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Integration of methods and means of distance learning of mathematics during the process of training future teachers of mathematics

Integración de métodos y medios de aprendizaje a distancia de las matemáticas durante el proceso de formación de futuros profesores de matemáticas

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Abstract

The article aims to study the peculiarities of applying different distance education methods and tools in training future teachers of mathematics. The task of the article can be conditionally divided into two stages: differentiation of means and methods of distance education in the conditions of higher education institutions; searching for a model (combination of social, pedagogical, and other elements) of forming professional competence through a combination of distance education tools and methods. The methodological basis of the study was scientific and pedagogical methods. The results of the study highlight the elements of distance education, capable in their totality to provide full and high-quality training of future teachers of mathematics in the digital environment of universities.

Keywords: modern education, mathematics education, distance learning tools, digital didactics, vocational training.

Resumen

El objetivo del artículo es estudiar las peculiaridades de la aplicación de diferentes métodos e instrumentos de educación a distancia en la formación de futuros profesores de matemáticas. La tarea del artículo puede dividirse condicionalmente en dos etapas: diferenciación de medios y métodos de educación a distancia en las condiciones de las instituciones de educación superior; búsqueda de un modelo (combinación de elementos sociales, pedagógicos y otros) de formación de la competencia profesional mediante una combinación de herramientas y métodos de educación a distancia. La base metodológica del estudio fueron los métodos científicos y pedagógicos. Los resultados del estudio ponen de relieve los elementos de la educación a distancia, capaces en su totalidad de proporcionar una formación completa y de alta calidad a los futuros profesores de matemáticas en el entorno digital de las universidades.

Palabras clave: educación moderna, educación matemática, herramientas de aprendizaje a distancia, didáctica digital, formación profesional.

Introduction

The relevance of the study is due to the need to solve problems of improving the quality of distance learning in mathematics in the preparation of future teachers of mathematical disciplines, which is caused by the need to organize the work of students in the course. In this regard, the improvement of distance learning is possible through the introduction of new tools that can provide solutions to the problems of improving the academic performance of students. Distance learning based on Internet technologies is considered a progressive form of

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professional education, aimed at the personal requirements of students and their qualifications, and also allows you to constantly increase the professional level, taking into account personal qualities. In the process of studying mathematical and pedagogical disciplines, the student of pedagogical HEIs in the online mode without any assistance is mastering learning materials, being tested (Catalano, Torff & Anderson, 2021). One of the directions of the informatization process of modern society is the informatization of the training process of future specialists in the educational sphere. This process consists in the research and provision of the educational sphere with the methodology, practice of development and optimal use of innovative technologies focused on the implementation of psychological and pedagogical goals of professional training of future teachers of mathematics. Among the innovative technologies, based on which the new learning environment should be created in HEIs, there are e-learning technologies, the use of which is able to make the learning process available at any time and in any place, to encourage students to self-education throughout life, while learning will become more attractive, democratic, comfortable. The use of modern technologies in the educational process of future teachers of mathematics promotes the quality of their professional training and competitiveness in the labor market (Karjanto, 2021). Distance learning technologies not only facilitate access to information and open up opportunities for the variability of learning activities, its individualization, and differentiation, but also allow the organizing interaction of subjects of learning at a new level, building an educational system in which students will be active and equal participants of educational activities. Distance learning technologies, based on the use of information and communication technologies, confidently enter the practice of many educational institutions of different forms and levels. Since one of its main features is independence from geographical location, from the distance between the teacher and students, it is called distance learning, that is learning at a distance (Chen, Liu & Tretheway, 2022). The purpose of the article is to update the methods and means of distance educational technologies in the process of forming the professional competence of future teachers of mathematical disciplines Based on the purpose of the study, the following problems have been identified: 1) Determination of means of distance education in the conditions of higher education institutions. 2) Search for the optimal model of coexistence of innovative and traditional educational technologies in the conditions of distance education.

Literature review

The question of the effectiveness of distance education arises against the background of socio-political shifts that have recently engulfed the whole world. The question arises of ensuring the effective training of future specialists in the pedagogical sphere, despite the challenges of an uncertain environment. It is with this duty that distance education facilities are increasingly being introduced to provide unimpeded access to educational services despite the dispersal of students from the educational institution. Tsekhmister (2021) examines the implementation of pedagogical innovation in the educational process. This is necessary to match the education system to the modern challenges of society associated with the development of technology, the emergence of new socio-economic relations. The introduction of pedagogical innovations, according to the author, brings with it the need to revise the existing traditional paradigms of the educational process organization. The new paradigm must take into account the need for asynchronous organization of the educational process by means of computerization and digitalization. Melnychuk (2022) discusses the methodological foundations for organizing teacher training in the conditions of distance education. The author notes the need to introduce innovative technologies as a tool to ensure quality teacher education. Also, the work of Korostiianets (2022) should be mentioned. The author considers the effectiveness of the use of modern didactic tools in the process of formation of professional competence of future teachers of mathematics in the conditions of higher education institutions.

In the process of preparing a future teacher of mathematics by means of distance education, special attention should be paid to specialized software for simulation and visualization of phenomena and processes. To this end, special attention needs the work of Karjanto & Husain (2021). The authors considered the peculiarities of using the wxMaxima software package in the process of training future teachers of mathematics. Together with researchers Velychko Stopkin & Fedorenko (2019), the authors of the article try to analyze the importance of computer algebra packages in the process of organizing the training of modern teachers of mathematics in distance education. Nichyshyna and Voinalovich (2022) were interested in the issue of the integrity of the

formation of mathematical knowledge. The authors substantiate the practicality of the application of opposition in the process of the formation of integrated systems of mathematical knowledge. Also, the work of Botuzova, Nichyshina and Rizhnyak (2022) is interesting for this study. The authors devoted their work to studying a complex integrative approach to the study of problem-solving methods by students of higher education institutions. Thus, despite the existence of a large number of studies, there are still a low number of unresolved issues. Firstly, the problem of organizing distance learning for future mathematics teachers by combining several methods and tools is still insufficiently covered. Secondly, the data from existing studies are still insufficient to draw conclusions about the optimal mechanisms and methods of distance learning for future mathematics teachers.

Materials and methods

The analysis of the integration of methods and means of distance learning in mathematics in the conditions of pedagogical HEIs has historical, didactic, and psychological peculiarities. Therefore, there is a need for a thorough analysis of the existing systems of distance learning organization in pedagogical HEIs taking into account the features of harmonization of the distance education system of training future teachers of mathematics. The methodological means that can provide analysis of the peculiarities of methods and means of teaching mathematics in the Ukrainian educational environment are general scientific methods (analysis, systematization, prediction, comparison) and scientific and pedagogical special methods (pedagogical observation, educational experiment). The didactic practice of introducing distance learning methods of mathematical disciplines in the pedagogical HEIs testifies to the high effectiveness of such a solution. However, there is still a certain lack of data for a full and comprehensive analysis of the effectiveness of popular methods of organizing distance learning of mathematical disciplines in the conditions of pedagogical HEIs. The study uses the methodological principle of systems theory to analyze the diversity of existing distance learning tools for mathematics. These difficulties are associated with the peculiarities of the transfer of theoretical knowledge in the use of computer tools in the educational process in the practice of teaching future teachers of mathematics and are due to the following factors:

- insufficient number of special studies in the training of future teachers of mathematics in the modern paradigm by means of distance education;
- orientation of digital educational resources not on the specific requirements for the future specialist, but on the implemented private author's concepts and the lack of taking into account their variability in accordance with the curricula of various pedagogical HEIs;
- psychological difficulties faced by future teachers of mathematics in the practice of using new computer tools in the study of mathematics.

The organization of the study was carried out in several stages. At the first stage the analysis of philosophical, psychological and pedagogical, scientific, and methodological literature on the topic of research, the study of the experience of HEIs, the identification of conditions for the formation of future teachers of mathematics readiness for professional activity, the definition of directions, methods of research. At the second stage, the existing models of distance learning for future teachers of mathematics were studied. The organizational and pedagogical conditions for the formation of professional competencies were determined, the criteria and indicators of the effectiveness of the formation of readiness for professional activities of future teachers of mathematics were determined. At the third stage, the processing and analysis of the results of the study were carried out. Conclusions on the results of the study are made.

Results

Future teachers of mathematics, starting to carry out professional activities, must be prepared to use the entire arsenal of teaching tools that modern didactics possesses. Of course, it is impossible to imagine modern education without innovative educational tools. To understand how important it is to pay attention to the use of a variety of distance learning tools in the professional training of future teachers of mathematics, it is necessary to find out what place of computer tools in the modern educational process. This study should consider their features and advantages over other means of education. By teaching aids (didactic means) we mean teaching and visual aids, demonstration devices, tools, etc. Didactic means are objects that provide students with sensorimotor stimuli that can affect their senses, facilitate their direct and indirect knowledge of reality.

The means of learning include: used in the process of training equipment, machinery, tools

and devices, rooms for classes (classrooms, laboratories), means of communication, means of obtaining and storing information. Modern didactics defines learning tools as instruments of activity of a teacher and students (as material and ideal objects), which are involved in the educational process as carriers of information and activity tools.

Material means of learning - teaching and visual aids (textbooks, didactic material, test material), didactic equipment, educational equipment, technical means of learning. Ideal learning tools - language (oral language), writing (written language), diagrams, drawings, works of art, opinion, training computer programs, etc. Of all the means of learning that have found use in distance education can include the following:

- audiovisual (educational videos, slides, educational films);
- electronic educational resources (multimedia textbooks, educational films on digital media, software for subjects often referred to as educational multimedia, educational and methodological programs);
- online educational resources, interactive whiteboards, etc.

The technical means of education (TTE), which are used in the organization of distance learning of future teachers of mathematics, can include the achievements of new information technology - computers and computer networks, media education, training equipment based on electronic equipment, and specialized software. Modern technical means that provide distance learning, called the means of new information technology. This notion should be understood as software, hardware, and software and technical means and devices that are based on microprocessor technology, modern systems, and means of information transfer, information exchange, providing access to information resources of computer networks (including global). This makes it possible to collect, accumulate, process, store, produce, transmit, use information (Martin, Harbour & Polly, 2022).

Computers as a medium of instruction have many characteristics of traditional teaching tools, but what makes them different is that they allow for a kind of student-computer dialogue, which is an undeniable advantage of this educational tool in terms of organizing and perceiving teaching material and controlling and assessing knowledge.

To achieve the goals of training future teachers of mathematics in a distance learning environment is possible to use such types of computer tools:

- general-purpose service software tools;
- software tools for mathematical and simulation modeling;
- software to control and measure the academic performance of future teachers of mathematics;
- electronic simulators;
- information retrieval and reference systems;
- software for remote access laboratories and virtual laboratories;
- expert learning systems (ELS);
- automated Learning Systems (ALS);
- electronic textbooks (ET);
- means of professional activity automation;
- intellectual learning systems (ILC);
- specialized training web-portals;
- training applications;
- learning forums and chatbots in social networks and messengers (Cano & Lomibao, 2022).

It is impossible to overestimate the benefits of the limitless possibilities of modern multimedia technology. Using computer tools in distance learning, it is possible to change the way visual and audio information is formed. Specificity is important when choosing an object of study to demonstrate with the help of traditional visualization, while the use of distance means provides the possibility of dynamic interpretation of both real objects and theories, scientific regularities, concepts (Sapiński & Ciupka, 2021). All of the above has allowed us to identify the essence of distance learning in the informational and productive approaches. The informational approach of distance education of future teachers of mathematics should be formed based on informational postulates, the method of informational modeling of the essence. The purpose of training is to form an information model of the student's brain with a given volume and quality of the thesaurus, the development of its knowledge as a mechanism for perception and extraction of information from natural and artificial sources. Productive learning is connected with the concept of socially significant result of student's activity. This result can be both internal, manifested in qualitative changes in the nature of the mental activity, and external, expressed in the creation of a product - a material or informational result of human activity. The peculiarities of the process of productive activity and its products can be used in diagnosing the

development of skills, student skills, development of cognitive processes, formation of the ability to plan their activities (Martin, Harbour & Polly, 2021).

For further consideration of the problem of providing distance education for future teachers of mathematics, it is necessary to define the structure of the concept of professional competence in order to make an idea of the ways of its formation on this basis. Based on the research on the named problem, we can say that competence as a professional quality is defined by the presence of three groups of attributes: technical competencies, subject, and methodological competencies (Table 1).

Table 1.
The structure of the professional competence of the future teacher of mathematics in distance education

Components	Competence of a mathematics teacher		
	Technical	Subject	Methodological
Logistical and organizational components	Providing appropriate technology. Providing access to high-speed Internet	Providing e-learning tools	Ability to create work programs, lesson plans, educational-methodical complexes
Theoretical component	Awareness of the capabilities of modern digital learning and communication tools	Possessing the subject at a high level	Awareness of methodological principles of teaching in the full-time, distance, and mixed forms of education. Awareness of the basic sanitary-hygienic and informational safety requirements for the organization of the educational process
Practical component	Know how to use digital technology and create, edit, and share learning materials remotely.	Using digital materials in their work	Mastery of methodological fundamentals of creating and using electronic educational resources
Personality component	Awareness of the capabilities of technology and computer-based learning tools; keep up to date with new tools and opportunities	Prospects for the use of distance methods in work	Participation in webinars, online courses, electronic conferences for the purpose of methodical qualification improvement

Source: Authors' development.

Technical competencies are a prerequisite for working in a remote format, which is the ability to use digital educational technology and techniques, IT-communications to mediate and fully implement the educational process. Subject competencies - the foundation of the professional skill of the teacher, his duty to know well the subject, the field of science in which it belongs, the application of this knowledge to solve professional and other problems. Methodological competencies - mastery of the basics of educational theory and methodology, the ability to "adjust" the methodological system of teaching to work in a remote format in compliance with appropriate pedagogical principles (Higgins, Huscroft-D'Angelo & Crawford, 2019).

Each of the attributes is defined by a number of descriptors categorized into four groups: logistical and instructional organization, theoretical component, practical component, and personal qualities of the teacher. Let us illustrate the structure of competence of a future teacher of mathematics during distance learning on the example of the subject area "Mathematics". The peculiarities of this field of knowledge are that the use of distance technologies until recently

were limited by technical conditions. The situation has changed with the replenishment of the arsenal of digital devices. Logistical support for the learning process should include the necessary technical means and a point of access to high-speed Internet. Technical means should include office computer equipment with installed standard software and video communication means; software packages for mathematical calculations (Excel, Statistica, etc.); graphic tablet (for handwriting input of mathematical information, formulas, drawings). The basis of subject support are the elements of the electronic educational-methodical complex: electronic textbook, work (possibly interactive) workbooks for practical work, electronic lecture notes, visualization tools of educational material (presentations, tables), control tools (tests, cards, individual assignments), etc.).

The creation of a set of teaching and learning materials should be distributed among the teachers of the discipline for sufficient time and constantly maintained. The organizational component of methodological competencies is also formed: course work programs, syllabi, and class schedules are created. These documents, as a rule, are placed in the electronic information and educational environment of the university. It is also important to decide on ways to communicate with students and administration: social networks, messengers, digital platforms, etc. The teacher needs to be able to inform students quickly and massively about upcoming events, and students need to be able to provide feedback (Martin, Polly & Ritzhaupt, 2020).

Discussion

Analysis of the works on the topic of research showed that the authors pay much attention to the issues of the distance learning organization, tools, and platforms for distance learning organization, problems of forming mathematical concepts with the support of electronic learning tools, and implementation of visual support of the educational process in mathematics, problems of assessing knowledge in mathematics. in distance learning format (Sherman, Puhovskiy, Kambalova & Kdyrova, 2022). In general, based on the analysis of the results of research literature, personal teaching experience, and accepted practice it is possible to highlight the following tools, especially popular in the organization of distance learning (Fig. 1):

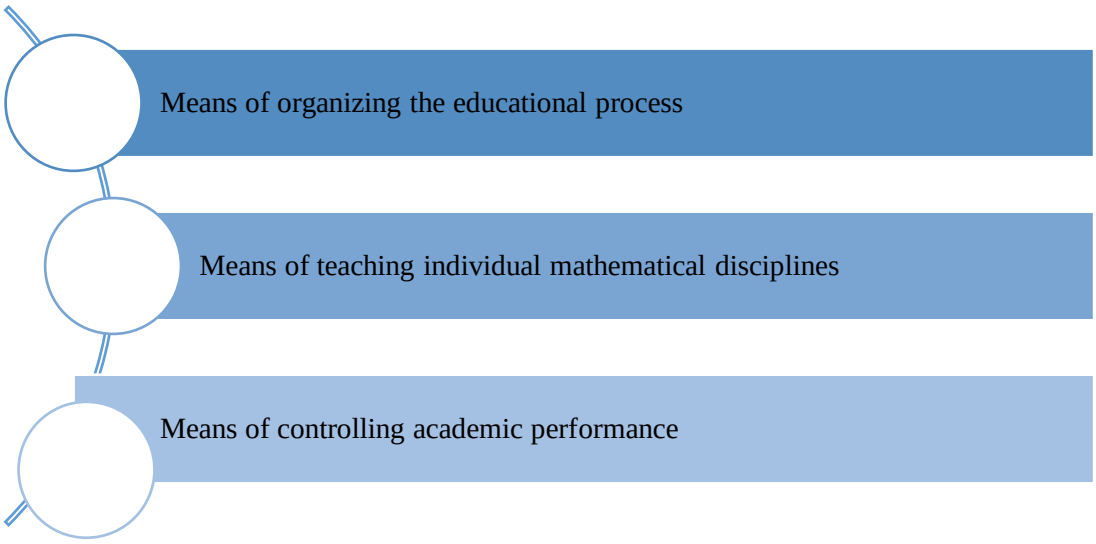

Fig. 1. Keyways to support distance learning for future mathematics teachers
Source: Authors' development.

The remote format of the educational process imposes an obligation on teachers to have a high degree of digital competence. Computer literacy ensures the use of innovative digital technologies and the latest didactic tools in the work. In addition, a high level of digital competence of both students and teachers can ensure a high level of communication during distance learning. Mastering digital technologies makes it possible to use a wide range of software aimed at organizing the distance learning process. This is especially true for the study of mathematics. (Higgins, Huscroft-D'Angelo & Crawford, 2019).

Today, specialized software for performing special mathematical calculations is gaining popularity. This software is called mathematical processors and is aimed at using both numerical and symbolic calculations. At the same time, such software requires users to have not only special mathematical knowledge, but also to have technical means of sufficient power. Until recently, this problem prevented the use of some special mathematical software in the educational process. It is known that the technical equipment of higher education institutions does not always meet the requirements of modern software, especially the one that requires large RAM resources, a modern powerful video card, a processor of the latest generations, etc. The solution to this problem came naturally. With the advent of cloud computing, the entire computing process, which has been performed on hardware, has now been moved to a cloud server. Thus, a significant technical resource has been saved. Large companies such as Google or Microsoft provide their own cloud computing capacities for educational purposes to universities absolutely free of charge. Thus, the problem of outdated equipment becomes irrelevant (Martin, Polly & Ritzhaupt, 2020).

But since the comfortable use of an online board determines the availability of a touchscreen, and in other cases, its use is less convenient, some additional features have to be sought. In the context of this study, Boiaryshcheva, Herych, Pohoriliak, Syniavska & Tehza (2022) are interesting. Researchers remain committed to traditional methods of education and see the only possibility of using distance learning technologies and methods in combination with face-to-face learning. Hodges, Lockee, Moore, Trust & Bond (2020) cite data fully confirming the full ability of distance education methods in the formation of professional competencies of future educational specialists.

Conclusions

Analyzed the experience of using distance means of organizing professional training of future teachers of mathematics, investigating the coverage of this topic in the scientific literature, the following conclusions are made. Distance form of education is a response to the challenges of the modern world, its task is to ensure continuous and quality education. In pedagogical practice, there are a large number of methods and means of organizing the educational process through the introduction of distance technology. As evidenced by the results of the study, the optimal result is achieved by a complex combination of several methods and means. The effectiveness of the distance form of education is determined by the level of formation of professional competence, which is reflected in the indicators of academic success of future teachers of mathematics. We can conclude that the use of distance form of education is a global trend and at this stage of pedagogical science development, we need to look for ways to improve its effectiveness.

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