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MOBILE TECHNOLOGIES AND LEARNING TOOLS IN MATHEMATICS: MODERN TRENDS IN THE USE OF EDUCATIONAL INSTITUTIONS

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INTRODUCTION

The development of new and constant updating of existing specialized software for teaching mathematics determines the process of rapid integration of mobile technologies and learning tools in the modern information and educational environment of educational institutions. The presence of smartphones or tablets in the educational process is one of the defining aspects of the existence of the classroom of the XXI century, because almost every school-age child has a mobile device to connect to the Internet. Therefore, pedagogical staff of general secondary education institutions, research and teaching staff of higher education institutions have a task to interest students to use gadgets not only for entertainment but also for various educational tasks, as well as to teach pupils or students to use mobile applications to achieve educational goals, in particular in mathematics.

Nowadays, almost every gadget can be used in education to facilitate the work of a pupil or student, teacher or lecturer. The main thing is to use them pedagogically and prudently in compliance with safety rules when searching for information, working with electronic educational resources, using applied mathematical applications, working together on projects, testing knowledge through electronic testing and more. This is not only interesting, but also facilitates the activities of participants in the educational process, saves their time and makes the learning process more technological and modern.

The timeliness of the use of mobile technologies in the educational environment of educational institutions is due to such prerequisites as a high level of software development and rapid dynamics of mobile devices, sustained interest in their use, the ability to create a vivid, visual and dynamic picture of mathematics, especially in blended learning, widespread use of e-learning technologies and STEAM education.

1. Foreign and domestic experience in the use of mobile technologies and learning tools in mathematics in educational institutions

In the era of rapid development of digital technologies, their availability and ease of use radically change the whole paradigm of education. To be successful and in demand in today's world you need to use all opportunities for continuous personal and professional development. The pricing policy for modern gadgets allows you to buy a smartphone or tablet and use them to organize an appropriate educational environment. Many educational institutions around the world are already actively replacing or supplementing traditional notebooks and textbooks with mobile devices. Instead of paper diaries, students use digital diaries to set reminders, set up to-do lists, view lesson schedules directly from their mobile device, and more.

According to UNESCO[1] recommendations, mobile technologies allow to expand and significantly improve learning in different conditions, as mobile devices provide an opportunity to optimize the learning process using new advanced methods. The use of mobile technologies allows a more productive implementation of the activity approach to learning. In particular, UNESCO has implemented a project to improve the literacy of educators using mobile technologies. The regular face-to-face training course for 250 teenage girls from remote areas of Pakistan has been complemented by mobile technology capabilities. UNESCO specialists provided remote support to the girls after the course.Mobile phones were the only way to communicate with students from villages where there were no computers or reliable landlines. Teachers sent text messages to students, reminding them to complete a written assignment or re-read a textbook. In addition, the teachers asked questions that the girls answered with text messages. Such classes and feedback from the teacher allowed the students to consolidate the knowledge gained during face-to-face classes. While the UNESCO project did not use mobile phones, only 28 % of literate girls received excellent marks in the exam. The use of mobile communication has increased the number of students who received the highest score by more than 60 %.

Consider the experience of some schools in the United States with best practices in the use of smartphones in education for their positive impact on student achievement.

Ten years ago, most Onslow County schools had no computer of their own at home or free access to the Internet. With the support of the K-Nect

[1] Рекомендации по политике в области мобильного обучения. *UNESCO*, 2015. С. 17. URL: www.unesco.org/open-access/terms-use-ccbyncnd-rus

project, these schools received smartphones. They were used in algebra and geometry lessons, which helped students to visualize educational information and faster perception of the material. The study found that students who used smartphones in class wrote an annual algebra test 25 % better than the previous year. Nearly two-thirds of students reported taking additional math courses, and more than 50 % of respondents considered a career in math as a result of participating in the K-Nect project[2].

At Cimarron County School, fifth graders were allowed to use smartphones to complete quests, browse educational website content, conduct lab experiments, and communicate with their teachers. After a year of studying with smartphones, the school administration reported that fifth-graders received higher grades in math and science. Lincoln High School students used mobile technology to perform practical and laboratory tasks and write essays, and used mobile math applications in their teaching. At the same time, their "mobile learning devices" were without text messaging functions and with limited access to the Internet. Teachers reported a high level of student interest in math and other subjects since the school began using such cell phones[3].

Also in North America, the learning model is being actively implemented, in which part of the educational activities are taken out of the classroom. Students are encouraged to listen to lectures outside of school, usually on mobile devices that they carry with them everywhere. Due to this, more time in the classroom is devoted not just to the transfer of knowledge, but to study their practical application. Tasks that used to be done at school become homework, and the classroom pays more attention to the social aspects of learning.

One of the most successful countries in the world in the study of mathematics is the People's Republic of China. The constant victories of the Chinese in the World Mathematical Olympiads are evidence of this. Their classrooms can be called classes without borders[4]. First, the classrooms are equipped with at least five cameras, so that every child who is unable to come to school can view the lesson record. Secondly, there

[2] Evans J. Project K-Nect mobile learning in onslow county (North Carolina). *Project Tomorrow*. 2011. URL: https://tomorrow.org/research/ProjectKnect.html

[3] Project K-Nect Bets on Cell Phones to Help Raise Math Scores in 9th Grade Classrooms. *Project K-Nect*. 2008. URL: http://www.projectknect.org/Project%20K-Nect/Press.html

[4] Ярмола Наталя, Костовець Андрій. Класи без кордонів і онлайн уроки: у школах Китаю успішно впроваджують систему електронної освіти. *ТСН*, 2017. URL: https://www.youtube.com/watch?v=3hvQjaeLWDo&t=149s

are tablets on each desk that children use during classes. The teacher can use the tablet in the process of explaining the educational material and its visualization, conducting tests and quickly obtain their results, which helps to quickly check the success of the study of the topic, to draw appropriate conclusions. China has long used the method of "assessment for teachers, not students", because student performance shows how well the teacher explains.

The experience of the Chinese education system is being actively implemented in Turkish schools.

Xinyou, Zhao & Toshio, Okamoto[5] introduced A Personalized Mobile Mathematics Tutoring System for Primary Education, which provides math instruction, exercises and discussions for Japanese students to improve their mathematical knowledge and skills. Based on the features of mobile devices, the needs and preferences of students, the system provides a personalized tutor and / or exercises for mobile students anytime, anywhere. A Personalized Mobile Mathematics Tutoring System for Primary Education also allows students to participate in a joint discussion or share ideas in the form of text, images, audio or video sent via an email client on a mobile device. Thanks to this mobile learning system, you can increase efficiency and interest in learning. A Personalized Mobile Mathematics Tutoring System for Primary Education helps to improve arithmetic skills and increase students' interest in learning math concepts.

M-Learning is a new paradigm of learning a new social structure with mobile and wireless technologies. Smart School is one of four flagship applications for a multimedia supercorridor initiated by the Malaysian government to improve education standards in the country. With the development of mobile technology, mobile learning can help the government implement this initiative. The authors[6] offer m-Learning for mathematics, which will expand technology in the traditional classroom in terms of teaching and learning.

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[5] Xinyou, Zhao & Toshio, Okamoto. A Personalized Mobile Mathematics Tutoring System for Primary Education. *Journal of the Research Center for Educational Technology*. 2008. Vol. 4, No. 1. P. 61–67. URL: vhttps://www.researchgate.net/publication/50848636_A_Personalized_Mobile_Mathematics_Tutoring_System_for_Primary_Education

[6] Saipunidzam, Mahamad & Ibrahim, Mohammad & Mohd Taib, Shakirah. M-Learning: A New Paradigm of Learning Mathematics in Malaysia. *International Journal of Computer Science & Information Technology*. 2010. URL: https://www.researchgate.net/publication/46105850_M-Learning_A_New_Paradigm_of_Learning_Mathematics_in_Malaysia

Our world revolves around science, technology and mathematics. Developed countries have already realized the need for technical specialists and are making great efforts to ensure that students have a good understanding of technology. That is why countries such as Australia, Great Britain, China, Korea, Israel, India, the United States and Singapore have been implementing government programs in the field of STEAM education for a long time. When mobile phones, tablets and laptops are part of school education, it is much easier to conduct STEAM lessons, making the courses more interactive, accessible and exciting. According to Igor Starenky[7], Head of Innovative Education Projects at Accord Group, "STEAM education allows teachers to more clearly explain the necessary material, because next to the theory, children immediately see what it looks like in real life. Experience shows that after lessons in STEAM-classes, they discuss the acquired knowledge for a long time".

According to the results of the PISA education quality survey for 2018, 36 % of Ukrainian schoolchildren do not understand the basic level of mathematics. According to officials, the first steps have already been taken to improve this situation[8], for example, from 2021 an external independent assessment in mathematics is mandatory. Money is also allocated for the purchase of electronic textbooks with high-quality visual images for a good visual perception of educational material.

According to the rating of the website "Osvita.ua" one of the leading cities in Ukraine according to the results of external independent assessment in mathematics is Lviv, and this is not surprising, because the city's schools are trying to introduce new information technologies in education[9]. Schools use multimedia boards, and even children who were not previously interested in the subject are now preparing for lessons to work on. Teachers point out that children are interested in working with new technology because it helps students combine visual, auditory, emotional and tactile memory. Teachers use software that contains ready-made materials for lessons, modules for exercise-tests in game forms, applications on the tablet, more than a thousand presentations and much

[7] Старенький Ігор. Що таке STEAM-освіта і чому вона така популярна *Українська правда*. 2019. URL: https://life.pravda.com.ua/columns/2019/03/26/236224/

[8] Молчанова Наталія. ЗНО з математики стане обов'язковим. *Укрінформ*, 2019. URL: https://www.ukrinform.ua/rubric-society/2844462-ganna-novosad-ministerka-osviti-j-nauki.html

[9] Красовська З. Е-школа у Львові: як технології перетворюють уроки на гру. *Твоє місто.* 2017. URL: http://tvoemisto.tv/exclusive/eshkola_u_lvovi_yak_tehnologii_peretvoryuyut_uroky_na_gru_89174.html

more. The experience of school № 210 in Kyiv is interesting, where the schedule of lessons is written in the form of a QR-code, students receive homework on social networks, and student projects are evaluated by the number of likes[10].

Ukraine is also developing in the field of STEAM education. The Conceptual Principles of Secondary Education Reform and the Concept of the New Ukrainian School have been published, where one of the main competencies of schoolchildren is the ability to think logically and mathematically. Interestingly, the focus of STEAM lessons is not the teacher, but the practical task that needs to be solved. Students learn to find solutions through trial and error, rather than learning the "dry" theoretical part. STEAM-approach to learning is confidently included in international educational programs and in accordance with state policy in the field of education is actively implemented in Ukrainian educational institutions.

1.2. Analysis of network resources for the prospects of using mobile technologies and learning tools in mathematics in today's conditions

The use of mobile technologies and learning tools in mathematics provides an opportunity for participants in the educational process to diversify mathematics lessons, to demonstrate a vivid experience of learning mathematics using a variety of tools of network resources. For example, with **the Ruler application** you can accurately measure the size of any object in three measurement modes: Screen ruler – objects placed on the phone screen; Photo Ruler – Take a photo of an object whose length you want to measure, and then use a reference object to measure the size of others. Image from the gallery – select the finished photo and use the previous method. **The Smart Protractor** also has several conveyor modes that easily measure the angles and inclination of the object.

The online resource **Matific** was developed by a team of experts in the field of education to consolidate students' conceptual understanding of the subject in the study of mathematics in grades 1-6 and in preparation for school. This is an international educational project in mathematics, translated into forty languages, including Ukrainian. All content is consistent with the state curriculum and textbook. Matific interacts with students through an exciting learning platform, and gives students the opportunity to master the material in a playful way, stimulating their thinking. Matific exercises are flexible in

[10] Скрипник Г. В. Використання мобільних додатків для проведення навчальних досліджень під час вивчення предметів природничо-математичного циклу. *Комп'ютер у школі та сім'ї.* 2015. № 3. С. 28–31.

terms of their use in the lesson: they are great for presentation and warm-up at the beginning of the lesson, for moving to a new topic during the lesson, for summarizing or for use at any other stage of the lesson. Each exercise is accompanied by guidelines for teachers, which explain the pedagogical aspects of how to understand new concepts and develop new skills. Each exercise is also accompanied by a proposed lesson plan, which outlines the best ways to create a sequence of Matific exercises for the lesson that will best contribute to the goal of learning. Basic tools are offered to mathematics teachers: reports on the results of student surveys, on progress in achieving the learning goals of each student and the class as a whole. This program works on smartphones and has two applications "Matific Student" and "Matific Teacher". To gain access, the school must apply and obtain a free license to use[11].

Mobile application for the development of oral account **Quick Brain**[12] is suitable for children of all ages. Like all educational games from this developer, Quick Brain has a good design. Using the game at the beginning of the lesson sets the children's brains to work and encourages students to focus on math. This game helps to develop students' intelligence by quickly solving various mathematical problems of addition, subtraction, multiplication and division, and a limited amount of time stimulates the brain to work faster and more efficiently. When you open one of the suggested games, the countdown timer starts for each question, and after each correct answer the difficulty increases. This game is best suited for the fifth grade, where topics such as "Addition and subtraction of natural numbers" and "Multiplication and division of natural numbers" are studied. To begin with, you can choose the game "Training", where the child can choose which skill of verbal arithmetic he wants to train, specify the time to think about one issue, type of game and difficulty, and only then move on to speed games. By completing tasks, the player receives coins that can be spent on additional attempts to pass the levels. After all, after a mistake, each level will have to go through again, which has a positive effect on motivation. The game has a multiplayer called "Arena", where you can play with both friends and random opponents. The winner is the player who solves all tasks faster and more correctly. Quick Brain is a free app with a user-friendly interface, and daily workouts will help you gain and consolidate new skills.

[11] Matific.com. Навчання XXI сторіччя : website. URL: https://www.matific.com/ua/uk/home/our-product/how-to-use/

[12] Сафонова Александра. Quick Brain – Карманные упражнения для мозга. 2018. URL: http://4pda.ru/2018/06/28/352091/

To study the topic “Ordinary fractions” you can use the application **Fractions. Smart Pirates. Free**[13]. This is an easy and fun way to learn fractions with Pirates of the Caribbean. The application is divided into four islands, ie games, each of which is divided into three levels of difficulty. For example, on the first island we learn to recognize fractions. To do this, you need to calculate what part of the pizza is left for the pirates in the boat, and if there is a mistake, the pirates will get into trouble. On the second island, pirates must cross the abyss. To do this, they must balance the bridge. In this game, the child helps the pirates to choose a basket with an equivalent share. On the third island, the student chooses a watermelon with more than the one-eyed captain. And on the fourth island, our pirates want to eat a cake, so the child has to add pieces and click on the correct answer. If the answer is correct, the pirate will eat the cake, and if not, the parrot will take the pieces.

Fraction Calculator **OMS Fractions Calculator** is a handy tool for adding, subtracting, multiplying and dividing common fractions and mixed numbers. The calculator calculates the answer and shows a detailed step-by-step solution. During the solution, all calculations are described in detail: conversion of mixed numbers into irregular fractions, reduction of fractions to a common denominator, reduction of the result, conversion of the solution from an incorrect fraction into a mixed number. This calculator, which details the steps of solving problems, will help students better understand how to solve problems with fractions. And it will always help parents to check their children’s homework. The calculator was developed by Ukrainian M. Dovzhyk[14], who has one of the most popular mathematical sites in Ukraine ua.OnlineMSchool.com, which is correctly displayed on both personal computers and mobile devices. The website contains sections – exercises, calculators, reference book, tables and formulas.

Exercises are online problems to solve that can improve your math skills. This section contains problems in mathematics of different levels of complexity, which are offered for independent study. Problem solving is the best way to prepare for tests, exams or math tests.

Calculators are a collection of online calculators that help you solve math problems quickly. Using an online calculator, you can solve a problem or check the correctness of your own solution. To solve the problem it is enough to choose the necessary online calculator and enter

[13] Fractions. Smart Pirates. Free : website. URL: https://play.google.com/store/apps/details?id=ru. vspacesfractionsFree

[14] Довжик М. В. OnlineMSchool. 2011-2022 : website. URL: http://ua.onlinemschool.com/

these problems, the program will perform all calculations and show the answer with step-by-step solution in expanded form, which will help to better understand incomprehensible material, find and correct errors or verify correctness its solution.

Handbook – a collection of theoretical materials with examples and videos.

Tables and formulas are important tables, properties, and formulas that are often used to solve math problems.

The **LearningApps.org**[15] website is a service to support learning and teaching processes through small interactive modules. These modules can be used directly as learning resources or for independent work. The purpose of the service is to create a public library of independent blocks suitable for reuse and modification. Blocks are not included in any specific scenarios or programs, so they are not considered holistic lessons or tasks. Instead, they can be used in any relevant methodological scenario.

LearningApps.org has the following tools that allow the teacher to prepare high-quality electronic visual aids, audio and video materials, as well as remotely communicate with students and colleagues:

- Notebook – the simplest text editor;
- Pinboard – an application for placing multimedia content (text notes, pictures, audio, video) with the imitation of attaching stationery buttons to the cork board;
- QikPad – an online editor in which several Internet users can work together;
- Mindmap is an easy-to-use and visual graphics map editor. It can be used both to demonstrate pre-compiled maps and to compile a mental map in class;
- Audio and video content – an application that allows you to not only download audio or video files, but embed them in applications;
- Calendar for scheduling in the form of a table;
- Grid – an application for creating a collection of multiple exercises to share with other users;
- Chat for online communication.

With the help of service templates you can create the following types of exercises: selection, distribution, sequence, text filling and online games. That is, the teacher can choose the exercises for his lesson and run them to perform on the interactive whiteboard. Under each exercise there

[15] LearningApps : website. URL: https://learningapps.org/about.php

is a QR-code that allows you to open it on your smartphone and do it in parallel with the class.

The teacher can create groups for which he will select exercises and invite students to work. Ready-made exercises are easily embedded in blogs and websites. The application can be used offline, and tasks can be created and edited online using various templates. The teacher can create their own or use ready-made exercises to solve specific problems in their subject area to consolidate theoretical and practical knowledge, their verification; activation of cognitive activity of students; application of different types of intelligent interactive tasks; organization of various competitive events.

Learning.ua[16] – educational application, where children can choose tasks independently, parents or teachers can create classes for children, online tests, interactive tasks in the largest application of the portal of interactive e-learning. In order to be able to use the educational online resource as an auxiliary tool to improve the teaching process, a teacher needs to register on the site as a teacher. After registration, he will be able to add Learning.ua exercises to his learning process through his account. The format of presenting the material on the site is perfect for consolidating the material at the end of the lesson as an interesting game task. It is also possible to train here for an external independent evaluation and to pass trial tests of previous years. You can work with the site in any convenient way: from interactive whiteboards, computers, tablets or smartphones. To access all tasks around the clock, you need to register and buy a Premium account.

GIOS[17] is a modern platform for organizing mathematics education, which is stamped by the Ministry of Education and Science of Ukraine. Methodist teachers turned the school program for grades 5-9 into interactive lessons with animated video explanations, reference notes and diagrams, interactive tests and practical tasks. There are two options for using the platform – the purchase of the package "Class", but provided that at least 15 students join one teacher, or "School" from 200 to 300 students. The advantages of the platform are that each student is attached to a specific teacher who can review student progress, quickly monitor and evaluate, maintains general class statistics. The teacher selects the materials to be used in the lesson and gives them to students for self-study, can use fragments of the lesson from the platform directly in the classroom (together with students, frontally, reviewing materials). All you need is a

[16] Learning.ua : website. URL: https://learning.ua/

[17] GIOS : website. URL: https://gioschool.com/ua

computer, internet and a projector. Also, GIOS has video tutorials, reference diagrams and examples of tasks that are not in the textbook. The child not only repeats the material passed with the class, but also learns a lot of interesting, new and useful. The simple interface helps to easily master and quickly start using the platform. And learning online is always fun for children, because they are growing up in a digital world that is a natural environment for them. It is convenient that the system independently checks the homework of students, which is done through a platform that saves a lot of time. There are no mobile applications, but the site is flexible and correctly displayed on the smartphone screen.

The **PhotoMath**[18]cellular application helps you instantly scan printed text and handwritten math problems with your device's camera, or enter and edit equations with a calculator. PhotoMath breaks down every math problem into simple, straightforward steps so that the user can really understand the basics. There are four buttons on the screen: History, Light, Calculator, Help. The History button shows the latest scans. The "Light" button turns on the LED of your phone if the natural light is not enough for a quality photo. The "Calculator" button switches to the mode of manual entry of examples. The Help button shows a short PhotoMath tutorial that greets the user when they first start the program. PhotoMath works without an Internet connection.

Like any calculator tool, PhotoMath's capabilities can be misused. Students often use this mobile application to solve math homework, get answers and do not learn concepts. However, using PhotoMath correctly can help you test your work and show you how to come up with the right answer. Analogs of Mathpix, MalMath, Mathway, MyScript Calculator have mostly inconvenient interface and fewer features.

The game "King of Mathematics"[19] is an application in which in order to determine the level of knowledge of a student in a particular section of mathematics, you need to complete the tasks of several books, each of which has 9 sections. The very first book is called "Addition", which asks how many will be, for example, "2 + 2" or "22 + 22". Depending on the speed with which the problem is solved, the child is assigned points that affect the progress of learning mathematics.

There are 12 books in the game, thanks to which you can study the following mathematical sections: addition, subtraction, multiplication, division, geometry, fractions, powers, statistics, equations and mixed

[18] PhotoMath : website. URL:https://photomath.com

[19] The game "King of Mathematics" : website. URL: https://play.google.com/store/apps/details?id=com.oddrobo. kom&hl=ru&gl=US

books, which contain questions from all these sections. With each level it becomes more difficult: unknowns, percentages, areas, perimeters, etc. appear. There is a basic version for Apple devices, which contains only the first three books: addition, subtraction and one mixed, and the full version for iPhone OS and Android must be purchased.

The possibilities of mobile in terms of the **Converter of Quantities** type can be used in mathematics lessons when studying the topics "Units of length", "Units of area", "Units of mass", etc. The page for converting some values to others looks very simple and not overloaded, resembles a calculator, contains two boards, with the initial dimension, which is converted, and the desired value, which we convert.

GeometryPad[20] is an application that allows you to create fundamental geometric shapes, explore and change their properties and calculate indicators. Forms are displayed in a scrollable and scalable workbook with a rectangular coordinate system.

For teachers, it allows you to add an interactive component to the teaching of geometry. The program has built-in tools:

- Movement and scale (to create, change and measure a shape).
- Point (contains the name and color of the point).
- Line (distance between points), middle of lines (show or hide the middle for lines and sides of a polygon), parallel, perpendicular, and tangent lines.
- Angle (angle with an accuracy of 1 degree, adjust the style and color of the angle line, use tools to create central and inscribed angles and to study circle theorems).
- Triangle (creating triangles of certain types, adjusting the style and color of the sides, calculating the perimeter and area of the triangle, the interior angles of the triangle and the length of its sides).
- Triangle lines (create the height, bisector and midline of the triangle, calculate the length of the sides of the triangle).
- Quadrilateral (creation of quadrilaterals of certain types, calculation of the perimeter and area of the quadrilateral, internal angles of the quadrilateral and the length of its sides).
- Circle and its radius (calculation of radius, perimeter and area of the circle).
- Text annotations (creation of floating and fixed text annotations) and measurement tool (to determine points of intersection, distance between points and angles between lines).

[20] GeometryPad : website. URL:https://apps.apple.com/us/app/geometry-pad/id517461177

Geometryx[21] is a program that allows you to quickly and easily calculate the most important values and parameters of flat and three-dimensional shapes. The application calculates the area, perimeter, length of diagonals, volume, coordinates of the geometric center, height, side length, degree of angles, radius, edges, arc length, base area, side surface area and total surface area of three-dimensional geometric shapes. This simple calculator, which uses trigonometric functions, the Pythagorean theorem and Thales' theorem, calculates various parameters of geometric figures. It is enough to enter all known information, and if it is enough, the application will give the lengths of all heights and diagonals, angles and other useful facts about the figure. The application has a section with all the formulas used, which you can look at to understand the material and next time solve the problem yourself.

ICrosss[22] is an application for constructing sections of different three-dimensional shapes, allows you to view a shape in space, as well as determine the type of shape obtained in the cross section of the polyhedron. It allows you to build sections of each of the available polyhedra with a given plane. The plane can be constructed at three points mounted on the surface of the polyhedron. The application supports the following types of polyhedra: regular polyhedra (Platon's bodies), pyramids, prisms, Archimedean bodies, etc. Polyhedra are displayed in 3D, which allows you to rotate them in any direction. Used to display the style of the blackboard, chalk and specially selected fonts improve the perception of information. There are several view modes that you can use when building a section: 3D mode, diagram mode (3 projections), 3D section mode, which is only available when you have already built a section. It is possible to print and mail a polyhedron or its cross section. It is possible to view information about the selected polyhedron, including a brief description, number of faces, vertices, edges, web links for more information and useful formulas. Polyhedra are presented as a simple list grouped by category. Additionally, you can select the polyhedra that interest you and add them to your favorites list.

GeoGebra[23] is a free dynamic math program for all levels of education that combines geometry, algebra, tables, graphs, statistics, symbolic calculations and arithmetic in one easy-to-use package. Www.geogebra.org allows you to share interactive teaching and learning

[21] Geometryx : website. URL: https://play.google.com/store/apps/details?id=com.famobix.geometryx &hl=uk&gl=US

[22] ICrosss : website. URL: https://iappideas.com/

[23] GeoGebra. URL: https://www.geogebra.org/?lang=uk

methods, resources created with GeoGebra. This is the most popular program in dynamic mathematics in the world. She has received many awards. GeoGebra supports STEM education and innovation in teaching and learning around the world. Key benefits: free to use software for teaching, learning and assessment, fully interactive, easy-to-use interface with powerful functionality, access to a constantly updated resource repository at www.geogebra.org, a fun way to really see, feel and understand math and natural sciences, possible adaptation to any curriculum or project.

International GeoGebra Institute, a non-profit organization, produces the most popular free math programs and calculators, which are also available on mobile devices.

GeoGebra Classic combines the capabilities of all the company's other products, such as graphics, geometry, 3D, spreadsheets, computer algebra and statistics in one powerful package.

Graphing Calculator GeoGebra will help to build graphs of functions and equations, find special points of functions.

GeoGebra Geometry builds triangles, draws points, draws parallel lines, and more.

3D Graphics GeoGebra will allow you to easily solve mathematical problems in space, build 3D functions and surfaces, create geometric constructions in 3D. If augmented reality is connected, you can place mathematical objects on any surface and walk around them.

GeoGebra Scientific Calculator is an easy-to-use calculator that can be used in tests in a special exam mode.

GeoGebra SKA Calculator for plotting functions, solving equations and finding special points of functions.

The Effect of Using Mobile Applications (GeoGebra and Sketchpad) on the Students 'Achievement was described by scientists Alkhateeb, Mohammad & Duwairi, Ahme[24].

Interesting and visual games based on mathematical laws often arise from geometric problems. In the **Pythagorea**[25] application, you need to build shapes and find distances on the coordinate plane. The application

[24] Alkhateeb, Mohammad & Duwairi, Ahmed. The Effect of Using Mobile Applications (GeoGebra and Sketchpad) on the Students' Achievement. *International Electronic Journal of Mathematics Education*. 2019 URL: https://www.researchgate.net/publication/332737791_The_Effect_of_Using_Mobile_Applications_GeoGebra_and_Sketchpad_on_the_Students'_Achievement

[25] Pythagorea : website. URL: https://play.google.com/store/apps/details?id=com.hil_hk.pythagorea&hl= uk&gl=US

presents tasks from individual sections of geometry with varying degrees of complexity (in total, the application has more than 300 levels). This application can be used to master geometry in the form of games. It covers the following topics of the school course: length, distance, area; parallels and perpendiculars; angles and triangles; bisectors, medians, heights, median perpendiculars; Pythagoras' theorem; circles and tangent lines; parallelograms, squares, rhombuses, rectangles and trapezoids; symmetry, reflection, rotation.

Euclidea[26] is a collection of interactive geometry problems containing 120 tasks of increasing complexity, 10 beginner levels, 10 construction tools, automatic construction verification, dynamic change of drawings, hints and research mode. The application helps to organize learning about geometric constructions in the form of a game, for example, with the help of a compass and a ruler. An additional motivation is that you need to find a solution for the minimum number of elementary constructions. If necessary, you can view tips on the sequence of steps or useful material on geometry.

The analysis of network resources is represented by educational platforms that widely cover the process of teaching mathematics in educational institutions. In general, many multifunctional mobile applications of mathematical orientation are freely available. The lesson of mathematics should fully develop students' mathematical abilities, logical thinking, computer skills and more. Mobile applications are a language understood by today's children who work actively and enthusiastically with them. Therefore, an individual educational institution or a specific teacher will always be able to choose the optimal software for themselves. Applications are constantly updated, which increases the number of their functions and overall performance. We believe that the use of mobile technologies and learning tools in mathematics in the educational process of educational institutions has great prospects.

3. Methodological aspects of the use of mobile technologies and learning tools in mathematics in educational institutions

After years of controversy between teachers and students over the use of smartphones at school, new educational trends and the introduction of blended learning are actually encouraging the use of these devices. There is a rapid development of educational software and telecommunications. Modern gadgets are equipped with significant multimedia capabilities and

[26] Euclidea : website. URL: https://www.euclidea.xyz/

combine many different functions in one portable device. The storage capacity allows you to download and install a large number of different mobile applications. Connecting devices to local networks and the Internet provides fast and high-quality data transfer. Different types of content make learning more lively and interesting. With the help of mobile technologies and tools, it is possible to simplify students' access to information by "moving" theoretical material from difficult textbooks to video, audio or e-books, etc. To enhance interaction, teachers can use mobile devices to conduct surveys or tests. Get quick feedback through face-to-face conversations via messages or chat with the class in a group discussion forum.

The task of mobile technologies and learning tools in mathematics is to provide students with the opportunity to independently choose educational content, the level of complexity of tasks, evaluate their results and quickly solve problems, performing the necessary tasks to consolidate the material; the ability to learn according to the individual educational trajectory, at its own pace, at a convenient time, regardless of the actual location of the participant in the educational process, using different ways of presenting information in the form of text, graphics, images, videos.

Mobile technologies provide:

− free access to all possible educational content; constant control of knowledge, both by the teacher and the student, for example through online testing;

− the ability to use cloud technology, ie to have constant access to cloud storage and materials of joint projects, which allows to achieve a previously inaccessible level of cooperation;

− implementation of game technologies that are the most progressive and effective for learning;

− availability of space that does not limit the student's classroom and teacher as the only correct and possible way of learning;

− development of interdisciplinary links between mathematics and computer science;

− formation of competent use of mobile technologies;

− implementation of an individual approach, development of creative and research abilities, development of students' independence[27].

Learning with smartphones helps to increase the general technical literacy of students, as they acquire a range of information skills and abilities when working with gadgets. Mobile learning fully meets the

[27] Heick T. 12 Principles Of Mobile Learning. *Teachthought*. 2018. URL: https://www.teachthought. com/learning/12-principles-of-mobile-learning/

demands of modern society: learning not only theoretical but also practical.

If we talk about the possibility of using a smartphone or tablet in math class, it should be noted that depending on the type of application, it is possible to use it in class when explaining new material (at the time of finding new laws and rules of math); in the process of working out and consolidating the acquired knowledge; for independent work and self-examination. Such technical features of the organization of the educational process open the door for the practical application of mobile technologies in education – we can say that we have a new era, the era of mobile learning. The introduction of mobile technologies and learning tools in educational institutions is not a tribute to fashion, but a necessity of today. But the result also depends on what methods the teacher uses during teaching.

"Teaching method is an orderly way of interdependent activities of teachers and students, aimed at solving problems of education, upbringing and development in the learning process"[28].

Mobile learning is a field that is developing very fast and is seen as future learning. Mobile devices improve learning anytime, anywhere, providing access to learning resources, even outside of school. Claire O'Malley et al. [29] define mobile learning as "any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile".

We can distinguish the following methods of mathematical mobile learning:

- verbal – is work with electronic textbooks, information from the Internet, mobile reference books with formulas and theorems;
- visual – work with educational applications, videos, etc .;
- practical – research work, computational experiments, etc.

Currently, the most common method is blended learning, which combines traditional teaching methods (lecture and practice) and online learning using modern tools and systems, which allows students to make better use of practical time. The main advantage of this method is not only

[28] Інноваційні інформаційно-комунікаційні технології навчання математики : навч. посіб. / Т. Г. Крамаренко та ін.; наук. ред. М. І. Жалдак. Вид. 2, перероб. і доп. Кривий Ріг : Криворізький державний педагогічний університет, 2019. С. 22.

[29] Claire O'Malley, Giasemi Vavoula, Jp Glew, Josie Taylor, Mike Sharples, et al. Guidelines for learning/teaching/tutoring in a mobile environment. 2012. P. 7. URL: https://hal.archives-ouvertes.fr/hal-00696244/document

in the active use of technology, but also in a combination of different teaching methods and types of work. Today's students want to learn fast, efficiently and mobile, and this is one way to give them that opportunity.

The method of blended learning is based on various forms of its implementation.

Inverted classroom as a pedagogical model in which the typical presentation of lectures and organization of homework are presented in reverse. Students watch short video lectures at home, and the class spends time on exercises, project discussions, discussions. Video lectures are often seen as a key component in the inverted approach, such lectures are either created by the teacher and posted on the Internet, or stored in an online file sharer. The availability of video viewing along with pre-recorded lectures has become so widespread that it makes it an integral part of the concept of inverted learning.

The concept of inverted learning is based on such ideas as active learning, involving students in joint activities, blended learning system and more. The value of inverted classes is the ability to use teaching time for group classes, where students can discuss the content of theoretical material, test their knowledge and interact with each other in practice. During classes, the role of the teacher is to act as a coach or consultant, encouraging students to independent research and teamwork[30].

Rotational form – in which the class is divided into groups based on personal needs and level of knowledge of each student. For example, one group discusses a topic with a teacher's explanation, while another works independently using innovative technologies, and a third works in a team and solves problems. Students have to go through each group during the lesson, where one completes tasks online and the other develops a project. Groups should consist of at least six students, ie this form of work is suitable for large classes.

Flex – a convenient form of blended learning, if there is a large classroom in which children are seated alone with their device. Everyone has their own task, selected according to the level of knowledge, and time to complete it, and if there is a problem, then turn to the teacher. He can form a group of children who have the same problems with the processing of materials and tasks and discuss their solutions. In the case of a large class, there should be at least two teachers so that other groups do not wait

[30] Логинова А. В. Особенности использования и принципы функционирования педагогической модели «перевернутый класс» *Молодой ученый*. 2015. № 9. С. 1114–1119. URL: https://moluch.ru/archive/89/18143/

too long. Students should be as mobile as possible and take into account their needs to study the topic.

Flexible form, which requires skills of self-organization and discipline, is suitable for exam preparation. The advantage of this model is the flexibility of load scheduling and distribution.

In highly developed countries, realizing that mathematics should be studied as an applied science because children do not understand where to use it outside the classroom, they developed a form of **STEAM Education**, which combines science, technology, engineering, art and mathematics in curricula, natural and scientific component and the use of innovative technologies in education.

Instead of teaching subjects as independent, unrelated disciplines, such lessons are clearly defined, design and research, with an emphasis on interdisciplinary learning. Focusing on **STEM education** (science, technology, engineering and mathematics) is widely recognized as necessary to train 21st century workers who need a variety of tandem skills. STEM research children acquire important skills such as critical thinking, problem-solving, communication, collaboration and innovation.

The inclusion of STEAM in the curriculum in mathematics involves:

− different learning opportunities: the inclusion of science, technology, and art can be a phenomenal catalyst for any student, especially for those whose strengths are overlooked in traditional teaching approaches to mathematics; STEAM education allows teachers to create more diverse learning opportunities and increase the potential for learning success for all types of students;

− broader skills: STEAM education is based on the idea that art can be approached as an applied subject as well as mathematics as a science;

− emphasis on teamwork: one of the cornerstones of a successful STEAM program is the emphasis on teamwork, communication and collaboration in a project environment;

− holistic education: today the technology-oriented world only increases the need to integrate STEAM areas into mathematics education; educational institutions are responsible for training whole individuals who are ready to reveal the full range of their talents and express themselves; students of all ages and types of study are engaged, motivated and actively interested in mathematics.

BYOD[31] (Bring Your Own Device). Students are invited to use their gadget in class to search for information, watch videos. Students are

[31] Кравчук С. Що таке BYOD? URL: http://thefuture.news/byod

interested in being able to use their tablet, smartphone or computer during the lessons, to which they are accustomed and receive information in the usual way (through videos, articles, chats, etc.). The learning process itself brings novelty and looks more modern and interesting. Students are more confident in their own education outside the classroom. For a teacher, working online allows you to quickly get processed results, conduct surveys, do not spend time working with teaching materials and create your own database of necessary bookmarks. Thanks to BYOD, you can not only make the learning process more interesting, but also speed it up.

Interactive learning is a pedagogical technology that involves students in learning through active interaction with peers in the classroom. This allows in practice to apply previously obtained theoretical information, systematize and critically rethink them. This format helps to reveal the creative potential of each student. For modern students, gadgets and devices (communication on social networks, watching movies, listening to music, etc.) become the key means of interaction with the outside world. This should not be ignored, but on the contrary, it is much more effective to actively involve the latest Internet technologies in the educational process. This will help you interact with your students in a format that is convenient for them.

Interactive exercises are used to consolidate the studied material. Students do them with a tablet or smartphone. These exercises may include compliance, filling out an open-ended form, and using mobile applications. Students are constantly using social networks, so uploading educational material to online communities or distributing relevant educational content is relevant.

Note that teaching mathematics using mobile technology has several development strategies. In particular, they can be used for two different types of learning: active and passive.

Active learning engages the student through activities and discussions that reinforce the concept. The benefits of active learning are that it helps students connect with real life. Ultimately, it gives them a better understanding of their place in the world and facilitates perception of the world through analysis, evaluation and collaboration. Active learning can also improve students' attention by encouraging meaningful discussions that have more than one correct answer to a question. Many educators consider active learning to be non-digital, but online games and tools that promote real-time collaboration, on the other hand, promote such learning.

Through passive learning, students are responsible for absorbing and storing information at their own pace. Passive learning develops skills such as reading, analysis, listening and writing. This method relies primarily on convergent learning, ie there is a clear answer to the question. Traditional tests and quizzes assess students' understanding of concepts learned through passive methods. Passive learning lessons give teachers a clearer understanding of how class time is spent and what is learned on a daily basis. They also offer a standardized presentation of learning material that can benefit some students. Reading something on a tablet, watching a training video or watching an online lesson are ways in which technology can facilitate passive learning.

Also with the help of mobile technologies you can organize the following forms of learning: frontal, individual, in pairs and groups. Mobile devices allow you to work with Internet resources and applications in a way that will satisfy each student, and will allow him to work independently and at his own pace, according to their learning abilities. You can use different types of games to diversify your math education, such as solving puzzles and crossword puzzles, and brainstorming, which can be done with mobile technology and learning tools. The variety of forms of interaction and communication provides a wide range of opportunities to involve students in educational activities. Forums, polls, voting, comments, subscriptions, sending personal messages, etc. provide various forms of collaboration. It is easy to share interesting and useful links to other resources on the social network.

However, teachers need to set healthy limits on the use of mobile technologies and learning tools in mathematics, ie they should be used only when it really improves learning and makes lessons more exciting and effective. For example, at the beginning of a new topic to visualize theoretical material, or at the end to monitor performance. During the study of the topic, the teacher has the opportunity to assess the activity of students, stimulate participants in the learning process, provide a broad demonstration visualization and filtering of content. For students, this is an opportunity for continuous learning, interaction between themselves and the teacher.

However, the main task of participants in the educational process who use innovative technologies and learning tools – to optimize the process of productive activities in the real educational information environment of the educational institution and in the virtual space of educational and entertainment content, mobile applications, social networks, managers, etc.

CONCLUSIONS

Current trends in the use of mobile technologies and learning tools in mathematics in Ukraine face a number of problems and obstacles associated with "the predominance of traditional approaches in education, its lack of dynamism; with the specifics of their use in the regions, in particular, uneven Internet access and different financial situation of Ukrainian families, with the motivation, willingness and ability of teachers and students, teachers and students to use mobile technologies and learning tools to provide and receive educational services"[32]. But the use of such innovative technologies gives ample opportunities for students to replenish the baggage of knowledge, teachers – to improve professional skills, all participants in the educational process – to develop creativity, to form information and communication and information competencies, etc.

Having studied domestic and foreign experience in the use of mobile technologies and learning tools in mathematics in educational institutions, it is safe to say that domestic teachers are taking all necessary steps to modernize methods of teaching mathematics and organization of the educational process in general.

Various mathematical applications for mobile devices, their features and functionality were considered and studied. Their analysis of practical significance proves that the selection of mobile applications of mathematics teaching covers a wide range of school mathematics courses and can be useful for subject teachers, graduates – future teachers of mathematics and computer science, specialists in teacher training. Methodological aspects of the use of mobile technologies and learning tools in mathematics have been studied. Methods of mathematical mobile learning are described. Their essence and possible scenarios of interaction of participants of educational process are considered. Different forms of implementation of blended learning are described, which combine traditional teaching methods and online learning with the use of modern tools and systems. Note that the ways of teaching mathematics with the use of mobile technologies and learning tools have different development strategies. The key factors of active and passive learning must be taken into account in the process of preparation and implementation of innovative methods of teaching mathematics.

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[32] Соя О. М., Тютюн Л. А., Косовець О. П. Загальна характеристика мобільних технологій та засобів навчання у закладах загальної середньої та вищої педагогічної освіти. Pedagogical and psychological sciences: regularities and development trends : Collective monograph. Riga, Latvia : "Baltija Publishing", 2020. P. 366-367. DOI https://doi.org/10.30525/978-9934-26-023-0-22.

SUMMARY

Mobile technologies and learning tools for mathematics have become an integral part of the process of providing educational services in the context of blended learning and STEAM education. Therefore, the topical issue is the study of current trends in their application. Analysis of the practical significance of mathematical mobile applications for further prospects for their use in educational institutions requires special attention. The article highlights foreign and domestic experience in the use of mobile technologies and learning tools in mathematics. The analysis of network resources for the practical possibilities of using the content of mobile applications of mathematical orientation in educational institutions is carried out. Methodological aspects of the use of mobile technologies and learning tools in mathematics are considered. Innovative methods and forms of teaching are described, the implementation of which includes mobile technologies and means of teaching mathematics.

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