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Advantages and disadvantages of laboratory lessons in mathematics teaching methodology under emergency remote teaching conditions

Olha Matiash^a, Liubov Mykhailenko^{a,*}, Diana Tiutiunnyk^a, Karyna Yashchuk^a, Halyna Kateryniuk^b

^a Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, 21001, Vinnytsia 32 Ostrozhko Str., Ukraine

^b Regional Scientific Lyceum of the Municipal Higher Education Institution "Vinnytsia Humanitarian Pedagogical College", Ukraine

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ABSTRACT

Certain features of the Ukrainian system for the methodological training of future mathematics teachers at a pedagogical university are described. The aim of this study is to identify the key advantages and disadvantages of conducting laboratory lessons in the methodological training of future mathematics teachers under emergency remote teaching conditions caused by unforeseen circumstances. The technologies developed by the authors of this article for conducting laboratory classes in the methodology of teaching mathematics in the conditions of emergency distance learning have been experimentally tested. A survey of the participants in such training was conducted. We found that conducting laboratory lessons for future mathematics teachers in a remote learning environment has not only disadvantages but also certain advantages. In particular, the advantages include: teachers more actively using access to new resources and applying new opportunities during specific classes; increased personal responsibility of students for focus and engagement in the class; an additional component of technology-techniques is added to the traditional teacher-student partnership. Based on the results of the study, we concluded that the possible need for emergency distance learning should encourage teachers to pursue professional development and to form skills for the operational and creative use of digital technologies in managing learning. In this article, we describe our own experience of conducting laboratory work in the methodology of teaching mathematics in the conditions of emergency distance learning. The forced conditions of emergency distance learning in the course on the methodology of teaching mathematics allowed us to significantly expand and diversify the usual tools for forming the methodological competencies of future mathematics teachers. Our experience may be useful to interested parties to better prepare for possible future needs in implementing emergency distance learning under unforeseen circumstances (quarantines, natural disasters, etc.).

1. Introduction

For the past two years, the Ukrainian system of education has been functioning in an extremely difficult situation that has developed due to the war. Two years before the whole world lived in the conditions of Covid-19 pandemic.

That is why, the last four years of the online or blended learning for Ukrainian education establishment was very crucial.

In general, after weakening of the quarantine, it became obvious that humanity entered new stage of development, where distance learning will play an important role. Under unforeseen, complicated conditions of learning, there emerged in Ukraine a great number of new services and tools, intended for the distance learning. In social networks there

appeared a great number of blogs, containing recommendations, regarding the problems of distance learning, distance courses, intended for the development of the educational resources and organization of distance learning.

Programming tool Zoom turned out to be very popular for holding video-conferences. Speaking about distance learning, we mean the totality of the information technologies and techniques of teaching, which provide the obtaining of education without physical presence of the students in the education establishment. Researchers, working in the sphere of the education technologies, note that it is important to distinguish the following notions, often used nowadays: distance learning, distributed learning, blended learning, on-line learning, mobile learning (Boudreau, 2020; Kukhareno & Bondarenko, 2020).

* Corresponding author.

E-mail address: liubov.mykhailenko@vspu.edu.ua (L. Mykhailenko).

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Efficient on-line education is the result of the extensive design and planning of the study, usage of systematized model for the design and development (Branch & Dousay, 2015). One of the most comprehensive results of the research in the field of the on-line education is contained in the book "Learning Online: What Research Tells Us About Whether, When and How" (Means et al., 2014). Nowadays, there exists the opinion that distance learning is a low-quality education. Although, in reality, nobody, who performs the transition to distance learning at special, unforeseen circumstances in reality does not plan to make complete use of the advantages and possibilities of the online learning (Hodges et al., 2020). That is why, in 2020 Hodge Charles and his colleagues introduced new notion "Emergency Remote Teaching", this is the temporary transition of the education process to the alternative mode of learning due to the crisis-related circumstances. Basic objectives in this situation is not to reconstruct the stable educational ecosystem but rather to provide temporary access to study and educational support which can be rapidly arranged and are accessible during the emergency situation or crisis (Hodges et al., 2020). Considering the examples of the education system operation in crisis-related conditions it becomes obvious that these situations require the creative solution of the problems. Emergency remote teaching supposes emergency ways of delivering the educational information, specific methods and tools for its processing, especially, when they correspond to rapidly changing needs and limited resources (Boudreau, 2020).

As a rule, teachers feel themselves more comfortable in the process of the online teaching during the second or third iterations of their online courses (Hodges et al., 2020). Corresponding studies are carried out to comprehend how the educational establishments cope with the digital transformation of teaching and learning process. Thus, there is an important distinction between the common type of the efficient distance education and the type that we do in great haste with minimal resources and limited time: emergency remote teaching. In our opinion, nowadays, it is very important to analyze the results not only of distance teaching and learning process but also emergency remote teaching.

This article presents certain results of conducting emergency distance learning for future mathematics teachers in the course "Methods of Teaching Mathematics" at Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University. In our case, the emergency distance learning is related to an extraordinary situation – the military actions on the territory of Ukraine. Analysis of these materials will make it possible to disseminate the actual experience of conducting laboratory classes in the process of the methodical training of the future mathematics teachers in the conditions of the emergency remote teaching, understand key advantages for further usage. Within the given context the problem how successfully integrates ICT in distance education of the students, in particular, to support study and provide the conditions for the methodical training of the future mathematics teachers is very important. That is why, we would like to share our experience of ICT usage to conduct laboratory practical on the methods of teaching mathematics in the conditions of the emergency remote teaching. Our experience will allow the parties involved reveal strong and weak aspects to prepare better for possible future needs, dealing with the implementation of the emergency remote teaching.

2. The state of the research analysis

Application of digital technologies, especially mobile technologies for teaching and learning mathematics gains interest among researchers and experts (Borba et al., 2017). In particular, key possibilities, challenges and barriers connected with the integration of digital technologies in mathematical education are considered. M. Borba, P. Askar, J. Engelbrecht, Z. Zadanidi, S. Linares, M. Aguila studied how both technical, social and information aspects, each of them separately and taken together, influence the implementation of new information technologies in teaching mathematics. This research was carried out in the educational medium K-12 and analyzed the corresponding activity of students

and teachers as well as the conditions for the improvement the quality of mathematical education in Sweden.

The article of H.R.F.L de Almeida (Almeida, 2016) is of the interest in the context of our research, the author considers the general history of education technologies and separate aspects of their usage for teaching mathematics. One of the conclusions is: modern technological innovations and wide choice of educational software, available in the Internet can make easy the process of teaching and learning mathematics and offer teachers and students vast experience. However, this is a complex process. Usage of the Internet or computer facilities in general as the support of full-time mode of study is the road, paved by very few (Almeida, 2016). Students have the problems with the usage of the educational software, if the teachers do not work on the development of the common practices of its usage. Researchers Olga Viberg, Åke Grönlundband, Annika Andersson, note that the integration of the digital technologies in the sphere of education is rather complex issue as when the teachers themselves do not actively use digital technologies, they cannot provide assistance to the students (Viberg, 2023). Teachers of mathematics faced the necessity of reorganization of the teaching methods and the Internet has to play an important role in this reorganization. H.R.F.L. de Almeida states that the usage of the Internet as a convenient storage space of the needed information, changes the way of the access and processing of this information, will improve the process of mathematics study (Almeida, 2016).

However, the surveys show that the teachers of mathematics use digital tools less frequently than the teachers of other subjects (Swedish National Agency for Education, 2016; Bray & Tangney, 2017). Swedish researchers (Viberg, 2023) note, that mathematics is a key subject besides it is a problematic subject for many students. That is why, it is important to understand how the digital tools can help improve the conditions for teaching mathematics. The results of the recent survey of the empiric studies concerning the usage of the digital technologies in mathematical education show that the usage of the digital technologies "on the whole does not correspond to the forecast potential of mathematics study improvement" (Bray & Tangney, 2017, p. 253). It has been established that the students seldom creatively use digital technologies in the process of learning, digital technologies are often applied for the improvement of the conventional practices (Bray & Tangney, 2017). During last decades the scientists keep on underlining that for the improvement of teaching mathematics it is important to combine the potential of ICT with the corresponding pedagogical resource (Bray & Tangney, 2017; Drijvers, 2015).

Researchers (Viberg et al., 2023) state that it is important to activate the following research: how digital technologies were integrated in mathematics teaching process? How this integration influenced the mathematics teaching process and the results of mathematics teaching? Nowadays, profound pedagogical studies are needed to investigate the drawbacks and advantages of the Internet usage in teaching mathematics, these studies should be directed also at the investigation of the advantages and disadvantages of the Internet usage for the improvement of the quality of the future teachers training, especially, if we understand modern challenges in the sphere of education. The researchers underline, that the integration of technologies in the sphere of education should be studied within the system of the interacting factors (Tondeur et al., 2017).

Summarizing the survey of the corresponding publications we should note that the researchers stress the essential need to teach the future teachers the skill to organize the efficient process of distance learning. Efficient practices of the interaction between the teachers and students, teachers and pupils have to be elaborated. For the realization of the successful transformation of the teaching process in the conditions of on-line-distance study, there emerges the need to change methods, tools of teaching and learning. There appears the necessity to analyze the practical examples of such successful transformation in the activity of the colleagues.

3. Objective and tasks of the research

Objective of the research – find out characteristic features, key advantages and disadvantages of laboratory lessons in the methodology of teaching mathematics (training of future mathematics teachers) under remote learning conditions, driven by rapidly changing demands, unforeseen circumstances, and certain resource limitations.

To achieve the objective, the target of the research was outlined:

- to test self-developed technologies for conducting laboratory lessons in the methodology of teaching mathematics under emergency remote teaching conditions, caused by unforeseen circumstances and limited resources;
- to analyze the perceptions of students and instructors regarding the tested technologies for conducting laboratory lessons;
- to determine the key advantages and disadvantages of the tested technologies for conducting laboratory lessons under emergency remote teaching conditions.

4. Materials and methods

4.1. Theoretical information

The methodological training of future mathematics teachers is a comprehensive and purposeful process of scientific-subject, psychological-pedagogical, and practical preparation aimed at developing the methodological competence of future mathematics teachers.

The methodological competence of a future mathematics teacher is the expected outcome of the teacher's methodological training, which includes methodological literacy, experience in methodological activities, and methodological beliefs. This expected outcome lies in the readiness and ability of the future mathematics teacher to competently solve a range of methodological tasks related to the formation of students' mathematical competence, stemming from the didactic, educational, and developmental goals of mathematics education in school ([On the approval of the Conceptual Framework for the Development of Teacher Education in Ukraine and its Integration into the European Educational Space](#), n. d.).

In the Conceptual Framework for the Development of Teacher Education in Ukraine and its Integration into the European Educational Space, it is stated that the methodological training of future teachers involves studying the methods of teaching subjects and the methodologies for conducting extracurricular and out-of-class activities. In Ukrainian higher education institutions preparing future mathematics teachers, the course "Methodology of Teaching Mathematics" is traditionally offered. Among the forms of instruction for this course are lectures, practical classes, and laboratory lessons. Thus, the formation of methodological competence in future mathematics teachers occurs during their methodological training, one of the forms of which is laboratory lessons in the methodology of teaching mathematics.

A laboratory lesson in the methodology of teaching mathematics is a form of instructional activity in which students, through engagement in tasks that simulate future professional activities, acquire practical skills in solving methodological problems related to the preparation and delivery of mathematics lessons in school ([Matiash, 2014](#)). In such conditions, the development of professional skills for future mathematics teachers occurs based on constructivist principles. From a constructivist perspective, the instructor's goal is not to convey specific truths to the audience, but to assist students in conceptually organizing their own experiences.

4.2. Research organization

To perform the research, one of the conventional forms of the methodical training of future mathematics teachers for our students was chosen – laboratory lessons. Such lessons are provided by the curriculum

and amount to 25% of the classroom activity.

Traditionally, our laboratory lessons on the methods of mathematics teaching are conducted in the form of the role-play game ([Matiash & Mykhailenko, 2020](#)). First, the students obtain the assignment to prepare the lesson (or the fragment of the lesson) of mathematics at school, for instance, in the 9th form on the subject "Sine theorem". All the students prepare the corresponding lesson plans and one of the students is warned in advance, that he will have to conduct this lesson or its fragment in the classroom. That is, during the classroom lesson, one of the students acts as a mathematics teacher and often students, including the university teacher, act as pupils, according to the situations, emerging during the lesson. Role-playing activity of the teacher, acting as a pupil is extremely important as he/she artificially creates pedagogical situations, which are to be solved by the student-teacher. Without preliminary preparation after the role-playing game the stage of the active discussion of different aspects of the conducted lesson is coming and the arrangement is made for: the student, who conducted the lesson should not be criticized. It is important that the conducted lesson is considered as the possible model of the teacher's activity in real conditions, that is why, successful aspects or faults of the lesson are analyzed and sometimes are discussed. It should be noted, that our long experience of laboratory classes conduction in the given format proves the efficiency of such quasi-professional activity of students and their satisfaction with such conditions of obtaining methodical competences.

For studying the possibilities of the laboratory classes on the methods of mathematics study in the circumstances of emergency remote teaching, we conducted such classes, using authors' technologies, under the conditions of the forces distance study (regular air alerts, frequent interruptions of the power supply, forced displacement of students as a result of the aggression on the part of Russian Federation). Authors of the given paper have analyzed materials, dealing with the observation of teachers and students' activities in the course of the laboratory classes on the methods of mathematics teaching under the conditions of the emergency remote learning. Corresponding survey of different teachers of the methods of mathematics teaching, analysis of their experience, synthesis and comparison of the results of their studies has been performed. Two different authors' models of the laboratory classes conducting in the condition of the emergency remote teaching have been selected, these models are described in the results of the research. The survey of students in order to determine the impact of the authors' technologies of laboratory classes conducting under the conditions of the emergency remote teaching on the formation of the methodical competence of the future teachers has been carried out.

On the basis of the analysis of the results of teachers (5 individuals) and students (48 individuals) of Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, surveys the components of the subject of the research were distinguished (advantages and disadvantages of the formation of knowledge and skills on the methods of mathematics teaching in the conditions of the emergency remote teaching), which, as a result of synthesis, were combined into the integral phenomenon and the conclusions were formulated. For the detail study of the peculiarities of the methodical training of the future teachers of mathematics in the conditions of distance teaching, we have analyzed the corresponding publications of foreign authors, synthesized and compared the results of the research. In the process of the investigations special attention was paid to the content-analysis of the Internet-resources.

4.3. Author's models of laboratory classes

Two different authorial models for conducting laboratory lessons in the methodology of teaching mathematics under emergency remote learning conditions have been selected.

Model № 1 of mathematics teaching methods laboratory classes under the conditions of the emergency remote teaching.

At the previous lesson the students (20 individuals) got home assignment: consider the material of the paragraph "Sine Theorem" and

read carefully the set of problems on the subject “Sine Theorem” from several alternative school text-books on geometry. Students participate in the laboratory class on-line (video conference ZOOM with video recording of the lesson). The objective is set-formation of the future teacher’s skill to explain pupils study material methodologically correctly. All the students obtain the assignment to prepare during 40 min the fragment of the lesson (15 min), explication of new material on the subject “Sine Theorem”.

In 40 min, somebody of the students (at will) makes the first attempt – demonstrates the prepared fragment of the lesson. The teacher arranges the discussion of the reviewed fragment of the lesson by the students relatively the completeness and correctness of the theoretical content, correctness of the teacher’s speech, expediency of the stresses in the process of explanation, appropriate usage of the methodological techniques. Everyone, who participates in the discussion of the reviewed fragment has to give obligatory a brief description of this project of the fragment of the lesson. At the end of the lesson the teacher analyzes the reviewed fragment: students’ attention is concentrated on the most important methodological aspects; methodical and mathematical errors in the action and reflections of the students are underlined; recommendations regarding the correction or prevention of the errors are provided. Video recording of the lesson is posted on Google Classroom.

Home assignment: prepare video-fragment of the lesson of the new material explanation on the subject “Sine Theorem”, taking into account the remarks of the colleagues and teacher. Each student has to send his/her video-fragment to Google Classroom one day before the next laboratory class.

The next laboratory class starts with the reviewing of three fragments (duration of each 15 min), these fragments have been chosen by the teacher after reviewing the fragments of the lessons, sent by the students. The reviewed fragments are again analyzed by the students and each student prepares during 15 min the list of good practices and drawbacks, detected in the activity of students-teachers, the volume of the student’s note is one-two pages. The prepared texts are sent to Google disk for further assessment by the teacher. For the convenience of students’ notes and the convenience of verification by the teacher in the common Google disk the table is prepared and each student has his/her page in it. Having sent the necessary texts, the students listen to the well-grounded methodical commentary of the teacher of mathematics teaching methods to the each of the reviewed fragments of the lessons, the teacher prepared to accompany the analysis with the convenient multimedia presentation (taking into account the time, left to the end of the laboratory class).

Home assignment: prepare the plan of the lesson of new material explanation on the subject, chosen from the list of topics, suggested by the teacher.

Model № 2 of mathematics teaching methods laboratory classes under the condition of the emergency remote teaching.

At the previous lesson the students’ (28 individuals) home assignment was: find and look through in the Internet 3–4 video lessons of geometry on the subject “Sine Theorem”. Among the reviewed lessons, the students were to choose the lesson they consider to the best and prepare its written analysis, obligatory giving accent to the most appropriate methodical techniques, used by the mathematics teacher. Written analysis of the lesson and references to the chosen video lesson are to be sent to Google Classroom one day before the laboratory class. Teacher of mathematics teaching methods looks through the obtained materials, forms his own set of video fragments of the lesson on the subject “Sine Theorem” (the set may contain the fragments of video lessons, selected by the students but it is not obligatory). The students participate in the laboratory class remotely (ZOOM video conference with video recording of the lesson). Teacher of mathematics teaching methods gives the extended consultation regarding the preparation of the quality fragment of the lesson, dealing with the explanation the new material on the subject “Sine Theorem”: he comments the video fragments of the lessons, selected by him, answers the students questions,

proposes the lists of the methodical recommendations, prepared in advance. Such recommendations are formed, taking into consideration the aspects, which the students emphasized correctly or incorrectly during the previous home assignment. Video recording of the conducted laboratory class is posted in Google Classroom.

Home assignment: prepare own video-fragment of new material explanation lesson on the subject “Sine Theorem”. Each student has to send his/her video-fragment to Google Classroom one day before the conduction of the next laboratory class.

The next lab class will start from the reviewing of one of the fragments (15 min), the fragment was chosen by the teacher after reviewing the fragments of the lessons, sent by the students. The teacher organizes active discussion of the fragment with the obligatory substantiation of the successful and not very successful points. After that one more fragment of the lesson is reviewed and the discussion, regarding its methodical perfection takes place. During the laboratory class 3–4 fragments of the lessons, prepared by the students could be reviewed and discussed.

Home assignment: prepare two plans of the lesson fragments dealing with the explanation of new material on different subjects, chosen from the list, suggested by the teacher (one topic for the 7th class, another – for the 8th class).

Research Features: Each of the models for conducting laboratory classes in the methodology of teaching mathematics discussed above was proposed and tested by us (the authors of this article), who are instructors of the methodology of teaching mathematics at Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University and have approximately the same teaching experience, academic degrees, and titles. The key ideas regarding the proposed technologies for conducting laboratory classes in the methodology of teaching mathematics in the first semester of the 2023–2024 academic year can be explained by the teachers’ desire to promptly organize a relatively safe environment for acquiring methodological competence for future mathematics teachers under the complex and unpredictable conditions of martial law in the country. The purpose of developing different models for organizing methodological training was to specifically organize laboratory work in a distance format under the same unpredictable circumstances. Although the proposed Models №1 and №2 are structurally different, they share a number of common techniques due to the similar circumstances under which these models were developed. Since these models were created under emergency distance learning conditions, we did not aim to compare their effectiveness with each other.

5. Results of the research

After conducting laboratory work for fourth-year students using the above models, we were interested in how the students assessed the technologies we proposed compared to the traditional technology for conducting laboratory classes in the methodology of teaching mathematics (third-year studies).

5.1. Results of student survey

- main discussion during the survey of the students (48 individuals) regarding the impact of the authors’ technologies of laboratory classes on the conditions of the formation of methodical competence of the future mathematics teachers, as compared with traditional technology, was conducted around the idea of video recording of the fragments of the lessons. Some students noted that much time was spent for the preparation of the video recording of the fragments. Others paid attention that there appeared the possibility to review several times the fragment, also the author of the fragment can review his/her product, improve it. As the advantages, the students note, that they feel calmer while preparing the lesson, as they realize that there exists the possibility to record the video fragment. Among the advantages of the traditional form of classes, almost all the

students mentioned unpredictable character of pedagogical situations, which may appear and require the immediate response.

- we determined students' acceptance or rejection of the distance format of laboratory classes, as proposed by us, by identifying the advantages (Table 1) and disadvantages (Table 2) indicated by the students in the corresponding survey. The survey was conducted in electronic format. We provided a list of 20 potential disadvantages and 20 advantages, as well as the opportunity for respondents to specify their own formulations of disadvantages and advantages in evaluating the proposed models of remote laboratory lessons. The students were asked to specify no more than four advantages and no more than four disadvantages of the tested emergency distance technologies (Model №1 or Model №2) compared to the traditional technology for conducting laboratory classes in the methodology of teaching mathematics. The tables include only those advantages and disadvantages mentioned by more than 30% of the surveyed students.

5.2. Results of the teacher's survey

Here we indicate the advantages and disadvantages of emergency distance learning in the methodological training of future mathematics teachers as expressed by instructors of methodological disciplines in the survey, which do not duplicate students' perspectives (hence, percentage indicators are not used).

5.2.1. Advantages

- ✓ Possibility to get acquainted with various interesting educational on-line platforms for distance education.
- ✓ Possibility to teach the disabled people.
- ✓ Possibility for mobility of the teachers and students.
- ✓ Improve the responsibility of the students: student in front of the computer monitor is responsible for his/her concentration and involvement in the class activity.
- ✓ More possibilities for personal-oriented and differentiated study.

5.2.2. Drawbacks

- ✓ Distance education is complex type of study for teachers: much time is spent for the development of the needed materials, for verification both of classroom tasks and home assignment; for video materials recording.
- ✓ Not all the students have the responsible attitude to their duties.
- ✓ Distance education does not fit the development of the communication skills of the future teachers.

Table 1

The advantages of remote laboratory work on the methodology of teaching mathematics, highlighted by students.

ADVANTAGES:	Percentage of students who indicated a preference
You can return to studying more complex issues, watch video materials several times, and reread correspondence with the teacher.	67%
More opportunities for individual consultations with the teacher.	54%
Interesting and unusual format of study.	73%
The ability to complete all stages of laboratory work at your own pace.	42%
Availability of educational materials at any convenient time.	86%
Conducting a fragment of the lesson in a more familiar and calmer environment.	52%
During distance learning, the student has a significant number of additional opportunities to complete all laboratory tasks with high quality.	48%
Possibility to study whenever and wherever you are	34%

Table 2

Disadvantages identified by students of remote laboratory work on the methodology of teaching mathematics.

DRAWBACKS:	Percentage of students who indicated a preference
Lack of face-to-face communication with classmates and teachers. Future teachers critically need "live" practice.	63%
A significant amount of time is spent on computer equipment, which negatively affects health.	71%
Not always the access to a quality Internet is available.	45%
No clear boundaries for the workday. The home environment often distracts from studying.	35%
Considering the unforeseen circumstances, it is difficult to maintain the necessary pace for preparing laboratory work.	31%

- ✓ In the condition of the extended period of distance education the daily routine is violated.
- ✓ Problem of student's identification. There exist more possibilities for the falsification of the results (the task is performed by another person).

5.3. Limitations of the study

Time period: The study is limited to periods of extreme conditions (pandemic, martial law, etc.), when remote learning became necessary.

Target audience: The study focuses only on instructors and students in educational institutions that train future mathematics teachers and offer laboratory lessons in the methodology of teaching mathematics.

Technological resources: The analysis is limited to specific platforms for remote learning (Zoom, Google Classroom).

6. Discussion

Scientific progress of the mankind enlarged knowledge about technological resources, which become more and more complicated. At the same time the developed technologies influence greatly social behavior of people, in particular, the education processes (Almeida, 2016). Digitalization is widely used in educational systems all over the world, many countries update their legislation to accelerate this process (Fransson et al., 2018). Problem of the integration of digital technologies in practical teaching and studying process becomes critical. A. Sacristán (Sacristán, 2017) considers the notion "inertia of educational systems". Author analyzed a number of studies (S.Papert, M.L.Miranda, A. Clark-Wilson, R. Sutherland) regarding the application of digital technologies at mathematics lessons in school and states that in spite of more than 20 years of studies, minor impact of digital technologies implementation could be noted. Scientists constantly require additional evidence of the efficiency of technological innovations usage, they seek the ways of the most efficient application of the digital technologies to support teaching process (Howard et al., 2019; Tondeur et al., 2013). In numerous publications A. Sacristán (Sacristán, 2017) considers the grounds for the discrepancy between the results of the experimental research and what happens in reality. In particular, she states that simple access to the technologies is not sufficient for the implementation of the changes in education process; the necessary precondition of the successful integration of the technologies is the improvement of teachers' qualification. It became obvious (Sacristán, 2017), that even most creative, devoted to the program of advanced training teachers, taking into account constant consultations, needed at least three years to perceive the key pedagogical ideas, dealing with the implementation of digital technologies and master the necessary tools. Thus, in order to overcome inertia of the educational system, it is important to comprehend that the key figure for the successful implementation of technologically-oriented educational innovations is a teacher.

Definitely, teachers are central figures of changes in the system of education (Datnow, 2020).

In our opinion, understanding the fact that the key figure for the successful implementation of technologically-oriented educational innovations is a teacher, puts forward new requirements to the programs of future mathematics teachers training. It is quite obvious, that the application of digital technologies should be paid serious attention in the programs of professional training of future mathematics teachers. Difficulties, challenges and obstacles for the efficient usage of modern digital technologies by the teachers of mathematics are analyzed by A. Clark-Wilson, O. Robutti, N. Sinclair in their book "The Mathematics Teacher in the Digital Era, An International Perspective on Technology Focused Professional Development" (Clark-Wilson et al., 2014) and propose the conclusions of their studies for the realistic way of professional development of mathematics teachers. Proceeding from a number of methodologies, theoretical fundamentals and specific technologies, the authors illustrate complex interaction between Pedagogics and the knowledge of information technologies, make a conclusion for all, those who seek to understand and change the practice of teaching mathematics.

Our research was aimed at determining the characteristics features of the methodical training of future mathematics teachers in the condition of the distance learning, what digital tools could be efficiently integrated in the methodical training of future mathematics teachers, proceeding from the above-mentioned tasks and conditions.

First, we note that the activity of the university teachers, who provide methodical training of the mathematics teachers in the condition of the emergency remote education, required substantial changes. Nowadays, little information is available about the efficiency of the distance education and problems, facing students and teachers (Mohd Basar, Mansor, Jamaludin, & Alias, 2021). Lack of the reliable on-line infrastructure can be the obstacle to the efficient distance education. Motivation of the students during distance education may be low, as this type of study requires self-motivation and discipline. Teachers have to study and improve the experience of student's distance education, using efficient pedagogical tools and methods (Mohd Basar et al., 2021).

Taking into consideration modern challenges, our teachers had to reconsider the available models of the methodical training of the future mathematics teachers and reshape them to make these models more productive in new conditions of the emergency remote teaching. It was important to provide various types of the efficient interaction: student-content, student-student and student-teacher. The study of the types of the interaction, which comprises student-content, student-student and student-teacher is one of the most reliable studies in the sphere of the on-line education, it shows that the presence of each of these types of interaction provides necessary results, when it is highly integrated in the educational process (Boudreau, 2020). Support of the students in the process of the emergency remote study provides the development of the practice, strategic tasks for the organization of the student's activities, regular monitoring of their work and orientation on the quality result of study. Usage of these tools requires active interaction in the pair's student – feedback content, student – student, student – teacher, so that the students could get rapid. We understood that to organize distance study means to help the student independently determine what he does not know and what he cannot do. Integration of the education technologies means the creation of the positive contribution of the technologies in the efficiency of the complex information system, which includes formal and informal usage of information-communication technologies (ICT) by the students and teachers. Integration also concerns a number of other dynamic factors, including efficient practices, technological aspects of new tools as well as development of new forms of teaching and practices of study (Howard et al., 2019). In general, it proves that the teachers have to work harder over the integration (Viberg et al., 2023). Our studies can be argued that all this leads to the sharp increase of teacher's academic loading that is one of the aspects which should be taken into consideration, analyzing the efficiency of distance education.

Organization of the emergency remote education comprises not only determination of the content to be included but also detailed monitoring how different types of interactions are maintained, as it is important for the education process. Such an approach admits the education to be the social and cognitive process but not simply the process of the information transfer.

Quality education is based on decision-making (Boudreau, 2020), based on the combinations of the content knowledge, pedagogical knowledge, culture and self-consciousness. In distance teaching, the computer technologies combine these four elements of decision-making. Educational materials should be accompanied with the instructions, indicate the time, needed for the work over the assignment and for learning the needed materials. It is important to recommend the students necessary strategies of the activity, provide free access to the methodological guidelines and relevant advice. Student should be explained the system of assessment for each executed assignment, provide the encouragement for active work. Organization of the emergency remote teaching requires: maximum accounting for the possibility of emerging unforeseeable situations for conducting distance lesson; methodically-considered selection of the digital services to be used; considerable increase of time for the preparation for the lesson and checking of the tasks, executed by the students; provide the possibility to obtain corresponding educational services for the students who could not participate in the lesson due to the extreme unforeseeable conditions.

We distinguish certain peculiarities of the integration of various technologies in the methodical training of future mathematics teachers in the conditions of distance teaching. These peculiarities include the necessity of the structural research approach and change of the role of the teacher from the instructor into the facilitator (Bray & Tangney, 2017). Integration of the digital technologies in pedagogical education is connected with three critical factors: design of the technologies, educational actions and tasks; role of the teacher; educational context (Drijvers, 2015). The teacher has to organize educational process, for instance, by means of the synthesis of the assessment of the results of technological activity, assistance in the development of the efficient methods of application of different tools and accumulation of the experience of the communication in the technological environment.

Our research shows that the teachers, who want to implement digital tools in pedagogical education have to study in details how these tools operate and develop educational situation. The main thing is not to propose the student's new technologies but work, develop along with them to promote common success of the education practice in new unforeseeable conditions. The survey of the students in the USA (Kelly, 2020) at the beginning of the quarantine (distance education) showed that the opinion on the quality of education worsened in 41% of students but in half a year almost seven out of ten students stated that their college had coped with the global pandemic excellently (23%) or well (46%). Almost seven out of ten teachers claimed that their school reacted the COVID-19 crisis excellently (25%) or good (41%). Our studies confirm such conclusions. System of methodical training of future mathematics teachers in the conditions of emergency remote education although has some problems, however, has a number of positive organization-methodical characteristics. That is creative teachers of Ukraine search and find ways to provide quality emergency remote education of future mathematics teachers.

Methodical activity of the teachers, training future mathematics teachers, their role in the realization of changes in the system of education is very important. Pedagogical convictions, mathematical and information competence of the teachers is important prerequisites how the application of digital technologies will influence the quality of methodical training of future mathematics teachers and, correspondingly, the quality of teaching mathematics in school. We revealed that methodical training of future mathematics teachers (in particular, in the form of laboratory classes) in the conditions of the distance education has such main advantages:

- pedagogical accessibility as the teacher can obtain access to a number of new resources and apply new possibilities in the course of the given lesson;
- possibility to connect to the lesson at any distance and the flexibility of the time-table;
- conventional partnership teacher-student is added one more component -equipment-technology;
- emerges understanding that it is impossible without the renovation of the system of the formation of the methodical competence of mathematics teachers to organize qualitative training of the teachers to future challenges in their professional activity.

It is important to avoid temptation to equate emergency remote teaching to on-line teaching (Hodges et al., 2020). However, if there appears the need to implement the emergency remote teaching it is important to analyze the results of such implementation, assess efforts, highlight strong points and reveal weak points to be well-prepared to future unforeseeable needs of the implementation of the emergency remote teaching. Modern realities (climatic, political, etc.) are such that the possible need in emergency remote teaching can make teacher master the skills of quality professional activity in a distance format. This is very important for the teachers, who works with the students of pedagogical specialties. Future teachers in the conditions of efficient emergency remote teaching at the university obtain experience of the future efficient activities in school on the conditions of the emergency remote teaching. Naturally, emergency remote teaching is the stress situation but the analysis of the experience of the professional decisions making in such conditions, analysis of the experience of the emergency integration of the on-line teaching technologies enables to comprehend new possibilities of new technologies application in the condition of full-time study. Usage of the Internet in the process of education can promote: obtaining the experiences of teaching, solving the problem of real data usage; greater autonomy and reliability for own education; cooperation between the students in extracurricular time, possibility to obtain individual support at any place (Fornelos, 2006). One of the great advantages of the Internet is the combination of various technologies in one environment: for instance, the Internet presents both audio and video resources, it is interactive and, finally, the Internet can unite geographically dissipated people at low cost (Almeida, 2016). Another advantage is that, without any doubt, this is the resource which provides the greatest volume and diversity of information in modern world. Thus, forced conditions of the emergency remote teaching of the methods of mathematics teaching enabled us to enlarge, diversify conventional tool kit, needed for the formation of the methodical competences of the future mathematics teacher. All the teachers can get profit from the knowledge of modern strategies of on-line teaching (Schrenk et al., 2021).

7. Conclusion

There exist substantiated problem of updating and improvement of mathematical education, its solution, in the opinion on the scientists from different countries, can be realized by means of methodologically-supported and professional application of modern digital technologies both in school mathematical education and in the system of professional training of future mathematics teachers (Kuleshova et al., 2020; Matiash et al., 2022; Mykhailenko et al., 2022; Rudenko et al., 2021, pp. 626–630; Shevchenko et al., 2022). Not underestimating the valuable scientific contribution of the scientists and researchers of different countries regarding the possibilities of using modern digital technologies in the conditions of the traditional and distance teaching, we, on the base of our own experimental studies, make conclusion that nowadays it is important to prepare for the adaptation of the education to unforeseeable conditions.

We presented models of laboratory lessons in the methodology of teaching mathematics during emergency situations (issues concerning

the safety of participants in the educational process) as those that allow the methodological training of future mathematics teachers to continue without interruption. Distance education is not the alternative to full-time study. Students must study in classes, communicate between each other, with teachers. Especially, this concerns the students of pedagogical specialties, future teachers. However, we cannot be sure that in future, in the period of study (at school or university) emergency situation or crises, safety problems will not emerge. Possible need in emergency remote teaching has to make teachers of schools and universities develop their professional skills, creatively use digital technologies for the education process management. Internet caused important changes in science and education. Indisputable is the possibility of lifelong self-education of the teachers by means of on-line distance education. This research showed that the distance format of the formation of the methodical competencies of the future mathematics teachers has not only disadvantages but also advantages.

CRedit authorship contribution statement

Olha Matiash: Writing – original draft, Validation, Methodology, Investigation, Data curation, Conceptualization. **Liubov Mykhailenko:** Writing – review & editing, Validation, Methodology, Investigation, Conceptualization. **Diana Tiutiunnyk:** Supervision, Formal analysis. **Karyna Yashchuk:** Investigation, Formal analysis. **Halyna Kateryniuk:** Project administration, Formal analysis.

Data accessibility

The manuscript does not have a linked data.

Ethical declaration

This project adheres to the relevant requirements regarding informed consent and confidentiality in research within the humanities and social sciences in Ukraine. Participants were informed about the objectives of the project and the methods of data usage. The purpose of the project and data storage methods were explained to the participants. Additionally, participants were informed that participation is voluntary and that they can withdraw from the study at any time without providing a reason for their withdrawal.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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