The Use of Cloud Technologies in the Process of Professional Training of Future Mathematics Teachers

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Abstract: During the restrictions caused by the COVID-19 pandemic, the education system was forced to make an urgent transition to e-learning. The transition revealed problems not only in the material part of the organization of education (lack of access to digital technology in a significant number of both students and teachers) but also in the lack of accessible electronic educational resources needed for educational activities. There were problems with the appropriate training of practical teachers. It cannot be said that this issue was not addressed by the educational community and state authorities, however, the results speak of the formality of the solution of these issues. The general level of teachers' mastery of information and communication technologies remains the main problem, and mathematics teachers are not an exception to this problem, the readiness to use electronic educational resources is at a low level due to the specificity of the methodological design of the educational process. The problem of joint activities of students and teachers during the synchronous and asynchronous interaction remains unsolved. The solution of these problems lies not only in the widespread use of information and communication technologies during the practical training of future mathematics teachers and during the practical re-training of practicing teachers, but also in the construction of an open educational environment on the basis of cloud technology, which solves the problem of interaction between the participants in the educational process.

1 INTRODUCTION

Due to the introduction of quarantine measures as a result of the spread of COVID-19 in 2020-2021 and the military aggression of Russia in 2022, distance learning has been introduced in Ukrainian schools (Hamaniuk et al., 2022). The organization of distance learning is possible through the use of distance learning systems. Despite the active use of distance learning systems by educators, there are some problems in organizing teaching and improving teachers' qualifications. One of the main problems is the lack of methods of using copyright services, which are not localized, but free for use in educational activities. We assume that the use of cloud systems will make the educational process not only possible, but will also gain the traditional form of education, as much as possible.

News reports, social media, reports on webinars of educators and teachers speak not only about the possibility of achieving the goal of learning through e-learning, but also about the problems that arise in this process. These problems affect each of the subjects of educational activity: students, teachers, lecturers, parents, and the administrations of educational institutions. General problems are related to the low level of knowledge of information and communication technologies among teachers, especially older teachers, lack of understanding of the specifics of the educational process when using electronic educational resources, the specifics of the ongoing and post-summary control through the use of information and communication technologies, etc.

Let's look at the problems that arise for teach-

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ers and educators during the transition to e-learning. The transition to the online space and transfer of even one course read at a higher education institution or a secondary educational institution is a long and complex work of a whole team of professors. Some examples are the Coursera or Prometheus courses. All video materials are recorded by professional operators in the studio, with the lecturer's voice overlaying on the video presentation, with a very accurate and competent distribution of information on the hour intervals. The course consists of 10-15 minutes informative videos with tests, a large amount of materials for self-study, peer to peer review assignments, and so on (Velychko and Fedorenko, 2020).

To implement such a feature, the teacher has to be competent in information and communication technology, have the necessary material base for shooting, editing, data processing, etc. Such work takes much more time than preparing for lectures or lessons and making presentations to them. The results of mastering the material in most subjects, disciplines or courses cannot be assessed by taking tests, there is a need to check the written work, listening to auditions, etc. Thus, the amount of mechanical work added to the duties of a teacher or educator is significantly increased. To practice this you can, for example, open 20 e-mail letters, download 20 completed tasks and store them in the appropriate folder. We can see that even such primitive mechanical operations are very costly in terms of working hours.

In addition, there is a great psychological problem if during the lessons online listener is just a passive observer, who does not even appear on the screen. Not every teacher or trainer can talk for 40 minutes to a black screen without any feedback from the audience, even if from time they can hear the responses in the form of voice messages from time to time. Also no less important is the problem of keeping the audience's attention during the lesson.

The results of scientific and methodological work are still one of the unresolved issues. This is required by the duties of educators. It is very important to get good results in the conditions of urgent creation of electronic educational resources. It is also important that the electronic educational resources should have no less functionality of teaching in comparison with the planned, verified face-to-face education.

Research conducted by the scientists and statistical data of mass open online courses have shown that distance learning is effective for 20-25% of listeners. This is the exact number of those who successfully complete the distance learning course as compared to the number of registrants. There is also another side which is the specificity of the selection of material for distance learning, which is determined by the professional competence of the curator of the content. The search for educational material, its systematization, processing in accordance with the level, goals and content of the training makes it necessary to process a large amount of existing digital content.

Students and learners are also exposed to a lot of stress. This category of participants in the educational process has several problems:

- the procedure for evaluating the submitted assignments is incomprehensible, especially those of a summary nature;
- learning at home is more likely to be relaxing than mobilizing and motivating for learning activities, and it deprives the teacher of visual supervision;
- lack of own room to work remotely (presence of parents, younger or older siblings) and, therefore, the simplest decision that students make is not to participate in online classes;
- cases of lack of access to Internet resources both due to the lack of devices and communication channels.

Secondary and higher education institutions are making great efforts to organize distance learning by means of distance platforms. Distance learning seminars, webinars, trainings on forms, methods and tools of distance learning for teachers and educators are held on an urgent basis. Teachers and educators communicate with their students by any means possible, from e-mails, messengers, and available distance learning platforms to phone calls. It should be noted that due to the different activity of participants in the educational process there is a great difference in the results. Thus, the need to investigate the professional preparation of future mathematics teachers for educational activities in a distance form of organization of the educational process is extremely interesting for us.

2 RESEARCH METHODS

The research work is carried out on the basis of the systematic approach as a methodological basis for studying pedagogical and social facts, phenomena, processes; the position of psychological and pedagogical science in the use of information and communication technologies in the educational process of educational institutions.

To solve the tasks set in the work such theoretical and general scientific methods were applied: the analysis of psychological and pedagogical, philosophical

databases on the problem of research to understand the state of development of the formation and development of the cloud-oriented systems of learning support, the identification of the research directions, the principles and approaches to the cloud-oriented systems of learning support; the analysis of existing standards and regulations on the use of digital services in the learning process and informatization of educational institutions; the generalization of the national and foreign experience in the use of digital services and technologies in the institutions of higher education to identify development trends, the clarification of the basic conceptual and terminological apparatus, establishing the conceptual foundations of the study; theoretical analysis, system analysis.

The empirical research methods were used to solve the set tasks: the experimental study of the use of cloud services in the institutions of higher education in Ukraine, the expert assessment of the results of the study, the monitoring of the initial activities with the use of cloud technologies in the educational activities.

3 LITERATURE REVIEW

The issue of using information and communication technologies, and cloud technologies in particular, in the process of professional training of future teachers of mathematics is the subject of active research of the scientists. We will consider in more detail some of those that are relevant to our research.

The professional preparation for the wide use of information and communication technologies in the educational activities of future mathematics teachers begins long before the entering the institution of higher education. Even during the study at the secondary general education institution, future mathematics teachers can extensively observe the forms and methods of using information and communication technologies. The research of the results of using information and communication technologies during the teaching in general secondary education institutions was presented by Vakaliuk et al. (Vakaliuk et al., 2020). The answer to question 13 of their survey is critical for our study: "Did any information and communication technology tools (curricula, multimedia, simulators, games, virtual laboratories, etc.) get used in the school/college by non-CS teachers?". Unfortunately, only 48.5% of respondents answered this question positively. The result suggests that every other future teacher has not acquired the necessary experience of using information and communication technologies in educational activities during his/her studies at a secondary general education institution. However, the variability at the time of answering question 14: "If the answer to the previous question is "Yes", in what lessons did the teachers use such tools?" (Vakaliuk et al., 2020)) indicate that some subject teachers, including teachers of language and literature, mathematics, physics, history, chemistry, biology and geography not only found the possibility of using information and communication technologies in teaching, but also that the use of these technologies was successful, otherwise they would not have been understood by the students. So, thanks to the introduction of information and communication technologies into the secondary school education system, future mathematics teachers are already occasionally familiar with the use of information and communication technologies in educational activities.

Let's review the approaches used in electronic education based on the results of the research by Proskura and Lytvynova (Proskura and Lytvynova, 2020) for Bachelors in Computer Science. The content analysis of the scientific paths of their colleagues and their own experience allowed the authors to develop "The Model of Web-based learning of Computer Science Bachelors" (see figure 1 in (Proskura and Lytvynova, 2020)). Considering such structural components as learning environment, web-oriented environment, control and evaluation unit, levels of students' educational achievements, the authors define the content of e-learning. E-learning components include cloud computing, working together classroom, web-automated knowledge validation systems and others. These components are realized through web technologies as a mean of data transport. Their appearance is conditioned by the presence of network technologies and they belong to the high quality services. Therefore, the need for the use of cloud services to support the training of future mathematics teachers is one of the current educational trends.

No less important for our research is the practice of online training of master's degree students in "Mathematics" for the practical training in universities. The research by Vlasenko et al. (Vlasenko et al., 2021) was focused on the organization of students' educational activities using the online course "Methods of Teaching Mathematics to Students of Technical Universities". The study examines the problems faced by the students during the internship in technical universities, and discusses the possibility of taking into account students' needs in developing the content of the course. This study provides a description of the activities of students while working on the course materials, requirements and recommendations to facilitate the learning process with the help of this course.

The active participation of students and their contribution to the discussion of the course, its content, and their support of the learning process implies that the implementation of the online course and its integration into the training program for master's students will increase their readiness for the internship.

Markova et al. (Markova et al., 2015) conducted a general review of the use of cloud computing in educational activities. The authors made a historical analysis of the stages of using computer technology in education, starting with the study of the problems of providing computer services conducted by Alan O. Mann and to the prospects for the use of cloud technologies in education in accordance with the forecast of their development. Researchers came to the conclusion that the consolidation of established and promising cloud technologies in education requires scientific forecasting of the development of cloud technologies in education based on taking into account historical trends in the development of ICT.

The logical continuation of our study is to identify specific tools to support the professional training of future teachers of mathematics. The specificity of professional training is determined by the specificity of the field of science. The specificity of mathematics is in its abstractness. The research of Vlasenko et al. (Vlasenko et al., 2020) discuss the requirements to modern web-based online courses for training of future mathematics teachers. The authors analyzed the ways of mathematical text presentation through the peculiarities of its formation and creation of mathematical content with a focus on measure use.

The study by Zhaldak et al. (Zhaldak et al., 2021) discusses the use of mathematical technologies in cloud calculations using Remote Desktop Ulteo OVD. As an example, the researchers examined in detail some examples of using pedagogical software for the educational purposes called Gran1. In particular, the calculation of approximate value of the subsumed integral; the graphical solution of two-dimensional tasks, the so-called linear programming tasks; two-dimensional problems including the convex programming – finding the highest value of a convex function (or the highest convex function) on a convex set of inequalities (including linear ones). However, the use in the educational process of any technology, including modern information and communication, as well as the content of the teaching must be pedagogically balanced, which will allow to avoid any negative influences on the formation of the personality of the future member of society, his mental and physical development.

Popel et al. (Popel et al., 2017) have investigated reasonable ways of using cloud systems to support student collaboration in mathematics courses. In particular, the researchers implemented a component based on SageMath that combines electronic resources for teaching several mathematical disciplines. They proposed a training methodology for using the SageMath in the training of educational personnel. In addition, the usefulness of implementing this methodology for the active development of innovative approaches, forms and methods of teaching mathematics using modern devices was proved. The experimental results of the implementation of the SageMath educational component and methods of its use which were developed in the course of the research are presented. The use of the proof-based method to improve the educational environment of the university, expand the possibilities of access to electronic teaching resources during mathematics teaching and involvement of the educational community into this process, as well as increasing their ICT competence is explained.

Shyshkina and Marienko (Shyshkina and Marienko, 2020) determined the content of necessary general skills and specific skills necessary for future mathematics teachers (see table 2 in (Shyshkina and Marienko, 2020)) based on professional functions and typical tasks that teachers of mathematics must be able to perform (see table 1 in (Shyshkina and Marienko, 2020)). The authors used Web-SCM CoCalc (SageMath) to conduct an experimental study that revealed the advantages of using the CoCalc cloud service in the professional training of prospective mathematics teachers.

Fedorenko et al. (Fedorenko et al., 2020) investigated the problem of studying virtual software through the use of cloud services. The results of this research had a positive result especially for the professional training of future mathematics teachers. Investigators have revealed the didactic capabilities of the cloud services, which allow you to run free software for mathematical orientation.

The GeoGebra environment is one of the most powerful systems of computer mathematics for dynamic visualization, calculations during problem solving, data processing and scientific and research work. Dubovyk and Rudnytskyi (Dubovyk and Rudnytskyi, 2022) have looked at the peculiarities of using the author's applets and other products of GeoGebra during the teaching of disciplines of differential geometry and linear algebra in the training of future mathematics teachers, in particular, their research describes the possibilities of using this tool to study the properties of space curves and to form practical skills and abilities to perform operations on matrices, finding the invertible matrices. The advantages and dis-

advantages of using the GeoGebra environment in the educational process of linear algebra and differential geometry are outlined.

Kholifah et al. (Kholifah et al., 2020) aimed to show how effective the use of blended learning model influences the learning motivation of vocational education students. The results obtained in the course of the research show that the use of the model of blended learning has a significant impact on the motivation of students of vocational education. Attard and Holmes (Attard and Holmes, 2020) investigated the willingness of teachers to use blended learning approaches. The study was conducted on teachers who taught mathematics classes in secondary schools. As a result of the study it was found that the use of technology expands the possibilities for students to study mathematics by providing multiple methods and access methods, and students can use mixed teaching approaches.

Kadirbayeva et al. (Kadirbayeva et al., 2022) have assessed the methods of using blended learning technology in school mathematics from the viewpoint of teachers. According to the results of the research, most mathematics teachers stated that the attitude of students to the mathematics lesson was ambiguous and negative. Most of the teachers who participated in the study stated that the combination of the wonderful characteristics of the classroom environment, the diversity of teaching and learning methods, the variety of teaching materials and increasing student success are the strengths of mathematics education in a mixed learning environment. Most teachers who participated in the study stated that a disadvantage of mathematics education in the mixed environment is the lack of educational programs suitable for mixed learning, the disadvantages of software and hardware that will be used in the course, and inability to use technology effectively and efficiently, and the learning environment.

4 RESEARCH RESULTS

The normative and regulatory documents that determine the content and organization of the educational process in institutions of higher education of Ukraine provide the main requirements for lectures. The implementation of these principles allows us to fully use the significant teaching and educational possibilities of this form of learning, to increase the impact of each lecture on the knowledge and feelings of the students. However, the lecture in some way trains the student to passive absorption of others' ideas, does not stimulate the desire for self-study, does not provide for an individualized, differentiated approach to learning. The leading role of the lecture in teaching disciplines associated with their contents aspect, organizing principles and methodological features. The main content consists of the central methodological, theoretical and practical problems. Not all questions of the topic are revealed, but the most important, the most essential, which require scientific discussion.

The pace of development of modern technologies significantly affects teaching methods and teaching models in general. This allows you to expand ways to implement the paradigm of competence in order to improve the quality of education. The model of blended learning has the greatest potential for optimizing the educational process. This model allows for the implementation of new technologies without disregarding the generally accepted teaching methods. Blended learning is a model for organizing the educational process because "it allows to increase the motivation of future teachers to learn, makes it transparent, interactive and guided, and ensures the constant involvement of students in the educational process" (Kukharenko, 2016) and continuous advancement of qualification. The aim of this form of learning is to combine the advantages of face-to-face learning and electronic educational resources through the combination of distance and traditional communication in an integrated educational activity. The integration of traditional and computer-based learning in the educational environment leads to a purposeful process of developing knowledge and skills and abilities in the classroom and post-attendance educational activities of the subjects of the educational process on the basis of the use of information and communication technologies. The existence of this form of learning is possible due to the effective combination of different ways of presenting educational content, teaching models and styles. It is based on the interaction between all participants in the educational process.

One of the forms of blended learning is implemented through Flipped Classroom. There are different ways of implementing the Flipped Classroom model, all of which are based on one basic principle: traditional learning takes place outside the classroom, while practical work and application of the acquired knowledge takes place in the classroom. In general, the essence of inverted learning lies in restructuring the key components of the educational process. With the help of this teaching model "the content of new educational material is mastered by oneself in the electronic environment, and then the acquired knowledge is used during practical lessons or discussions" (Hlazova et al., 2018).

The shortening of classroom hours (lectures,

workshops, seminars, laboratory classes) leads to a failure of the traditional logics of the educational process. This fact leads to loss of quality of teaching. One of the ways to "renew the balance of the educational process is to use the mixed teaching model with Flipped Classroom technology" (University of Queensland, 2017). In this case, the key components of the learning process change places: the basic components of the new material are studied independently at home, and in the classroom the studied material is consolidated and the more complex issues and practical use of the teaching information are discussed together with the tutor. The Flipped Classroom technology is characterized by the fact that the necessary "theoretical knowledge is acquired in the classroom, and in the classroom the individual tasks are performed or a group project is developed" (Pieri and Laici, 2017).

Flipped Classroom technology was used in the study of mathematical disciplines "Mathematical Logic and Theory of Algorithms" and "Elementary Mathematics" at the 3rd year of the Physics and Mathematics Faculty of the Donbas State Pedagogical University. Taking into account the fact that the students of the specialty "Secondary education (mathematics)" specialization "Informatics" at the 3rd year of study have significant experience of educational activities, and the level of self-awareness is already sufficient for the personal motivation to learn, it is not only logical, but also quite profitable to use the elements of Flipped Classroom technology. Moreover, this model of learning does not interfere with the educational program, in which the main part of the years is allocated for the students' self-directed work.

Based on the practical experience of use, the following structure of the approach to each individual topic was formed:

1. Formulation of the topic and the goal.
2. Identifying the place of the topic in the work program of the discipline.
3. Suggesting sources of information.
4. Definition of types and content of control.
5. Control and evaluation.

Implementing the Flipped Classroom technology while teaching the course "Mathematical Logic and Theory of Algorithms" it is advisable to consider the following topics:

- Boolean n-ary functions;
- Zhegalkin Polynomial;
- Complete systems of Boolean functions;
- Mathematical theories of the first order.

For each of the proposed topics identified a place in the work program and sources of information, selected the content of tasks for the control of the type.

For example, to study the topic "Boolean function systems" students receive the following information (table 1).

The main reason for the implementation of the Flipped Classroom model of teaching in the educational process of the university is the active cooperation between the students and the teacher and, as a result, increasing the success and motivation of the students. A special feature of this model is the possibility of using group classroom sessions where students can discuss key aspects of lecture materials, test their knowledge and interact with each other. The task of the teacher is to explain the problems, comment on the work of students. Thus, we came to the need to have in their arsenal of specialized mathematical platforms for collaborative work. Through the use of collaborative platforms, or even mathematical platforms that allow the exchange of output data, with the results of calculations or developed electronic educational resources for mathematics courses, we get a mechanism for organizing blended learning with Flipped Classroom technology for future mathematics teachers.

It is necessary to review the training tools for future teachers of mathematics, which implement the above-mentioned ideas. The CoCalc Cloud Platform (https://cocalc.com/) is part of the SageMath Project (https://www.sagemath.org/) developed by William A. Stein. The main idea is that currently there is a large number of open and complete mathematical software already developed but they are implemented in various programming languages. The SageMath project integrates all existing developments and adds its own, and integrates them with the Python language. The cloud service CoCalc provides the opportunity not only to work online with SageMath worksheets via Jupiter notepad, but also to use the LaTeX language for the design of documents. Merzlykin et al. (Merzlykin et al., 2022) investigated the capabilities of the CoCalc system for scientific and educational purposes and came to the following conclusions:

- the use of cloud services leads to the formation and development of forms of learning focused on collaborative learning activities on the Internet;
- cloud services can be used in the training of mathematics teachers as tools: communication; collaboration; storage and processing of data.

An example of supporting the process of professional training of future teachers of mathematics is the use of computer-based mathematics systems in

Table 1: Information resources of the topic.

Topic	Complete Systems of Boolean Functions
Purpose	To learn the concepts of classes of functions that store zero, functions that store one unit, self-similar functions, monotonic and linear functions. To define the criteria of totality.
The sources of information (self-selection of sources of information is encouraged)	• Borodkina I. Teoriia alhorytmiv. Posibnyk dlia studentiv vyshchykh navchalnykh zakladiv. (A guide for students of higher educational institutions.) K.: Tsentr navchalnoi literatury, 2019. 184 p. • Zubenko V.V., Shkilniak S.S. Osnovy matematychnoi lohika: navchalnyi posibnyk. (The Fundamentals of Mathematical Logic: A Tutorial.) K.: NUBiP Ukrainy, 2020. 102 p. • Kaidan N.V., Pashchenko Z.D. Metodychni vkazivky do praktychnykh zaniat z kursu "Matematychna lohika ta teoriia alhorytmiv". Rozdil "Matematychna lohika" dlia spetsialnosti 014 Serednia osvita (Matematyka) (The methodological guidelines for practical exercises in the course "Mathematical Logic and Theory of Algorithms". Section "Mathematical Logic" for the specialty 014 Secondary Education (Mathematics)). Sloviansk: Vyd B. I. Matorina, 2019. 92 p. • Matviienko M.P., Shapovalov S.P. Matematychna lohika ta teoriia alhorytmiv : navchalnyi posibnyk. (Mathematical Logic and Theory of Algorithms: A Manual.) Kyiv : Lira-K, 2018. 211 p. • Rosen K.H. et al. Handbook of Discrete and Combinatorial Mathematics. 2000. 1183 p. • Discrete Mathematics. Lecture: Completeness criterion of a Boolean function system. Access mode: https://cutt.ly/jJaHyNj • "Collect the Crystals" game simulator. Access mode: https://cutt.ly/SJaHK3c • Simulator "Logical Elements". Access mode: https://cutt.ly/0JaHMwY • A Simulator for Minimizing Logic Functions by the Quine-McCluskey Method. Access mode: https://cutt.ly/hJaH49v • Creating the Truth Table. PDNF. PCNF. Zhegalkin polynomial. Access mode: https://cutt.ly/IJaJqzR • Truth table. Access mode: https://cutt.ly/3JaJufo
Types of control	Test for the comprehension of the material (carried out remotely during class time), individual assignment to determine the completeness of the system
Date of control	Conducting a self-study test

the form of cloud services. One of these free services is Math Partner, available at http://mathpar.com. This service allows you to create your own cloud math "Workbook", in which the user performs the necessary mathematical calculations. To ensure quality and comfortable work this service provides access to a large amount of guidance material with examples. The language of this service is Mathpar, based on TeX, a widely used by mathematicians special-purpose data layout language developed by Donald Knuth. There is a possibility to save both the statement of the problem and its solutions. You can save both textual and pictorial views. Although for studying mathematical logic Math Partner system does not contain expanded functions, the basic logical operations the system is able to process (figure 1).

In particular, Math Partner allows you to efficiently perform such common tasks as finding the shortest distances between all vertices of the graph (\searchLeastDistances(A)) and finding the shortest path between vertices (\findTheShortestPath(A,i,j)). It should be noted that this service is convenient to use for checking your own connections, because it gives the answer itself, without access to the intermediate results of the calculations.

The Graph Online service https://graphonline.ru/en/), which is available under the MIT License, is designed for graph visualization and execution of algorithms on the created graph. The graph is created using the complexity matrix or the incident matrix. Besides searching for the shortest path, you can also search for the connectivity component. The service

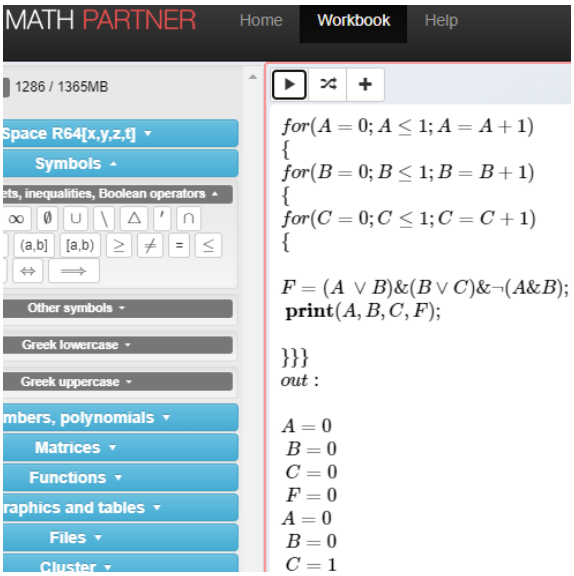

Figure 1: Calculation of logical function values in the Math Partner system.

supports work with directed graphs (digraphs) and non-directed graphs. You can save the result of the work, i.e. the generated graph, and continue working on it later. In addition, the cloud service Graph Online gives the user a number of additional functions to make the work easier. Graph saving and loading is available with maintenance of visual representation, quick conversion between all supported types, vertex, arc, background, constructor mode, etc.

Let us demonstrate the application of the presented services when solving the problem of finding the shortest distances between graph vertices, which are often encountered in practice. It is clear that for the possibility to find the shortest distances at least one path from vertex 0 to each other vertex must exist, i.e. the graph must be connected. For this problem the most well-known connectivity algorithm is the Dijkstra's algorithm. The idea of this algorithm is that at first each vertex other than vertex 0 is given a distance equal to $+\infty$, and then we decrease these distances step by step until we find the minimum distance $d(v)$ and the shortest path $p(v)$ for each vertex v.

Problem statement: In an arbitrary graph $G = (V,E)$, the set of vertices $V = \{0,1,2,3,4,5\}$, and the set of edges E is given by a matrix of weights:

$$E = \begin{pmatrix} - & 8 & 7 & - & 10 & 12 \\ 8 & - & 5 & 1 & 4 & - \\ 7 & 5 & - & 3 & - & 4 \\ - & 1 & 3 & - & 2 & 1 \\ 10 & 4 & - & 2 & - & 3 \\ 12 & - & 4 & 1 & 3 & - \end{pmatrix}$$

Use Dijkstra's algorithm to build a spanning tree

Table 2: The progress of the Dijkstra algorithm.

1	2	3	4	5
8	**7**	10 **9**	**10**	12 11 **10**
0; 1	0; 2	0; 2; 3 0; 1; 3	0; 4	0; 5 0; 2; 5 0; 1; 3; 5

of the shortest paths from vertex 0 to all other vertices of graph G and find the shortest distances.

Solution: Let's show the progress of the Dijkstra's algorithm in the table 2.

During the execution of the Dijkstra's algorithm, the vertices were in this order: $2,1,3,4,5$. Thus, the shortest distance to vertex 1 is 8, $d(2) = 7$, $d(3) = 9$, $d(4) = 10$, $d(5) = 10$. The shortest path to vertex 1 is 0.1; $p(2) = 0.2$; $p(3) = 0.1.3$; $p(4) = 0.4$; $p(5) = 0.1.3.5$. Figure 2 shows these shortest paths in the form of a tree.

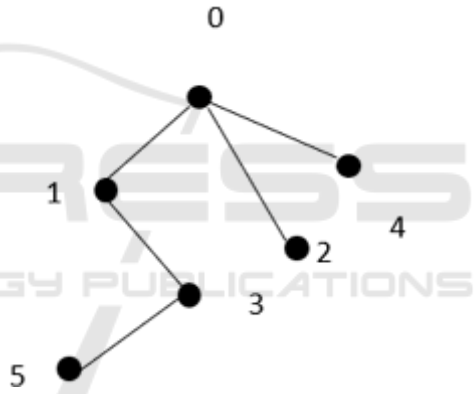

Figure 2: The spanning tree of the shortest paths from vertex 0 to all other vertices of graph G.

With the Math Partner service, we have the opportunity to check the correctness of the results in figure 3. But the visualization of the graph is better performed by Graph Online in figure 4.

The Robert Coleman SA403_FY17 project (https://cutt.ly/PKp7bJ4) on the CoCalc platform includes the implementation of popular graph algorithms. In particular, Dijkstra's algorithm was implemented (https://cutt.ly/FKp7eLy). Thus, we can conclude that during the professional training of mathematics teachers, the use of various cloud services is not only possible but also appropriate.

The students of the 2nd-4th years of Secondary Education (Mathematics) at the Faculty of Physics and Mathematics of the Donbas State Pedagogical University were repeatedly interviewed (the first one was described in the study (Velychko et al., 2021)) in order to find out what means of computer teaching are

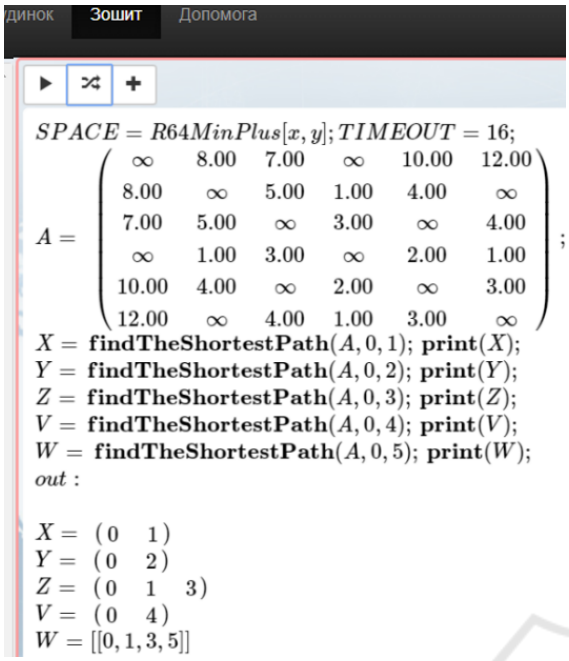

Figure 3: The shortest distances from the vertex 0 to all other vertices of graph G in the Math Partner service.

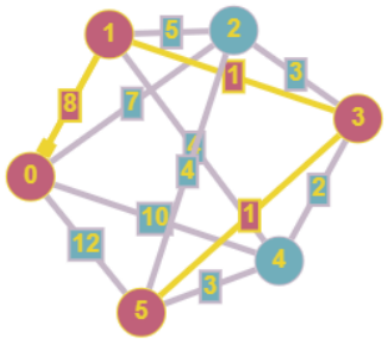

Figure 4: The visualization of the graph G and the shortest distance from the vertex 0 to the vertex 5 of the graph G in the Graph Online service.

used by future mathematics teachers in the process of their professional training, including during the self-study activity. A total of 80 students were involved in the survey (in the first one – 120 respondents). We asked the respondents the following questions:

1. Have you used electronic educational resources during your studies?
2. Did you use the cloud services during the study period?
3. Did you use the cloud services during self-study activities?
4. If the answer to the 2nd or 3rd question is positive, then what cloud services did you use?
5. If the answer to the second and third questions is negative, what kinds of software did you use during the training?

We received the following results:

- 100% positive result on the first question. This result indicates that future mathematics teachers understand the concept of "electronic educational resources" without regard to their diversity.
- The second question was answered positively by 92% of respondents (in the first survey – 82%). The result of the answer to the second question shows that not all respondents identify the concept of a cloud service. We reached this conclusion during the discussion of the results of the survey with the respondents since during the practical exercises that we described in the study all the students were involved in the use of cloud services.
- 76% of respondents (46% in the first survey) responded positively to our third question. This number is a good result of self-awareness activities.

The answer to the fourth question is shown in the figure 5.

It should be noted that there was a significant outpacing of cloud communication services due to quarantine measures caused by COVID-19 pandemic and cloud file-saving and collaborative work servers. In comparison with the first study, tools for creating infographics and interactive presentations appeared. A positive result of the study is an increased use of mathematical cloud services. The answer to our question 5 is shown in figure 6.

By comparing the results of the study with those described in the publication "The support of the process of training pre-service mathematics teachers by means of cloud services" (Velychko et al., 2021) we get both quantitative and qualitative changes. First of all, the respondents not only expanded their knowledge of cloud technologies, but also expanded their use in their own teaching activities. Software on the

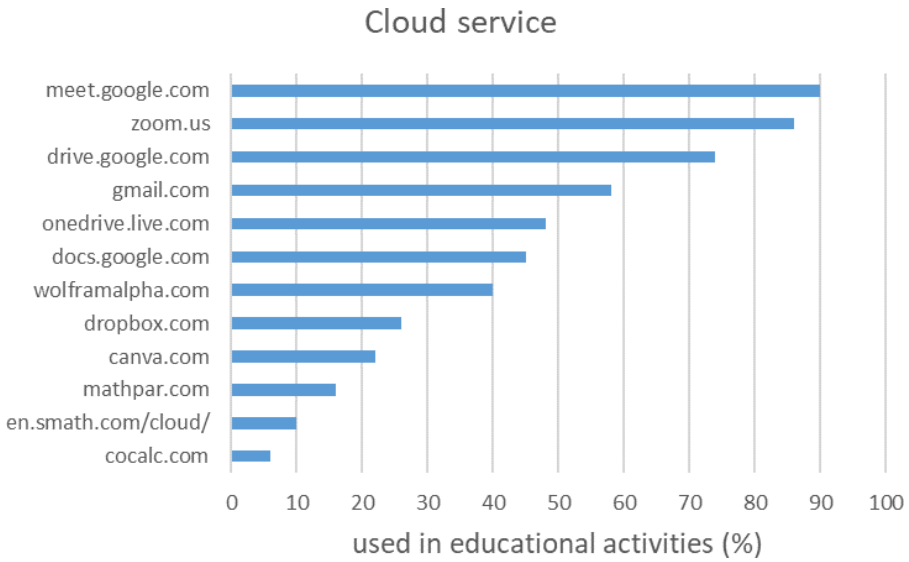

Figure 5: Cloud services which were used by the future mathematics teachers.

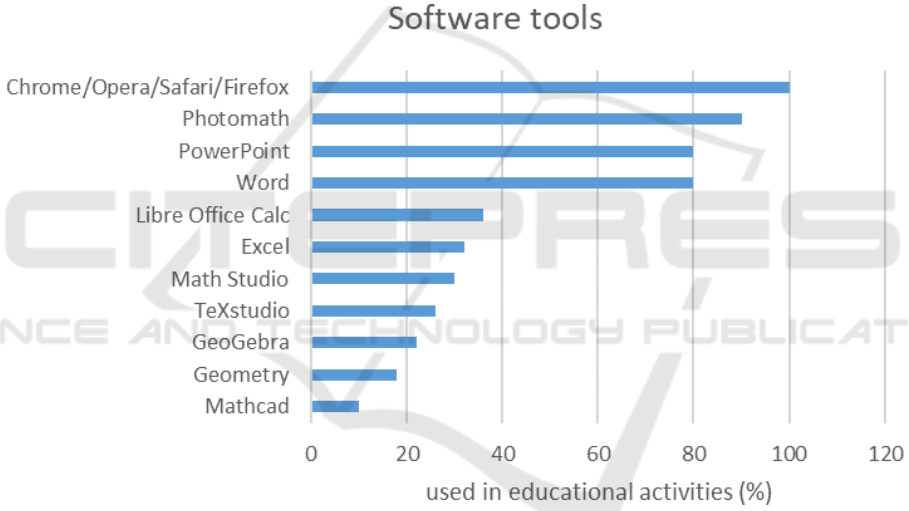

Figure 6: Software tools used by future mathematics teachers.

desktop system as well as on mobile systems has a greater focus on learning, the advantages are given to the available software. Respondents' responses are more demanding compared to the previous one. As before, special software for mathematical purposes is not used as often as desired, however, the rate of its use is increasing.

5 CONCLUSIONS

The learning process at a high school is implemented within a diverse and integral system of organizational forms and teaching methods. Each form carries out its own specific task, but the totality of forms and methods of learning creates a single didactic complex, the functioning of which is consistent with the specific psychological and pedagogical laws of the educational process. The advantages of the cloud services lead to their widespread use in educational activities. Experience gained in implementing cloud technologies in educational activities make it possible to begin to analyze the work carried out – what results were obtained, which are the best practices of their use. Quarantine restrictions and the rapid transition to e-learning has led to the creation of electronic educational resources, development of methods of e-learning, in which the cloud services play a significant role.

The results of the research allow us to conclude that cloud technology is used in the process of teaching mathematics in secondary schools. Future math-

ematics teachers have the opportunity to use cloud technology during their professional training. Modern cloud technologies have a wide range of use in mathematics education. The training of future mathematics teachers has begun to be based on new teaching tools and technologies.

The next step of the research is the accumulation of empirical data on the use of cloud computing in the process of professional training of future teachers of informatics and software for applied orientation. We have analyzed the trends in the use of cloud computing and software of mathematical orientation both during the professional training of future mathematics teachers and during the professional activities of practicing mathematics teachers. The problem of harmonious combination of digital technology and classical methods of mathematics learning, even in modern pedagogical teaching technology, is not solved. In our opinion, the feasibility of reduction of computing operations through the use of information technologies in opposition to the loss of skills of operational competence is interesting.

REFERENCES

Attard, C. and Holmes, K. (2020). An exploration of teacher and student perceptions of blended learning in four secondary mathematics classrooms. *Mathematics Education Research Journal*. https://doi.org/10.1007/s13394-020-00359-2.

Dubovyk, V. and Rudnytskyi, S. (2022). Using GeoGebra environment to visualize educational material in the process of training pre-service mathematics teachers. *Physical and Mathematical Education*, 34(2):33–37. https://doi.org/10.31110/2413-1571-2022-034-2-005.

Fedorenko, E. H., Velychko, V. Y., Omelchenko, S. O., and Zaselskiy, V. I. (2020). Learning free software using cloud services. *CTE Workshop Proceedings*, 7:487–499. https://doi.org/10.55056/cte.387.

Hamaniuk, V., Semerikov, S., and Shramko, Y. (2022). ICHTML 2022 - Education under attack. *SHS Web Conf.*, 142:00001. https://doi.org/10.1051/shsconf/202214200001.

Hlazova, V. V., Kaidan, N. V., and Kaidan, V. P. (2018). Practical use of remote training elements and methods of "flipped classroom" at professional training of future computer science teachers. In Ostenda, A., Ekkert, M., and Mikos, P., editors, *Information and innovation technologies in education*, volume 19 of *Series of monographs Faculty of Architecture, Civil Engineering and Applied Art*, pages 192–199, Katowice. Wydawnictwo Wyższej Szkoły Technicznej w Katowicach. http://www.wydawnictwo.wst.pl/uploads/files/b36a49544b9f35584d39768fddc393b2.pdf.

Kadirbayeva, R., Pardala, A., Alimkulova, B., Adylbekova, E., Zhetpisbayeva, G., and Jamankarayeva, M. (2022). Methodology of application of blended learning technology in mathematics education. *Cypriot Journal of Educational Science*, 17(4):1117–1129. https://doi.org/10.18844/cjes.v17i4.7159.

Kholifah, N., Sudira, P., Rachmadtullah, R., Nurtanto, M., and Suyitno, S. (2020). The Effectiveness of Using Blended Learning Models Against Vocational Education Student Learning Motivation. *International Journal of Advanced Trends in Computer Science and Engineering*, 9(5):7964–7968. https://doi.org/10.30534/ijatcse/2020/151952020.

Kukharenko, V. M., editor (2016). *Teoriia ta praktyka zmishanoho navchannia [Theory and practice of blended learning]*. Miskdruk, NTU "KhPI", Kharkiv. http://repository.ldufk.edu.ua/handle/34606048/24840.

Markova, O. M., Semerikov, S. O., and Striuk, A. M. (2015). The cloud technologies of learning: Origin. *Information Technologies and Learning Tools*, 46(2):29–44. https://doi.org/10.33407/itlt.v46i2.1234.

Merzlykin, P., Marienko, M., and Shokaliuk, S. (2022). CoCalc Tools as a Means of Open Science and Its Didactic Potential in the Educational Process. In Semerikov, S., Osadchyi, V., and Kuzminska, O., editors, *Proceedings of the 1st Symposium on Advances in Educational Technology (AET 2020)*, volume 1, pages 109–118. SciTePress. https://doi.org/10.5220/0010921000003364.

Pieri, M. and Laici, C. (2017). The Flipped Classroom approach in the "Avanguardie Educative" Movement. *Italian Journal of Educational Technology*, 25(3):55–66. https://doi.org/10.17471/2499-4324/948.

Popel, M., Shokalyuk, S. V., and Shyshkina, M. (2017). The Learning Technique of the SageMathCloud Use for Students Collaboration Support. In Ermolayev, V., Bassiliades, N., Fill, H., Yakovyna, V., Mayr, H. C., Kharchenko, V. S., Peschanenko, V. S., Shyshkina, M., Nikitchenko, M. S., and Spivakovsky, A., editors, *Proceedings of the 13th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer, ICTERI 2017, Kyiv, Ukraine, May 15-18, 2017*, volume 1844 of *CEUR Workshop Proceedings*, pages 327–339. CEUR-WS.org. https://ceur-ws.org/Vol-1844/10000327.pdf.

Proskura, S. L. and Lytvynova, S. H. (2020). The approaches to web-based education of computer science bachelors in higher education institutions. *CTE Workshop Proceedings*, 7:609–625. https://doi.org/10.55056/cte.416.

Shyshkina, M. P. and Marienko, M. V. (2020). The use of the cloud services to support the math teachers training. *CTE Workshop Proceedings*, 7:690–704. https://doi.org/10.55056/cte.419.

University of Queensland (2017). Flipped classroom project (OLT). https://www.pinterest.com.au/pin/258534834836373906/.

Vakaliuk, T. A., Antoniuk, D. S., and Soloviev, V. N. (2020). The state of ICT implementation in institutions of general secondary education: a case of Ukraine. *CTE*

Workshop Proceedings, 7:119–133. https://doi.org/10.55056/cte.316.

Velychko, V. Y. and Fedorenko, E. G. (2020). Organization of educational activities on microlearning technology during the COVID-19 pandemic. *eLearning TeXnology*, 4:67–75. https://doi.org/10.31865/2709-840002020222557.

Velychko, V. Y., Fedorenko, E. H., Kaidan, N. V., Soloviev, V. N., and Bondarenko, O. V. (2021). The support of the process of training pre-service mathematics teachers by means of cloud services. *CTE Workshop Proceedings*, 8:318–332. https://doi.org/10.55056/cte.265.

Vlasenko, K., Lovianova, I., Chumak, O., Sitak, I., and Achkan, V. (2021). The arrangement of on-line training of master students, majoring in Mathematics for internship in technical universities. *Journal of Physics: Conference Series*, 1840:012007. https://doi.org/10.1088/1742-6596/1840/1/012007.

Vlasenko, K. V., Volkov, S. V., Kovalenko, D. A., Sitak, I. V., Chumak, O. O., and Kostikov, A. A. (2020). Web-based online course training higher school mathematics teachers. *CTE Workshop Proceedings*, 7:648–661. https://doi.org/10.55056/cte.420.

Zhaldak, M. I., Franchuk, V. M., and Franchuk, N. P. (2021). Some applications of cloud technologies in mathematical calculations. *Journal of Physics: Conference Series*, 1840(1):012001. https://doi.org/10.1088/1742-6596/1840/1/012001.