# REMOTE SUPPORT OF PRIMARY SCHOOL MATHEMATICS LESSONS

*Andrii Lytvynov*
*Oleksandr Dovzhenko Hlukhiv National Pedagogical University*
*Hlukhiv, Ukraine*
*andrii.lytvynov@gnpu.edu.ua*

**Introduction.**

The features of the modern educational process include the constant updating of information and easy access to it. This realization has underscored the necessity of updating educational technologies to ensure the high quality of educational services. Furthermore, the widespread impact of the pandemic and the implementation of quarantine measures have accelerated the adoption of information technology. Consequently, the scientific community has initiated extensive discussions on various aspects of e-learning, including its advantages and disadvantages, as well as effective methods for optimizing the educational process. The problem of finding effective technologies for e-learning education has become a focal point for scientists, as pedagogical activities require specialists to continually adapt to new and rapidly changing conditions, process the influx of new information, and introduce pedagogical innovations, etc. (Lytvynov et al., 2022).

Today, as the country faces challenging conditions due to military aggression, the education system is encountering significant difficulties. Distance learning is due to the use of the latest pedagogical technologies that meet the needs of modern education.

Distance education is one of the forms of education. Particularly in times of significant obstacles, such as limitations on students and teachers being physically present in the same educational institution, distance learning emerges as an essential direction in education's development. It serves as a valuable auxiliary tool for working with gifted students and applicants requiring special learning conditions. Under such circumstances, the relevance of distance learning becomes particularly evident.

Distance education represents a fundamentally distinct approach from traditional methods, integrating diverse forms of educational activities such as communication, collaboration, cooperation, independent study, and ongoing self-improvement. This approach relies on technical support provided by information and communication technologies (ICT).

The shift to distance learning demands a broad spectrum of knowledge, skills, and abilities from teachers. This necessitates a reevaluation of traditional methodological and organizational approaches to teaching, alongside adaptations to lesson formats. According to the Laws of Ukraine "On Higher Education" and "On Education", distance education is characterized as an individualized process facilitated by modern pedagogical and information and communication technologies. It operates through indirect interactions among remote participants in a specialized environment.

**Review of Current Research.** One of the significant areas in pedagogy is the integration of information technology. Numerous scientific studies have been dedicated to investigating and addressing this issue within the framework of the New Ukrainian School. Researchers such as V. Bykov (Bykov, 2005), A. Gedzik (Gedzik, 2012), L. Kartashova (Kartashova & Danyliuk, 2013), Y. Ramskyi (Ramskyi & Oleksyuk, 2008), Y. Trius (Trius, 2005), S. Yashanov (Yashanov, 2003) and others, have highlighted in their works that teaching with the use of information technology is highly effective. They emphasize its ability to facilitate the implementation of didactic principles, introduce new approaches, forms, and methods into the professional activities of primary school teachers, and foster a focus on key functions: educational, developmental, and instructional.

The utilization of Internet resources in educational institutions has been extensively discussed in the works of researchers such as I. Danylchenko (Danylchenko et al., 2023), O. Glazunova and N. Morze (Morze & Glazunova, 2008), V. Osadchy (Osadchy, 2007), E. Patarakin (Patarakin, 2007), T. Zenchenko (Lytvyn et al., 2021) among others. The scientific underpinnings of technology-enhanced learning are elucidated in the

studies of scholars like I. Bogdanov (Bogdanov, 1999), L. Panchenko (Panchenko, 1994), and others.

**Objective:** Objective: to theoretically substantiate the effectiveness of utilizing electronic applications for creating computer models in mathematics lessons within primary school settings, particularly in the context of distance learning.

**Research results.**

**1. The essence of distance educational technologies**

Currently, teachers are expected to be proficient in shaping the educational environment using information technology. This involves ensuring an appropriate level of learning, modeling individual learning and development trajectories for students, as well as charting their own career paths (Kukharenko & Bondarenko, 2020). One such technology employed in the learning process is distance learning technology.

Distance learning technologies, which rely on the utilization of information and communication technologies, are steadily being integrated into the practices of numerous educational institutions across various forms and levels. One of its primary characteristics is the independence from geographical constraints, allowing teachers and students to interact regardless of their physical location. This approach is commonly referred to as distance learning (Smyrnova-Trybulska, 2009; Thorpe, 1993).

In a narrow sense, the concept of 'distance education' refers to a process or system implemented using telecommunication and information technologies to educate individuals who are physically distant from the educational institution. This interpretation is espoused by American scholars, including C. Wedemeyer (Wedemeyer, 1971), R. Kauffman (Kauffman & Watkins, 2000), Michael Moore (Moore, 2007), R. Shearer (Shearer, 2007), and others.

In this definition, 'indirect interaction' refers to interaction conducted at a distance. The educational process, facilitated using distance learning technologies, should always be viewed through the lens of traditional pedagogy and adhere to the established terminology within the field of education.

The field of distance learning technologies lacks uniform terminology, with the conceptual framework still in its infancy. In literature, terms such as distance learning, distance education, online learning, and distance learning technologies are actively employed. These terms describe various aspects of distance learning, whether utilizing modern information technologies or traditional postal and fax communication (Korsunska, 2000).

Let's delve deeper into the concept of 'distance learning.' Currently, there is no consensus on a single definition of distance learning. Researchers and specialists in this field often attribute different meanings to the concept.

Distance learning is a purposefully organized and coordinated in time and space interaction between teachers and students, as well as with teaching tools, using pedagogical, information, and telecommunication technologies (Bykov, 2005).

Several authors define distance learning as a form of education where students are physically separated from each other, or as a new educational approach built upon the principle of independent student learning (Bykov, 2005).

Distance learning involves the interaction between teachers and students at a distance, encompassing all components inherent in the educational process (goals, content, methods, organizational forms, teaching tools). It is implemented with the assistance of specific Internet technologies or other information technologies (Herasymenko et al., 2013).

Distance learning is recognized by many researchers as an independent form of organizing the educational process. In their works, scientists interpret the concept of distance learning in various ways:

- distance learning is a method wherein the teacher and students are physically located in different places and utilize audio, video, Internet, and satellite communication channels for educational purposes (Kozlakova, 2002);

- purposeful and organized process of interactive interaction between teachers and students, utilizing teaching aids that are invariant to their location in space and time within a certain didactic system (Korsunska, 2000);
- telecommunication training primarily utilizes Internet technologies and resources, involving distance subjects such as students, teachers, tutors, and moderators in the educational process. This process is accompanied by internal changes (increments) among participants and the creation of educational products (Shunevich, 2005).

In the scientific and methodological literature, various approaches to defining the concept of 'distance education' have been identified:

- ***the method of distance*** learning involves the physical separation of teachers and students, who utilize audio, video, Internet, and satellite communication channels for educational purposes;
- ***a purposeful and organized process of interactive interaction*** between teachers and students, facilitated by teaching aids that are independent of their physical location in space and time. This approach is implemented within a specific didactic system;
- ***telecommunication-based training*** allows distance education participants (students, teachers, tutors, moderators, etc.) to engage in the educational process using telecommunications technologies. This approach results in the creation of educational products and internal changes among participants.

Contemporary distance learning primarily relies on technologies and Internet resources.

After considering various approaches to defining the concept of distance learning, let's examine its distinctive features. Scientists have identified the following features of distance learning (Bykov, Kukharenko, & Bogachkov, 2008):

- physical separation of the teacher and some or all of the students for at least a significant portion of the learning process;

- use of educational multimedia and electronic resources, both remotely and in the immediate environment of students;
- provision of telecommunication between teachers and students, as well as among students themselves;
- productive nature of the educational process, resulting in the creation of educational products that differ from those used in a traditional classroom environment.

According to O. Komar and L. Royenko, the dominant feature of distance learning is the separation between the teacher and the student, with educational materials being presented using various means of communication (Komar & Royenko, 2021).

**2. Features of teaching mathematics in the context of distance learning**

Numerous studies have demonstrated that the successful development of mathematical competence and the enhancement of the quality of mathematical education in primary school depend significantly on the selection of appropriate educational technologies. The adequacy of these technologies to the specific situation and the composition of the student body is crucial. The choice of educational technology entails strategic decisions regarding priorities, interaction systems, teaching tactics, and the teacher's instructional style during lessons.

To organize the teaching of mathematics using distance learning technologies, let's outline the purposes of their use:

- *meeting the educational needs of learners* (technology of lifelong learning);
- *enhancing the quality of education* through the implementation of modern technologies, facilitating purposeful, indirect, or partially mediated interaction between students and teachers, regardless of their location, through the use of telecommunications;
- *free use of* various information resources for the educational process at any convenient time;

- *strengthening the personal orientation of the learning process*, activating the student's independent work. Improving the effectiveness of training through the introduction of innovative educational technologies;
- *ensuring the advancement of the entire education system*, emphasizing the dissemination of knowledge among the population, and raising the general educational and cultural level;
- *creation of conditions for the* application of *the education quality control system.*

To determine the requirements for organizing the educational process using distance learning technologies, we highlight the features of distance learning (Bykov, Kukharenko, & Bogachkov, 2008):

- separation of teaching and learning processes in time and space;
- utilization of the modular principle, which involves dividing the subject into logically closed blocks, known as modules, within which both the study of new material and control measures to check its assimilation take place;
- management of students' independent work by educational institutions using curricula, specially prepared educational and methodological materials, and special control procedures;
- mandatory use of communication technologies for the transfer of knowledge, mediated, dialogue, and interactive interaction among learning subjects and solving administrative problems;
- creation of a specialized information and educational environment that includes various educational products, ranging from working textbooks to computer training programs, slide lectures, and audio and video courses.

The information approach in education should be formed based on information postulates, the method of information modeling of the essence. The purpose of the training is to develop an information model of the student's brain with a specified volume and quality of the thesaurus, fostering their ability to perceive and retrieve

information from both natural and artificial sources (Lopatina & Belenkova, 2017). Productive learning is associated with the concept of a socially significant result of students' activities. This result can manifest internally through qualitative changes in the student's mental activity, or externally through the creation of a product – whether material or informational – those results from human activity. The characteristics of productive activity and its products can be utilized in diagnosing the development of a child's skills, cognitive processes, and ability to plan activities (Beziulova et al., 2010).

To organize the teaching of mathematics using distance technologies, we categorize **the methods and means of distance learning.**

We classify **methods** according to three criteria.

1. The classification of methods *is based on the simultaneous consideration of the division of methods into three areas*:

- coverage of the contingent (frontal for large groups, group for small groups, individual, without focusing on the number of listeners);
- characteristics of the orientation of interaction between the subjects of the pedagogical field (unidirectional, multidirectional, active, interactive);
- characteristics of means of communication (traditional or new information technologies).

2. Classification of methods *is based on the characteristics of the method (format)* of communication between the individual and the available educational information about knowledge and methods of activity. These methods can be categorized as follows: methods of activity of the individual, which depend on other subjects of the pedagogical field; activity of the individual, independent of the methods of activity of other subjects of the pedagogical field.

3. Classification of methods *based on the orientation of methods for obtaining* or *transforming information* with a target or functional difference in the inclusion (use) of distance learning technologies includes:

- methods of the student's activity to acquire knowledge and develop skills when using distance learning as a means of searching, transmitting, storing and transforming information;
- methods of applying knowledge and developing skills in using distance learning technologies as a means of searching, transmitting, storing and transforming information;
- methods of applying knowledge and developing skills when using distance learning technologies as a tool for processing and changing information;
- methods of creating new knowledge and designing methods of activity, as well as objects, when using distance learning technologies as a means of searching, transmitting, storing and transforming information;
- methods of creating new knowledge and designing methods of activity, as well as objects when using distance learning technologies as a tool for processing and changing information.

Separately, we highlight **the methods of distance learning.**

*Methods of "ecological" learning* encompass a collaborative effort between teachers and students to organize the exchange of educational information and manage its perception, understanding, memorization, and correct application through the use of distance learning tools. These tools are integrated into a specific information educational environment, such as Personal Learning Environments (PLE) and Personal Teaching Environments (PTE). PLE and PTE educational environments are defined as follows: Personal *PLE is a student's personal educational resource* created in a virtual space, supported, and developed by their own information resources for educational purposes. This could include a personal page on a social network, a blog, Twitter, or a website. *The personal learning environment* established by the teacher in the virtual space consists of components of the educational process such as content, forms, methods, and means of teaching, as well as communication tools. This environment facilitates

individual and collaborative learning, fostering student activity in the process of mastering educational material (Starosta, 2023).

*Methods of "virtual" learning* are individually oriented teaching methods that are tailored to the content of students' personal educational environments and their proficiency in applying these methods in practice. These methods encompass a range of approaches used by students within a given environment, in conjunction with the personal environments of educational process participants and other environments within the global information and communication space.

Classification of **distance learning technology** according to several criteria.

*By the nature of execution:*

Electronic learning tools are any programs or documents made with the help of a computer, designed to carry out the educational process.

Pedagogical software – programs (electronic learning tools are performed).

E-learning materials are documents that necessitate the use of a program designed for material creation.

*According to the organization of the student's educational activities*.

Tools (programs) used directly by students:

- research simulation programs;
- computer simulators;
- computer control programs;
- reference and information systems.

The group of training programs includes:

- demonstration simulation programs;
- programs for generating and checking individual tasks.

*According to the degree of integration:*

- private (the software product solves a separate didactic task – training, control);
- complexes (for solving several didactic tasks).

*According to the nature of the management of the student's actions:*

- no management (electronic directory);
- strict control (the teacher cannot change control);
- according to the scenario (examination procedure);
- adaptive.

*Distance learning tools are:*

- educational books (electronic versions of textbooks, teaching aids, reference books, etc.);
- online tutorials;
- computer-based learning systems;
- audio, educational and informational materials;
- video, training and informational materials;
- laboratory remote workshops;
- simulators with remote access;
- databases and knowledge with remote access;
- digital libraries with remote access;
- teaching aids based on expert training systems;
- educational tools based on geoinformation systems;
- learning tools based on virtual and augmented reality.

Here are some examples of distance learning tools that can be used, in particular, in the process of teaching mathematics:

- e-mail (E-mail);
- chat – correspondence in real time;
- video conferencing, which allows you to transmit sound and video;
- Internet navigation;
- active subscription channels to sites;

- web service, web conferencing, bulletin boards, registration forms, tests, counters, etc.;
- FTP servers and file archives, etc.

Mobile applications can serve as one of the tools for distance learning. The article "Useful Mobile Apps for Learning Mathematics" (2019) showcases the most popular mathematical mobile applications, which can assist teachers in achieving specific didactic goals.

To enhance the efficiency of the educational process, it is advisable to identify **the advantages and disadvantages** of the training method utilized

When considering the advantages and disadvantages of using distance learning technologies in the teaching of mathematics, it is essential to take into account a number of principles. These principles, as outlined by Kukharenko and Bondarenko (2020), include:

*Full assimilation of basic educational information* (cognitive component of the standard). This involves all trainees comprehensively assimilating basic information without gradations of success on a dichotomous scale.

*Individualization of learning.* This principle encompasses variability in the presentation of information and the organization of activities, allowing for individual learning trajectories after mastering the basic part. It also involves expanding interactive communication between participants in the educational process and ensuring individual educational and cognitive activity.

*Temporary effectiveness of training.* This principle focuses on minimizing the time for mastering the main content; using generalized methods of working with educational information in presentation and training; competent use of channels of perception in the process of presenting educational information (in particular, visual and sound).

*Systematic learning management.* Continuous measurement of the success of educational information assimilation by each student and prompt feedback between participants in the educational process.

Additional principles of distance learning, as described by Vishnevsky, Hnidenko, Haydur, and Ilyin (2014), include:

- *flexibility*, which is characterized by the absence of regular classes such as lectures and seminars, allowing students the freedom to choose the time necessary for mastering the course;
- *modularity*, which is expressed in the fact that each individual discipline presents a holistic view of a certain subject area, with each section or module contributing to the overall understanding of the course;
- *parallelism* is due to the fact that training can be conducted concurrently with the student's main professional activity;
- *long-range*, which consists in the absence of obstacles in the form of remoteness from the student's place of residence to the educational institution (teacher);
- *asynchrony* – students have the freedom to implement teaching and learning technologies independently in terms of timing;
- *mass* determines that the "number of students" parameter is not critical;
- *profitability*, which implies the economic efficiency of distance learning;
- wide *application of new information technologies*.

The relationship between the principles of using distance learning technologies and the classical principles of didactics with comments on changes is presented in figure 1.

Considering the above principles, we can conclude the advantages and effectiveness of distance learning in the process of teaching mathematics.

To begin with, let's consider the advantages and disadvantages of supporting distance learning regardless of the specific academic subject (Bykov et al., 2008):

- the possibility of educating the general population;
- availability of an individual approach, considering the needs and psychological characteristics of the student;
- objectivity of knowledge assessment, facilitated by special programs;

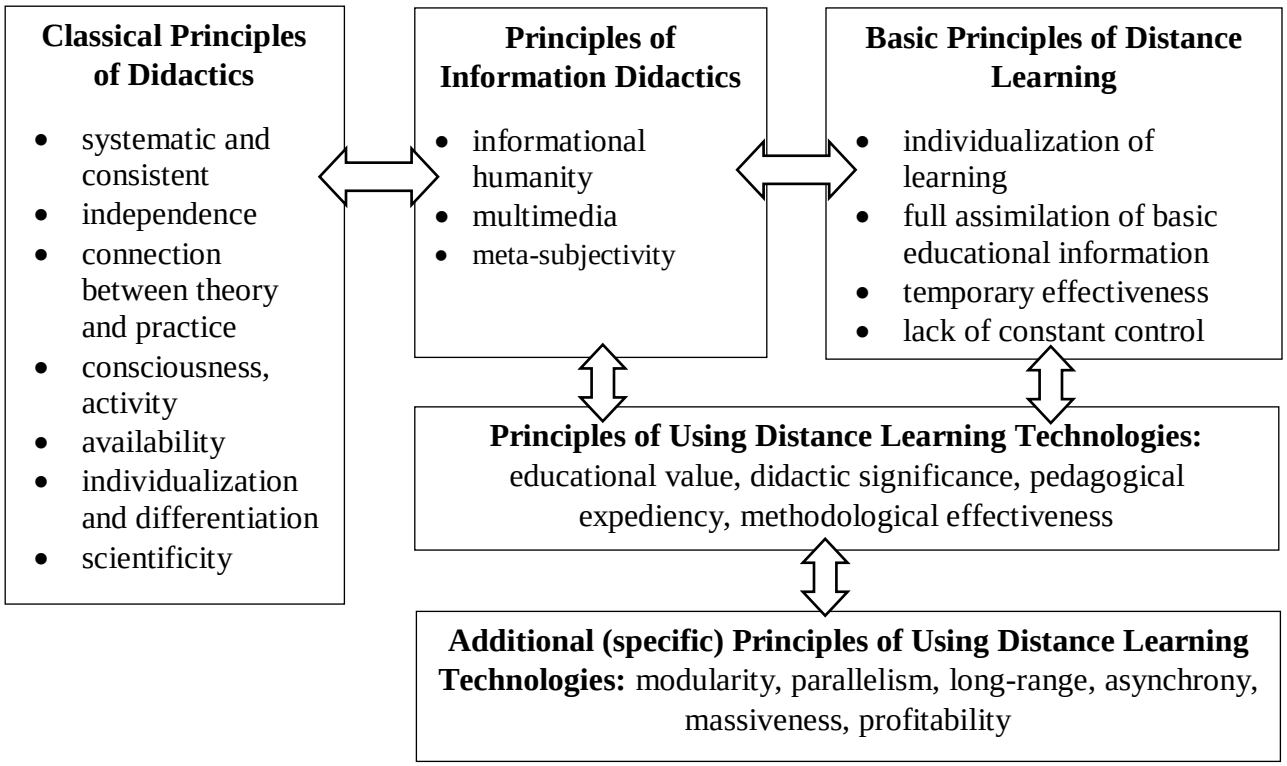


*Figure. 1. Relationship between the principles of distance learning and the classical principles of didactics*

- flexibility: students can work in a convenient place, at a convenient time, and at their own pace. Due to the fact that everyone can study as much as they personally need to master the subject, distance learning is available for people with disabilities;
- accessibility: access to quality education from anywhere in the world;
- mobility: having a laptop computer with educational materials allows immediate application of theoretical knowledge in practice;
- face-to-face communication: video lectures, video conferencing, forum communication partially compensate for the lack of direct eye contact;
- meetings with classmates: computer programs facilitating learning and data exchange enable contact with each participant in the educational process;
- improvement of students' cognitive skills and development of independence, creativity, and intellectual potential.

The disadvantages of distance learning include (Polat, 2010):

- narrowing of the potential audience of students due to the lack of technical resources for participation (computer, mobile devices, Internet connection);
- compulsory computer training as a prerequisite for distance education;
- lack or insufficient adaptation of educational materials to distance courses, particularly electronic textbooks;
- underdeveloped systems for administering the educational process, leading to a decrease in the quality of distance education compared to full-time education;
- lack of personal contact with the teacher;
- increased requirements for the listener's ability to self-education.

The listed advantages and disadvantages of distance education can also be applied to the teaching of mathematics. However, in addition to these, there are several "specific" positive and negative aspects of distance support for teaching mathematics.

So, the advantages include:

- the ability for the teacher to incorporate a wide range of examples into the e-learning course for further study by students;
- offering differentiated assignments for students, including homework, independent work, and testing;
- integration of interactive presentations that can serve as guides for students;
- utilization of interactive drawings and augmented reality;
- provision of various links to mathematical educational resources;
- facilitation of communication between the teacher and students (individual communication) and among students (group communication);
- enhancement of the information content of mathematical materials, presented in an engaging and attractive format for students.

The disadvantages of remote support for teaching mathematics include:

- difficulty in creating electronic educational content, particularly due to the complexity of typing mathematical texts;

- difficulties in independent understanding of mathematical terminology by students;
- difficulties in in submitting detailed solutions to mathematical problems by students;
- inability to accurately attribute the authorship of problem solutions (homework, independent work, testing) submitted for verification.

A significant challenge of distance learning is the need to rethink many established pedagogical methods to enhance memorization and assimilation of material. For example, the method of landmarks, the method of conscious mistakes, the method of choosing the best solution, etc. The utilization of these pedagogical methods is heavily reliant on technical resources and methods of organizing interaction with students.

To organize the educational process using methods and means of distance learning, it is essential to define the potential forms and activities of students.

Let us characterize the model of distance learning based on a didactic constructor (Bohachkov et al., 2012).

A didactic constructor is defined as an artificially created conditional sample of a pedagogical phenomenon (process) in the form of a set of structural components, a description of these components and their relationships. The main structural components of the didactic constructor for distance learning are highlighted and supplemented by the characteristics of the learning process, in particular:

- target orientation – the level of target categories (knowledge, skills, understanding and proficiency);
- competence and proficiency levels;
- principles of teaching such as pedagogical expediency, didactic significance, cognitive relevance, and methodological effectiveness;
- groups (classifications) of teaching methods – categorized by the nature of activities with educational information, types of educational activities, target categories, and cognitive processes involved;

- form of education – lesson, lecture, practical or laboratory session, control;
- content and type of educational activities – project-based learning, research activities, etc.;
- modes of communication – unidirectional transmission of information, multidirectional active, multidirectional interactive learning;
- synchronicity – synchronous, asynchronous learning;
- frequency of interaction – in face-to-face classes, consultations, regular classroom sessions, etc.;
- degree of individualization – individual, group, frontal activities;
- degree of independence – independent educational activities, educational interaction;
- adaptation to individual student characteristics: ranging from no adaptation to considering specific individual traits or implementing individualized educational pathways and adaptive pedagogical systems.

To construct such a model, a specific profile is established within the framework of the constructor's invariance. The designer generates the content (selecting specific components) and describes their connections in particular psychological and pedagogical contexts, aligning them with the didactic system. This process always results in a variant of the distance learning model. The defining components of the didactic constructor include the training's target orientation and the psychological and pedagogical characteristics of the student cohort.

The presented constructor for constructing a training model is particularly noteworthy for its ability to address all essential questions: "Why?" (establishing learning objectives), "What?" (defining the content of teacher and student activities), "How?" (describing teaching methods and the interaction between educational process participants), "Who?" (identifying the psychological and pedagogical characteristics of the student cohort), and "Under what circumstances?"

Based on this model, we will build a scheme of the educational site of a mathematics teacher, which presents the interaction of participants in the educational process and the relationship between the components of the site (figure 2).

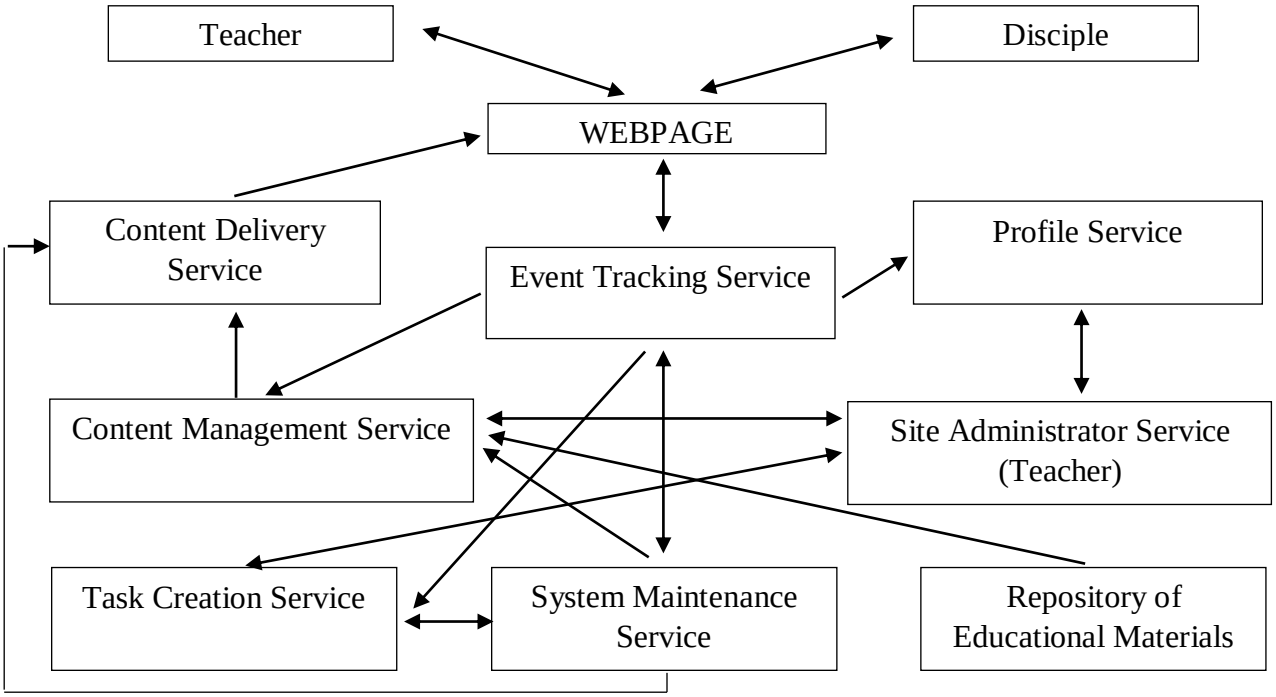


*Figure. 2. Interaction of participants in educational activities and the component of the teacher's personal web page*

According to the above scheme, access to the information resources of applicants is carried out through the website. The management service allows you to use resources such as forums, chat, private messages, comments on the results of tasks, a record book, tasks in various forms, etc.

The channels involved in obtaining information are unidirectional, while channels of interaction with interactive sources are bidirectional.

The teacher can interact and manage the work of an individual student through individual means of communication. Additionally, the teacher can remotely post information and monitor the progress of the work.

The proposed scheme includes information resources, their consumers and information flows between the subjects of the educational process, which are implemented through the educational website. The combination of these components forms a closed communication field.

The system of control in the process of teaching mathematics in the system of distance learning includes the following methods:

- written survey (conducted in synchronous interaction mode);
- tests designed to assess the assimilation of each educational element, with online performance and verification;
- independent work, complementing the test system and aimed at assessing the acquisition of skills to apply learned mathematical concepts in problem-solving;
- individual homework assignments;
- comprehensive tests assessing the overall assimilation of knowledge on the topic under study.

Distance learning support can be considered as an element of distance learning. The primary means of distance support include educational Internet resources available online, as well as those created by teachers and shared on the Internet, along with remote network interaction ("Distance Learning…", 2021).

Forms of distance learning support are:

- personal email and shared email;
- communication within a social media group;
- use of personalized interactive resources;
- development and use of a website/blog on the relevant subject;
- use of a distance course on the topic;
- web conferencing, webinars, distance lessons.

Support for distance learning is directly related to the organization of the educational space, which includes the following elements (Gurevich et al., 2012):

- selection of educational resources (educational materials);
- creation of pages for presenting students' work;
- administration of resources (managing access for learners, updating materials, monitoring demand and sufficiency of educational materials);
- selection of means for organizing feedback with participants in the educational process for consultations, answering questions, etc.

In organizing the educational space (see figure 3) and managing the educational process through distance learning, the teacher should consider several crucial aspects. These include ensuring students' access to educational materials, determining the placement of learning materials and assignments, organizing educational activities for students online, selecting appropriate tools to facilitate interaction between students and teachers, and establishing methods for monitoring task completion and assessing students' educational progress.

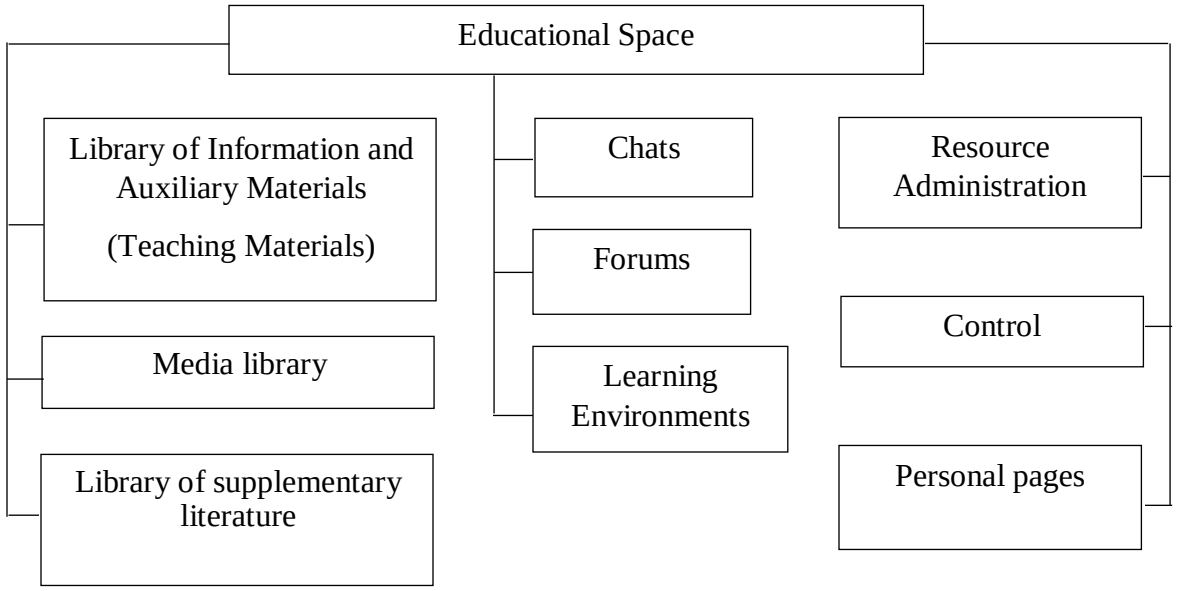


*Figure 3. Educational space*

In this capacity, the teacher assumes the role of an organizer of students' learning activities. Throughout various stages, the teacher not only facilitates the teaching of

educational material but also serves as an active and objective participant in the educational process, acting as a facilitator.

In the process of organizing the educational process through distance learning systems, the teacher is tasked with the following:

- assisting students in maximizing their learning outcomes;
- monitoring students' progress in their studies;
- providing feedback on completed tasks;
- offering guidance and support to students;
- sustaining a continuous interest in learning throughout the lesson.

During the organization of distance learning, it is possible to organize the following types of student activities on the Internet (Korsunska, 2000):

- working with information, namely: writing essays, conducting surveys, collecting multimedia material on the topic, consulting experts, etc.;
- communication: correspondence, discussions, role-plays, virtual meetings, etc.;
- publication on the web: publication of articles, creation of thematic databases, creation of thematic web pages, creation of multimedia resources, etc.

In the process of training using distance learning technologies, controlling tasks play an important role. Control tasks for target objectives are divided into:

- trainings (simulators) aimed at comprehending and consolidating the material, as well as forming key and subject competencies;
- controlling is designed to evaluate the level of knowledge assimilation after studying a certain part of the course.

Knowledge control by function can be classified as follows:

- for preliminary or initial control – determines of the individual level of training;
- for constant control or progress monitoring (current testing) – provides information about the progress of knowledge assimilation over a specific period, such as after studying a topic or paragraph;

- for intermediate control (for example, conducted after studying large sections of a course);
- for final control (for example, final testing) – assesses knowledge for the entire course.

When selecting teaching methods for distance learning, it's essential to prioritize those that activate students' communicative and cognitive abilities, fostering independent and collaborative problem-solving. It's especially important to carefully plan the trajectory of students' study of educational material, ensuring regular communication through consultations, discussions, etc., even in asynchronous modes.

The educational process, which is implemented in distance form, should adhere to the classical principles of didactics, and be aimed at achieving predefined goals.

In mathematics, distance learning can serve as a substitute for a teacher's extracurricular work with students who are lagging behind or have missed certain topics. Additionally, distance learning can function as a supplementary tool, beneficial for all students, even if only a limited number of sessions are allocated for it.

The methodological system of distance learning in mathematics is regarded as an independent, open, and evolving framework. Through interaction with the information and educational environment of distance learning, it ensures that learners achieve both normative and individual goals in the study of mathematics.

The implementation of distance learning in mathematics entails specific activities for students to master mathematical content under distance learning conditions. This necessitates the introduction of distance learning in mathematics through a sequence of technological cycles: preparatory, educational, and final stages.

*The preparatory cycle* involves organizing educational materials for the distance learning system in mathematics by establishing an individual approach to students; facilitating students' seamless integration into the online educational community and conducting an orientation process; designing individual learning paths for assimilating mathematical content.

*The educational cycle* reflects the structure of mathematical learning activities, necessitating interaction between teachers and students and facilitating students' assimilation of mathematical content aligned with both general and personalized objectives. It also includes preliminary assessments to adjust the subsequent learning trajectory.

*The final cycle* is aimed at assessing the level of mathematical competency attainment.

The process of constructing the methodological framework for distance learning in mathematics involves transforming both the traditional teaching methodology of mathematics to suit the specifics of distance learning conditions and the didactic system of distance learning to accommodate the unique characteristics of the subject "mathematics".

The outcome of this process is a model of the methodological system for distance learning in mathematics, comprising three subsystems: educational, control and diagnostic, and the subsystem for providing methodological support to teachers.

*Training subsystem.* The components of the educational subsystem include individual learning objectives, content, methods, means, and forms of interaction organization. These factors are tailored to accommodate the unique characteristics of subjects involved in facilitating the distance learning process for mathematics.

*Control and diagnostic subsystem.* These include the goals of controlling results and diagnosing the assimilation process of mathematical content. Additionally, it encompasses the content, means, methods, and forms of control and diagnostics. These aspects are tailored to accommodate the unique characteristics of the process of assimilating educational material in mathematics within the distance learning system.

*Subsystem of methodological support of a mathematics teacher.* The subsystem of methodological support for mathematics teachers comprises various elements, including goals, content, means, methods, and forms of organization. These components are essential for providing effective support to mathematics teachers. However, it's

important to note that they may not always be developed based on the formulated principles of design and functioning within the methodological support system.

Therefore, considering the need for integrating distance learning technologies into the educational process, it fosters the creation of an information-rich educational environment. This environment facilitates the enhancement of each student's mathematical abilities and aligns with the principles of contemporary pedagogy. Consistent utilization of distance technologies by students will guarantee the acquisition of relevant competencies and versatile educational skills.

The transition to a more flexible, dynamic, and personalized learning approach, facilitated by the utilization of distance learning technologies, aids in addressing the primary didactic objectives. These include fostering students' acquisition of profound and comprehensive knowledge through the utilization of information and communication technologies, enhancing their cognitive abilities, fostering independent assimilation, expansion, and deepening of knowledge, and facilitating its practical application.

**3. Electronic applications for creating computer models**

Visualization is an important means of activating the cognitive activity of younger schoolchildren, as it facilitates their exploration of the world around them. Additionally, the use of visuals is grounded in the cognitive development of children at the primary school age, progressing from concrete (visual-figurative) to abstract-logical thinking. The clarity of educational materials enhances cognitive interest in acquiring knowledge and renders the learning process more accessible to younger students with varying levels of intelligence.

In order to enhance the cognitive activity of younger schoolchildren, it is imperative to develop a methodology for working with students and to select the most effective and rational teaching methods that seamlessly integrate into the educational process. One such approach is to prioritize visual learning, as it enables teachers "to employ active teaching and nurturing methods, while also facilitating the principles of

scientific and accessible material presentation. This approach contributes to the overall development of younger students, ensuring a comprehensive understanding of specific concepts, sustaining interest in learning, and fostering higher levels of logical thinking, aesthetic perception, and a creative approach to knowledge acquisition" (Hnatyuk, 2018).

The implementation of visualization methods in primary school education is essential for stimulating students' cognitive activity. Through engaging in non-standard, interesting, and creative activities, students' interest in learning is sparked, leading to their emotional, spiritual, and intellectual development.

The analysis of scientific literature regarding visualization in the education of primary school children reveals that the significance and function of visual materials in the learning process at this level are determined by the interaction between students' cognitive activity and the visual content inherent in the learning process. Visualization enables young students to create distinct mental images of the objects they encounter. Given that younger students readily comprehend only what they can directly perceive, and that the involvement of multiple senses facilitates easier and more robust comprehension, the utilization of visual aids is deemed essential for fostering cognitive engagement among primary school students.

The development of effective methods for utilizing information and communication technologies in mathematics education is a pressing matter in the field of mathematics methodology. An analysis of both domestic and foreign literature indicates widespread use of computer programs worldwide in mathematics instruction. Thus K. Polhun talks about creating an open learning environment that involves integrating traditional and distance, electronic, mobile learning (blended learning).

Online services like GeoGebra, Gran, SketchUp, and CleverMaths have gained widespread popularity worldwide due to their diverse set of tools and user-friendly interface. These tools offer significant opportunities for teaching mathematics, both in university and school settings. Incorporating such programs in mathematics classes

involves creating and utilizing interactive drawings by teachers for classroom demonstrations. Furthermore, they aid in effectively assimilating complex geometric material.

GeoGebra (2024) is a powerful, free online service and mobile application with robust computing capabilities. It is particularly useful for studying geometric shapes on the plane, especially in elementary school. One of its key advantages is its accessibility online, which simplifies its usage. Since GeoGebra does not require installation on a computer, users can simply open the website and log in, eliminating the need for high computational power. Additionally, there is a free smartphone application available. The service features a user-friendly and intuitive interface (figure 4).

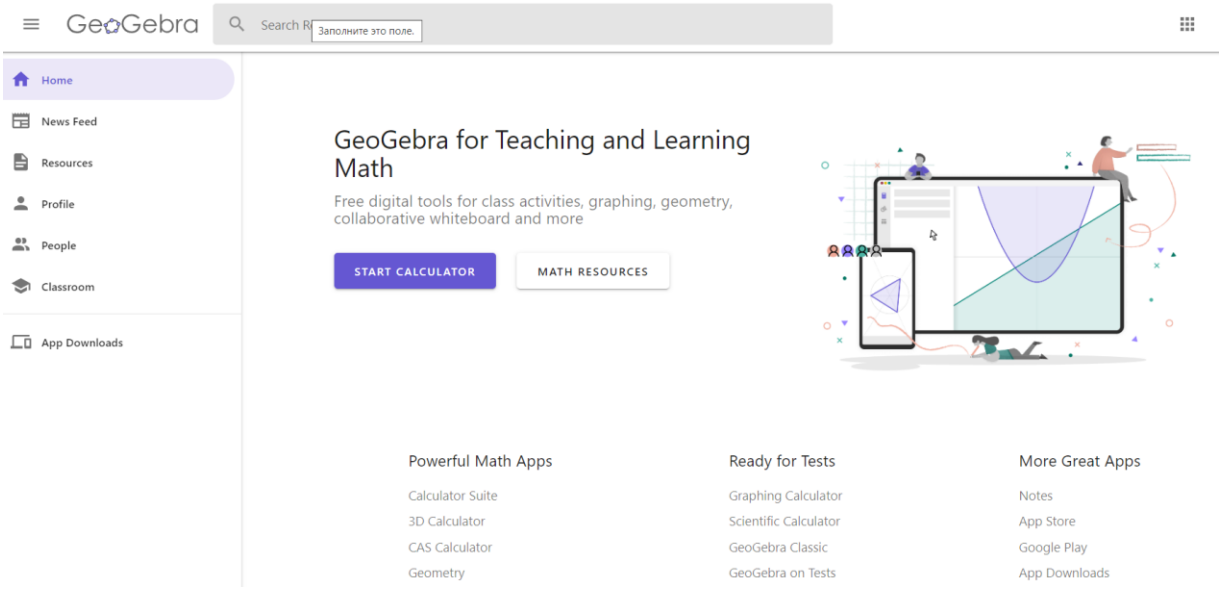


*Figure 4. Main page of the GeoGebra online service*

The system allows users to switch between operating modes for the convenience of creating objects, enabling the use of this program for studying various topics (figure 5).

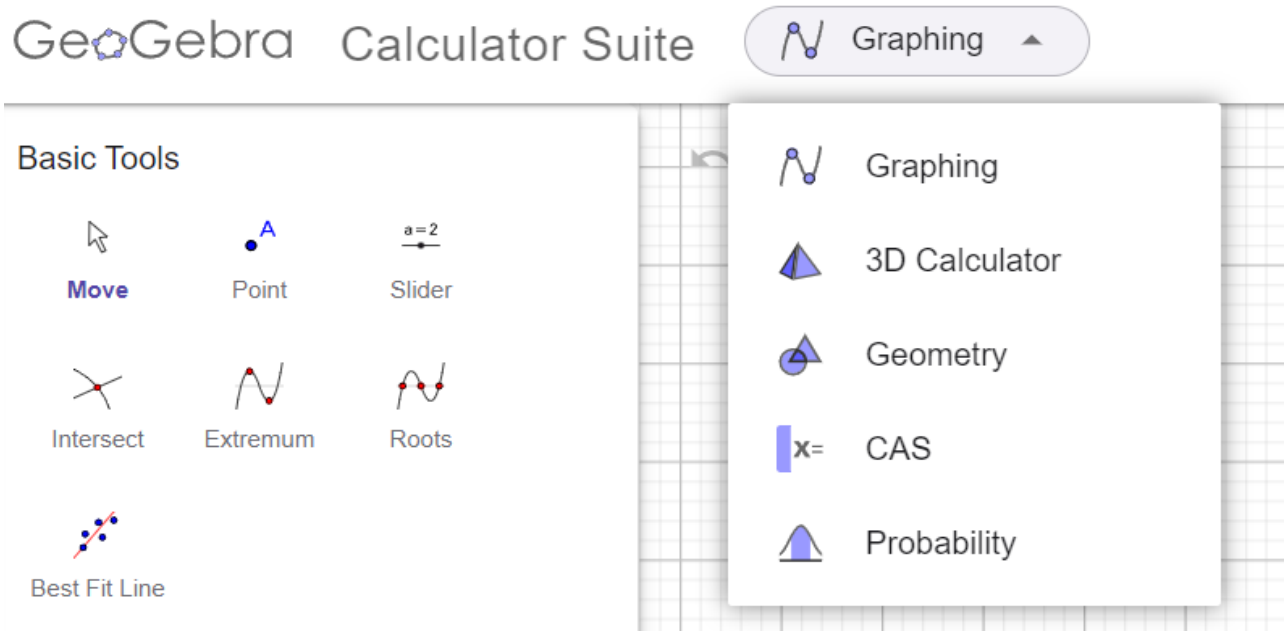


*Figure 5. GeoGebra Calculator Mode*

The online service offers a diverse array of tools for constructing the desired figure (figure 6).

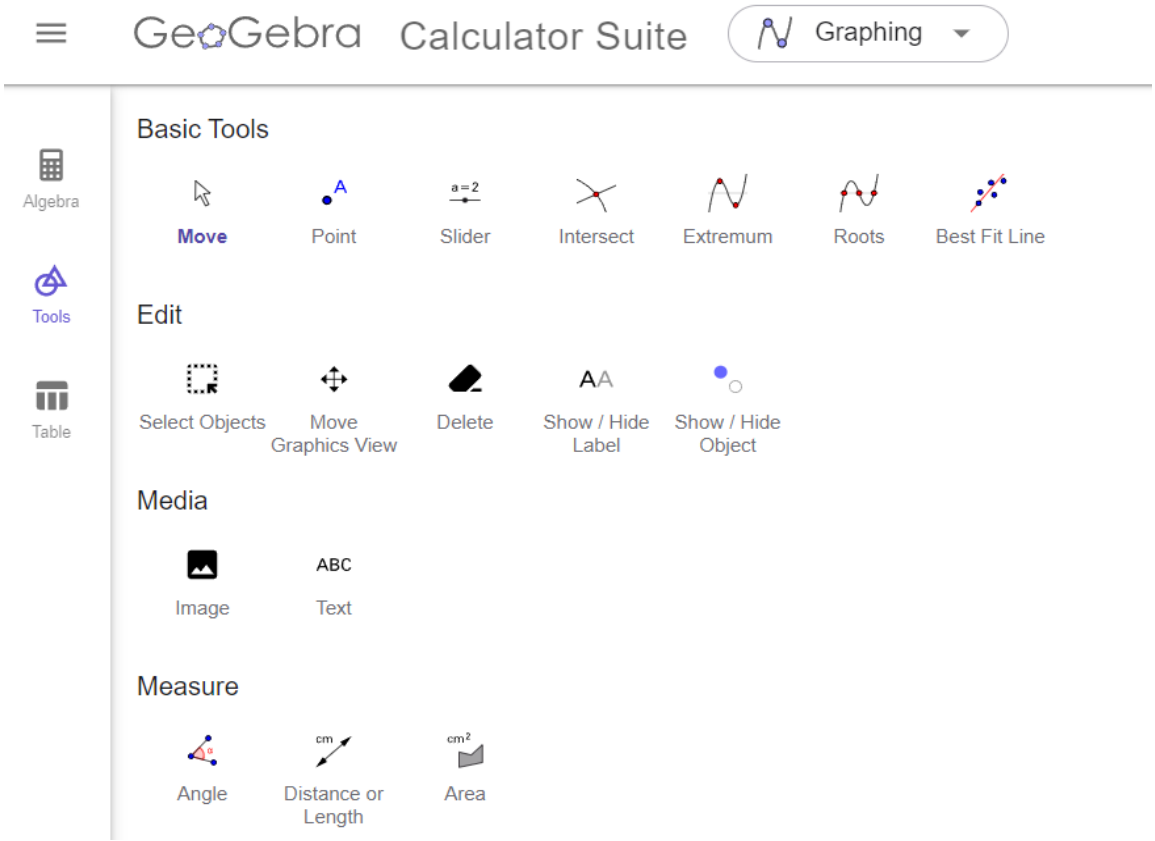


*Figure 6. GeoGebra Online Service Tools*

You can swiftly construct the desired figure using solely the coordinate plane displayed on the screen (figure 7).

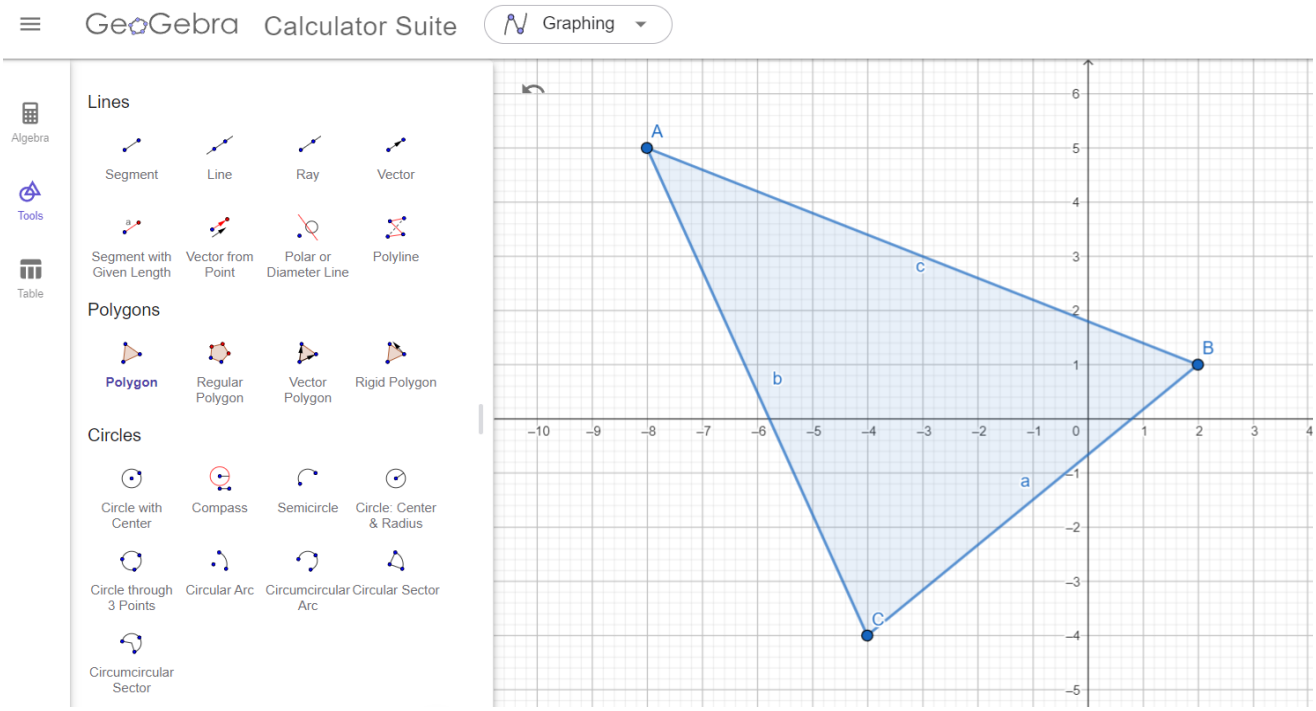


*Figure 7. Triangle Construction Example*

GRAN (2011) is a series of applications designed for graphical analysis of various objects. The service includes three applications: GRAN1 for analyzing functions graphically (GRaphic ANalysis), GRAN-2D for analyzing systems of geometric objects on a plane (GRaphic Analysis 2-Dimension), and GRAN-3D for analyzing three-dimensional objects (GRaphic Analysis 3-Dimension).

Let's delve into the application for working with geometric objects on the GRAN-2D plane. Unlike GeoGebra, this application needs to be installed on a computer. However, it doesn't demand significant resources and supports a Ukrainian-language interface.

The GRAN-2D interface is quite difficult to understand intuitively (figure 8).

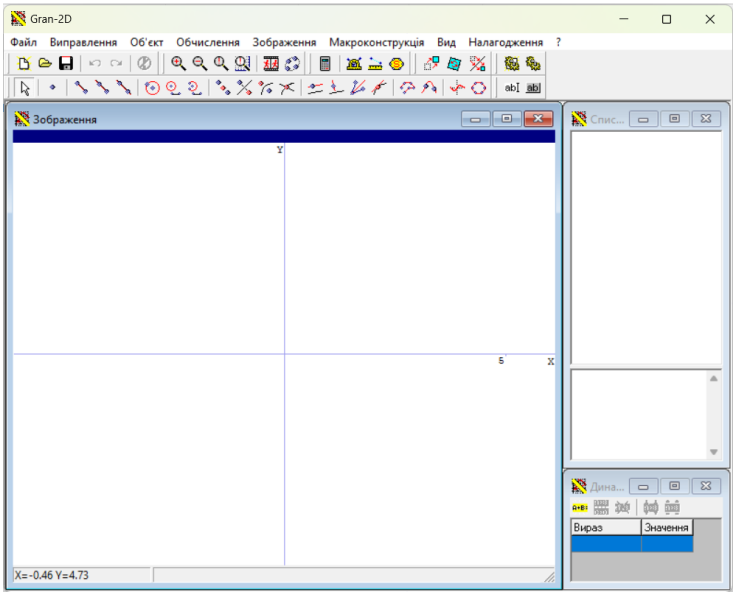


*Figure 8. GRAN-2D Main Window*

The program menu enables users to create basic objects (figure 9).

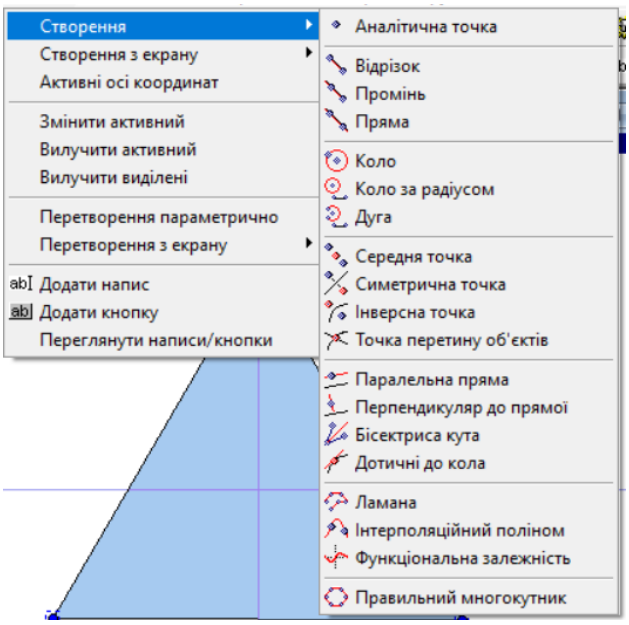


*Figure 9. Shape-Making Menus*

Although creating an object is not as simple as in the previous appendix, GRAN-2D calculates all the basic characteristics of the shape at once (figure 10).

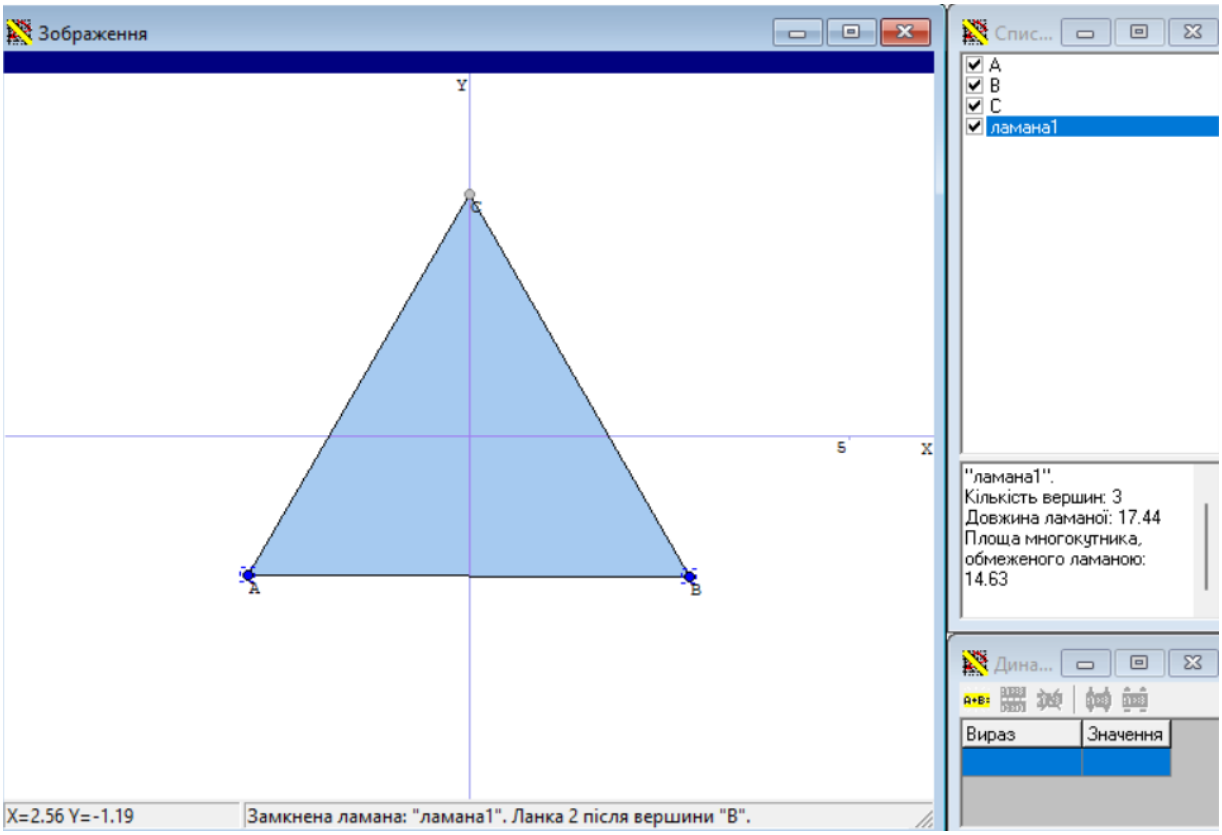


*Figure 10. Example of constructing a triangle*

SketchUp (2024) is a free app offered by Google for Education, accessible in the edu.ua domain. The application is designed for building 3D objects and can be particularly useful for studying three-dimensional shapes. One of its advantages is that it operates online, eliminating the need for pre-downloading and installation on a computer. Additionally, all created models are automatically saved to the user's Google Drive. SketchUp is also available for download on smartphones, making it convenient for classroom use.

Let's take a closer look at how this application operates.

After logging in to our Google account, we arrive at the main page of the service, where we are prompted to start modeling (figure 11).

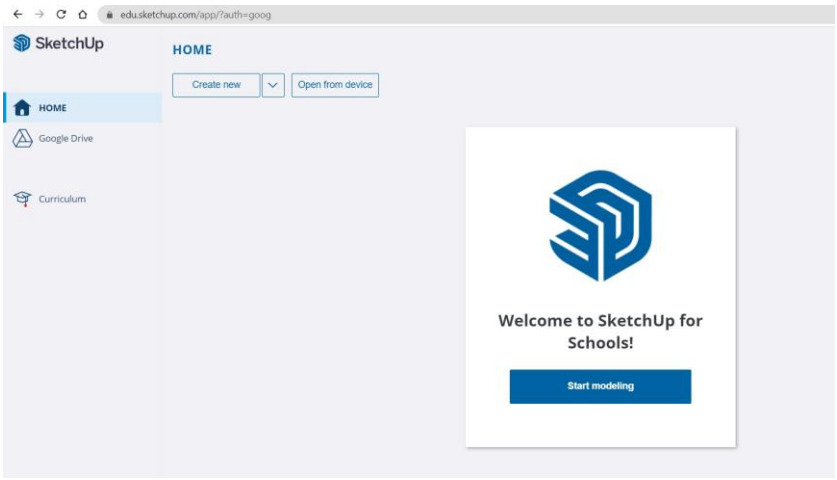


*Figure 11. SketchUp Home Page*

As we begin modeling, we encounter the main scene, featuring coordinate axes and a background resembling a courtyard (figure 12). This setup allows students to envision shapes as realistic objects with dimensions. On the left side, there is a menu where necessary tools can be selected.

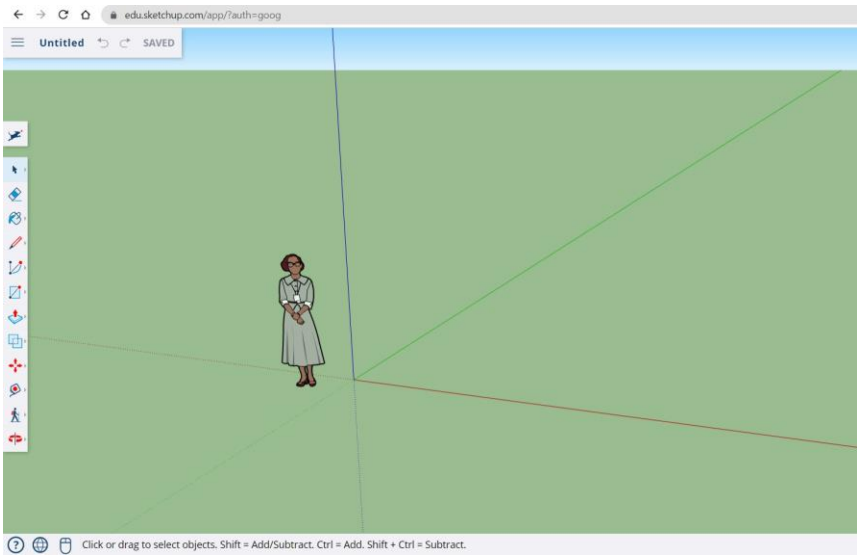


*Figure 12. SketchUp Home Scene*

Comparing SketchUp with the previous two applications, we note that it has a somewhat limited toolkit. In SketchUp, we can only build a rectangle or a hexagon.

There are no other shapes in the menu (figure 13).

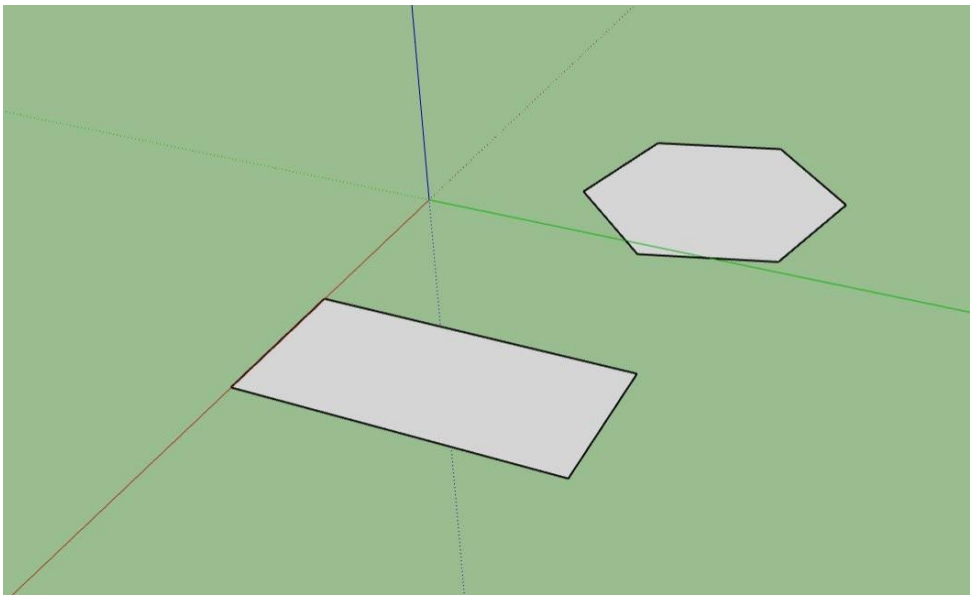

*Figure 13. Example of constructing polygons*

However, it is quite easy to convert flat shapes into three-dimensional shapes using the Push/Pull tool (figure 14).

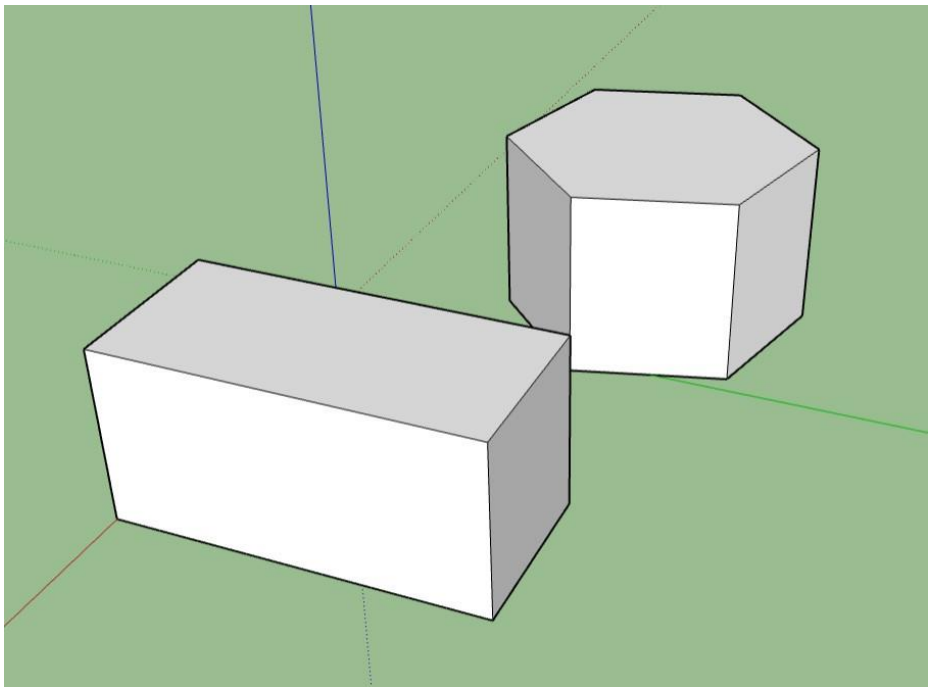

*Figure 14. Example of constructing prisms*

Also, one of the advantages is a wide range of tools for measuring distances and angles (figure 15).

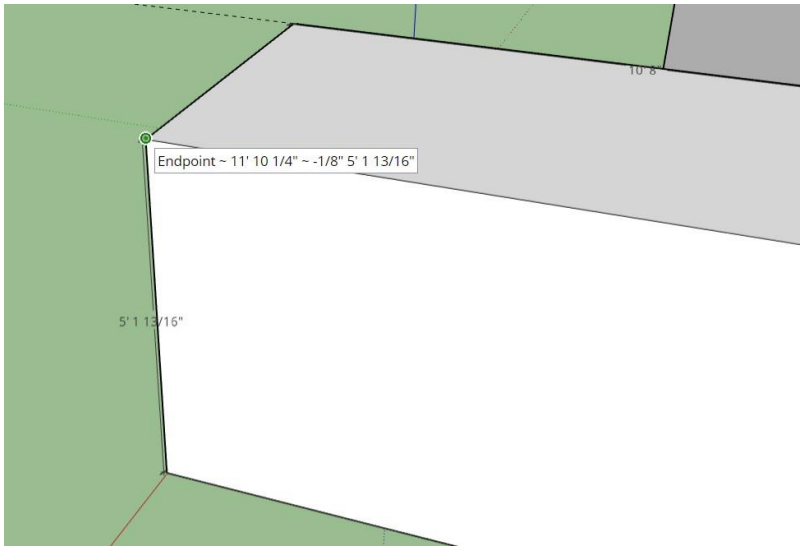


*Figure 15. Measurement Tool Example*

A freely distributable dynamic geometric environment that makes it possible to create "living drawings" for use in mathematics classes for constructions using a compass and a ruler.

The CleverMaths board is a tool for building an effective math lesson (Bardus, 2023).

On the left side of the screen, on the mini-panel, you can choose one of the proposed boards, depending on the topic and purpose of the lesson, which also changes the toolbox at the bottom of the screen. Additionally, the "+" button at the bottom right of the screen allows you to create multiple whiteboards for more efficient placement of study material.

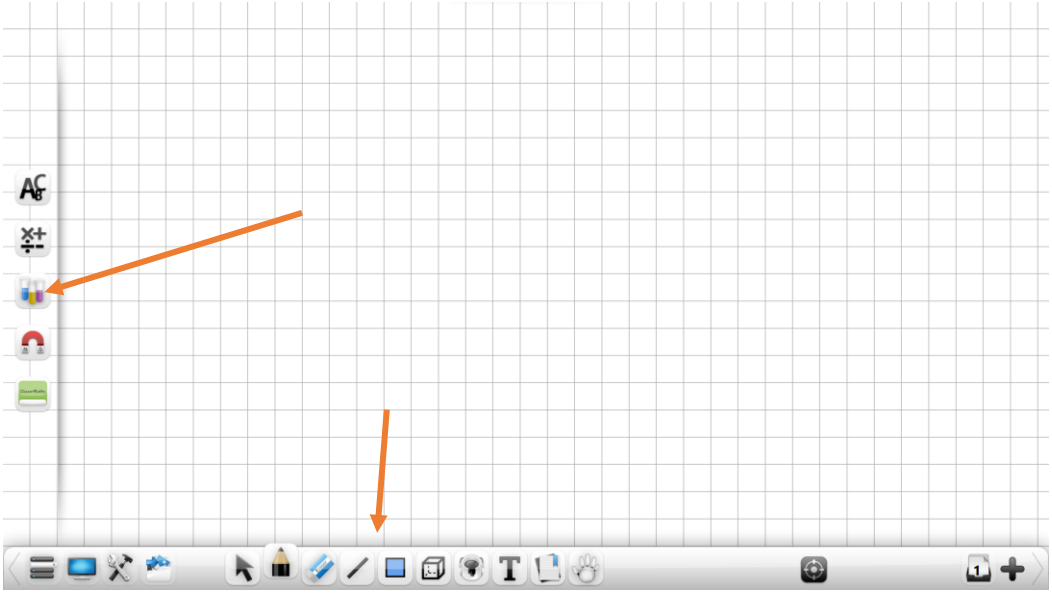

*Figure 16. CleverMaths General Board Window*

**The Menu button** at the bottom of the screen contains familiar functions such as **Open, Create, Paste, Save, and Import**. It's worth noting that on the start board, you can save the document in PDF format (under the **Save As** section). Additionally, you have the option to insert images, documents, and media files onto the whiteboard.


*Figure 17. Saving and Importing Files*

The whiteboard occupies the entire screen. To access the computer desktop using the **Screen key**, a mini-panel appears, providing functions for creating notes for open documents (pencil, marker, eraser, and cursor). The program allows users to take screenshots of either a part or the entire screen, facilitating the creation of lesson outlines (after taking a screenshot, there is an automatic transition to the board).

The Toolbox section contains 4 subsections:

- Background image themes (allows users to change the themes of the starting board, for other subject boards the background is preset);
- Disciplines (there are tools for studying individual subjects, for mathematics – a ruler, a square, a protractor, a compass, a coordinate system, a calculator);
- Mini-tools (contains auxiliary tools that can be used during the lesson, such as a timer, clock, magnifying glass, flashlight, page playback, others);
- Keyboard shortcuts (users have the option to add a shortcut that will allow them to access an external resource).

A highly convenient tool is the Resource Bank. In the My Resource subsection, users can store materials that are used systematically, such as formulas, tables, images, and figures.

On the bottom panel of the mathematical board, there are buttons that are used to design the board pages, including cursor, pencil, eraser, geometric shapes, geometric solids, lines, typing tools.

The Recognition Formula button allows you to translate handwritten text into typed text, which is very convenient when using a graphics tablet.

When using **mathematical tools**, it's important to pay attention to the buttons located on these tools:

- The button with a rotated arrow allows you to rotate the figure (the angle of rotation is fixed);
- The bidirectional arrow button allows you to change the size of the tool;

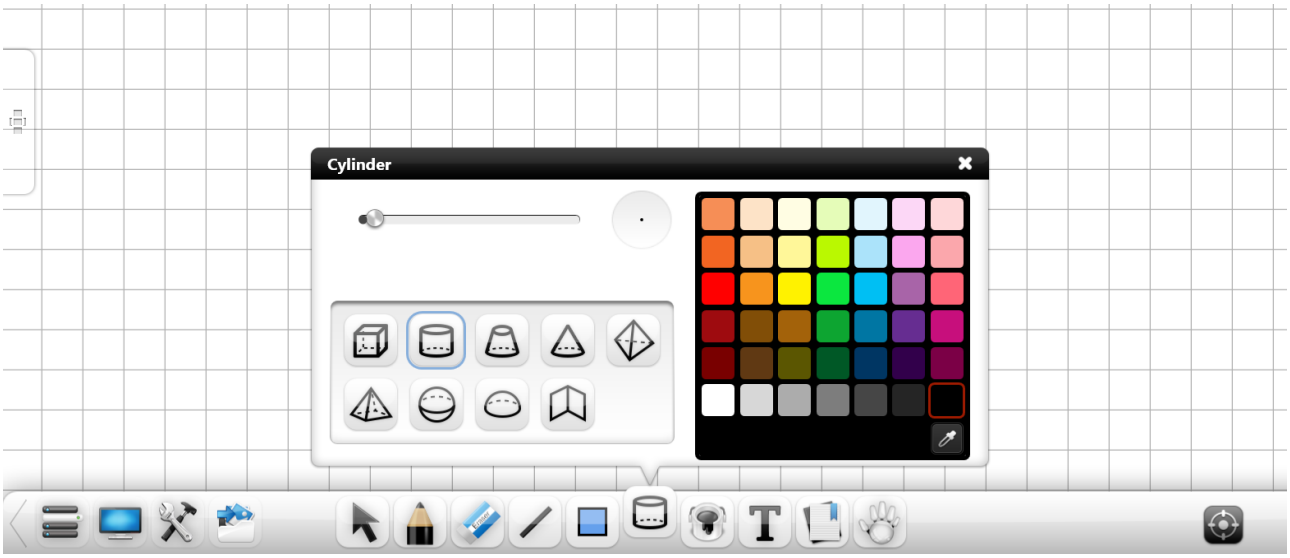


*Figure 18. Set of geometric shapes*

- The cross button enables you to remove the tool.

To insert tools on the board, hover over them with the cursor and then press the left mouse button.

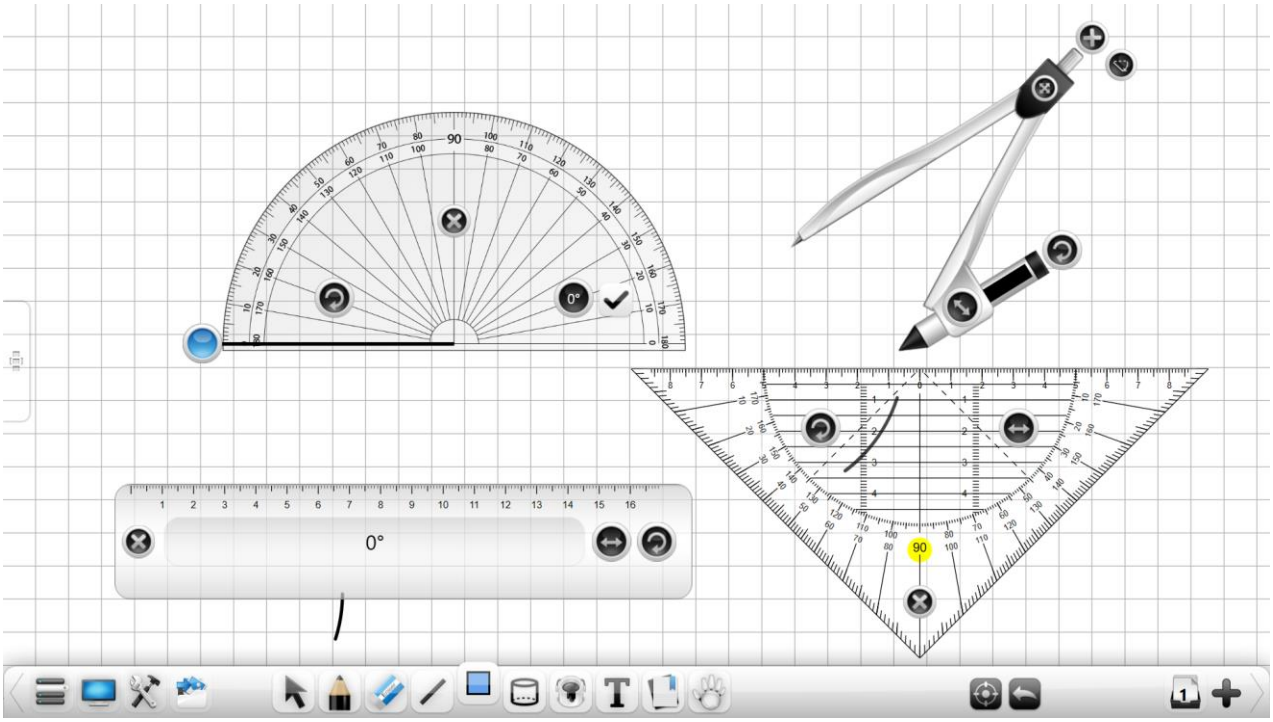


*Figure 19. CleverMaths Whiteboard Toolkit*

**Conclusions.** The capabilities of online services allow for their effective use in the process of learning mathematics for various purposes. With their help, high-quality images of mathematical objects can be quickly created and saved in files for further demonstration or use in multimedia presentations or "traditional" didactic materials such as task cards and posters.

The dynamic and graphical capabilities of online services enable the analysis and simplification of mathematical problems by creating dynamic models of the objects under study. This encourages the exploration of problems and the development of students' spatial imagination and logical thinking. Additionally, it fosters the ability to predict the results of research. And this is the basis for making math classes more meaningful and effective.

The methodological features of software allow for its use both at school and at home, accommodating different forms of classes and varying classroom computer equipment. This provides the opportunity to master mathematical knowledge and skills more efficiently, leading to increased material retention. Additionally, it facilitates the study of mathematics based on an active and heuristic approach by introducing elements of experimentation and research into the educational process. This approach boosts student motivation and enables the assignment of creative tasks and organization of project work. Moreover, it demonstrates how modern technologies effectively model and visualize mathematical concepts.

The capabilities of online services can be utilized to create specific model tasks comprising explanations of the material, templates of geometric shapes, textual conditions, and drawings with data, as well as step-by-step construction plans. In this case, students will engage with pre-prepared models rather than directly with the program's tools.

The services can also serve as a tool environment for students to work in the classroom or at home. At the same time, students are assigned tasks involving the

construction and exploration of specific objects, resembling traditional paper-based construction using drawing tools.

A dynamic computer model enables users to interactively adjust various parameters of the simulated object. The advantage of this interactivity is that students can directly observe the effects of changing specific parameters on the object's state or behavior.

The use of computer models in the educational process is an important factor in improving the effectiveness of a mathematics lesson, as practice shows. These models can serve various purposes, including:

- interactive computer models – dynamic visual aids;
- models designed to automate calculations;
- computer models used as exercises on ready-made platforms.

With the help of built-in tools you can create interactive computer models that I use at different stages of the lesson:

- as dynamic visual aids (updating basic knowledge and skills, assimilation of new knowledge and ways of acting);
- to organize heuristic learning (consolidation of new knowledge and ways of acting);
- to automate calculations (consolidation of new knowledge and ways of doing things);
- as exercises on ready-made drawings (actualization of basic knowledge and skills; assimilation of new knowledge and methods of action).

During distance learning, optimal forms of organizing students' educational activities (individual, pair, group, frontal, cooperative) are utilized. These forms enable students to follow individual educational trajectories and engage in various forms of active, independent knowledge acquisition.

Given that mathematics instruction relies heavily on the visualization and manipulation of mathematical objects, online dynamic mathematics services prioritize capabilities such as visualization, modeling, and dynamic interaction. The utilization of

these features introduces innovations to the traditional methodology of mathematics instruction.

Online dynamic mathematics services facilitate independent research among students and diversify forms of work, particularly during distance learning. They significantly enhance the proportion of active creative engagement in educational activities and foster increased interest in mathematics and research through interactive constructions and exploration.

Thus, the essence and variety of remote learning technologies warrant further detailed investigation. Distance learning represents a promising area of development within the education system, and its ongoing evolution continues to unfold.

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