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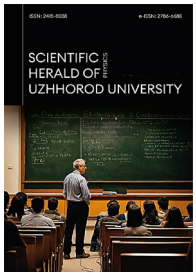

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Use of modern digital educational resources in geometry lessons in higher educational institutions of the Republic of Kazakhstan

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Abstract

Relevance. In the era of global digitalisation, more and more spheres of public life are switching to the use of innovative technologies, which also applies to the educational process. Especially important is the process of using digital technologies for exact sciences and those requiring modelling and graphical operations, geometry being one of them. This explains the relevance of the issue of student-teacher interaction during the use of digital programmes for studying geometry in higher educational institutions of the Republic of Kazakhstan.

Purpose. The purpose of the study is to analyse the impact of innovative technologies on the processes of teaching and assimilation of educational material on geometry by students and to determine the role of digital programmes in the process of establishing communication between a student and a teacher.

Methodology. It is necessary to systematically apply various means for scientific research, in particular, dialectical and activity-based methodological approaches, methods of logical analysis, synthesis, comparative analysis, content analysis, modelling, and analysis of scientific literature.

Results. The main findings of the paper are the theoretical and practical background to the issue. That is, the theoretical component of the study includes the concept of digital technologies, their features, and types. The practical part includes an analysis of the effectiveness of using digital technologies in the context of studying geometry and determining the level of prevalence of relevant programmes abroad. As for the prospects for the following studies, it would be necessary

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to conduct a comparative analysis of the use of innovative technologies in higher educational institutions before and after the COVID-19 pandemic.

Conclusions. The practical value of the study is quite high since it determines the possibility of using the findings in further developments, in particular, in the construction of geometry curricula in universities, or use as a means for the development and improvement of current curricula.

Keywords: digital educational resources; geometry; innovative technologies; students; higher educational institutions.

Introduction

The use of digital technologies is commonplace in every area of public life, including education. In general, this is conditioned by the fact that the use of such programmes simplifies and speeds up the educational process, respectively, for any speciality, if they are used correctly. However, as for the exact sciences, namely geometry, digital resources generally occupy leading positions, moreover, they are a necessary element for obtaining high-quality knowledge on this science. In addition, the inclusion of digital resources in the educational process not only opens up a range of possibilities for the variability of educational activities, in particular through its individualisation and differentiation, but also organises the interaction of all subjects of learning in a new way, that is, students and teachers, while forming an integral educational system in which the person receiving education acts as an active and an equal participant in educational activities.

Thus, the use of digital resources in universities of the Republic of Kazakhstan in the study of geometry allows, first of all, increasing the level of assimilation of the content of mathematical education of students, in addition, intensifying the learning process, i.e., strengthening and increasing the level of productivity and efficiency of students' work. It is also important that the involvement of innovative programmes promotes the stimulation of cognitive activity of students and the implementation of the training of real specialists who are able to work in an information society and effectively use mathematical knowledge of geometry in practice [1]. The understanding of digital educational resources as a wide range of different in purpose, level the complexity, form of technical execution and types of interface of pedagogical software, electronic textbooks, electronic tests, computer models, simulators, didactic games and simulators [2] will lay the basis for the disclosure of their essence and role.

It is important that these resources are usually divided into two types, namely: information sources and information tools. The first group includes a set of various kinds of materials in digital format, which in turn are actively used in educational work, that is, they should include: texts, static and dynamic images, animation models, presentations. As for information tools, they respectively ensure the work and interaction of the student and the teacher with information sources of a different nature [3]. Considering the practical part of the study, then first of all it is necessary to determine which digital programmes are most often used for learning geometry in universities of the Republic of Kazakhstan. These include those that allow designing various kinds of geometric models of the objects under study, in addition, manipulating them, that is, interactively changing their parameters or entering additional data, observing the dynamics of changes in the parameters of these models. As a rule, packages of such resources are called dynamic geometry packages.

Quite common at the moment are GRAN 1 (GRaphicANalysis), GRAN 2D, DG (Digital Graphic), which allow developing images of basic planimetric or stereometric figures, their combinations, and transforming them on the coordinate plane, conducting computer experiments with mathematical models. A programme called GeoGebra is also effective, which is available for many platforms, it is aimed at studying and teaching mathematics at universities. With its use, it is possible to create from points, vectors, segments, lines, polygons, conic sections, implicit polynomials and functions, in addition, all of them can be dynamically changed [4].

Considering the above, the purpose of the study is to determine the role of digital resources when learning geometry in universities of the Republic of Kazakhstan. As for the tasks of the work, they should include: consideration of the concept of digital resources in education, determination of their signs and types, and the features of their application in higher educational institutions. In addition, it is necessary to consider existing programmes, analyse international experience, and identify foreign technologies that may be useful for universities of the Republic of Kazakhstan [5].

Materials and Methods

The study of the process of interaction between a student and a teacher is a rather complex phenomenon, since it includes a number of both objective and subjective properties. In addition, the subject of this study is narrowed to the category of mastering geometry, based on the use of digital resources and technologies. That is why a lot of methodological tools were used in the course of the study. Thus, the study is based on a dialectical methodological approach, which allowed establishing causal relationships between digital resources and the process of assimilation of educational material by students, the process of differentiation and integration of the main concepts studied, the constant contradiction between the essence and phenomenon of digitalisation, content and form, objectivity in assessing reality. In addition, this approach has enabled the process of work to evolve from a general, specifically a system of digital resources, to the specific use of such resources in geometry classes at higher educational institutions in the Republic of Kazakhstan. As for the activity approach, this methodological principle is based on the category of subject activity of a person, in particular, a teacher and students during the educational process, including when solving common tasks. Considering general theoretical methods, then one of those is the method of logical analysis, which is based on the differentiation of the subject under study into individual

elements. This method allowed investigating the essence of the concept of digital resources, their significance in the educational process, and the features of their application.

Based on the synthesis method, all these separated structural parts were combined, so this method established the existing connection between the above concepts. As for the process of comparing digital resources and the process of studying geometry by students in universities, the method of comparative analysis is optimal for its implementation, since due to it the influence of such technologies on the educational process was determined, and the experience of foreign countries on this issue was analysed. In addition, the method of content analysis was used, which consists in a qualitatively quantitative approach to the study of documents, which is accordingly characterised by the objectivity of the conclusions obtained, and a certain formality of the procedure. In addition, it consists in quantifying text processing with subsequent interpretation of the results, which accordingly plays a significant role in this particular study when studying theoretical material that reveals the procedure for studying geometry in universities and the principles of implementing digital technologies in teaching. The analysis of scientific literature is also important, which allows considering the theoretical component of the work, in particular, through the study of modern views and approaches of researchers to the issue under study, and the analysis of scientific theses, papers, diploma theses and master's theses. As for the procedure for conducting the study, it consists of three stages:

1. At the first stage, the content of the concept of digital educational resources, their types and principles determining their application in teaching, in particular, during the study of geometry, was determined. In addition, a work plan was formed and the purpose and objectives of the study were defined.

2. At the second stage, the level of influence of such technologies on the educational process and the effectiveness of students was determined, and the resources currently used in universities of Kazakhstan were also considered.

3. At the third stage, the results were analysed and conclusions were formulated; in addition, promising areas for further study on this topic were identified.

Results

The use of digital educational tools has become quite common in recent years, both in the education systems of the Republic of Kazakhstan and in foreign countries. At the moment, such digital educational resources are implemented in the form of online courses, multimedia textbooks, distance learning courses, interactive posters, presentations, the involvement and application of which requires educational institutions to have appropriate technologies, techniques, innovative forms and methods, respectively aimed at ensuring the effectiveness of digital learning tools. Thus, these educational resources are a modern version of the general system of information resources used in education. Digital educational resources are presented in electronic form based on teaching materials, containing both elementary objects, in particular, texts, drawings, animations, models, and complex forms, such as documents, slides, presentations, tests, courses. Education in Kazakhstan has quite solid developments in the field of electronic, that is, digital learning, in particular, the development and active use of electronic learning tools are widespread [6].

As for the specific academic discipline of geometry, then, accordingly, it is characterised by such means as electronic, multimedia textbooks, and a system of separate software pedagogical tools. In addition, quite often various multimedia content is included in the educational process, such as video and audio fragments, various animations, photographic materials, illustrations, and methodological materials, additional information sections and methodological recommendations for their installation and application. All of the above e-learning tools belong to the category of local and, accordingly, require certain material costs to install them on a computer, which limits the possibilities of their use. In addition, it is important to note that quite often there are isolated examples of electronic textbooks and manuals on geometry created by enthusiasts. Thus, e-learning in higher educational institutions takes place through the use of various software suites, such as local learning tools or websites designed specifically for online learning [7].

Therefore, the concept of educational digital resources implies any information of an educational nature that is stored on digital media. It is worth noting that digital educational resources are usually used in electronic form, in particular, in the form of teaching materials containing such elementary objects as texts, drawings, animations, models, and complex forms, in particular, documents, slides, presentations, tests, courses. In addition, when developing and implementing such resources, special attention is paid to their visibility, accessibility, usability, and methodological correctness.

An important element in the system of digital educational resources is network learning technologies, characterised by accessibility for a large number of people, in particular, students. Thus, it is necessary to establish what dynamically contributes to the development of such systems, information support of the educational process, in particular the study of geometry, as: online electronic libraries, courses, and other information resources. Considering the theoretical basis of digital educational technologies and their impact on the study of geometry by students in higher educational institutions, it is still necessary to focus on the advantages that such an approach gives. Thus, the use of information technology in geometry lessons provides an opportunity for the teacher to significantly reduce the time to study the material due to the clarity and speed of work. However, it is important to note that despite the reduction in the period of consideration of a certain educational topic, the student continues to receive the necessary amount of information and, accordingly, can demonstrate the level of knowledge [8].

In addition, such digital resources allow students to test their knowledge interactively, both directly by the teacher and by the student during self-testing. This approach significantly increases the effectiveness of teaching and the future results of students, and also helps to realise the full potential of the individual, in particular, cognitive, moral, creative, communicative, and aesthetic, which is extremely important for the process of self-development. Moreover,

the use of digital resources involves the development of intelligence, information culture of students, and also makes classes more creative and interesting, which provokes an increase in student interest. As a result, all these aspects are combined with each other in the process of organising training within specific universities of Kazakhstan and, accordingly, contribute to changes in the content and organisation of the current procedure for teaching geometry [9].

The study of geometric bodies is generally the primary type of intellectual activity of mankind. Since geometry studies spatial forms and their relationships with each other, these elements are traced accordingly wherever the slightest accuracy is required in determining the shape and dimensions. In addition, it is proved that every tenth scientific invention is made with the use of geometric knowledge due to digital resources, the choice of a convenient shape, a good location. During this study, it was found that the need to investigate the student-teacher interaction in the context of studying geometry with the involvement of digital resources is necessary not only exclusively for mathematical specialities, but also for engineering, architectural, construction and even design specialities, in particular during the training of fashion designers, and researchers from various fields of science, in which a thorough knowledge of geometry is required, including knowledge of geometric bodies [10].

Having considered the concept of digital educational resources and the specifics of their application, it is advisable to determine the requirements for such resources. They can be divided into standard, specific, psychological, technical and technological, health-saving, and ergonomic nature. The standard ones should include the requirement of scientific character, ensuring the problematic nature of teaching, ensuring clarity, consciousness of learning, consistency and systematicity. As for specific requirements, they include adaptability, interactivity, promotion of intellectual potential, and communicative abilities. Considering psychological requirements, they consist in the fact that the presentation of educational material should correspond not only to the verbal and logical, but also to the sensory and perceptual levels of the cognitive process, and, in turn, the presentation of educational material should be focused on the vocabulary of a specific age contingent, and the specifics of training a certain group of students [11].

Technical and technological requirements are important, which are revealed in the features of the functioning of an electronic resource in the web space, functioning under the control of various operating systems, in local and network modes, maximum use of multimedia and telecommunication technologies, reliability and long-term performance, resistance to defects, the presence of protection against unauthorised user actions, effective and expedient use of resources, ease and reliability of installation and uninstalling [12].

As for the health-saving requirements, they are certainly the main ones, since they relate to the health and life of the student, therefore, they are consolidated in the requirements for the implementation of the educational process in the context of distance learning. As for the ergonomic requirements, the name of which suggests that they include the requirement to ensure a humane attitude to the student, the organisation of a friendly interface, providing the trainees with the necessary tips and methodological instructions, providing the opportunity to choose the sequence of studying the material and choosing the pace of work, which will avoid a negative impact on the psyche. In addition, due to these requirements, the teacher is obliged to create a friendly atmosphere in the classroom; they also include requirements for the colour characteristics of the software, for the spatial placement of information on the screen, for the organisation of dialogue, for the font design of symbols and signs, and for audio accompaniment [13].

Discussion

As already noted, the informatisation of society, in particular in the context of the development of digital tools and resources for graphics, has a significant impact on the development of geometry in general, especially its algorithmic aspects. Thus, information achievements in geometry stimulate the development of computer science, respectively, formulate new tasks and challenges for geometry. The high achievements of computer graphics allow creating more new programmes, which, accordingly, can be applied in the process of developing and improving geometry as a science [14].

Thus, some of them allow building geometric models of the studied objects, performing various operations with them, for example, interactively changing their parameters and tracking the trajectory of changes in the parameters of these objects. Such a system of programmes is often called a system of dynamic geometry, which is most often studied in universities. Such system digital programmes as GRAN 1, GRAN 2D, DG are extremely common in the context of studying geometry. Their popularity is conditioned by the ability to design images of both basic and stereometric figures based on them, in addition, the ability to consider their combinations and manipulate them, for example, by converting them on a coordinate plane or conducting computer experiments with mathematical models [15-18]. The above digital tools are quite easy to use, moreover, they are equipped with a fairly convenient and intuitive interface, namely, as close as possible to the interface of the most common general-purpose digital programmes, such as word processing systems, database management, spreadsheets, graphic and music editors, and they also have context-sensitive help. In addition, an extremely important property of such digital resources is the absence of a requirement for a student to have a relatively significant amount of special knowledge in computer science, the basics of computer technology, or programming, with the exception of the simplest concepts that are quite accessible to people of this age [19; 20].

The use of digital educational programmes gives the applicant the opportunity to independently solve individual tasks without having the appropriate analytical tools, methods, and formulas. For example, a student can solve equations and their systems, and various kinds of problems without knowing formulas for finding roots, the method of excluding variables, the method of intervals, etc.; calculate derivatives and integrals without remembering their tables, explore functions without knowing algorithms, find optimal solutions to the simplest linear and nonlinear

programming problems without using the simplex method, gradient methods, etc [21-24].

Thus, based on the opportunities provided during the use of graphical support for a computer solution of a problem, an educational applicant can clearly and easily solve fairly complex problems, in addition, confidently own the appropriate system of concepts and rules. However, this information does not indicate that the student does not need to study theorems and formulas, the above data only indicate that functionally all the necessary elements can be automatically recorded by the programme and do not require additional re-introduction by the student [25; 26]. Analysing the general fundamentals of the practical implementation of digital resources in teaching geometry in universities, the use of such software tools allows in a large number of cases to make the solution of the problem as accessible and understandable as possible for each student, regardless of their level of knowledge, by simply examining drawings or graphic images previously generated by the teacher. Thus, these digital software tools integrate individual sections and topics of mathematics into easy and convenient cases for use, and accordingly, the problem solver automatically becomes a user of mathematical methods, perhaps even without fully possessing their construction and justification, only by performing similar actions to those performed using other similar computer programmes, such as: text, graphics, music editors, spreadsheets, databases, operating systems, and expert systems, without knowing how and by what internal algorithms they are constructed, in which programming languages are described, and which theoretical provisions are based on them [27-30].

As for the GRAN 1 digital methodological complex specifically, based on it, students can design and explore functional dependencies and signs of explicit and implicit form, respectively set in Cartesian coordinates, or tabular. In addition, due to the use of this resource, applicants for education have the opportunity to graphically solve equations, inequalities and their systems with one or two variables, also approximate the roots of polynomials, and explore numerical sequences and functions. It is important that they can process statistical data, plot distribution functions, calculate certain integrals, areas of curved trapezoids, surface areas and volumes of bodies of rotation. Moreover, GRAN 1 is extremely easy to use, which ensures its accessibility and ease of use [31; 32].

Considering such a digital resource for studying geometry in universities as GRAN 2, then it should be noted that with its help, students can conveniently and quickly solve problems for building on a plane, or check and, accordingly, refute individual assumptions. Thus, as a result of creating dynamic models and analysing the corresponding dynamic expressions, it becomes possible to consider individual geometric places and points, designate extreme values of certain quantities, establish patterns, and also track the sequence, which, in turn, can be applied by the student when proving certain theorems. In addition, this digital educational tool is directly aimed at the implementation of graphical analysis of systems of geometric objects on a plane, hence the name GraphicAnalysis2-Dimension. Considering the above, it is advisable to establish that the Gran-1 and Gran-2 programmes are usually used in the educational process in the course of mastering such sections as plotting functions and solving geometric problems. It is also important to consider such a system of digital means of dynamic geometry as DG, which supports the constructive area in teaching and the principle of visibility, by providing an environment for experimentation to student trainees. Based on the above, DG is an interactive environment for experimentation in the field of geometry [33-35].

This digital system is aimed at providing students with the opportunity to independently discover geometric patterns by experimenting on a computer, to a certain extent this can be associated with research work. In addition, this resource can be used when demonstrating or visualising a separate problem or theorems of the planimetry course, developing and using visual interactive educational materials developed by the teacher. It is also important that this digital package can be actively used in the course of research, in particular, for the development of illustrations, modelling, forming hypotheses, and verifying their authenticity. Moreover, this digital resource is currently enjoying high success among students of mathematical specialities and all others interested in studying and analysing such a scientific branch as geometry. This is conditioned by the effectiveness of this programme and a large range of functions that allow the aforementioned subjects to carry out scientific, cognitive, and reflexive activities. Thus, the main advantage of using such a digital resource at this stage of the development of the information society is to provide the user with the opportunity to work on a computer, in particular, building and modelling various geometric objects in the educational process.

As for the foreign experience of using digital educational resources in universities, in particular, in the context of studying geometry, discussions about the improvement of the modern generation of educational resources, which is usually called the Next Generation of Digital Learning Environment (NGDLE), are increasingly characteristic of this environment. This concept should be understood as the digital educational environment of the next generation, which involves the involvement of a large number of information resources for learning, and the process of establishing communication between the student and the contributor. Thus, NGDLE is a clear, universal digital learning platform for both teachers and students, and also embodies a place of accumulation and dissemination of various educational programmes, including geometry. Accordingly, this digital software of educational resources provides for the concentration of all necessary educational tools in one place, and is also responsible for the implementation of such important functions as presentation of materials, testing, data management, class schedules, learning analytics, multimedia, means of cooperation and communication, tools for the exchange of materials and support of learning. This platform should provide support for the educational activities of both teachers and students.

In the USA, the application of the basics of the above software began back in 2015, in particular, at several universities in the USA. In addition, specialists in the field of innovative approaches to education continue to further develop this digital educational environment, in particular, by developing special software with additional extensions,

which in turn allow configuring resources faster, improving the functionality of use, and increasing security to protect students' data, especially their papers, on which they work on these platforms. That is, this refers to new standards and principles of user interaction with learning tools, which, in turn, provoke the integration of educational applications and tools into digital programmes for the organisation of training, including the study of geometry. In addition, the development of new standards is associated with a large number of available e-learning platforms and e-learning resources, which are not always effective and correct. Thus, these standards develop an ecosystem of digital resources for teaching at universities, and also make it more interactive for the teacher. Moreover, the auxiliary extensions of such standards ensure the implementation of the principle of integrating resources, applications and educational tools into the course of studying geometry, since it requires the development of theoretical and practical skills of students. In addition, the above-mentioned software allows students to visualise tasks and, accordingly, trace actions with data, and determine the relationship between individual parameters of the object being studied.

Conclusions

After the conducted research, the results were obtained in the form of theoretical and practical aspects of the issue under consideration, namely, the interaction of a student and a teacher when using modern digital resources in higher educational institutions of Kazakhstan, in the context of studying geometry:

- the general foundations and features of the concept of digital educational resources are established:
- the advantages characteristic of them are considered;
- the use of digital educational resources contributes to the establishment of close contact between the teacher and the student, since it allows them to communicate informally.

In addition, the study proves the practical significance of educational digital resources for the geometry course, since possible functions and tasks that can be performed through their use are described. As for the universality of this approach, it is reflected in the fact that students can independently hone their own knowledge and perform practical work, teachers can thoroughly explain the material through vivid visualisation of tasks, and researchers can explore geometry, deduce their own theorems and hypotheses.

The practical part of the study considered such widespread digital educational programmes as GRAN 1, GRAN 2, DG. In addition, an important aspect in the study is the analysis of international experience. Since most of the leading countries of the world coincide in their policies on the development of higher education, their experience has been characterised in general. Thus, at the moment, most universities are developing an educational digital environment that would give students the opportunity to perceive and display knowledge in a completely different way.

Thus, for the Republic of Kazakhstan, this trend would also be positive and certainly useful, especially in the context of the study of exact sciences, namely geometry, but it should be understood that such a process is quite long-term and requires financial support. As for future study, it is advisable to perform a comparative analysis of the use of innovative digital technologies in higher educational institutions before and after the COVID-19 pandemic, or to establish the prospects for the formation of a unified digital educational space in Kazakhstan.

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Conflict of Interest

N/A.

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Використання сучасних цифрових освітніх ресурсів на уроках геометрії у вищих навчальних закладах Республіки Казахстан

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Анотація

Актуальність. В епоху глобальної цифровізації все більше сфер суспільного життя переходять на використання інноваційних технологій, що стосується й навчального процесу. Особливо важливим є процес використання цифрових технологій для точних наук і тих, що потребують моделювання та графічних операцій, однією з яких є геометрія. Цим пояснюється актуальність питання взаємодії студента з викладачем під час використання цифрових програм для вивчення геометрії у вищих навчальних закладах Республіки Казахстан.

Мета. Мета дослідження – проаналізувати вплив інноваційних технологій на процеси викладання та засвоєння учнями навчального матеріалу з геометрії та визначити роль цифрових програм у процесі налагодження комунікації між учнем і вчителем.

Методологія. Для виконаня роботи необхідно системно застосовувати різноманітні засоби наукового дослідження, зокрема діалектичний та діяльнісний методологічні підходи, методи логічного аналізу, синтезу, порівняльного аналізу, контент-аналізу, моделювання, аналізу наукової літератури.

Результати. Основними висновками статті є теоретичне та практичне підґрунтя проблеми. Тобто, теоретична складова дослідження включає поняття цифрових технологій, їх особливості та види. Практична частина включає аналіз ефективності використання цифрових технологій у контексті вивчення геометрії та визначення рівня поширеності відповідних програм за кордоном. Що стосується перспектив наступних досліджень, то необхідно було б провести порівняльний аналіз використання інноваційних технологій у вищих навчальних закладах до та після пандемії COVID-19.

Висновки. Практична цінність дослідження є досить високою, оскільки визначає можливість використання отриманих результатів у подальших розробках, зокрема, при побудові навчальних програм з геометрії у ВНЗ, або використання як засобу для розробки та вдосконалення поточних навчальних програм.

Ключові слова: цифрові освітні ресурси; геометрія; інноваційні технології; студенти; вищі навчальні заклади.