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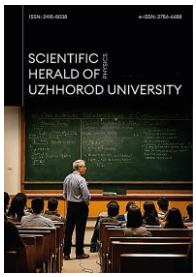

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Creation of mobile electronic educational resources based on instrumental complexes

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Abstract

Relevance. The relevance of the research is determined by the ever-increasing importance of the modern education informatization, which is defined as a systematically organized process that includes a number of studies of various directions, designed to implement the wide possibilities of information, communication technologies.

Purpose. The main research purpose is to study the prospects for the development of mobile educational resources based on the use of instrumental complexes.

Methodology. The methodology of this research paper is based on a combination of the method of system analysis of key aspects of the development and practical implementation of information and communication technologies with a comprehensive study of various options for their use in the creation of mobile electronic educational resources based on instrumental complexes.

Results. The research results illustrate the significant importance of creating mobile electronic educational resources based on instrumental complexes and their practical application in the modern education system as a means of information support, assessment of students' knowledge and implementation of the principles of a full-fledged cultural exchange. Varieties of digital educational resources were presented, as well as an example of the functioning of a mobile electronic educational resource in the framework of solving practical issues of assessing students' knowledge.

Conclusions. The study underscores the practical importance of mobile electronic educational resources for enhancing information access, knowledge assessment, cultural exchange in modern education. These resources facilitate the integration of smart technologies and digital information, supporting teachers and students in achieving a more effective and comprehensive educational process. The practical significance of the research lies in the possibility of application the obtained results in the creation of mobile electronic resources and knowledge bases in the field of education, in order

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to ensure the access of teachers and students of educational institutions to the information necessary for the full-fledged educational process.

Keywords: educational complex; digital culture; education system; smart technologies; information and communication technologies; digital information resources.

Introduction

The problem considered by this research lies in the need to form a qualitative assessment of the development processes of informatization of the modern education system through the widespread use of remote learning technologies. In turn, this necessitates the development and practical application in the educational process of a wide range of mobile electronic educational resources based on instrumental complexes. Such resources are presented in the form of electronic versions of lecture notes, electronic presentations of program disciplines, computer models of course projects and laboratory work, as well as comments on the results of checking program tasks and projects.

In her scientific research, E. P. Tikhonova [1] raises a number of problematic aspects of the search for new educational technologies in the formation of the learning environment through the implementation of the possibilities of modern digital culture. According to the scientist [1], modern technological capabilities significantly simplify the life of humankind, opening up significant prospects for the implementation of educational programs. Globalization and the dominance of digital culture are significantly shifting priorities in the field of obtaining and processing information, which is of key importance in the context of the prospects for the development and implementation of mobile electronic resources in the education system [2-4].

The issue of the competencies of digital culture and its development in modern mathematical education is considered in a joint scientific study by O. A. Kuzenkov and I. V. Zakharova [5]. The authors note that the computer tools currently used in the education system provide ample opportunities for improving the education system, taking into account today's real needs. The education system solves the issues of training specialists who fully meet the needs of modern society, which necessitates the development of effective tools for managing mobile electronic educational resources, the presence of which ensures the modernization of the educational process and the accelerated integration of the education system in science and economics [5; 6].

The issues of developing the theory and methodology of informatization of the modern education system are considered in the scientific research by I. V. Robert [7]. At the same time, it is noted that the increased importance of intellectual labor is a characteristic feature of today's society. At the same time, there is an orientation towards the use of information resources on a global scale, which necessitates a constant increase in the level of professionalism of individuals and teams in general. In such a situation, a rational way out is to activate social processes in the field of mastering information and communication technologies, which are effective means of increasing the intellectual activity of individuals and improving their intellectual activities [7; 8].

The scientific research by O. V. Nass [9] considers the issues of creating web content as the basis for the functioning of modern electronic resources and information systems. The author draws attention to the fact that the quality of creating modern mobile electronic resources is of fundamental importance in terms of the effectiveness of their functioning and the success of solving all the tasks. According to the scientist, the knowledge transfer is the main function of methodical electronic learning systems, while the quality of the presentation, preservation and provision of knowledge in modern electronic resources of the education system is of particular importance [9].

The joint scientific research by O. V. Nass and G. A. Kamalova [10] considers the problematic aspects of the use of artificial intelligence systems in the development of information systems. At the same time, scientists note that the high relevance of creating artificial intelligence systems in managing processes in various areas of the economy, science and the education system necessitates the creation of electronic resources containing reliable information on a variety of issues of interest to users. At the same time, according to the authors, modern information technologies should be used to effectively meet user requests at any stage of managing information projects [10].

The main purpose of this scientific research is to study the prospects for the development and practical implementation of mobile electronic resources of the education system, created using modern instrumental complexes.

Materials and Methods

The methodological approach of this scientific research is based on a combination of the method of system analysis of the general principles of the development of modern information and communication technologies with a comprehensive study of the practical aspects of their application in the creation of mobile electronic resources of the education system based on the use of instrumental complexes. The main research is preceded by the formation of a theoretical base, which includes an analysis of the papers of several authors who conducted a scientific analysis of a number of problematic aspects of the use of information and communication technologies in the modern educational space.

The practical application of the method of system analysis of the key principles for the development of modern information and communication technologies made it possible to determine the essence of the concept itself, as well as to define ICT tools and the main tasks that such technologies face in the system of modern education. In addition, the relationship between information and communication technologies and mobile electronic educational resources created on their basis, designed to solve the problems of information support in the system of modern education, was determined.

The practical application of the method of a comprehensive study of the prospects for the use of

information and communication technologies in order to create mobile electronic educational resources enabled defining the concept of a digital educational resource, as well as the key varieties of DER and the opportunities that open up with their practical use in the modern education system. In addition, the key types of digital educational resources were considered, as well as their role and place in the learning process of the modern education system.

The chosen combination of scientific research methods determined the presence of its following stages. At the initial stage of this scientific research, the definition of information and communication technologies in the system of modern education was presented and the main ICT tools used in the educational process were noted. The possibilities of using digital educational resources in the modern education system at any of its stages were noted. In addition, the key types of digital educational resources are identified, which are actively used today in order to meet the information needs of all participants in the educational process and organize their remote interaction with each other. A schematic representation of the varieties of modern digital educational resources in their systemic relationship is presented.

At the next stage of this research, key aspects of the development of mobile electronic educational resources based on instrumental complexes were considered. The Plickers application was considered as an example of a mobile electronic educational resource, an algorithmic sequence of working with a mobile resource was determined when conducting a test assessment of students' knowledge within the framework of the studied program disciplines. In addition, there were noted significant advantages of using mobile educational resources of this kind when conducting a training session as part of an educational program in a particular academic discipline.

At the final stage of this scientific research, an analytical comparison was carried out of the results obtained during the research with the results and conclusions of other researchers who studied the development and implementation of electronic information and educational resources into the modern education system. This made it possible to clarify the obtained results and to formulate the final conclusions of the scientific research on their basis, which act as their logical reflection and summarize the entire complex of scientific papers.

Results

Information and communication technologies (ICT) in the modern education system are designed to address topical issues of providing the necessary information to all participants in the educational process, as well as building a high-quality data exchange between all its participants on their basis in order to effectively address all issues raised during planning and implementation of teaching programs within individual academic disciplines [11]. Information and communication technologies within the framework of the current education system are a set of methods and training systems, as well as software and hardware that have passed the integration stage in order to obtain, systematize, store and issue the necessary information at the right time with the aim of using it for solving issues that arise during the implementation of the learning process.

Today, the means of information and communication technologies (ICT) shall mean software, hardware-software and technical equipment, which function on the basis of modern computer and microprocessor technologies. In addition, the use of information and communication technologies involves the use of modern means of information and resource exchange and transmission of information necessary for successful reception, systematization, storage and transmission of information, as well as to ensure timely access to information resources [12-14].

The means of information and communication technologies include electronic computing equipment, local area networks, all possible varieties of communications and mediums, means of broadcasting all graphic, textual and audio information, as well as equipment for storing it.

A digital educational resource (DER) is a source of information that contains a given amount of text, graphics, speech, video and other information intended for the systematic implementation of the program tasks of the modern education system.

Digital educational resources should be considered the basis of modern information and communication technologies (ICT) in the existing education system. They are sources of information presented in digital form, which are actively used in the educational process of a modern educational institution in order to provide the necessary information within the framework of the main and auxiliary program disciplines of all participants in this process [15].

Currently, the creation and development of digital educational resources (DERs) is defined as one of the most priority areas of informatization of various forms and levels of the modern education system. The full-fledged development of the industry of providing information services to the educational sector naturally includes the production of digital educational resources, as well as software and methodological support [16]. In addition, a single complex with the development of digital educational resources includes the creation and subsequent distribution of telecommunication structures of individual institutions of the education system, as well as the entire sector as a whole [17]. At the same time, it is imperative to ensure proper quality control of education in the context of using modern digital educational resources, which also contributes to the full-fledged formation of a modern infrastructure for informatization of the existing education system.

The use of digital educational resources in the modern education system opens up the following opportunities:

1. Expanding the possibilities of organizing the educational process by providing students with the opportunity to improve the skills of independent search for information and its processing.

2. Using all the possibilities of modern information and communication technologies for the high-quality implementation of various educational activities, including recording, saving, accounting, systematization, as well as providing upon request any information necessary for the full-fledged educational process.

3. Additional introduction of information into the educational process, including data obtained through the

use of multimedia technologies, the creation of virtual reality, as well as systems that require large volumes of documents in text and media format.

4. Conducting an objective assessment and diagnosis of the real intellectual abilities of students, determining the actual level of their knowledge and competencies developed during the learning process, as well as comparing the level of students' knowledge with the requirements put forward by state educational standards.

5. Effective management of the educational process and student activities in the context of comparing the provisions and requirements of the curriculum with the actual intellectual level of students, their knowledge, skills and abilities, as well as the level of motivation achieved taking into account the teaching methods used.

6. Formation of all the necessary conditions for the development of independent work of students, which will contribute to the development of their skills of independent work, self-education and self-actualization.

7. Timely provision of all participants of the educational process with the full amount of necessary information that is fully consistent with the goals and objectives of education.

8. Creation of a qualitative basis for continuous and timely communication and interaction of teachers, students and other persons involved in the educational process in order to effectively exchange the information received and increase the effectiveness of the learning process.

Modern digital educational resources have certain types.

Electronic libraries are distributed information systems that provide reliable storage and subsequent practical application of various types of electronic documents.

Libraries of electronic visual aids allow transferring information via a set of multimedia components that display objects, processes and phenomena of the initially given subject area.

Electronic encyclopedias are visual aids that include large amounts of information on a wide variety of areas from various fields of knowledge. They contain illustrations, audio and video clips, 3D and animation models.

Electronic workshops are educational and methodological complexes that provide opportunities for self-study for classes and exams with the possibility of self-assessment of students' own knowledge.

Multimedia textbooks are software and methodological complexes designed for students to independently complete a training course within specific program disciplines with the possibility of communication with the teacher at any stage. This requires a computer and the skills to work with it [18].

Virtual textbooks are educational complexes that enable conducting experiments within a single subject. At the same time, it makes experiments that are difficult to perform in the stationary conditions of an educational institution realistic, since this requires the presence of special equipment and an expensive material base.

The creation of mobile electronic educational resources based on instrumental complexes enables students to take part in the educational process, being practically anywhere, while the quality of education remains practically unchanged and is determined only by the interest of the student and the efforts made by them [19; 20]. Working with them requires a smartphone or tablet, as well as the Internet access. In some cases, the QR code technology is used to provide access to the necessary information.

As an example of mobile electronic educational resources, it is proposed to consider the Plickers application, which is freely available in the Internet. To use this application, one should sign up at Plickers.com. The use of this electronic educational resource allows to effectively and quickly conduct a test assessment of the answers of a class or study group within a specific topic [21].

Working with this mobile electronic educational resource implies the need to perform a certain algorithm of actions:

1. After signing up on the Plickers.com website, the application is downloaded to a smartphone or tablet and installed. Displaying the software interface on the screen using a projector facilitates the efficiency.
2. Pre-designed test questions are loaded into the app.
3. After opening the application on a mobile device, the Classes tab is selected, after which the class number is loaded with the names of all its students.
4. The order of testing and displaying the results is determined and established.
5. The Plickers.com website opens on the desktop device and the Live View tab opens to monitor the results of the test survey online.
6. In the application installed on a mobile device, survey cards are generated, which are printed out and distributed to participants.

All cards are presented in QR-code format. They contain numbers indicating card numbers and the student's serial number, as well as Latin letters illustrating the correct answers to test questions.

An example of such a card is shown in Figure 1.

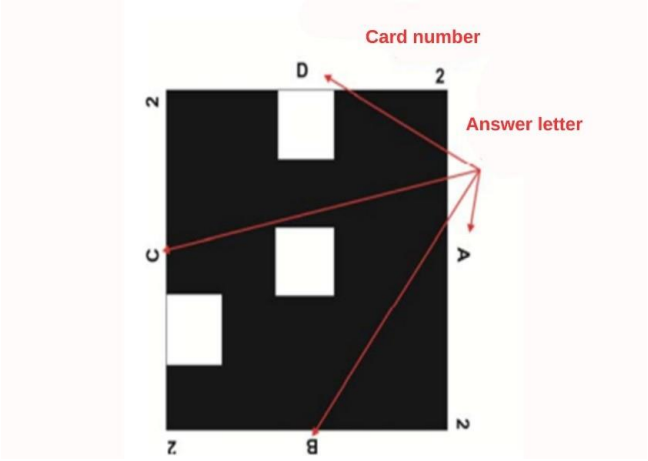

Figure 1. Sample card with QR codes
Source: [21].

The sides of each card are marked with the letters A, B. C. D. When the student chooses the correct answer in their opinion, they must turn the card up with the letter that, in their opinion, corresponds to the correct answer.

1. The Plickers app opens on a mobile device.
2. The class or study group that is currently being tested is selected.
3. A specific question on the tested subject and the given topic is marked and displayed on the screen.
4. Testing is carried out, in which the students sequentially holding up answer cards. The teacher scans the cards using the camera of their mobile device. In this case, the information received is sent to the database of the Plickers mobile electronic educational resource and the survey results are displayed on the screen.
5. In the same sequence, the answers to the subsequent questions of the proposed test are scanned.
6. Testing is analyzed, after which the obtained results are automatically entered into the database of the educational resource (Figure 2).

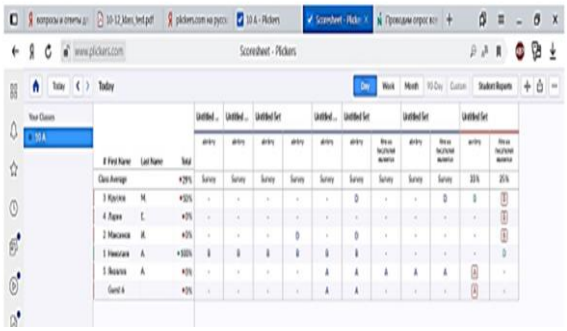

Figure 2. Test results
Source: [21].

The considered electronic educational resource processes the results obtained during testing and displays them on the screen and computer. The results can be presented in any previously specified format (tables, graphics, histograms).

The use of modern information and communication technologies in the education system allows teachers to conduct classes at a higher technical level using a wide range of illustrative possibilities of digital educational resources. The creation of mobile electronic educational resources in this context opens up the following opportunities for all participants in the educational process:

1. The ability to participate in the educational process, while being anywhere where there is an Internet connection.
2. The ability to display any educational information on the monitor screen and analyze it online irrespective of time.
3. The ability to communicate effectively online with other participants in the educational process: ask questions, exchange information, accept and pass test tasks, assess knowledge and evaluate the level of their mastering.
4. The possibility of timely receipt by all students in full of all the information necessary for the high-quality study of specific topics and the development of competencies necessary for subsequent professional activities.
5. The ability to effectively manage the educational process, taking into account current changes in the requirements of the curriculum and the addition of new information that needs to be processed and mastered.

Mobile electronic educational resources play an important role in optimizing the educational process by providing the possibility of continuous access to educational information, assessing students' knowledge, without being tied to a specific place and time. The creation and development of such resources ensures the expansion of real opportunities for remote learning, which today represents a whole range of educational services for various population groups through the formation of a specialized educational space [22; 23]. In the future, the improvement of the principles for the development and implementation of mobile electronic educational resources in the educational space will contribute to the creation of the necessary conditions for raising the general level of the educational process and the development of the modern education system as a whole.

Discussion

Joint scientific research by O. V. Nass, Zh. M. Abuova and A. Kh. Vakhitova [24] considers a number of problematic aspects of the prospects for the development of electronic educational resources for the implementation of smart technologies in the learning process. According to a group of researchers, it is only possible to achieve significant success in developing the educational process in a modern educational institution if electronic resources are developed and effectively implemented in the learning process, which can be accessed by both students and representatives of the teaching staff of an educational institution [24]. At the same time, the effectiveness of using these technologies largely depends on the level of preparedness of users and their ability to search for the necessary information and manage it. The conclusions of the researchers to some extent expand the results of this scientific paper, since they draw attention to the need to improve the qualifications of the user of modern electronic educational resources.

In turn, P. Wilson and H. A. Mantooth [25] conducted joint scientific research of the key principles for creating models of electronic systems, in which they came to the conclusion that the use of modern information systems in recent years has sharply increased the need for high-quality mobile electronic resources that contain a large amount of data and access to them. At the same time, according to the authors, the creation of effective resources can largely meet the needs of information exchange between all users of digital educational resources, which is of fundamental importance in terms of improving the overall level of functioning of the current education system [25]. The conclusions of the researcher are controversial, since in order to meet the needs of information exchange between users, they must have the proper training and ability to manage the proposed electronic resources.

At the same time, G. Stachokas [26] in his own research work considered the role and importance of electronic libraries in the modern educational system. The

scientist came to the conclusion that modern e-learning methodological systems help to increase the efficiency of the education system and develop competencies the students need in their subsequent professional activities. According to the author, this is achieved through the use of information and communication technologies in the development of modern digital educational resources, which ensures effective interaction of all participants in the educational process at all its stages [26]. The conclusions of the scientist are in full accordance with the results obtained in this scientific paper.

The subject was further investigated by R. M. Thomas and V. N. Kobayashi [27] in a joint scientific study of the peculiarities of the creation and development of modern educational technologies. The authors point to the fact that information and communication technologies are increasingly being used in the modern education system, constituting the qualitative basis of modern software and methodological means of information impact. Such technologies are clearly focused on various types of activities for the collection, processing and practical application of a wide variety of information, which is the qualitative basis of the modern education process [27; 28]. This causes the formation of certain trends in the informatization of the educational process and the creation of a social order for a specific professional level of a specialist in various fields of activities. The conclusions of the researcher are in full accordance with the results obtained in this research paper.

For his part, J. Secker [29] conducted scientific research of the basic principles of creating electronic resources in a virtual learning environment. The scientist came to the conclusion that the rapid changes in the modern information environment cause high requirements for the quality of education in the existing education system, which, in turn, justifies the high requirements that are currently put forward to the level of information resources used in the educational environment. The author expresses the opinion that digital educational resources play a crucial role in the modern educational space, since they are entrusted with the function of providing teachers and students of educational institutions with complete and reliable information on all curriculum aspects, as well as, to a large extent, controlling the level of knowledge and competencies obtained during the learning process [29; 30]. The results obtained by the researcher and the conclusions formulated on their basis are fully consistent with the results of this research paper.

In a similar direction, a joint scientific study was also conducted by F. Blumberg and P. Brooks [31], which studied the general principles of the cognitive development of children and adolescents in a digital context. The authors emphasize that the active use of information and communication technologies at the stages of primary education of children in educational institutions leads to the development of their online communication skills and the ability to independently find and apply the necessary information in practice [31]. An opinion is expressed that such skills are of key importance in the development of independence and creativity of students in the early stages of education, which is important from the viewpoint of the prospects for their further professional actualization. In the context under consideration, the conclusions of the researcher seem disputable, since the development of independence and creativity students requires achieving a certain level of training in using the proposed information resources.

In an independent scientific research, N. Patra [32] considered the issues of the modern digital revolution and the management of electronic resources. It is noted that the development of digital educational resources has made it possible to bring the issues of preserving and systematizing information that is used in the modern educational space to a qualitatively new level. At the same time, the ability to properly manage such information, navigate the information arrays contained in electronic educational resources and correctly formulate user requests is of great importance [32]. According to the researcher, it is realistic to achieve this through the correct direction of the efforts of students in the course of the educational process and the systematic implementation of all program tasks. The conclusions of the researcher do not fundamentally contradict the results of this scientific paper, adjusted for the fact that in order to achieve the correct direction of the students' efforts, it is necessary for them to master at least the initial skills of obtaining information from mobile electronic resources of the education system as well as managing them.

The team of authors represented by Y.-T. Sung, H.-Y. Lee, J.-M. Yang and K.-E. Chang [33], in a joint scientific study, considered a complex of problematic aspects of drawing up curricula using mobile electronic educational resources. Scientists note that in recent years, mass communications have had a strong impact on the education system, prompting the introduction of the latest information technologies in the educational process. It is argued that the rate, at which modern students acquire communication skills in the era of digital technologies, will largely determine their effectiveness in their future professional activities, since information and communication technologies are rapidly developing, putting forward newer requirements for their development [33]. The authors' conclusions do not fundamentally contradict the results of this scientific research, complementing them in the context of assessing the importance of students quickly mastering the skills of communication in the realities of the modern educational system.

The topic of applying the state-of-art technical innovations in the educational process is being developed by Y. Maeda, S. Caskurlu, R. H. Kenney, K. Kozan and J. C. Richardson [34] in a joint scientific study of the prospects for the use of modern information technologies in the education system. The authors conclude that the effectiveness of the practical application of modern information technologies to a large extent depends on the quality of their mastering by the educational process participants, as well as on their desire to learn and develop new competencies [34; 35]. The role of the mentor in this process is to properly direct the efforts of students and to assist them in mastering the principles of working with electronic educational resources. The conclusions of the researchers on assessment of the role of a mentor in the educational process fundamentally coincide with the results obtained in this scientific research.

Thus, the discussion of the results of this scientific research with the results and conclusions of a number of studies on related topics demonstrates their fundamental coincidence on the key issues under consideration, which indicates the relevance and scientific validity of the results of this research paper.

Conclusions

The use of digital educational resources in the modern education system provides numerous benefits that are of key importance in terms of improving the efficiency of the educational process and developing students' skills and competencies they need in their subsequent professional actualization. At the same time, the possibilities of practical application of this kind of resources are of fundamental importance in terms of assessing the real prospects for their use in the modern education system. Digital educational resources in all existing varieties significantly expand the prospects for the educational process, taking into account the expected effect from their use in the context of providing all its participants with the necessary information and opportunities for direct interaction with each other.

The creation of mobile electronic educational resources based on instrumental complexes opens up additional opportunities for all participants in the educational process. When using them, the location of the student and teacher does not matter, since to conduct classes online, Internet access is required to participate in classes, obtain all the necessary information and assess the current level of knowledge. In addition, the capabilities of modern mobile electronic educational resources allow displaying all the necessary educational information on the monitor screen of a mobile or desktop device, which makes the educational process completely visual.

In general, the practical application of modern educational technologies using digital educational resources makes it possible to conduct classes at a high technical level, which opens up additional opportunities for all participants in the educational process. The use of modern mobile devices and electronic educational resources increase the information value of the lesson, expand the range of expressive possibilities of the education system. At the same time, the introduction of information and communication technologies in the modern education system involving the use of tablets and smartphones allows to effectively assess students' knowledge at any stage of the educational process, as well as contributes to the creation of all the necessary conditions for improving the quality of education and expanding the currently available opportunities for mastering educational material.

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Conflict of Interest

The authors declare that there is no conflict of interests.

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Створення мобільних електронних освітніх ресурсів на основі інструментальних комплексів

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Анотація

Актуальність. Актуальність дослідження визначається постійно зростаючим значенням інформатизації сучасної освіти, яка визначається як систематично організований процес, що включає низку досліджень різних напрямів, націлених на реалізацію широких можливостей інформаційних, комунікаційних технологій.

Мета. Основною метою цього дослідження є вивчення перспектив розвитку мобільних освітніх ресурсів на основі використання інструментальних комплексів.

Методологія. Методологія цього наукового дослідження базується на поєднанні методу системного аналізу ключових аспектів розвитку та практичної реалізації інформаційно-комунікаційних технологій з комплексним вивченням різних варіантів їх використання у створенні мобільних електронних освітніх ресурсів на основі інструментальних комплексів.

Результати. Результати дослідження ілюструють значну важливість створення мобільних електронних освітніх ресурсів на основі інструментальних комплексів та їх практичне застосування в сучасній системі освіти як засобу інформаційної підтримки, оцінки знань студентів та реалізації принципів повноцінного культурного обміну. Були представлені різновиди цифрових освітніх ресурсів, а також приклад функціонування мобільного електронного освітнього ресурсу в рамках вирішення практичних питань оцінки знань студентів.

Висновки. Дослідження підкреслює практичну важливість мобільних електронних освітніх ресурсів для підвищення доступу до інформації, оцінки знань, культурного обміну в сучасній освіті. Ці ресурси сприяють інтеграції смарт-технологій і цифрової інформації, підтримуючи викладачів та студентів у досягненні більш ефективного та всебічного навчального процесу. Практична значимість дослідження полягає в можливості застосування отриманих результатів для створення мобільних електронних ресурсів і баз знань у сфері освіти, з метою забезпечення доступу викладачів та студентів навчальних закладів до інформації, необхідної для повноцінного навчального процесу.

Ключові слова: освітній комплекс; цифрова культура; система освіти; розумні технології; інформаційно-комунікаційні технології; цифрові інформаційні ресурси.