

The Use of ICT Tools to Organize Distance Learning of Mathematics for Primary School Students under COVID-19 Pandemic Conditions

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Abstract

The research substantiates the pedagogical expediency and didactic value of the use of E-resources and modern IR technologies in the organization of distance learning in mathematics in primary school. A survey of primary school teachers and students was conducted in order to study the problem of forming an E-environment in mathematics in primary school. The authors identify the information resources of the e-environment and describe the method of their application in mathematics lessons. The study substantiates that in the organization of distance learning in primary school it is advisable to use gamified children's educational portal Vchy.ua, interactive learning platform to create educational material Classtime, designer of interactive worksheets Liveworksheets, create mental maps of mathematics lessons (FreeMind, Bubbl.us, MindMeister), virtual interactive whiteboards for group work with a variety of content with the ability to edit it together (Educreations, Padlet, Popplet, etc.), use a mathematical interactive constructor to illustrate Mathdisk, digital mathematical platform for independent, personalized learning (Matifik), digital textbooks with using interactive 3D-animations, educational videos and tasks (Mozaik education), to test knowledge with the help of test tasks (resource Liveworksheets, Kahoot!), etc.

Keywords

E-resources, IR technologies, distance learning, primary school, mathematics lesson

1. Introduction

The challenges posed to humanity by the COVID-19 pandemic have led to the longest and most extensive transition to distance learning in the history of education worldwide. In April 2020, UNESCO estimated that more than 1.6 billion children studied at home [1]. Thus, during the period of quarantine restrictions, there was a need to organize distance learning even in primary school. One of the most important and complex subjects studied by younger students is mathematics, as it is a fundamental science that combines abstract and general knowledge, is used in all fields of knowledge and is a unique means of forming the intellectual potential of the individual, the development of logical thinking. Therefore, it is important to create appropriate pedagogical conditions for distance learning of mathematics in primary school, which would increase the interest of primary school students in this subject and ensure the development of their abilities in the further study of subjects in high school that include basic mathematical knowledge.

In the context of global trends in education, the New Ukrainian School singles out mathematical competence as a personal education that characterizes the ability of primary school students to create mathematical models of environmental processes, apply the experience of mathematical activities in

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solving practice-oriented and educational tasks; takes a course on the organization of the educational process, which develops students' ability to act, apply experience in problematic circumstances, and not just accumulate normative knowledge. The effectiveness of distance learning in mathematics in primary school depends on the quality of the e-environment created for this purpose. It is a powerful tool for conducting online math lessons and improving the quality of education of primary school children, as interesting interactive tasks, educational games contribute to the development of subject and key competencies of students.

The purpose of this study is to select and substantiate the pedagogical feasibility and didactic value of the use of E-resources and modern IR technologies in the organization of distance learning in mathematics in primary school. This goal involves solving a number of tasks: to investigate the state of the problem of forming an E-environment in mathematics in primary school; identify information resources of the e-environment and describe the methods of their application in mathematics lessons; to investigate their effectiveness in the organization of distance learning in mathematics for primary school students and the formation of subject competence in them.

2. Analysis of Publications

The works of Ukrainian scientists L. Koval, O. Komar, S. Logachevska, T. Logachevska, O. Onoprienko, S. Skvortsova and others are devoted to the issue of methods of teaching mathematics in primary school. Problems of application of information and communication technologies and features of use of the Internet in educational process are devoted to research of scientists: V. Bykov, M. Zhaldak, M. Kademiya, G. Kedrovych, M. Kozyar, N. Morse, N. Opushko, O. Spivakovsky, etc. The works of scientists L. Karamushka, O. Komar, L. Pyrozhenko, O. Pometun, G. Syrotenko, S. Syssoeva and others are devoted to the research related to the organization and methods of interactive learning. The works of V. Andrievska, N. Kovaleva, N. Olefirenko, T. Pushkareva, O. Rybalko, N. Rudenko and others are devoted to the study of the use of ICT in mathematics lessons in primary school. Some aspects of the formation of students' interest in the study of mathematics are considered by S. Shumigay [2].

Pedagogical play and learning are considered by such foreign scholars as: Carr, V., Luken, E. [3]; multimedia learning was considered by: Pañella, O. G., Escudero, D. F., Zaragoza, M. P., Portero, E. V. [4]; automation of teaching mathematics in elementary school: Ginsburg, H.P., Wu, R.E., Diamond, J. S. [5]; education and leadership in STEAM: Merrill, C., Daugherty, J. [6]; gamification of educational space in mathematics lessons: Morris, B.J., Croker, S., Zimmerman, C., Gill, D., Romig, C. [7]; the development of video conferencing in distance learning: Rachel Roberts [8]; Distance Education in High Schools: Davison M. Mupinga [9], Distance learning in elementary schools in Cyprus: Panagiotes S. Anastasiades [10]; new mode of distance learning in primary schools in the environment of multimedia computer assisted instruction: Xiaoyan Gao [11].

D. Passey has undertaken a wide range of evaluation studies, which have looked at developing distance learning practices in primary schools [12].

3. Discussion

Innovative combinations of interactive learning technologies and information and communication technologies have become popular in the field of education. Due to the challenges posed to humanity by the COVID-19 pandemic, there is a need to introduce distance learning, which is possible through the creation of an e-environment in primary school. It is a powerful tool for conducting online lessons and improving the quality of primary school education.

When forming the E-environment in mathematics for primary school, it is important to consider the need to form cognitive motivation of students by creating successful situations. Problems in mathematics using ICT tools were developed for primary school students to enhance their creative activity and improve the quality of knowledge. The research used IR technologies, which are focused on the development of critical thinking, creating an information product, willingness to work with searching in Internet.

When designing and implementing distance learning in elementary school in mathematics, it is advisable to use ready-made software products: electronic textbooks, manuals, encyclopedias, curricula

and more. Extensive opportunities to intensify the process of learning mathematics provides Microsoft Office, which contains, in addition to the text editor Word, also an Access database system, PowerPoint presentations, Excel spreadsheets. Of course, the database system involves a lot of preparatory work in designing classes, but it can result in an effective system of learning and testing students' knowledge and skills. In addition to these services in the arsenal of the modern primary school teacher there are various other resources. The list and purpose of resources of the E-environment of primary school are presented in Table 1.

Table 1
Assignment of primary school e-environment resources

The purpose of the e-environment	E-resources	Description of resources
Visualization	Mathdisk (http://www.mathdisk.com/)	Mathematical interactive constructor
Organization of training and cooperation between participants	Wikiwall (http://wikiwall.ru/); Gloster (https://www.gloster.com/)	Online boards for creating interactive posters
	Drawonthe.net (http://drawonthe.net/); Flockdraw (http://www.pearltrees.com/u/1075480-collaborative-whiteboard); Scribblar (https://scribblar.com/); CoSketch (http://cosketch.com/)	Online drawing boards
	Scrumbler (http://scrumbler.ca/); Conceptboard (https://conceptboard.com/)	Online note storage boards
	Padlet (https://padlet.com/) Educreations (https://www.educreations.com/); Lino it (https://en.linoit.com/); Rizzoma (https://rizzoma.com/); Popplet (https://www.popplet.com/)	Online boards for organizing group work with a variety of content with the ability to edit it together
Independent, personalized study of mathematics	Matifik (https://www.matific.com/ua/uk/home/)	Digital mathematical platform developed by education experts
Educational interactive services	LearningApps (https://learningapps.org/);	Service with small interactive modules;
	Liveworksheets (https://www.liveworksheets)	Interactive worksheet designer
E-literature for learning	Mozaik education (https://ua.mozaweb.com/)	Digital textbooks with interactive 3D animations, educational videos and tasks
Playing	Пустунчик (https://pustunchik.ua/ua)	Children's interactive portal

In the organization of distance learning in primary school, it is advisable to use an interactive learning platform to create educational material Classtime, which allows you to analyze the learning process and strategically implement an individual approach to each student. This service has its own library of resources, which stores more than 50,000 ready-mades, developed tasks in various subjects. It is also possible to create your own tasks that can be shared with students. With the help of this E-resource, the teacher can track and monitor the progress of each student in real time. The convenience of the platform is that you can integrate tasks and involve students from a class such as Google Classroom. The Classtime platform also has team games, which is an urgent problem in distance learning when creating group work.

On the Classtime platform, the teacher has a personal digital classroom to create tasks to test students' knowledge. To connect students to a class or test, the teacher only needs to provide individual code, which the platform generates automatically, for quick access of students to the test tasks themselves (Fig. 1).

The screenshot shows the Classtime interface. On the left, a sidebar lists tasks for 'Сесія R1ZNIW6'. The main area displays 'Питання 5' (Question 5) with a 'правильні' (correct) status. The question is: 'Встанови відповідність з числом рівним за значенням' (Establish correspondence with a number equal in value). The table below shows the options and their corresponding values:

	3100 кг	32 год	310 кг	90 хв
5400 с	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
3 ц 10 кг	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
3 т 1 ц	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1 доба 8 год	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

Below the table, there is a 'Відповідь' (Answer) field and a 'Вашу відповідь надіслано. Змінити відповідь' (Your answer has been submitted. Change answer) button. At the bottom, a solution box provides the following calculations:

- $90 \text{ хв} = 90 \cdot 60 \text{ с} = 5400 \text{ с}$
- $3 \text{ ц } 10 \text{ кг} = 3 \cdot 100 \text{ кг} + 10 \text{ кг} = 300 \text{ кг} + 10 \text{ кг} = 310 \text{ кг}$
- $3 \text{ т } 1 \text{ ц} = 3 \cdot 1000 \text{ кг} + 100 \text{ кг} = 3000 \text{ кг} + 100 \text{ кг} = 3100 \text{ кг}$
- $1 \text{ доба } 8 \text{ год} = 24 \text{ год} + 8 \text{ год} = 32 \text{ год}$

Figure 1: Test tasks for 4th grade students on the Classtime platform

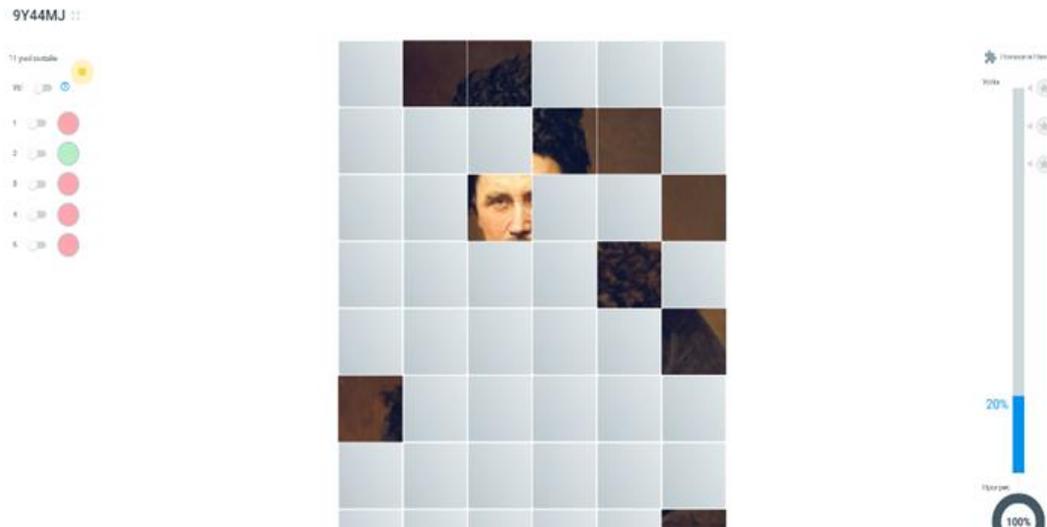


Figure 2: Interactive team game for 4th grade students on the Classtime platform

In the process of distance learning, it is appropriate to conduct group work on the Classtime platform, as it has interactive team tasks. For example, students connected to the same platform and tested must open a coded image. An example of an inter-active team game is shown in Fig. 2.

In the study of mathematics, the designer of Liveworksheets interactive work-sheets has proved its effectiveness. The advantages of this designer are that it is as close as possible to a printed worksheet. You can use your entries in the Word text editor, as well as in PDF or JPEG images, to create interactive worksheets. Liveworksheets provides the ability to create tasks and integrate them from a workbook or tutorial online. Here is an example of a task for testing knowledge from the work-book of S. Skvortsova and O. Onoprienko, which was created in Liveworksheets with the possibility of remote testing (Fig. 3). Students, performing tasks on this platform, will be able to check the correctness of the task both independently and with the help of the teacher, sending him the completed tasks.

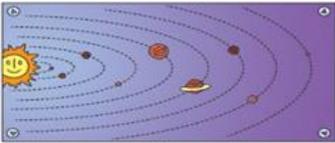
► Юпітер має 16 супутників, що на 3 супутники менше, ніж має Сатурн, а Уран має на 4 супутники менше, ніж Сатурн. Скільки супутників має Уран?

Ю. $\overbrace{\hspace{10em}}^{16}$

С. $\overbrace{\hspace{10em}}^{3}$

У. $\overbrace{\hspace{10em}}^{4}$

?




Обери вираз для розв'язання задачі.

1) $16+3$ 2) $(16+3)-4$ 3) $4-3$ 4) $16-(4-3)$

5 Обчисли трьома способами.

$64 - 39 = 25$	$33 - 16 = \square$
$\begin{array}{r} 64 \\ - 39 \\ \hline 30 + 9 \end{array}$	$\begin{array}{r} 33 \\ - 16 \\ \hline \square + \square \end{array}$
$64 - 39 = 25$	$33 - 16 = \square$
$\begin{array}{r} 64 \\ - 39 \\ \hline \square + \square \end{array}$	$\begin{array}{r} 33 \\ - 16 \\ \hline \square + \square \end{array}$
$64 - 39 = 25$	$33 - 16 = \square$
$\begin{array}{r} 60 + 4 \\ - 30 + 9 \\ \hline \end{array}$	$\begin{array}{r} \square + \square \\ - \square + \square \\ \hline \end{array}$

Figure 3: Liveworksheets – Comparison of mathematical expressions in the initial notebook of S. Skvortsov and O. Onoprienko

Recently, an international online platform for primary school students Vchy.ua has become popular in Ukraine. The International Mathematical Platform is presented in 4 languages: Platform called

Vchy.ua (<https://vchy.com.ua/>) - Ukrainian version; Happy Numbers (<https://happynumbers.com/>) - American version; Zhixuelong (<https://zhixuelong.com/>) - Chinese version; Uchi.ru (<https://uchi.ru/>) - Russian version. In Ukraine, primary school teachers use the Ukrainian version of Vchy.ua, but we will give an example in the English version of Happy Numbers for a wider range of researchers. Happy Numbers technology allows you to practically simulate tasks using a variety of sets of built-in manipulators. With the help of several blocks (numerical line, diagram, blocks of 10 elements, etc.), students approach the study of mathematics from different angles and move from concrete to abstract thinking. For example, with the help of "Happy Numbers" students learn to "think mathematically" and achieve easy learning of material, through mathematical games (Fig.4).

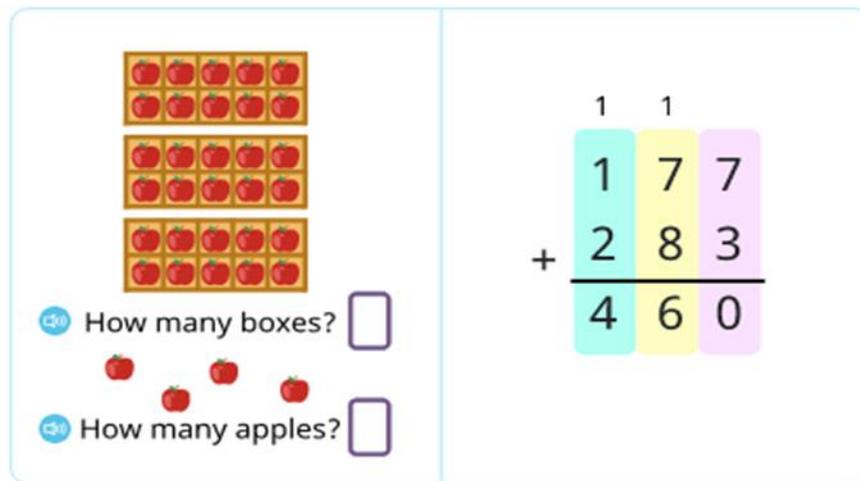


Figure 4: Game on the Happy Number platform

This online platform facilitates the interactive study of mathematics and contains more than 1,000 tasks on all topics of primary school mathematics, developed by professional methodologists and in accordance with the curriculum. The initial course of mathematics consists of a system of interactive tasks that allow one to build an individual educational trajectory for each student. In the distance learning of primary school students successfully used educational platform Vchy.ua for first graders, in particular the following sections with tasks: "Numbers and figures", "Addition and subtraction", "Geometry". The platform is designed by sections. After selecting a section, for example "Numbers and figures", a certain block of tasks is selected ("Numbers and figures up to 10", "Numbers and figures from 11 to 20", "Round numbers up to 100", "Numbers and figures up to 100"). Each block has several tasks and a mandatory final test to check students' knowledge, skills, and abilities. Thus, students of grades 1-2 form subject mathematical competence, which involves the detection of simple mathematical dependencies in the world; modeling of processes and situations with the use of mathematical relations and measurements; awareness of the role of mathematical knowledge and skills in personal and social life.

Thus, distance learning, based on IR technologies, Internet resources and services, affects the selection and structuring of content, the implementation of certain methods and forms of learning that significantly affect the development of students' skills. Note that thanks to these services the teacher can test, monitor, systematize, evaluate the activities of each student, review the results and analyze the implementation of exercises, apply various forms of assessment and control, comment and organize effective communication with students in real time.

Creating mental maps of mathematics lessons in primary school (FreeMind, Bubbl.us, MindMeister) has improved the perception of mathematical material. With the help of a mental map of an interactive lesson, it is convenient for the teacher to reproduce the content of the math lesson, because practice has shown that students remember information better if it is presented in a structured form and displayed graphically.

An example of a lesson outline in the form of a mental map created with Mind-Meister (<https://mm.tt/1858639898?t=OQkyCjYFOG>). The map was made with the definition of the topic of the lesson, from which the branches with keys (triggers) were built. They reflect the stages of the lesson.

At each stage there is an opportunity to place tasks, numbers of exercises from the textbook, electronic notebooks with tasks, references to fragments of video from YouTube and various resources of video archives. The video from YouTube is built into the map for a more detailed understanding of the topic. The interactive map has online tasks hosted on Liveworksheets, where students can perform them on any device (smartphone, tablet, computer that has an Internet connection) and be an active participants in the educational process in various forms of learning.

Scientists say that educators should use mental maps, because they put into action the whole psyche and brain: external sensations, search emotions, figurative and logical thinking, all kinds of memory, secret reserves of consciousness and subconscious. The use of mental maps in mathematics lessons in primary school improves the quality of students' knowledge, as it facilitates the perception of information through visualization (visualization of material), allows one to quickly process large amounts of material, improves understanding of ideas, concepts, processes through associative thinking. In mathematics lessons in primary school, the visualized material facilitates the perception of new information. For example, the creation by students of a mental map of a simple plot problem in the 1st grade of NUS promotes the mastery of the structure of the problem (condition, question), facilitates students' understanding of the concepts of "numerical data" and "desired task". In the process of learning mathematics (and not only) maps can be created as an advanced home-work, as an element of independent work, etc.

During distance learning it is appropriate to use a virtual interactive whiteboard – a network resource for coordinating collaboration in class, real-time communication. It is the latest learning tool that allows one to combine text, images, audio, and video files simultaneously on one platform. Now it is possible to use virtual interactive whiteboards: to create interactive posters, school newspapers (Wikiwall; Gloster); for drawing (Drawonthe.net; Flockdraw; Scribblar; CoSketch); for storing notes (Srumblr; Conceptboard); to organize group work with a variety of content with the possibility of joint editing (Educreations; Lino it; Padlet; Popplet, etc.). In particular, the Padlet interactive whiteboard facilitates the convenient placement of information that the teacher can prepare in advance so that students do not spend time searching for it. The main thing is that students must learn the material through interactive tools and teaching methods. As students explain the problem-solving algorithms, one can click on the appropriate block and the algorithm will appear on the Padlet wall (Fig. 5).

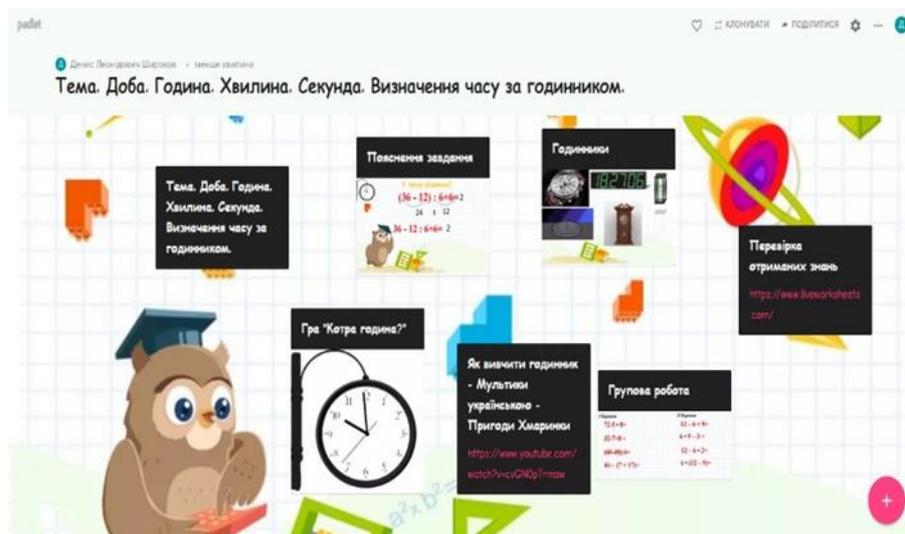


Figure 5: Stages of the lesson on the wall Padlet

During distance learning, it is appropriate to check knowledge with test tasks (Live-worksheets resource, Kahoot!). The cross-cutting skills of primary school students were manifested in working with information, carrying out analytical and synthetic activities, the manifestation of creative abilities and critical thinking.

4. Results of the Research

In order to identify the effectiveness of the use of e-resources in the study of mathematics in primary school during the period of quarantine restrictions and the organization of distance learning, a survey of students was conducted. 250 respondents from Kyiv schools took part in the survey. Answering the questions: "What tasks in mathematics did you perform with the greatest interest during distance learning?", The answers of the respondents were divided into "Calculations" - 43.8%, "Problem Solving" - 25%, "Equations" - 18, 8%, "Problems with geometric content" - 6.3%, "Working with data" - 0%, "All" - 6.3%. To the question "Do you like interactive math problems created with the LearningApps, Kahoot web resource?" most students answered 87% - "Yes". To the question "Do mental maps help you to systematize your knowledge of mathematics?" the answer was as follows: "Yes" - 75%, "No" - 12.5%, "I do not know" - 12.5%. When we asked elementary school students if they performed creative tasks in mathematics, we received the following answers: "Yes" - 87.5%, "No" - 12.5%. To the question "What math problems do you remember the most?" respondents' answers were divided into: "Equations" - 18.8%, "Problems" - 6.3%, "Expressions" - 18.8%, "Logical problems" - 50%, "Problems with geometric content" - 6.3%. To the question, "Do students like to discuss online discussion questions on the Padlet online board?" respondents answered about online discussions: "Yes" - 75%, "No" - 25%. To the question "Is it convenient to watch the lesson on the Padlet online board?" the following answers were received - "Yes" 87.5%, "No" - 6.3%, "I do not know" - 6.3%.

In order to study the problem of the use of information resources in the organization of distance learning in mathematics for primary school students, a survey was conducted among teachers. 48 schoolteachers from Kyiv took part in the survey. To the question "How do you assess distance learning in primary school during quarantine?" 51% of respondents answered, "not effectively", "effectively" - 49% of respondents. To the question "With the help of which e-resources do you organize learning in mathematics and establish cooperation between students during distance learning?" The answers were distributed as follows: GoogleClass - 41.7%, Zoom - 87.5%, Padlet - 41.1%, Google Meet - 41.7%, All-Ukrainian online school - 10.3%, My class - 12.5%, The united school - 12.5%, Classtime - 40.2%. To the question "Is there a need to create an E-environment to organize distance learning?" 95.8% answered "Yes", 4.2% of respondents answered "No". The survey showed that modern primary school teachers actively use mental maps in their work. To the question "Do you use mental maps when teaching the discipline?" The answer "Yes" was given by 91.7% of surveyed teachers, "No" - 8.3%. To the clarifying question "If your answer is positive, what resources do you use to create mental maps", teachers named the following e-resources: FreeMind - 12.5%, XMind - 16.7%, Bubbl.us - 45.8%, Mind-Meister - 58.3%. "I don't use" - 8.3% of teachers answered. To the question "Is it possible to study mathematics independently, personally during quarantine?" teachers answered: "Yes" - 54.2% of respondents, "No" - 45.8%. Among the educational inter-active services used to test the knowledge of elementary school students in mathematics, primary school teachers named: Kahoot - 54.2%, LearningApps - 25%, Google forms - 12.5%, Tests on the site "For a lesson" - 8.3%. To the question "Do you use interactive technologies during distance learning?" The answers of the surveyed teachers were distributed as follows: "Yes" - 66.7%, "No" - 33.3%. The results of the survey of primary school teachers are shown in Fig.6.

To the question "How do you understand the concepts of "IR technology", "E-resources", "E-environment"?" teachers responded by linking infrared technology to computers, software, audio and video programs to receive, process, store and transmit information; E-resources with electronic data and programs that can be used to either watch or create various educational products; E-environment with resources and programs for storing, processing and transmitting information, a virtual environment with the ability to organize distance learning and more. Note that the vast majority of primary school teachers understand the importance of these resources as an aid to learning in modern conditions, the organization of distance learning. To the question "What components of the E-environment are necessary for the effective organization of distance learning of primary school students?" teachers answered: tests, links to media, videos, presentations, interactive exercises; IR technologies and E-resources; logical tasks, explanations; video tutorials, online tasks, testing, interactive technologies, timely support, and feedback; didactic materials: theory, examples, exercises, tasks, cognitive video, cartoons. To the question "How do you manage to illustrate the teaching material in mathematics? What E-resources do you use?" teachers indicated the following e-resources: Power Point; Canva, YouTube, Quizlet, Padlet LearningApps, Kahoot. Bubbl.us., Geo-gebra.

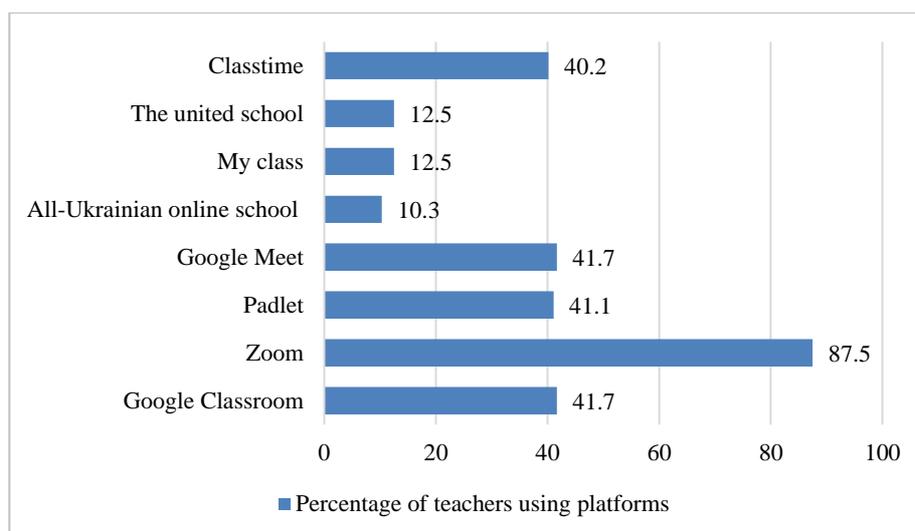


Figure 6: Results of the survey of primary school teachers

5. Conclusions

The use of information and communication technologies in primary school is not just a tribute to time, but the need and search for a new meaning of learning, which implements the principles of NUS. The end-to-end use of the e-environment in the educational process should become a tool to ensure the success of the New Ukrainian School during distance learning.

The formation of the ability of primary school students to create mathematical models of environmental processes, experience of mathematical activities in solving practice-oriented and educational-cognitive tasks provide in distance learning such subject information resources of the E-environment as mathematical interactive constructor Mathdisk, digital mathematical platform Matifik for self-study of mathematics, gamified educational portal Vchy.ua, as well as additional resources: online boards for creating interactive posters (Wikiwall; Gloster), for creating notes (Srumblr; Conceptboard), for organizing group work (Padlet; Educreations; Lino it; Rizzoma; Popplet) etc. Formative assessment in the practice of interviewed teachers of Kyiv confirms the effectiveness of the use of distance learning in mathematics in primary school interactive learning platform Classtime, especially in the creation of team games, designer of interactive worksheets Liveworksheets. The practice of conducting distance mathematics lessons in primary school with the help of mental maps (FreeMind, Bubbl.us, MindMeister) shows an improvement in the perception of mathematical material by primary school students.

The introduction of e-environment in primary school significantly expands the possibilities of the teacher, becomes the newest means of teaching mathematics in modern primary school which: expands the forms and ways of acquiring mathematical knowledge by students through the organization of practical activities with objects of study in different situations, under different conditions according to individual learning abilities; promotes the acquisition of skills needed by modern students for the realization of personal primary and social goals, mastering various ways of processing educational information by means of e-environment; creates a positive-emotional atmosphere of educational activity, due to the use of software developed taking into account the age characteristics of primary school students.

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