_{x=1}^{k_2}\left(\frac{n_{xy}^2}{n_x}\right)}{n_1} + \frac{\sum_{x=1}^{k_2}\left(\frac{n_{xy}^2}{n_x}\right)}{n_2} + \frac{\sum_{x=1}^{k_2}\left(\frac{n_{xy}^2}{n_x}\right)}{n_3} - 1. \qquad (3)$$

Let's find the numerical value of the Chuprov K correlation coefficient.

Let's calculate individual components:

$$A_1 = \frac{\sum_{x=1}^{k_2}\left(\frac{n_{xy}^2}{n_x}\right)}{n_1} = \frac{\frac{11^2}{21}+\frac{8^2}{35}+\frac{8^2}{21}+\frac{2^2}{3}+\frac{1^2}{2}}{30} \approx 0{,}42;$$

$$A_2 = \frac{\sum_{x=1}^{k_2}\left(\frac{n_{xy}^2}{n_x}\right)}{n_1} = \frac{\frac{6^2}{21}+\frac{17^2}{35}+\frac{10^2}{21}+\frac{0^2}{3}+\frac{1^2}{2}}{34} \approx 0{,}45;$$

$$A_3 = \frac{\sum_{x=1}^{k_2}\left(\frac{n_{xy}^2}{n_x}\right)}{n_1} = \frac{\frac{4^2}{21}+\frac{10^2}{35}+\frac{3^2}{21}+\frac{1^2}{3}+\frac{0^2}{2}}{18} \approx 0{,}24.$$

Let's define a parameter φ^2:

$$\varphi^2 = 0{,}42 + 0{,}45 + 0{,}24 - 1 \approx 0{,}11.$$

Table 3. Distribution of students according to the results of pedagogical research[1].

A contingent of students (parameter Y)	1. In your opinion, can the virtual mathematical educational space affect your motivation to study mathematics? (parameter X)					Total
	Yes[1]	Yes[2]	Neutral [3]	No[4]	No[5]	
1-2 courses, bachelor's degree	11	8	8	2	1	30
3-4 courses, bachelor's degree	6	17	10	0	1	34
1-2 courses, master's degree	4	10	3	1	0	18
Total	21	35	21	3	2	82

[1] Yes, it has a positive effect on the motivation to study mathematics.

[2] Yes, it can boost motivation as it allows you to use interactive tools and track your progress.

[3] Neutral, the motivation to study mathematics does not depend on the form of the educational space.

[4] No, it doesn't affect motivation because the math remains challenging regardless of the format.

[5] No, it can even reduce motivation due to the lack of personal contact with the teacher and the community in general.

We will obtain the numerical value of the Chuprov K correlation coefficient:

$$K = \sqrt{\frac{\varphi^2}{\sqrt{(k_1 - 1)(k_2 - 1)}}} = \sqrt{\frac{0{,}11}{\sqrt{(3-1)(5-1)}}} \approx 0{,}19.$$

The value of Chuprov's coefficient $K \approx 0{,}19$ indicates an insignificant mutual relationship between the parameters X, Y. From a practical point of view, this is a confirmation of the hypothesis that the influence of the virtual mathematical educational space on the motivation to study mathematics actually depends little on the distribution of students by courses of study. Junior year students began blended learning at school during the COVID-19 pandemic. And at the university, all students are forced to adapt to wartime conditions. Therefore, the use of a virtual mathematical educational tool is relevant for all students. 25.6% of respondents believe that the virtual educational space has a positive effect on the motivation to study mathematics. 42.7% of students are inclined to think that the virtual educational space can stimulate motivation, as it provides an opportunity to use interactive tools and track their progress. 25.6% of respondents have a neutral attitude, their motivation to study mathematics does not depend on the form of educational space. 3.7% of students think that the virtual educational space does not affect motivation, because mathematics remains difficult regardless of the format. 2.4% of respondents answered that the virtual educational space can even reduce motivation due to the lack of personal contact with the teacher and the community in general.

We will make similar calculations with the survey results presented in the Table 4.

Let's calculate individual components:

- $A_1 \approx 0{,}40$; $A_2 \approx 0{,}46$; $A_3 \approx 0{,}23$.
- Parameter $\varphi^2 \approx 0{,}09$.
- Numerical value of Chuprov's correlation coefficient $K \approx 0{,}18$.

Table 4. Distribution of students according to the results of pedagogical research[2].

A contingent of students (parameter Y)	2. Do you think that the virtual mathematical educational space makes mathematics more accessible to students? (parameter X)					Total
	Yes[1]	Yes[2]	Neutral [3]	No[4]	No[5]	
1-2 courses, bachelor's degree	17	8	4	0	1	30
3-4 courses, bachelor's degree	9	14	10	0	1	34
1-2 courses, master's degree	8	7	3	0	0	18
Total	34	29	17	0	2	82

The value of the Chuprov coefficient $K \approx 0{,}18$ indicates a slight mutual relationship between the parameters X, Y. In fact, this is a confirmation of the hypothesis that the influence of the virtual mathematical educational space on the accessibility of mathematics for students depends little on the distribution of students by courses of study. Therefore, the use of a virtual mathematical educational space is a sought-after resource for all students. 41.5% of respondents agree that thanks to convenient learning and interactive tools, mathematics has become more accessible to them. 30.5% of students tend to think "Yes", especially for those who have limited access to traditional resources. 25.6% of respondents have a neutral attitude, because for them the availability of a virtual mathematical educational space depends on the individual circumstances of the student. None of the students think that the virtual mathematics educational space does not make mathematics more accessible to all students. 2.4% of respondents answered that the virtual mathematical educational space may be less effective for understanding mathematical concepts.

[1] Yes, thanks to convenient learning and interactive tools.

[2] Yes, especially for those with limited access to traditional resources.

[3] Neutral, because the availability of the virtual mathematical educational space depends on the individual circumstances of the student.

[4] No, does not make math more accessible to all students.

[5] No, may be less effective for understanding mathematical concepts.

5 CONCLUSIONS

In martial law, when access to traditional education may be limited, digital technologies provide the opportunity to continue learning and develop students' mathematical skills remotely.

A virtual mathematics website based on WordPress provides students with an effective tool for learning mathematics in an interactive and adaptive environment that ensures the implementation of effective student-centered learning. Modeling the educational process with the help of digital technologies allows students to get access to relevant educational content, interact with teachers and classmates, as well as perform dynamic tasks and tests online.

As we can see, the changing trends in the development of society require from students the ability to adapt to new conditions of the organization of the educational process, and from teachers - the desire to change, to get used to living and working in conditions of uncertainty [19]. In the era of informatization (digitalization) of society and education, in particular, "a modern teacher must possess innovative practices for implementing adaptive, mixed, distance, cloud, and mobile learning" [20]. This prompts teachers to pedagogical design and development of digital technologies for the transformation of traditional approaches to learning and increasing work productivity, revealing one's own individuality.

REFERENCES

[1] T. Vasylieva and Y. Petrushenko, "Digital technologies in education: modern experience, problems and prospects," In: monograph. Sumy: Sumy State University, 2022, 150 p.

[2] Economy reports & analysis. Global Innovation Index. 2022, [Online], Available: https://www.globalinnovationindex.org/analysis-economy.

[3] N. Sinclair and O. Robutti, "Teaching practices in digital environments," In S. Lerman (Ed.), Encyclopedia of mathematics education, 2nd ed, Dordrecht: Springer, 2020. pp. 845-849.

[4] A. Clark-Wilson, O. Robutti, and M. Thomas, "Teaching with digital technology," ZDM Mathematics Education, vol. 52, 2020, pp. 1223-1242, [Online], Available: https://doi.org/10.1007/s11858-020-01196-0.

[5] J. Monaghan, L. Trouche, and J. Borwein, "Tools and mathematics, Dordrecht: Springer, 2016, 483 p.

[6] G. Aldon and J. Trgalova (Eds.), "Technology in Mathematics Teaching," Selected Papers of the 13th ICTMT Conference, vol. 13, 2017, [Online], Available: https://hal.science/hal-01632970/file/book-ictmt13-en.pdf.

[7] P. Black and D. Wiliam, "Developing the theory of formative assessment," Educational assessment, Evaluation and Accountability, vol. 21, no. 1, 2009, pp. 5-31.

[8] G. Aldon and M. Panero, "Can digital technology change the way mathematics skills are assessed?" ZDM Mathematics Education, vol. 52, 2020, pp. 1333-1348, doi: 10.1007/s11858-020-01172-8.

[9] L. Antoniuk, O. Soia, O. Kosovets, A. Klimishyna, M. Kovtoniuk, and O. Tryfonova, "Ensuring the Innovativeness of Vocational Education: Neuropedagogical Aspect". BRAIN. Broad Research in Artificial Intelligence and Neuroscience, 2022, no. 13(4), pp. 242-263, [Online], Available: https://doi.org/10.18662/brain/13.4/386.

[10] M. Kovtoniuk, O. Kosovets, O. Soia, and I. Leonova, "The architecture of digital technologies in the educational environment of the teacher as a transfer of innovations to the economic space of the state," Modern information technologies and innovative teaching methods in the training of specialists: methodology, theory, experience, problems, vol. 68, 2023, pp.93-106, [Online], Available: https://doi.org/10.31652/2412-1142-2023-68-93-106.

[11] J. Lipeikiene, "Virtual Learning Environments as a Supplement to Traditional Teaching," Informatics in Education, vol. 2, no. 1, 2003, pp. 53-64.

[12] P. Mulesa and O. Semenikhina, "Pedagogical conditionsfor preparing future mathematicsand computer science teachersfor the usage of virtual clarity tools in professional activities," Phisical and Mathematical Education, vol. 38, no. 2, 2023, pp. 37-42, [Online], Available: https://doi.org/10.31110/2413-1571-2023-038-2-006.

[13] M. Mintii, N. Sharmanova, A. Mankuta, O. Palchevska, and S. Semerikov, "Selection of pedagogical conditions for training STEM teachers to use augmented reality technologies in their work," Journal of Physics: Conference Series, 2023, doi: 10.1088/1742-6596/2611/1/012022.

[14] WordPress, [Online], Available: https://wordpress.com.

[15] MasterStudy LMS WordPress Plugin – for Online Courses and Education, [Online], Available: https://wordpress.org/plugins/masterstudy-lms-learning-management-system/.

[16] Elementor Website Builder – More than Just a Page Builder, [Online], Available: https://en-ca.wordpress.org/plugins/elementor/.

[17] WP Mail SMTP by WPForms – The Most Popular SMTP and Email Log Plugin, [Online], Available: https://wordpress.org/plugins/wp-mail-smtp.

[18] V. Rudenko, "Mathematical statistics," Study guide, Kyiv: Centre for Educational Literature, 2012, 304 p.

[19] R. Hurevych, V. Kobysia, A. Kobysia, S. Kizim, L. Kutsak, and N. Opushko, "Use of digital services and tools in professional training of future teachers," Modern information technologies and innovative teaching methods in the training of specialists: methodology, theory, experience, problems, vol. 64. 2022, pp. 5-22, [Online], Available: https://doi.org/10.31652/2412-1142-2022-64-5-22.