

## Pupils' mathematical competence components formation in the conditions of distance learning

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**Abstract.** The article looks at the possibilities of electronic resources (a virtual board (the analog of a school board), LearningApps, GeoGebra) to form components of students' mathematical competence in distance learning. The considered services allow optimizing an educational process, more rationally using time; to facilitate the formation of logical skills and experience of their use through the inclusion in the educational process of different types of problems, the purpose of which is the outcome (problem-solving) and the process of solving, during which components of students' mathematical competence are formed.

**Keywords:** *mathematical competence of students, distance learning, virtual board, LearningApps, GeoGebra.*

**Introduction.** Given the rapid development of information technology, changes in the educational process requirements and society in general, the emergence of quarantine measures, the education system must respond to the quick search for new learning tools, methods, and approaches to using information and communication technologies. The means of information and communication technologies in the conditions of distance learning for components of students' mathematical competence formation are highly relevant.

**Analysis of recent research and publications.** O. O. Andreyev, V. I. Hrytsenko, N. V. Morse, E. M. Smyrnova-Trybulska, and others were engaged in the development of theoretical aspects of distance learning; theoretical and practical aspects of the use of distance learning technologies are revealed in the works of M. I. Zhaldak, V. M. Kukhareenko, N. V. Morse, S. O. Semerikova, E. M. Smyrnova-Trybulska, Y. V. Tryus, and others.

Methodical and didactic problems and prospects of using modern information and communication technologies in the educational process are reviewed in the works of Y. V. Goroshko, L. V. Grambovska, M. I. Zhaldak, T. H. Kramarenko, V. M. Monakhov, S. A. Rakov, Y. S. Ramsky, S. O. Semerikova, O. A. Smalko, O. I. Skafy, Y. V. Tryus, S. V. Shokalyuk and others.

Analyzing the works of foreign scientists, we note that mathematics teachers show great interest in the means of visualization of mathematical concepts and objects and emphasize that the visualized material in mathematics lessons contributes to the development of abstract logical thinking [4]. Therefore, when teaching mathematics, it is necessary to use visualization tools to improve existing knowledge and expand them [17; 16]. In particular, scientists have studied the methods of presentation in mathematics teaching, which consist of various forms of visualization to identify the most effective [22].

Visualization is one of the most critical elements for understanding theoretical statements and solving geometry problems. The use of multimedia presentation (animated visualization) of the problem instead of a static image, helps in solving geometric problems [2; 20].

Modern multimedia learning methods include a range of different possibilities used in mathematics lessons. These authors suggested the use of different types of software in

the study of mathematics. Many studies have been devoted to the use of software in teaching geometry, such as GeoGebra [2; 6; 8; 9; 14], Geometers' Sketchpad (GSP) [9; 12; 13; 16], etc. It is essential to use multimedia tools to study geometric transformations in the context of distance learning, as this material is used indirectly during the further study of geometry [15; 19; 20]. Animation allows students to see not only a geometric transformation outcome but also the movement that gave rise to it.

Research conducted by scientists confirms that teaching and learning through multimedia changes students' work results dramatically. The lesson presented in this way is more organized and meaningful. Multimedia is an effective tool for teaching topics that are difficult to understand. The results of a study conducted by scientists show that learning through multimedia is more effective than the traditional way of learning. [18].

Modern information and communication technologies open up great opportunities for teachers. The study by Spanish scientists looks at the role that technological resources can play in improving logical thinking. The study involved 255 2nd and 3rd-year students of Spanish secondary education (Educación Secundaria Obligatoria, ESO), which correspond to grades 8-9 of primary school. The lessons of probability theory and statistics were conducted in the format of video podcasts. The animated effect improves the synchronization of verbal and visual information. The gradual presentation of written information attracts students' attention, improving the assimilation of relevant information. The presence of animated elements in multimedia materials allows students to remember better and apply what they have learned. The study results show that the inclusion of the animation effect in the educational material contributes to the formation of logical thinking, including information analysis, building a mathematical model of the problem, classification, and establishing relationships [13]. A study by Canadian scientists evidences the effectiveness of video podcasts. Fifty-nine video podcasts covering functions (linear, quadratic, exponential, logarithmic, and trigonometric), solving equations, and inequalities were created as learning tools and used by 288 students. The results showed that most students regularly used video podcasts, evaluating them as very useful, practical, and easy to use learning tools [11].

The study by Australian scientists demonstrates the potential of a personal computer, a tablet, a virtual board, and other online resources to teach math. As teachers move into a virtual environment, online resources are an essential tool that can maximize student's learning opportunities by expanding the capabilities of both the student and the teacher. Among the advantages of using online resources for teaching mathematics identified in the study of Australian scientists [7] are

- the ability to respond to students' questions while keeping records;
- opportunity to consider complex geometric constructions, which are difficult to draw on the board;
- opportunity to coordinate group or individual work;
- certain moments can be quickly recorded and reused to analyze and perform additional tasks by students.

**The aim of the article** is to reveal the possibilities of some electronic resources as an effective means of pupils' mathematical competence components formation in terms of distance learning.

**Results and discussion.** In Ukraine, distance learning using distance technology has been introduced at the legislative level for some time. In particular, the Resolution of the Ministry of Education and Science in 2000 approved the "Concept for the distance education development." Also, by the Resolution of the Cabinet of Ministers of Ukraine, «On approval of the Distance Learning System Program for 2004-2006» in 2004, the Regulation on distance learning was approved.

The Order of the Ministry of Education and Science of Ukraine «On approval of the Regulations on distance learning» provides the following interpretation: «distance learning is an individualized process of acquiring knowledge, skills, abilities, and ways of human cognitive activity, which occurs mainly through the indirect interaction of distant participants in the learning process in a specialized environment that operates based on modern psychological, pedagogical and information and communication technologies» [21].

The situation caused by the emergence of quarantine measures has led to a transition from theoretical aspects of distance learning to practical ones. The learning process was made possible only by technologies that were previously used as teaching supports. Therefore, the transition to distance learning has become a serious challenge for the traditional education system.

According to the guidelines for the organization of distance learning at school, approved for use in secondary schools (Letter of the Ministry of Education and Science of Ukraine № 22.1 / 12-G-372 from 18.06.2020) to provide distance learning, students can create their web resources or use other web resources of their choice.

The primary teacher's tool in a math lesson has always been a blackboard, so it is vital to use an analog of a school board in distance learning, which will provide the same functionality. The virtual board is a tool that should be actively used in distance learning. One of the most important features of it is powerful feedback and interactivity. A virtual interactive whiteboard is a networked social resource designed to work together for creating and editing images or documents, communication in real-time.

The possibilities of working on virtual boards are very diverse: from importing and sharing files to simultaneous

editing of material in real-time. You only need to choose the one whose tools and functions will be most convenient. Thus, it is possible to diversify pedagogical activities with a convenient, accessible tool for organizing collaboration with different content in a specific virtual space using virtual boards. Thanks to interactive interaction in the process of work, independent development of the studied material by students, and consulting support from the teacher, there is an opportunity to learn effectively at a distance.

You can place pre-prepared materials (texts, images, videos, audio) on the board, make notes by printing text or creating drawings. Besides, usually in the services of online boards, there is an opportunity to use additional tools for constructing equal figures, ready-made templates of organizational diagrams (concept maps, brainstorming, algorithm, etc.). You can work with the board, especially during a synchronous online lesson. Students can write on the board at the same time or in turns. The advantage of the online board is that all records can be saved and provided for those absent from class. Examples of digital online board services are Padlet, Jamboard, Miro, and more.

To form the components of mathematical competence of students during distance learning, we offer to use online boards for:

1) problem solving or analysis of the ready solution of the problem:

By adding a solution to the online board, students can analyze, leaving appropriate tags: comments, selections, etc. In this way, students will develop the ability to analyze, compare and justify their own opinions.

2) application of interactive technologies:

- brainstorming (the teacher names a problem; students' task is to write ideas for its solution on stickers, which are then placed on the interactive whiteboard)
- incomplete sentences (students should rearrange rectangles with words or phrases to make a correct mathematical statement, theorem, formulas, etc.)
- decision tree (students develop a strategy, action plan to solve; create a mathematical model (determine the components, relationships between them), choosing a mathematical apparatus to build a model).

The other service, which, in our opinion, will be helpful for the formation of components of mathematical competence, is LearningApps, which is a designer for the development of interactive tasks.

This service provides an opportunity to develop and use interactive tasks to contribute to the formation of components of students' mathematical competence.

Here are examples of such tasks:

1. Divide the properties of triangles into categories.
2. Using spatial imagination to divide the properties of figures into groups.
3. Continue the specified sequences.
3. Establish patterns.
5. Establish correspondence between symmetrical figures constructed relative to a point/line.
6. Classify mathematical objects by common features.

Among the types of exercises provided by the LearningApps service, we highlight those that will contribute to the formation of mathematical competence: find a pair, classification, ordering, table of correspondence, or fill in the table.

Multimedia resources are the most effective electronic resources because they present learning objects in different ways: through text, graphics, photos, videos, audio, or animation. Interactive learning tools provide an opportunity for independent research activities of students. Multimedia resources create fundamentally new opportunities for the formation of mathematical competence of students.

The use of electronic educational resources makes it possible to «design» mathematics lessons, determine the optimal content, forms, methods, and techniques of teaching that will contribute to the formation of components of mathematical competence of students in traditional and design distance learning. Electronic resources in mathematics lessons provide an opportunity to develop the ability to analyze and formulate goals and objectives independently, plan activities, search and analyze information, compare, summarize, draw conclusions and present them.

Using e-learning tools, the teacher has more opportunities to organize students' work, choose different ways to use e-learning tools, and find new ones.

Research tasks are considered difficult due to the somewhat unusual way of formulating the condition and finding the answer, especially difficult to implement the solution process in distance learning.

GeoGebra's capabilities help to radically change the educational process in distance learning, in which the student moves from an observer to an active researcher. Let us consider the possibilities of GeoGebra to form the components of students' mathematical competence on the example of problems.

- to perform practical tasks in algebra to build graphs and study functions;
- to perform practical tasks in geometry for construction, proof, and research;
- for creative and research projects that are performed by students independently.

Beginning from the 7th grade, students study the topic of "Functions," get acquainted with the main types of functions, functional dependencies, learn the concepts of argument, function, domain, and values, the graph of a function, intervals of monotony, and familiarity, zeros of a function, develop the ability to graph the function.

To form the mathematical competence of students, you can use the program GeoGebra to explore the properties of functions.

**Task 1.** Investigate the function  $y = kx + b$  depending on its coefficients (Fig 1).



Fig. 1. Graphing linear functions in GeoGebra

It is clear that students, plotting these functions, can immediately answer at what values of  $k$  the function will increase, at what values it will decrease, and at what values of  $b$  it will rise or fall. By demonstrating how to use this service, students will be able to explore more difficult research tasks.

**Problem 2.** Prove that of all right triangles with a given hypotenuse, an isosceles triangle has the largest area (Fig. 2).

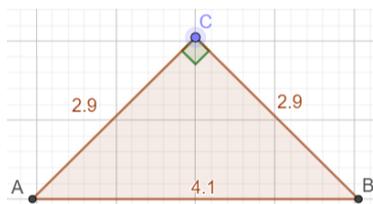


Fig. 2. The isosceles right triangle in GeoGebra

**Task 3.** What should be the angle of the isosceles triangle vertex of a given area so that the radius of the inscribed circle in this triangle of the circle is the largest? (Fig.3).

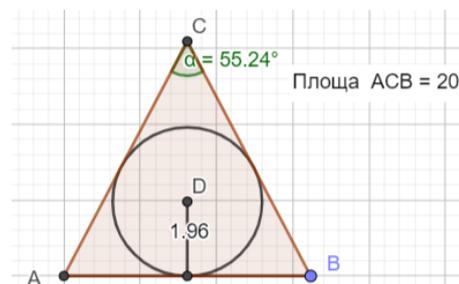


Fig. 3. The isosceles triangle with the inscribed circle in GeoGebra

While doing research, the student solves problems without using known algorithms. Performing construction with the help of computer simulation programs minimizes students' mistakes when constructing drawings on their own. In the conditions of distance learning, the teacher cannot control. Thus, the problem solution is accompanied by a visual representation of the conditions in the form of a dynamic figure, which helps to analyze the problem condition, find possible cases for its solution, and justify the results.

Therefore, the use of the services considered by us in mathematics lessons in the conditions of distance learning allows us to optimize the educational process, using time more rationally; to implement a differentiated approach to learning; to promote the formation of logical skills and experience of their use through the inclusion in the educational process of different types of problems, the purpose of which is not only the outcome (problem solving) but also the process of solving, during which components of mathematical competence are formed.

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