The support of the process of training pre-service mathematics teachers by means of cloud services

Vladyslav Ye. Velychko[1], Elena H. Fedorenko[1], Nataliia V. Kaidan[1], Vladimir N. Soloviev[2] and Olga V. Bondarenko[2]

[1]*Donbas State Pedagogical University, 19 Heneral Batiuk Str., Sloviansk, 64122, Ukraine*
[2]*Kryvyi Rih State Pedagogical University, 54 Gagarin Ave., Kryvyi Rih, 50086, Ukraine*

Abstract

The training of pre-service mathematics teachers is a complex process due to the specifics of the field. Informatization of education affects all the areas, and pre-service mathematics teachers can not be left out. The article is devoted to the problem of supporting the process of professional training of pre-service mathematics teachers by means of cloud services. Examples of the use of cloud technologies are given. The analysis of a survey of pre-service mathematics teachers on the use of information and communication technologies in the training process is done.

Keywords

training of pre-service teachers, cloud services, mathematics teachers, training system

1. Introduction

During the constraints caused by the COVID-19 pandemic, education was forced to switch to e-learning as a matter of urgency [1, 2, 3, 4, 5]. The transition revealed problems not only in the material part of the organization of education (lack of access to digital technologies for a significant number of both students and teachers) in the lack of electronic educational resources needed for educational activities. There were problems with the appropriate training of pre-service teachers. It cannot be said that this issue has not been raised by the educational community and government agencies, however, the results indicate a formality in resolving these issues.

2. Statement of the problem in general

News reports, social networks, reports at webinars of teachers and educators speak not only about the possibility of achieving the goal of learning through e-learning. It also speaks to

Cloud Technologies in Education 2020, December 18, 2020, Kryvyi Rih, Ukraine
vladislav.velichko@gmail.com (V. Ye. Velychko); fedorenko.elena1209@gmail.com (E. H. Fedorenko); kaydannv@gmail.com (N. V. Kaidan); vnsoloviev2016@gmail.com (V. N. Soloviev); bondarenko.olga@kdpu.edu.ua (O. V. Bondarenko)
0000-0001-9752-0907 (V. Ye. Velychko); 0000-0002-1897-874X (E. H. Fedorenko); 0000-0002-4184-8230 (N. V. Kaidan); 0000-0002-4945-202X (V. N. Soloviev); 0000-0003-2356-2674 (O. V. Bondarenko)

the problems that arise. These questions concern each of the subjects of educational activity: students, teachers, parents and the administration of educational institutions.

Let's consider what problems teachers have when moving to the online space. Going online and transferring even one course taught in a higher education institution or a general secondary education institution is a huge long-term work of a whole team of professionals. The examples are Cousera or Prometheus resource courses. All videos are recorded by professional cameramen in the studios, with a professional overlay voice of the lecturer of the presentation on the video, with a very careful and competent distribution of information over time. The course consists of 20-30 minute informative videos, for which tests, a large amount of materials for self-study, tasks such as peer to peer review and so on are prepared.

In order to implement such functionality, it is not enough for a teacher to have information and communication technologies, to have the necessary material base for shooting, editing videos, informational material, etc. Such work takes much more time than preparing for lectures or conducting a lesson and creating presentations for them. The results of mastering the material from most subjects, disciplines or courses cannot be assessed by passing tests, there is a need to check written works, listen to auditions and so on. It significantly increases the amount of mechanical work that is added to the responsibilities of a teacher or lecturer. For clarity purposes, you can, for example, open 20 e-mails, download 20 completed works and save them in the appropriate folder. We see that even such primitive mechanical operations are very time consuming.

In addition, there is a big psychological problem if during online classes students are a passive cluster that is not even displayed on the screen. Not every teacher is able to tell 40 minutes on the black screen without any impact on the audience, even if from time to time there are single answers in the form of voice messages. It is also important to hold the attention of the audience during the lesson.

Another unresolved issue is the results of scientific and methodological work. It is required by the job responsibilities of educators. In the situation of excessive creation of electronic educational resources it is extremely difficult to get good results. It is also important that e-learning resources have no less functional teaching compared to planned, verified, proven full-time learning.

Researches and statistics from mass open online courses have found that distance learning is effective for 20-25% of students. This is the number of them who successfully complete the distance course compared to the number of registered ones. There is another side – the specifics of the selection of material for distance learning, which is determined by the professional competence of the content curator. The search for educational material, its systematization, processing in accordance with the level, goals and content of training forces to process a huge amount of existing digital content.

Students are no less stressed. There are several problems in this category of participants in the educational process:

- the construction of the procedure for evaluating the completed tasks, especially those of a final nature, is not clear;
- learning at home relaxes rather than mobilizes and motivates learning activities, and leaves visual control on the part of the teacher;

- lack of own room for working remotely (presence of parents, younger or older siblings) and therefore, the simplest solution that students come to is not to participate in online classes;
- cases of lack of access to Internet resources due to lack of devices and lack of communication channels.

General secondary and higher education institutions make great efforts to organize learning with the help of distance platforms. Seminars, webinars, trainings on forms, methods and means of distance learning for teachers are held in an accelerated manner. Teachers communicate with their students by any possible means, from e-mails, instant messaging, available distance learning platforms to telephone communication. It should be noted that due to the different activity of participants in the educational process there is a big discrepancy in the results. Thus, it is extremely interesting for us to explore the issues of professional training of pre-service teachers of mathematics for educational activities in the distance form of organization of the educational process.

3. Review of the current state of the problem

The issue of application of information and communication technologies (ICT), and cloud technologies in particular, in the process of professional training of pre-service mathematics teachers is the subject of active research by Bobyliev and Vihrova [6], Clark-Wilson et al. [7], Drijvers [8], Kiv et al. [9, 10], Kramarenko et al. [11, 12], Kumar and Bhardwaj [13], Lovianova et al. [14], Merzlykin et al. [15], Mulenga and Marbán [16], Ndlovu et al. [17], Papadakis [18], Perienen [19], Ponomareva [20], Popel [21], Purnomo and Jailani [22], Pyper [23], Semenikhina et al. [24], Vlasenko et al. [25, 26, 27, 28, 29, 30, 31, 32, 33], Yang [34]. We will consider in more detail some of them related to our study.

Professional training for the widespread use of ICT in the educational activities of pre-service mathematics teachers begins long before entering higher education. During their studies in a general secondary education institution, pre-service mathematics teachers can already clearly observe the forms and methods of application of ICT. The study of the results of the use of ICT during training in general secondary education was presented in a study by Vakaliuk et al. [35]. Useful for our study is the answer to question #13 of their study: “Did any information and communication technology tools (curricula, multimedia, simulators, games, virtual laboratories, etc.) be used in the school / college by non-CS teachers?”. Unfortunately, only 48.5% of respondents answered this question positively. The result suggests that every second pre-service teacher while studying in a general secondary education institution has not received the necessary experience of using ICT in educational activities. However, the variety in answering question #14: ”If the answer to the previous question is ”Yes”, in what lessons did the teachers use such tools?” (see figure 14, [35]) indicates that some subject teachers, including teachers of language and literature, mathematics, physics, history, chemistry, biology and geography have found not only the possibility of using ICT in learning activities, and this application was successful, otherwise it would not be remembered by students. Thus, due to the introduction of ICT in the secondary school education system, pre-service mathematics teachers are occasionally familiar with the use of ICT in educational activities.

Let's consider the approaches used in e-learning based on the results of the study of Proskura and Lytvynova [36] for bachelors of computer science. The conducted semantic analysis of scientific achievements of colleagues and based on their own experience allowed the authors to develop the model of Web-based learning of Computer Science Bachelors (see figure 1 in [36]). Considering such structural components as learning environment, web-oriented environment, control and evaluation unit, levels of student's educational achievements, the authors determine the content component of e-learning. Among the components of e-learning there are such as cloud computing, working together classroom, web-automated knowledge validation systems and others. These components are implemented through network technologies as means of data transportation. Their appearance is caused by the availability of network technologies and they belong to cloud services. Thus, the need to use cloud services to support the training of pre-service mathematics teachers is one of the current educational trends.

A logical continuation of our study is to identify specific cloud tools to support the training of pre-service mathematics teachers. The specifics of professional training is determined by the specifics of the field of science. The specificity of mathematics lies in its abstractness. The study by Vlasenko et al. [37] examines the requirements for modern web-based online training courses for pre-service mathematics teachers. Researchers have analyzed the ways of presenting mathematical text through to the specifics of its formation, and the creation of mathematical content with a focus on network use.

Shyshkina and Marienko [38] determined the content of necessary general skills and specific skills needed for pre-service mathematics teachers (see table 2 in [38]) based on professional functions, typical tasks of mathematics teachers (see table 1 in [38]). Using the example of Web-SCM CoCalc (formerly called SageMathCloud), the authors conducted an experimental study that revealed the benefits of using the CoCalc cloud service in the training of pre-service mathematics teachers.

Fedorenko et al. [39] studied the problem of studying free software using cloud services. The results of this study had a positive result, for the training of pre-service mathematics teachers in particular. Researchers have discovered the didactic capabilities of cloud services that allow you to run a free mathematical software.

4. Research results

According to the Law of Ukraine "On Higher Education", the educational process at the university is carried out in the following forms: classes; individual work; practical training; control measures [40]. The most common types of training are lectures. A lecture is a clear, systematic presentation of a particular scientific problem or topic. Its additional purpose is to help students with mastering the methods of independent work with textbooks, manuals, primary sources. This is one of the most important factors in the organization of educational activities of students and occupies a significant place in the training of pre-service professionals receiving higher education.

The normative-directive documents, which determine the content and organization of the educational process in higher education institutions of Ukraine, substantiate the main requirements for this type of classes. Their implementation allows to fully use the significant educational and upbringing opportunities of this form of education, to increase the impact of each lecture on the consciousness and feelings of students [41]. However, the lecture to some extent accustoms the student to the passive appropriation of other people's thoughts, does not stimulate the desire for independent learning, does not provide an individual, differentiated approach to learning.

The leading role of the lecture in the teaching of academic disciplines is related to their content aspect, organizational principles and methodological features. The main content is the central methodological, theoretical and practical problems. Not all issues of the topic are revealed, but the most important, most significant ones that require scientific substantiation.

The pace of development of modern technologies has a significant impact on teaching methods and learning models in general [42]. This allows to expand the ways of implementing the paradigm of competence in order to improve the quality of education. The model of blended learning has the greatest potential for optimizing the learning process [43]. This model allows you to implement new technologies without abandoning conventional teaching methods. Blended learning is a model of organization of the educational process, as "it allows to increase the motivation of future teachers to learn, makes it transparent, interactive and manageable, provides constant involvement of students in the educational process" [44].

A blended form of learning is the individualization of learning, the creation of a favorable psychological climate, continuous training. The purpose of this form of learning is to combine the benefits of face-to-face learning and electronic educational resources through a combination of distance and traditional communication in integrated learning activities. The integration of traditional and computer-based learning in the educational environment will lead to a purposeful process of acquiring knowledge, skills and abilities in the classroom and extracurricular learning activities of the subjects of the educational process through the use of ICT. 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 of the educational process.

One of the forms of blended learning is realized through flipped learning (flipped classroom) [45, 46]. There are different ways to implement the model of flipped learning and they are all based on one basic principle: traditional learning is carried out outside the classroom, and practical work and application of knowledge is classroom. In general, the essence of flipped learning is to regroup the key components of the learning process. With the help of this model of learning "the content of new educational material is independently mastered in the electronic environment, and then the acquired knowledge is applied in practical classes or discussions" [47].

Reduction of classroom hours (lectures, practices, seminars, laboratory classes) leads to a violation of the traditional logic of the educational process. This fact leads to a loss of quality of education. One of the ways to "restore the balance of the learning process is to use a mixed learning model with Flipped Classroom technology" [48]. At the same time, 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 together with the mentor more complex issues and practical application of the mastered information are considered. Flipped classroom technology is characterized by the fact that the necessary "theoretical knowledge is obtained outside the classroom, and in the classroom individual tasks are performed or a group project is developed" [49].

Flipped classroom technology was used by us in the study of mathematical disciplines "Mathematical Logic and Theory of Algorithms" and "Elementary Mathematics" in the 3rd year of the Faculty of Physics and Mathematics of Donbas State Pedagogical University. Taking into account the fact that students majoring in "Secondary Education (Mathematics)" specializing in "Computer Science" in the 3rd year have significant learning experience, and the level of self-awareness is sufficient to use elements of Flipped classroom technology in not only logical but also appropriate way. In addition, this model of study does not contradict the work program, in which the main number of hours is set aside for independent work of students.

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

1. Formulation of the theme and purpose.
2. Determining the place of this topic in the work program of the discipline.
3. Offering sources of information.
4. Definition of types and content of control.
5. Monitoring and evaluation.

While introducing the flipped classroom technology during teaching the course of "Mathematical Logic and Theory of Algorithms" it is advisable to consider the following topics:

1. Boolean n-ary functions;
2. Zhegalkin polynom;
3. Complete systems of Boolean functions;
4. Mathematical theories of the first order.

For each of the proposed topics, the place in the work program and sources of information are determined, the content of tasks for control and its types are selected.

For example, to study the topic "Complete systems of Boolean functions" students receive the following information in table 1.

The main reasons for the introduction of a blended learning model with flipped classroom technology in the educational process of the university are active cooperation between students and teachers and, as a consequence, increasing students' success and motivation. A feature of this model is the possibility of using group classes 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 problematic issues, to comment on the work of students.

Another example of supporting the training of pre-service math teachers is the use of computer math systems in the form of cloud services. One such free service is the Math Partner computer math system, which is available at http://mathpar.com. This service allows you to create your own cloud mathematical "Notebook", in which the user performs the necessary mathematical calculations. To ensure quality and comfortable work, this service provides access to a large amount of reference material with examples. The language of this service is the Mathpar language, which is based on the widely used language of mathematicians and physicists TEX, which is usually used for typing mathematical texts. It is possible to save both the problem statement and its solution. You can save both text and images.

Table 1
Tasks for studying the topic "Complete systems of Boolean functions"

Theme	Complete systems of Boolean functions
Meta	Learn the concepts of classes of functions that store zero, store unity, self-dual functions, monotonic and linear. Master the criterion of completeness.
Sources of information (independent selection of sources of information is encouraged)	• Bondarenko M.F., Belous N.V., Rutkas A.G. Computer discrete mathematics: textbook. – Kharkiv: SMITH Company, 2004. – 480 p. • Khromoi J.V. Mathematical logic. – Kyiv: Higher School, 1983. – 208 p. • Kaidan N.V., Pashchenko Z.D. Methodical instructions for practical classes of the course "Mathematical logic and theory of algorithms. Section "Mathematical Logic" for the specialty 014 Secondary Education (Mathematics). – Slovyansk: B.I. Motorin Publishing, 2019. – 92 p. • Rosen K. H. Handbook of Discrete and Combinatorial Mathematics, 2000. – 1183 p. • Discrete Math. Lecture: Criterion of completeness of the system of Boolean functions (https://www.youtube.com/watch?v=CYL7o4Ru35c) • Game simulator "Collect crystals" (http://www.ggpk.by/virt_cab/102/Files/logic.zip) • Exercise machine "Logical elements" (http://www.ggpk.by/virt_cab/102/Files/log.rar) • Quine – McClassky logic function minimization simulator (http://www.ggpk.by/virt_cab/102/Files/KMK.rar) • Construction of the truth table. SDNF. SCNF. Zhegalkin polynomial (https://programforyou.ru/calculators/postroenie-tablitci-istinnosti-sknf-sdnf) • Truth table (https://allcalc.ru/node/745)
Types of control	test for mastering the material (conducted remotely outside the classroom), an individual task to determine the completeness of the system
Date of control	conducting a test for self-study of the material

In particular, Math Partner allows you to effectively solve such common problems as finding the smallest distances between all vertices of the graph and finding the shortest path between the vertices. For the first task the command $\backslash searchLeastDistances(A)$ is used, and as a result the matrix of the shortest distances between vertices will be received. For the second task, use the $\backslash findTheShortestPath(A, i, j)$ command, resulting in the shortest path between the vertices i and j. It should be noted that this service is convenient to use to check your own solutions, because it provides the answer itself, without access to intermediate results of calculations.

Another relatively new service is Graph Online, which is available at http://graphonline.ru. This is a free cloud service designed to visualize the graph and find the shortest path on the graph, finding the Euler cycle. Creating a graph is performed on the adjacency matrix or incidence matrix. In addition to finding the shortest path, you can search for connectivity components. The service supports work with oriented (digraphs) and non-oriented graphs. The result of the work, the constructed graph can be saved thus you can continue working with it later.

In addition, the cloud service Graph Online provides the user with many auxiliary functions to facilitate work. Available to save and load a graph with support for saving the visual representation, fast conversion between all supported types, determining the appearance of vertices, arcs, background, constructor mode, etc.

Let's consider the example of the use of the presented services in solving the problem of finding the shortest distances between the vertices of the graph, which are often found in practice. It is clear that in order to be able to find the shortest distances, there must be at least one path from vertex 0 to every other vertex, i.e. the graph must be connected. For this problem, the most well-known solution algorithm is the Dijkstra algorithm. The idea of this algorithm is that first for each vertex other than vertex 0, we set the distance equal to $+\infty$, and then step by step we reduce these distances until we find the minimum distance $d(v)$ and the shortest path $p(v)$ for each vertex v.

Condition: Suppose that in a weighted 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:

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

Using the Dijkstra algorithm, construct a skeleton tree of the shortest paths from vertex 0 to all other vertices of the graph G and find the shortest distances.

Solution: The progress of the Dijkstra algorithm is shown in the table 2.

Table 2
The progress of the Dijkstra algorithm

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

When performing the Dijkstra algorithm, the current vertices were in the following order: 2, 1, 3, 4, 5. Thus, the shortest distance to the vertex 1 is 8, $d(2) = 7$, $d(3) = 9$, $d(4) = 10$, $d(5) = 10$. The shortest to the top 1 is the path 0.1; $p(2) = 0.2$; $p(3) = 0.1.3$; $p(4) = 0.4$; $p(5) = 0, 1, 3, 5$.

Using the Math Partner service we have the opportunity to check the correctness of the results in figure 1.

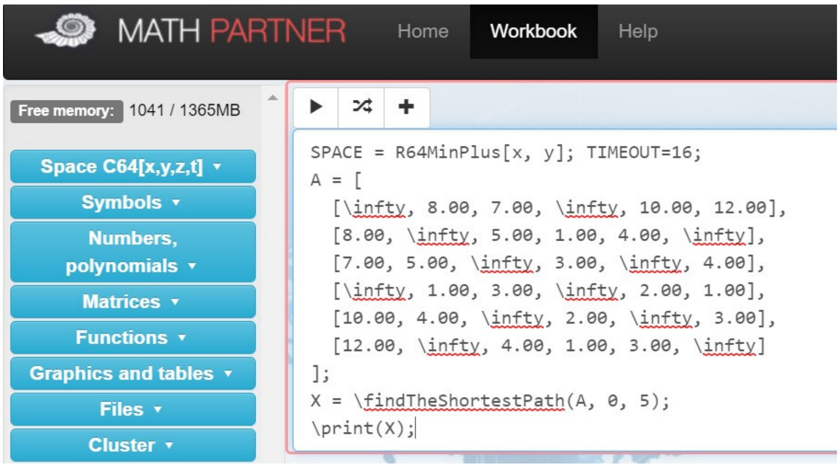

Figure 1: The shortest distances from vertex 0 to all other vertices of graph G in the Math Partner service.

But graph visualization is better performed by Graph Online (figure 2).

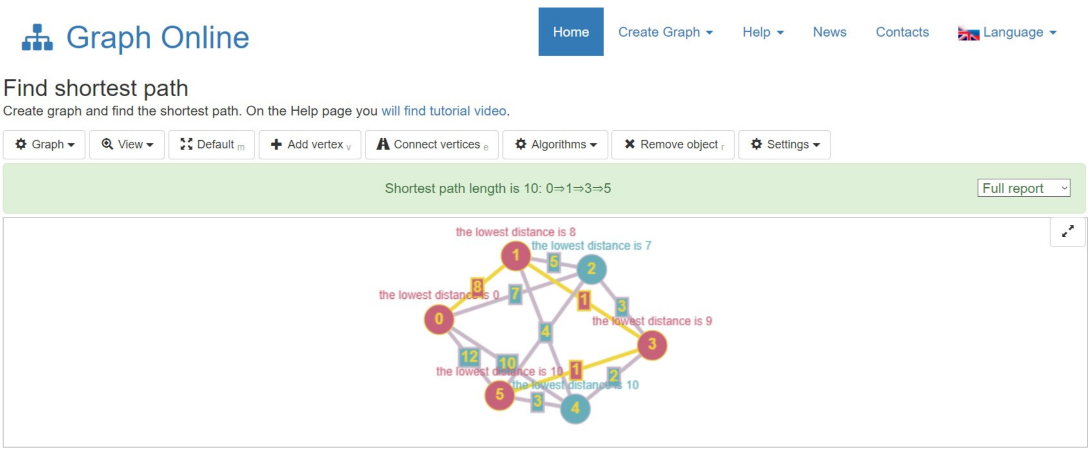

Figure 2: Graph G visualization and the shortest distance from vertex 0 to vertex 5 of graph G in the Graph Online service.

Among the students of 2-4 courses of the specialty ”Secondary education (Mathematics)” of the Faculty of Physics and Mathematics of Donbass State Pedagogical University was conducted a survey to find out which tools of computer training are used by pre-service teachers of mathematics in professional training, including self-education. A total of 120 students were involved in the survey. We asked the respondents the following questions:

1. Did you use e-learning resources while studying?
2. Did you use cloud services during your training?

3. Have you used cloud services during self-education activities?
4. If the answer to 2 or 3 questions is yes, then which cloud services did you use?
5. If the answer to 2 and 3 questions is no, then what software did you use in the learning process?

The following results were obtained:

- 100% positive result on the first question. This result suggests that pre-service mathematics teachers understand the concept of "electronic educational resources" despite their diversity.
- 82% of respondents answered positively to the second question. The result of the answer to the second question shows that not all respondents identify the concept of cloud service. We came to this conclusion when discussing the results of the survey with the respondents. After all, during the practical classes that we described in the study, all students were involved in the use of cloud services.
- 46% of respondents answered positively to our third question. This percentage is a good result of self-educational activities.

The answer to the fourth question is shown in figure 3.

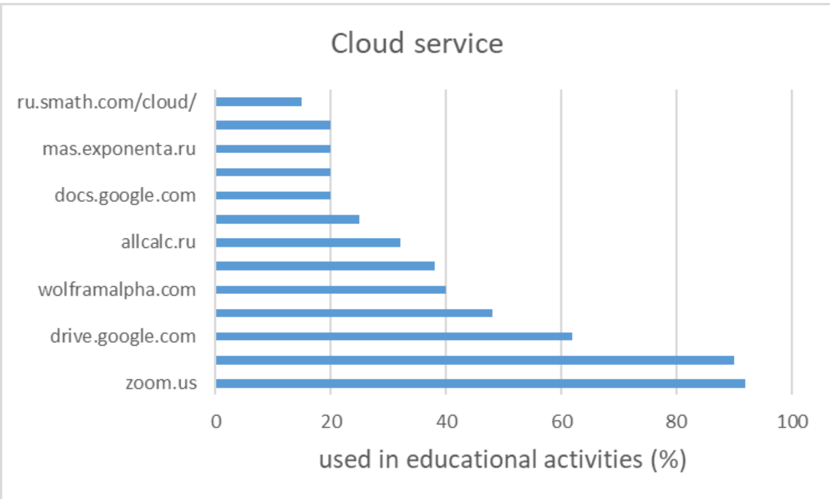

Figure 3: Cloud services used by pre-service math teachers.

It is important to note the significant advancement of cloud communication services due to quarantine measures caused by the COVID-19 pandemic and cloud file storage services. A positive result of the survey is the availability of cloud services for mathematics.

The answers to our question 5 are presented in figure 4.

At the first glance, pre-service math teachers use a regular calculator and calculator on mobile devices and make presentations and reports in a word processor. Note that the presented list includes purely mathematical programs, which are extremely necessary in the training of pre-service teachers of mathematics.

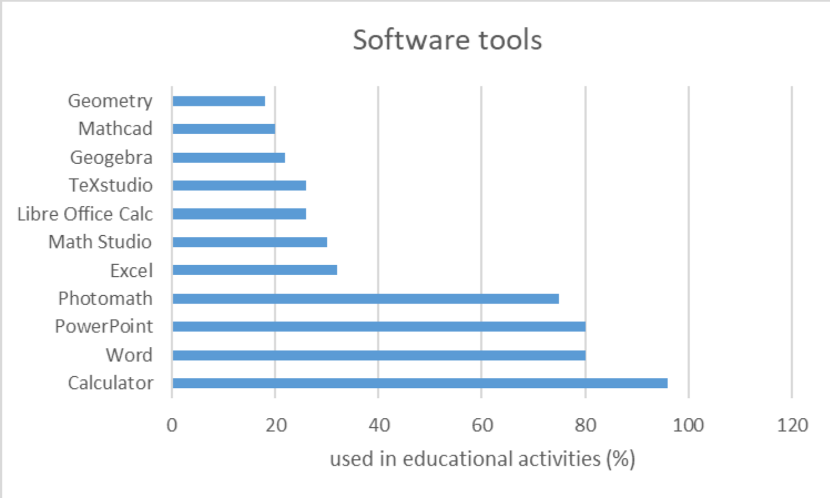

Figure 4: Software used by pre-service math teachers.

5. Conclusions

The learning process in higher education is implemented within a diverse integral system of organizational forms and methods of teaching. Each form solves its specific task, but the set of forms and methods of teaching creates a single didactic complex, the functioning of which is subject to the objective psychological and pedagogical laws of the educational process.

The results of the study provide an opportunity to claim that cloud technologies are used in the teaching of mathematics in high school. Pre-service mathematics teachers have the opportunity to use cloud technology during their training. Available cloud technologies have a wide range of applications in mathematics education.

References

[1] V. Hamaniuk, S. Semerikov, Y. Shramko, ICHTML 2020 - How learning technology wins coronavirus, SHS Web of Conferences 75 (2020) 00001. URL: https://doi.org/10.1051/shsconf/20207500001. doi:10.1051/shsconf/20207500001.

[2] S. Semerikov, S. Chukharev, S. Sakhno, A. Striuk, V. Osadchyi, V. Solovieva, T. Vakaliuk, P. Nechypurenko, O. Bondarenko, H. Danylchuk, Our sustainable coronavirus future, E3S Web of Conferences 166 (2020) 00001. doi:10.1051/e3sconf/202016600001.

[3] O. Burov, A. Kiv, S. Semerikov, A. Striuk, M. Striuk, L. Kolgatina, I. Oliinyk, AREdu 2020 - How augmented reality helps during the coronavirus pandemic, CEUR Workshop Proceedings 2731 (2020) 1–46.

[4] K. Polhun, T. Kramarenko, M. Maloivan, A. Tomilina, Shift from blended learning to distance one during the lockdown period using Moodle: test control of students' academic achievement and analysis of its results, Journal of Physics: Confer-

ence Series 1840 (2021) 012053. URL: https://doi.org/10.1088/1742-6596/1840/1/012053. doi:10.1088/1742-6596/1840/1/012053.

[5] V. Tkachuk, Y. Yechkalo, S. Semerikov, M. Kislova, Y. Hladyr, Using Mobile ICT for Online Learning During COVID-19 Lockdown, in: A. Bollin, V. Ermolayev, H. C. Mayr, M. Nikitchenko, A. Spivakovsky, M. Tkachuk, V. Yakovyna, G. Zholtkevych (Eds.), Information and Communication Technologies in Education, Research, and Industrial Applications, Springer International Publishing, Cham, 2021, pp. 46–67.

[6] D. Y. Bobyliev, E. V. Vihrova, Problems and prospects of distance learning in teaching fundamental subjects to future mathematics teachers, Journal of Physics: Conference Series 1840 (2021) 012002. URL: https://doi.org/10.1088/1742-6596/1840/1/012002. doi:10.1088/1742-6596/1840/1/012002.

[7] A. Clark-Wilson, O. Robutti, M. Thomas, Teaching with digital technology, ZDM 52 (2020) 1223–1242. URL: https://doi.org/10.1007/s11858-020-01196-0. doi:10.1007/s11858-020-01196-0.

[8] P. Drijvers, Head in the clouds, feet on the ground – a realistic view on using digital tools in mathematics education, in: A. Büchter, M. Glade, R. Herold-Blasius, M. Klinger, F. Schacht, P. Scherer (Eds.), Vielfältige Zugänge zum Mathematikunterricht: Konzepte und Beispiele aus Forschung und Praxis, Springer Fachmedien Wiesbaden, Wiesbaden, 2019, pp. 163–176. URL: https://doi.org/10.1007/978-3-658-24292-3_12. doi:10.1007/978-3-658-24292-3_12.

[9] A. E. Kiv, V. N. Soloviev, S. O. Semerikov, XII International Conference on Mathematics, Science and Technology Education, Journal of Physics: Conference Series 1840 (2021) 011001. URL: https://doi.org/10.1088/1742-6596/1840/1/011001. doi:10.1088/1742-6596/1840/1/011001.

[10] A. E. Kiv, V. N. Soloviev, S. O. Semerikov, A. M. Striuk, V. V. Osadchyi, T. A. Vakaliuk, P. P. Nechypurenko, O. V. Bondarenko, I. S. Mintii, S. L. Malchenko, XIII international conference on mathematics, science and technology education, Journal of Physics: Conference Series (2021).

[11] T. Kramarenko, O. Pylypenko, V. Zaselskiy, Prospects of using the augmented reality application in STEM-based Mathematics teaching, CEUR Workshop Proceedings 2547 (2020) 130–144.

[12] T. Kramarenko, K. Bondar, O. Shestopalova, The ICT usage in teaching mathematics to students with special educational needs, Journal of Physics: Conference Series 1840 (2021) 012009. URL: https://doi.org/10.1088/1742-6596/1840/1/012009. doi:10.1088/1742-6596/1840/1/012009.

[13] V. Kumar, A. Bhardwaj, Role of cloud computing in school education, in: L. A. Tomei, D. D. Carbonara (Eds.), Handbook of Research on Diverse Teaching Strategies for the Technology-Rich Classroom, IGI Global, 2020, pp. 98–108. doi:10.4018/978-1-7998-0238-9.ch008.

[14] I. Lovianova, K. Vlasenko, I. Sitak, I. Akulenko, O. Kondratyeva, Model of the on-line course for training master students majoring in mathematics for teaching at university, Universal Journal of Educational Research 8 (2020) 3883–3894. doi:10.13189/ujer.2020.080912.

[15] P. Merzlykin, M. Popel, S. Shokaliuk, Services of SageMathCloud environment and their didactic potential in learning of informatics and mathematical disciplines, CEUR Workshop

Proceedings 2168 (2017) 13–19.
[16] E. M. Mulenga, J. M. Marbán, Is COVID-19 the gateway for digital learning in mathematics education?, Contemporary Educational Technology 12 (2020) 98–108. URL: https://www.cedtech.net/article/is-covid-19-the-gateway-for-digital-learning-in-mathematics-education-7949. doi:10.30935/cedtech/7949.
[17] M. Ndlovu, V. Ramdhany, E. D. Spangenberg, R. Govender, Preservice teachers' beliefs and intentions about integrating mathematics teaching and learning icts in their classrooms, ZDM 52 (2020) 1365–1380. URL: https://doi.org/10.1007/s11858-020-01186-2. doi:10.1007/s11858-020-01186-2.
[18] S. Papadakis, Evaluating pre-service teachers' acceptance of mobile devices with regards to their age and gender: A case study in greece, International Journal of Mobile Learning and Organisation 12 (2018) 336–352. doi:10.1504/IJMLO.2018.095130.
[19] A. Perienen, Frameworks for ict integration in mathematics education – a teacher's perspective, Eurasia Journal of Mathematics, Science and Technology Education 16 (2020). doi:10.29333/ejmste/7803.
[20] N. S. Ponomareva, Role and place of informatics in the training of future teachers of mathematics, Journal of Physics: Conference Series 1840 (2021) 012035. URL: https://doi.org/10.1088/1742-6596/1840/1/012035. doi:10.1088/1742-6596/1840/1/012035.
[21] M. Popel, Cloud service CoCalc as a means of forming the professional competencies of the mathematics teacher, volume XVI of *Theory and methods of teaching mathematics, physics, computer science*, Kryvyi Rih National University, Kryvyi Rih, 2018.
[22] J. Purnomo, Jailani, ICT literacy of high school mathematics teacher: online learning competence with heutagogical approach, Journal of Physics: Conference Series 1321 (2019) 032128. URL: https://doi.org/10.1088/1742-6596/1321/3/032128. doi:10.1088/1742-6596/1321/3/032128.
[23] J. S. Pyper, Learning About Ourselves: A Review of *The Mathematics Teacher in the Digital Era*, Canadian Journal of Science, Mathematics and Technology Education 17 (2017) 234–242. doi:10.1080/14926156.2017.1297509.
[24] O. V. Semenikhina, M. G. Drushliak, Y. V. Khvorostina, Use of geogebra cloud service in future math teachers' teaching, Information Technologies and Learning Tools 73 (2019) 48–66. URL: https://journal.iitta.gov.ua/index.php/itlt/article/view/2500. doi:10.33407/itlt.v73i5.2500.
[25] K. Vlasenko, O. Chumak, I. Sitak, I. Lovianova, O. Kondratyeva, Training of mathematical disciplines teachers for higher educational institutions as a contemporary problem, Universal Journal of Educational Research 7 (2019) 1892–1900. doi:10.13189/ujer.2019.070907.
[26] K. Vlasenko, O. Chumak, I. Lovianova, D. Kovalenko, N. Volkova, Methodical requirements for training materials of on-line courses on the platform "Higher school mathematics teacher", E3S Web of Conferences 166 (2020) 10011. doi:10.1051/e3sconf/202016610011.
[27] K. Vlasenko, S. Volkov, I. Sitak, I. Lovianova, D. Bobyliev, Usability analysis of on-line educational courses on the platform "Higher school mathematics teacher", E3S Web of Conferences 166 (2020) 10012. doi:10.1051/e3sconf/202016610012.

[28] K. Vlasenko, O. Chumak, V. Achkan, I. Lovianova, O. Kondratyeva, Personal e-learning environment of a mathematics teacher, Universal Journal of Educational Research 8 (2020) 3527–3535. doi:10.13189/ujer.2020.080828.

[29] K. Vlasenko, V. Achkan, O. Chumak, I. Lovianova, T. Armash, Problem-based approach to develop creative thinking in students majoring in mathematics at teacher training universities, Universal Journal of Educational Research 8 (2020) 2853–2863. doi:10.13189/ujer.2020.080712.

[30] K. Vlasenko, D. Kovalenko, O. Chumak, I. Lovianova, S. Volkov, Minimalism in designing user interface of the online platform “Higher school mathematics teacher”, CEUR Workshop Proceedings 2732 (2020) 1028–1043.

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

[32] K. V. Vlasenko, I. V. Lovianova, O. G. Rovenska, T. S. Armash, V. V. Achkan, Development of the online course for training master students majoring in mathematics, Journal of Physics: Conference Series (2021).

[33] K. V. Vlasenko, I. V. Lovianova, T. S. Armash, I. V. Sitak, D. A. Kovalenko, A competency-based approach to the systematization of mathematical problems in a specialized school, Journal of Physics: Conference Series (2021).

[34] J. Yang, Researches on cloud computing-based design of online mathematics teaching system for colleges and universities, Revista de la Facultad de Ingenieria 32 (2017) 882–888.

[35] T. Vakaliuk, D. Antoniuk, V. Soloviev, The state of ICT implementation in institutions of general secondary education: A case of Ukraine, CEUR Workshop Proceedings 2643 (2020) 119–133.

[36] S. Proskura, S. Lytvynova, The approaches to web-based education of computer science bachelors in higher education institutions, CEUR Workshop Proceedings 2643 (2020) 609–625. URL: http://ceur-ws.org/Vol-2643/paper36.pdf.

[37] K. Vlasenko, S. Volkov, D. Kovalenko, I. Sitak, O. Chumak, A. Kostikov, Web-based online course training higher school mathematics teachers, CEUR Workshop Proceedings 2643 (2020) 648–661.

[38] M. Shyshkina, M. Marienko, The use of the cloud services to support the math teachers training, CEUR Workshop Proceedings 2643 (2020) 690–704.

[39] E. Fedorenko, V. Velychko, S. Omelchenko, V. Zaselskiy, Learning free software using cloud services, CEUR Workshop Proceedings 2643 (2020) 487–499.

[40] Ministry of Education and Science of Ukraine, On approval of the Concept of development of pedagogical education, 2018. URL: https://mon.gov.ua/ua/npa/pro-zatverdzhennya-koncepciyi-rozvitku-pedagogichnoyi-osviti.

[41] V. L. Ortynsky, Pedagogy of higher school, Center for Educational Literature, Kyiv, 2009.

[42] S. O. Semerikov, I. O. Teplytskyi, V. N. Soloviev, V. A. Hamaniuk, N. S. Ponomareva, O. H. Kolgatin, L. S. Kolgatina, T. V. Byelyavtseva, S. M. Amelina, R. O. Tarasenko, Methodic quest: Reinventing the system, Journal of Physics: Conference Series 1840 (2021) 012036. URL: https://doi.org/10.1088/1742-6596/1840/1/012036. doi:10.1088/1742-6596/1840/1/012036.

[43] O. Bondarenko, S. Mantulenko, A. Pikilnyak, Google Classroom as a tool of support of blended learning for geography students, CEUR Workshop Proceedings 2257 (2018) 182–191.
[44] V. M. Kukharenko (Ed.), Theory and practice of blended learning, Miskdruk, NTU "KhPI", Kharkiv, 2016. URL: http://repository.kpi.kharkov.ua/bitstream/KhPI-Press/23536/3/Kukharenko_Teoriia_ta_praktyka_2016.pdf.
[45] O. Glazunova, T. Voloshyna, V. Korolchuk, O. Parhomenko, Cloud-oriented environment for flipped learning of the future it specialists, E3S Web of Conferences 166 (2020) 10014. doi:10.1051/e3sconf/202016610014.
[46] O. Klochko, V. Fedorets, S. Tkachenko, O. Maliar, The use of digital technologies for flipped learning implementation, CEUR Workshop Proceedings 2732 (2020) 1233–1248.
[47] V. V. Hlazova, N. V. Kaidan, V. P. Kaidan, Practical use of remote training elements and methods of "flipped classroom" at professional training of future computer science teachers information and innovation technologies in education, in: Katowice School of Technology Monograph 19, Series of monographs Faculty of Architecture, Civil Engineering and Applied Art, Wyższa Szkoła Techniczna w Katowicach, Katowice, 2018, pp. 192–199.
[48] University of Queensland, Flipped classroom project (olt), 2017. URL: https://www.pinterest.com.au/pin/258534834836373906/.
[49] M. Pieri, C. Laici, The Flipped Classroom approach in the "Avanguardie Educative" Movement , Italian Journal of Educational Technology 25 (2017) 55–66. doi:10.17471/2499-4324/948.