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METHODOLOGY OF TEACHING GEOMETRY IN THE CONTEXT OF DIGITALIZATION OF EDUCATION

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Abstract. Improving the quality of mathematical education is one of the most pressing problems of the modern educational space. The relevance of the study is due to the need to use digital interactive services and programs to improve the efficiency of the level of knowledge and skills of students; lack of methodological materials in the application of interactive technologies in the process of teaching mathematics. The article considers the problem of updating of the methodology of teaching Geometry. The solution to this problem in the context of teaching and learning Geometry is proposed to be partially solved by introducing digital technologies. A brief review of the most suitable, in the author's opinion, programs for the implementation of new methodological approaches to teaching Geometry is made. The purpose of the study is to study the possibilities of using digital educational technologies and resources in the modern educational process. The object of the study is digital educational technologies and resources in teaching Geometry. The following methods were used in the study: theoretical - analysis and synthesis of scientific, methodological and psychological-pedagogical research on the problem under study; empirical - observation and comparison, construction of dynamic models. Digital educational technologies and resources, considered in the example of the developed electronic educational module in the GeoGebra environment, contribute to increasing the effectiveness of teaching Geometry. The author conducted a survey with respondents on the use of digital applications in Geometry lessons. The majority of respondents accept the use of applications positively. The materials of this study can be recommended to teaching staff and students studying the methodology of teaching mathematics using digital educational resources and technologies. It is assumed that the use of modern technical means through dynamic modeling of the properties of geometric objects will increase the completeness of the assimilation of geometric concepts.

Key words: methodology, teaching, geometry, digitalization, pedagogical technologies, digital technologies, education, computer programs

Introduction

In the field of education, digital technologies are both didactic tools and pedagogical technologies as ways of organizing learning in a digital environment [1].

An analysis of scientific and methodological literature on the problem of digitalization of the educational sphere allows us to identify a number of research areas: concepts and models of digital education, development of the digital educational environment, educational potential of digital technologies, and problems and prospects of digitalization.

Modern experience confirms that in geometry lessons the use of such classic objects as a board, chalk, paper and a pen is not enough. Transition to digital education is dictated by the emergence of a new generation of students, whose socio-psychological, including cognitive, characteristics make it difficult for them to integrate into the traditional educational process [2]. Digital technologies help to actually use new pedagogical practices (new models of organization and implementation of educational work), which previously could not take a worthy place in mass education due to the complexity of their implementation by means of traditional (paper) technologies of communication and work with information. However, many modern students, despite a high level of technical skills in using digital tools, have not developed a culture of interaction with the information space. Therefore, the task of school education is, among other things, the development of a cognitive culture in students that is in demand in the digital environment.

The issue of using the didactic and developmental potentials of digital technologies in teaching Geometry remains insufficiently studied. As the analysis of the articles shows, the use of these technologies often performs only a purely illustrative function; however, the strong sides of software (modeling, computing, archival capabilities) are not used. The above determines the expediency of defining the conditions and possibilities of effective inclusion of digital technologies in the content-methodological aspect of teaching Geometry. It should be noted that many studies of the use of digital tools in education today actualize the possibility of such technologies in the mode of classroom interaction between a teacher and students and its additional support.

Digital technologies enable the teacher to make lessons more dynamic and interesting without much effort. Special training programs provide information on the composition and purposes of various actions within geometry. These actions, such as construction, determining properties, working with geometric objects on a sheet within the boundaries, help students develop mathematical abilities. Measuring, finding relationships, analyzing, comparing geometric figures, etc. develop analytical abilities. Even if the task is only about comparison, it will include various actions.

In the process of learning geometry, spatial imagination and visual skills of students, their logical thinking are developed. Nevertheless, for students, geometry remains one of the most difficult sections of mathematics. Many students do not always succeed in constructing spatial figures and manipulating them. Modern digital technologies come to the rescue. Informatization of all spheres of human activity is one of the main factors determining the vector of development of society. The introduction of digital technologies in education is one of the important areas of informatization of society. Geometry classes are associated with working with graphic images of spatial geometric figures, which do not always clearly display their properties. The use of digital technologies in the learning process in Geometry is especially relevant given the wide possibilities of visualizing constructions on electronic displays.

Thus, the use of digital technologies in the learning process is a relevant task for geometry due to their great potential. However, these possibilities have not yet been sufficiently studied. The specific possibilities of using digital technologies specifically for teaching geometry have not been fully disclosed.

Materials and methods

The study involved the use of such research methods as theoretical analysis of literary sources on the research topic, observation of students' activities in the educational process, systematization and generalization of scientific facts, processing of the results of the work, and construction of dynamic models.

Technology is defined as the combination of *hardware* devices (the computers, mobile devices, smartphones etc.) with the *software* [3].

Pedagogical software is a complete didactic system based on the use of computer technologies and Internet tools and aiming to provide training according to individual and optimal educational programs with the management of the learning process. Pedagogical software is a modern highly effective teaching tool developed with the aim of facilitating the process of education and perception of material [4].

The software available today allows organizing the learning process based on information technology. These tools allow not only to automate the learning process, but also to involve students in active work, to increase the visibility of theoretical material.

An analysis of typical mistakes made by students when completing exam and test tasks leads to the conclusion that for young generation, who have a predominantly clip-based thinking, it is important to use modern teaching methods that allow visualizing and animating the material being studied in full.

These educational programs are based on the principle of dynamic geometry, which gives each object dynamic properties. Programs that work on this principle are included in the class of interactive geometric systems (IGS).

Geometric environments (GE) are understood as software specially developed for educational purposes and allowing to perform geometric constructions on a computer, consisting of geometric objects, as well as to set relationships between these objects. Interactive geometric environments provide the ability to change geometric objects within the framework of specified relationships. At the same time, other geometric objects are also changed, preserving the specified ones. Currently, several interactive geometric environments are used in the educational process, each of which has both its strengths and weaknesses. These are programs such as "Live Mathematics", "Mathematical Constructor", "GeoGebra", etc.

In the course of this study, interactive geometry worksheets were developed based on the GeoGebra environment for students. The material from the section "Tetrahedron, parallelepiped" was chosen as the theoretical basis for developing digital resources. The hypothesis of the study was that working with dynamic drawings would help to consolidate the basics of the theory being studied and would improve the effectiveness of training. The worksheet includes one or more interactive tasks, during which it is possible to use the parameterization of the problem condition and the capabilities of computer animation. The process of creating a worksheet consists of two stages: methodological and technical [5].

The methodological stage consists of selecting tasks or their complexes and setting the main goal of including computer animation in it. A visual representation of theorems and definitions allows the student to grasp their essence and apply them in solving problems. The technical stage consists of developing an animation algorithm for objects or describing the operation of control buttons and input windows. The description of the algorithm for working with a sheet does not require the developer to have deep knowledge of programming languages and, therefore, is available for development to a large percentage of teachers.

When reviewing the material, computer programs are widely used: the Geometer's Sketchpad, Cabri, Microsoft Math, Tarsia, Cinderella, Live Geometry, Poly, Mathematical Constructor, GeoGebra, etc. These tools allow not only to automate the learning process, but also to involve students in activities and increase the visibility of theoretical material. Computer programs and presentations with moving (animated) graphics can be used to conduct practical work of a creative, research nature. When performing practical work, the student will have to conduct an individual study of the properties of a geometric figure, try to notice some patterns, express their own hypotheses, and experimentally test their validity [6].

One of the computer programs systematically used by teachers in the classroom as a tool for learning is the *Live Geometry* environment. This program allows you to model geometric problems, and therefore, with a certain methodological approach, purposefully work on the formation of research skills in students. Using dynamic geometry packages, students learn the power of the

world of geometry, create figures and explore them with the help of various manipulations.

Poly is a program for studying polyhedral surfaces. The program can show polyhedral surfaces in three main ways: as a three-dimensional image, as a flat, two-dimensional scan, as a topological embedding in a plane.

Live Mathematics 5.0 includes computer albums with examples and problems, containing ready-made drawings on planimetry and stereometry. The product can help:

1. discover patterns in observed geometric phenomena, formulate theorems for subsequent proof, confirm already proven theorems;

2. set coordinate systems and draw function graphs;

3. differentiate (both exactly and approximately), edit functions and calculations in the operating mode;

4. embed network resources directly into drawings and publish a live drawing on the Internet as a JAVA applet.

The *Mathematical Constructor* software environment is designed to create interactive mathematical models that combine design, modeling, dynamic variation, and virtual experimentation.

On the Mathematical Constructor website, you can find educational materials, including the Planimetry laboratory, the Stereometry laboratory, and many others. They are accompanied by methodological recommendations for using the laboratories, interactive tasks, and a reference book on using the laboratory tools.

The process of studying the problem is also facilitated by the implementation of the *GeoGebra* program, which allows the implementation of geometric constructions [7]. GeoGebra combines graphs, geometry, 3D, spreadsheets, computer algebra and probabilities in one easy-to-use powerful package.

The GeoGebra program is a free, cross-platform dynamic mathematical program for all levels of education in one easy-to-use package. In addition, this program allows you to set up geometric experiments, conduct experiments, illustrate formulas and theorems, establish dependencies between geometric quantities, etc [8].

One such tool is the *CloudText* (cloudtext.ru) for checking written homework online. Computer technologies allow visualizing various mathematical objects, so students who are interested in computers can write programs demonstrating a particular fact or object.

Many students know how to use programs such as "Living Geometry", "GeoGebra", which allow using a set of tools for constructing drawings and their research.

For example, using GeoGebra online geometry can replace a long explanation of the properties of a quadrilateral. The interactive manual "Visual Mathematics. Stereometry" allows students to evaluate the relative position of a

point, a line and a plane. Using the digital technologies allows the wide use of various manuals, in which students in the process of assimilating information or its consolidation and generalization can add something, draw, fill in, and also make teaching aids independently and defend them in their classes.

However, one should keep in mind that, the technological tools are only means and "the focus of mathematics classes should not deviate from mathematics" [9].

Results

Digital technologies are developing rapidly and continuously, and teaching methods are unable to adapt to these changes. Today, new devices connected to the Internet are registered nearly every day. The ICT infrastructure of educational institutions is improving. And this applies to all levels of education. An information and educational environment for an educational organization is being created.

This study shows that the educational process can contain components of modern digital technologies and at the same time maintain its integral unified structure. This allows us to assert that the active introduction of interactive online services and programs into the educational process.

Digital technologies in mathematical education promote more efficient interaction of all its participants, and allows us to highlight the following positive changes:

- increasing the motivational component of training;
- the ability to more effectively reconstruct information into subject knowledge;
- the ability to use and transform exercises with modern tools of interactive platforms;
- implementation of personalized learning technologies.

New technological developments over the past decades have led to the emergence of new problems that can be used in teaching of Geometry. Digital technologies help reach a new level with compatible work in the classroom. The main elements of application of digital technologies in Geometry are that students master modeling, compare images, find differences, determine features and possibilities of combining elements. In mathematics lessons, the computer allows students to research, solve, analyze data, reason, etc. Here, the main goal is to ensure the behavior of the student studying mathematics. Each result, regardless of its correctness or incorrectness, should not upset the student. Such dynamic geometry systems as Geometer's, Sketchop, Cinderella, etc., include both private and general programs. At present, with the help of digital tools that have more powerful graphic capabilities than conventional computer programs, it is possible to carry out transformations of any geometric figure [10]. These systems provide the following capabilities:

- it is easy to construct geometric figures;
- various measurements can be made on the constructed drawings (length, volume, etc.);
- drawings can be demonstrated in different projections (for example, a pyramid - as a polygon);
- the student's work with these training programs is considered more thoughtful.

Discussion

An analysis of the role of digital technologies in teaching Geometry allows us to identify three aspects. The first aspect is related to the introduction of modern computer hardware and software into the teaching process. The second aspect is related to the development of a methodology for teaching Geometry using new digital technologies. And finally, the third aspect is related to the experimental verification of the effectiveness of new digital technologies and the corresponding teaching methodology [11].

The 10th grade students of specialized lyceum named after Al-Farabi, Almaty region, Karasai district answered survey questions to identify their opinions on the appropriateness of using digital applications in Geometry lessons (Table 1). 42 students answered the test.

Table 1 - Students' opinions on the effectiveness of using digital applications in Geometry lessons

Do you agree that…	Answer options			
	Strongly agree	Agree	Disagree	Strongly disagree
the use of digital applications in Geometry lessons is appropriate?	75%	25%	-	-
the use of digital applications increases motivation for classes?	83%	17%	-	-
the use of digital learning programs helps me collaborate and effectively exchange ideas with my peers;	86%	14%	-	-
the use of digital learning programs helps me in completing assigned tasks in Geometry lessons.	80%	20%	-	-
the use of digital learning programs helps me in understanding the theoretical concepts in Geometry lessons.	95%	5%	-	-

The data from students' responses provide insights into how they assess the effectiveness of using digital applications in Geometry lessons. According to the students' survey, a significant majority (75%) agreed that the use of digital applications in Geometry lessons is appropriate. A majority of students (86%) agreed that the use of digital learning programs helps them collaborate and

effectively exchange ideas in class. 80% of students agreed that the use of digital learning programs helps them in completing assigned tasks in Geometry lessons.

Thus, the survey results show that digital applications are mostly preferred by today's learners in Geometry lessons as they increase motivation, support their collaboration, also improve students' understanding of theoretical concepts.

Conclusion

The use of digital tools and practices plays an important role in the field of education. The intention of including technical resources in the Geometry classroom is based on motivating and stimulating creativity, developing logical reasoning and mathematical foundations in order to encourage and prepare students to build and study mathematical models.

Nowadays technical means are replaced not just by more advanced ones, but by means that have a new characteristic, expressed in the fusion of means and technologies.

The number of software used on modern technical means is updated and expanded. The work analyzes several interactive educational programs that work on the principle of dynamic geometry.

The use of such resources in a geometry lesson allows students to better navigate the essence of the theory being studied, to learn the main criteria for the completeness of concepts.

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БІЛІМ БЕРУДІ ЦИФРЛАНДЫРУ ЖАҒДАЙЫНДА ГЕОМЕТРИЯ ПӘНІН ОҚЫТУ ӘДІСТЕМЕСІ

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Аңдатпа. Математикалық білім беру сапасын арттыру қазіргі білім кеңістігінің өзекті мәселелерінің бірі болып табылады. Зерттеудің өзектілігі математиканы оқыту үдерісінде интерактивті технологияларды қолдануда әдістемелік материалдардың жетіспеуімен және оқушылардың білім мен дағды деңгейінің тиімділігін арттыру үшін цифрлық интерактивті қызметтер мен бағдарламаларды пайдалану қажеттілігімен түсіндіріледі. Мақалада геометрияны оқыту әдістемесін жаңарту мәселесі қарастырылған. Геометрияны оқыту контекстінде бұл мәселені шешуді сандық технологияларды енгізу арқылы ішінара шешу ұсынылады. Геометрияны оқытудың жаңа әдістемелік тәсілдерін жүзеге асыру үшін автордың пікірі бойынша ең қолайлы бағдарламаларға қысқаша шолу жасалды. Зерттеудің мақсаты – заманауи білім беру үдерісінде цифрлық білім беру технологиялары мен ресурстарын пайдалану мүмкіндіктерін зерттеу. Зерттеу нысаны – геометрияны оқытудағы цифрлық білім беру технологиялары мен ресурстары. Зерттеу барысында келесі әдістер қолданылды: теориялық – зерттелетін мәселе бойынша ғылыми, әдістемелік және психологиялық-педагогикалық зерттеулерді талдау және синтездеу; эмпирикалық – бақылау және салыстыру, динамикалық модельдер құру. ГеоГебра ортасында жасалған электрондық білім беру модулінің мысалында қарастырылған цифрлық білім беру технологиялары мен ресурстары геометрияны оқытудың тиімділігін арттыруға ықпал етеді. Автор респонденттермен геометрия сабақтарында цифрлық қосымшаларды қолдану бойынша сауалнама жүргізді. Зерттеу көрсеткендей, респонденттердің көпшілігі қосымшаларды пайдалануды оң қабылдайды. Бұл зерттеудің материалдарын сандық білім беру ресурстары мен технологияларын пайдалана отырып, математиканы оқыту әдістемесін оқитын оқытушылар мен студенттерге ұсынуға болады.

Геометриялық объектілердің қасиеттерін динамикалық модельдеу арқылы заманауи техникалық құралдарды қолдану геометриялық ұғымдарды меңгерудің толықтығын арттырады деп болжанады.

Тірек сөздер: әдістеме, оқыту, геометрия, цифрландыру, педагогикалық технологиялар, цифрлық технологиялар, білім беру, компьютерлік бағдарламалар

МЕТОДИКА ПРЕПОДАВАНИЯ ГЕОМЕТРИИ В УСЛОВИЯХ ЦИФРОВИЗАЦИИ ОБРАЗОВАНИЯ

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Аннотация. Повышение качества математического образования является одной из наиболее актуальных проблем современного образовательного пространства. Актуальность исследования обусловлена необходимостью использования цифровых интерактивных сервисов и программ для повышения эффективности уровня знаний и умений учащихся и недостаточностью методических материалов по применению интерактивных технологий в процессе обучения математике. В статье рассматривается проблема актуализации методики обучения геометрии. Решение этой проблемы в контексте преподавания и изучения геометрии предлагается частично решать путем внедрения цифровых технологий. Сделан краткий обзор наиболее подходящих, по мнению автора, программ для реализации новых методических подходов к обучению геометрии. Целью исследования является изучение возможностей использования цифровых образовательных технологий и ресурсов в современном образовательном процессе. Объектом исследования являются цифровые образовательные технологии и ресурсы в обучении геометрии. В исследовании использовались следующие методы: теоретические — анализ и синтез научно-методических и психолого-педагогических исследований по изучаемой проблеме; эмпирические — наблюдение и сравнение, построение динамических моделей. Цифровые образовательные технологии и ресурсы, рассмотренные на примере разработанного электронного образовательного модуля в среде GeoGebra, способствуют повышению эффективности обучения геометрии. Автором был проведен опрос респондентов по использованию цифровых приложений на уроках геометрии. Исследование показало, что большинство респондентов относятся к использованию приложений положительно. Материалы данного исследования могут быть рекомендованы педагогическим работникам и

студентам, изучающим методику обучения математике с использованием цифровых образовательных ресурсов и технологий. Предполагается, что использование современных технических средств посредством динамического моделирования свойств геометрических объектов позволит повысить полноту усвоения геометрических понятий.

Ключевые слова: методика, обучение, геометрия, цифровизация, педагогические технологии, цифровые технологии, образование, компьютерные программы

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