International Journal of Pedagogics

VOLUME Vol.06 Issue04 2026
PAGE NO. 626-634
DOI 10.37547/ijp/Volume06Issue04-129

Efficiency of Working with Virtual Educational Technology of a Future Chemistry Teacher in A Digital Educational Environment

Rajabov Khudayor Madrimovich
Associate Professor of the Department of "Chemistry" of Urgench State University, Uzbekistan

Received: 18 March 2026; **Accepted:** 05 April 2026; **Published:** 30 April 2026

Abstract: The article provides information about digital educational technologies and their importance in teaching subjects based on the STEAM educational system. In addition, the concept of the STEAM educational system is defined and its role in training future specialists is described. Virtual educational technology is presented as a digital technology, its structure and application procedure are given, and the purpose is to analyze the impact of using virtual reality on the basis of the effective use of virtual laboratories in teaching chemistry, as well as to provide an integrated web-learning environment for simulating chemical experiments.

Keywords: Information technologies, digital educational technologies, STEAM educational system, virtuality, virtual reality, virtual laboratory.

Introduction: In the context of the digital transformation of education, great attention is paid to the development of digital infrastructure, a digital technology park (EduTech), the introduction of digital educational platforms into school practice, the perfect mastery of the “21st century competencies” of a chemistry teacher, and the development of innovative models for increasing professional competitiveness in line with the requirements of the labor market.

The rapid development of pedagogical science and information technologies in recent decades requires an intensification of the search for ways to improve the professional training of future specialists, including for the field of education. Today, one of the main requirements of society for a graduate of a pedagogical higher educational institution is the acquisition of a number of professional competencies. This requirement is reflected in all state standards of higher education.

Improving the system of training personnel in the field of information technologies is one of the important conditions for the successful implementation of the “Digital Uzbekistan - 2030” strategy, the development of digital technologies and their widespread introduction into the daily lives of the population [1].

The measures taken to increase the efficiency of the system of professional training and retraining in the field of information technologies create a solid foundation for providing state bodies and sectoral organizations with qualified IT specialists.

Research, the experience of pedagogical universities and institutes of our republic have shown that the level of preparation of university graduates for professional activity does not always meet the requirements of modern society and the latest achievements of pedagogical science, which was confirmed by the results of a survey conducted among chemistry teachers working in educational institutions of our republic. Thus, more than 50 percent of the chemistry teachers we surveyed experience the greatest difficulties in solving the problems of using modern methods and technologies, methods of diagnosing students' achievements in ensuring the quality of the educational process, and the use of basic scientific research methods. At the same time, teachers emphasize the relevance of these competencies for modern school practice. A modern chemistry teacher prepares

schoolchildren using various forms, methods, methods and teaching aids, taking into account their psychological and physiological characteristics and the specifics of the subject being taught, uses modern means of diagnosing students' achievements, and ensures the quality of the subject being taught. A future chemistry teacher should learn all this during professional training at the university [2].

The use of information technologies should help improve the educational process by improving the quality of the content, methods and organizational forms of teaching and upbringing; creation of methodological educational systems aimed at developing students' skills in independent acquisition and processing of knowledge, skills in teaching and research activities; creation and use of electronic textbooks with the ability to self-control, methods of computer testing and assessment of students' knowledge level; introduction of a distance learning system, etc. [3].

METHOD

We answer the question of what digital technology is as follows: it is a modern form of business. In it, a large set of digital data and the process of their processing serve as the main factor of production and management. The practical use of the results obtained allows us to achieve much greater efficiency compared to traditional forms of business. For example, various types of automated production processes, 3D technology, cloud technologies. Examples include the provision of remote medical services, the production and delivery of products using smart technologies, and the storage and sale of various types of goods.

If education is provided through digital technologies, the methods of learning become easier for learners. In this case, multimedia, overhead projectors, computers, laptops, Internet-connected televisions, telephone lines, smart boards, and projectors play the role of the educational system. For educators, conducting classes with such tools ensures an increase in the quality of education. We all know that the use of digital technologies in online classes gives good results. For example, online classes given via television can be considered a type of digital education [4].

So, in digital education:

- you have the opportunity to learn anywhere and anytime;

- a culture of obtaining and using information from the Internet is formed;

- it raises the education system to a new level;

- dramatically reduces the cost of time and money;

- you do not get lost in the “digital world” and have advantages in finding a good job, etc.

We can now see an unconventional approach to education. In it, students do not study dozens of subjects and textbooks as a separate subject. This is the STEAM education system. What is the STEAM education system? If we write this abbreviation in full, we get the following: STEAM is S - science, T - technology, E - engineering, A - art and M - math. Its translation into English is: natural sciences, technology, engineering, art and mathematics. These areas are becoming the most popular in the modern world. Therefore, the STEAM system is developing as one of the main trends today. The direction of STEAM education and the use of a practical approach are based on the integration of all five areas into a single educational system [5].

The impact of the STEAM approach on educational effectiveness is that it makes practice as important as theoretical knowledge. That is, when learning, we need to work not only with our brains, but also with our hands. Learning only on the blackboard does not keep pace with the rapidly changing world. The main difference of the STEAM approach is that learners use both their brains and their hands to successfully learn various subjects. They “learn” the knowledge they receive themselves. In a STEAM learning environment, learners acquire real knowledge and immediately learn to use it. Therefore, when they grow up and face life problems, whether it is environmental pollution or global climate change, they understand that such complex issues can only be solved by relying on knowledge from different fields and working together [6-7]. Relying on knowledge in only one subject is not enough here. By focusing on practical skills, learners develop their will, creativity, flexibility and learn to cooperate with others. These skills and knowledge constitute the main educational task, that is, what the entire education system strives for. This new approach to education is a logical result of combining theory and practice. STEAM was developed in America. In this, some schools took into account the careers of

graduates and decided to combine such subjects as science, technology, engineering and mathematics, and this is how the STEM system was formed. (Science, technology, engineering and mathematics). Later, Art was added to it here, and thus STEAM was finally formed.

Teachers believe that knowledge in these areas, or rather, in these subjects, will help students become highly qualified specialists in the future. After all, students strive to get good knowledge and apply it in their future work. The world is changing, along with the forms, means and methods of teaching. The changes in recent decades are positive, but at the same time they worry us. With the invention of new things, people are faced with many new problems that they have not encountered before.

Every day, new types of work and even entire professional fields appear, so modern teachers need to think about whether the knowledge and skills they teach meet the requirements of the time. Knowledge helps to find your own idea, but the real work is to turn this idea into reality. If we say that the main goal of traditional education is to teach knowledge and use this knowledge to think and create, the STEAM approach teaches us to combine the acquired knowledge with real skills. This gives learners the opportunity not only to have some ideas, but also to apply and implement them in practice.

To achieve the above results, we can use the following real virtual technologies.

The current reality in the world is increasingly raising new pressing issues and conflicts related to the need to effectively solve them. In particular, while there is a widespread development of information and communication technologies related to the Internet system, on the one hand, there is a need to prepare society and the education system to fully benefit from the achievements of these processes.

Identifying new opportunities in the use of computers and their consistent implementation in practice is one of the important factors in the modern stage of development of educational processes. In turn, the rapid development of computer technologies creates favorable conditions for their widespread use in educational processes. The introduction of the Internet in all aspects of human activity, including the education system as one of the leading factors in the development of society, and the consistent solution of issues related to the formation of learners' skills to perceive existence on the basis of virtual tools are urgent problems. In particular, the problem of creating educational resources based on virtual reality is of particular introduction to researchers [8].

Virtual reality is an artificially created information environment, which is aimed at replacing the usual perception of the environment with information generated on the basis of various technical means. The creation of information visualization tools aimed at developing virtual reality tools for educational purposes can provide a pedagogical effect that cannot be achieved using other technical means. The term "virtuality" is derived from the Latin word "virtualis" and means "that which occurs or can occur under certain conditions", or a process that does not exist, but has the possibility of occurring. Since this term is found in so many areas of human activity, there are sufficient grounds for introducing it into the educational system. Many examples can be given when explaining concepts related to various disciplines. In particular, in physics, particles that can only exist in the interaction of other particles are called virtual particles (virtual photons, bosons, etc.). It is only thanks to virtual particles that real elementary particles interact, and in this case, virtual particles are exchanged. The concept of virtuality is also used in meteorology. In this field, the dry air temperature corresponding to the same pressure with a certain humidity is called virtual temperature. In psychology, the terms "virtual image", "virtual object" are used. For example, the consideration of human activity together with a machine is considered a virtual object. Because the work performed directly by this virtual object is not inherent in the function of either a person or a machine, this characteristic of the object arises only when a person and a machine are taken together. Psychologically, the following specific features of virtual existence are distinguished: creation, relevance, autonomy, interactivity. Psychological virtual existence arises as a product of the human psyche. Virtual existence can exist only when the object that creates it is active.

The imaginary memory of a computer is considered to be virtual memory, which does not physically correspond to any separate memory carrier, that is,

virtual memory arises as a result of the functional interaction of computer elements. Thus, with the help of software tools that create virtual memory, a person has the opportunity to access a huge amount of information. All modern computers in use are equipped with a special Java virtual machine.

Virtual reality elements based on films and various illustrations have long been used in education. Computer technology, which is able to combine information related to movement and sound into a single complex, has created opportunities for learners to actively influence (interact) with the observed processes, which has made a qualitative leap in the creation of educational resources based on virtual reality.

Today, educational resources based on virtual reality can be classified as follows:

• first level - achieving full virtuality using special technical means (helmet-display, special gloves, etc.);

• second level - creating a three-dimensional image using three-dimensional (or stereoscopic) monitors or a projector and special glasses;

• third level - displaying virtual reality on the basis of a standard computer monitor or projection device.

In turn, the problem of creating modeling pedagogical software tools is divided into the following areas related to the application and further improvement of functional theories:

1) Philosophy of virtual reality design. Problems of perceiving information provided on the basis of modeling and convincing the learner of its correspondence to reality.

2) Mathematical modeling. Problems of studying the properties of mathematical models in modeling for educational purposes.

3) Theory of information representation. Problems of using and improving visualization methods aimed at constructing real images using graphic machine control tools that create the impression of working in real conditions.

4) Psychology of perceiving the computer environment. Problems of taking into account the uniqueness of the thinking of modern youth, who are accustomed to receiving the main part of information through television and computer monitors.

5) Ecology of virtual reality. Problems of choosing an individual trajectory of interaction with virtual reality.

6) Basic principles of didactics. When developing modeling software tools, didactic principles formed on the basis of the experience of educational practice and reflecting the laws of the educational process should be taken as a basis. The didactic and methodological problems of determining the optimal ratio of knowledge provided in real and simulated forms are also a separate area of research.

The emotions that arise during communication with a computer (for example, with the help of virtual helmets) are very close to the emotions that a person experiences during communication with a real being, and sometimes when comparing these emotions, the superiority of the former is clearly felt. The special effects of deep penetration into the mind in computer game technology can also be effectively used in the educational process. In this sense, considering that the human mind interprets various tasks, images and ideas initially on the basis of imaginary actions, it becomes clear that it itself has a virtual nature in some sense.

Today, the most popular application of the concept of "virtual being" in relation to computer modeling is the one in which a person interacts with an artificial three-dimensional or sensor environment in order to create a virtual practice. To do this, he uses a virtual helmet, special gloves or a full-body suit as communication equipment. With the help of these devices, a person enters a machine-generated environment, performs certain actions in it, such as moving in different directions, controlling objects, and experiences various emotions under the influence of virtual events.

Virtual reality is directly related to many areas of human activity, such as medicine, biotechnology, design, marketing, art history, ergonomics, and the entertainment industry. The technology of creating virtual reality is effectively used in computer games, space simulators, and trade shows, where there is a great need to model real and virtual processes.

The examples listed above make it possible to clarify the concept of "virtual education" and characterize its virtual qualities. The main cause of virtual processes is the interaction of real objects. The interaction-based activity of the teacher and the student in the educational process creates a virtual state. The internal

changes of real subjects (teacher-student) in the virtual state are characterized by the educational process and its quality.

The main features of virtual processes include: the strength of the level of abstraction of virtual processes for interacting subjects; the uniqueness of the interaction for each participant; the realization of existence only in the interaction process.

The virtual process occurs only in a specific virtual space under the influence of the unique interaction of important virtual objects.

Virtual education in a broad sense is understood as a process and its results, the main subjects of which are the direct interaction between the teacher and the student during the acquisition and provision of education. It is impossible to imagine a virtual educational space without the interaction of the main objects of education with the student and the teacher, who are its subjects. In other words, the virtual environment in education is created not by classrooms, their equipment, textbooks or technical means of teaching, but only through the interaction of objects and subjects participating in the educational process. It is worth noting that in some places in the programs, there are cases where educational materials are presented without sufficient consideration of the level of real mastery of students and the interaction of educational subjects.

Thus, virtual education is not only a feature of distance telecommunications, but also has the property of being manifested in the interaction of the teacher, student, and objects being studied in all forms of education, including full-time education. Distance technologies serve to expand the possibilities of full-time education on the basis of virtual education. The main goal of virtual education is to realize the fundamental essence of a person's place in real existence - to ensure the harmony of his virtual and other capabilities.

DISCUSSION AND RESULTS

Various programs - virtual laboratory software has additional specific features. To facilitate work with the program, there is a concept of "assistant", a set of converters based on calculations, a laboratory journal for recording experiments. The concept of virtual experiments appeared about 20 years ago, when the interface is actively used, the teacher can manually add more chemicals and reactions to the software, thereby increasing the experience of students. Thus, it provides "interactive modeling" of virtual laboratory exercises. Many studies have been conducted on the effectiveness, shortcomings and achievements of using virtual laboratories in chemistry education. In particular, according to the results of the conducted studies, the use of VL (virtual laboratory) applications increases students' achievements in science. In addition, teachers and students who use VLs consider multimedia education to be useful (Bakar & Zaman, 2007), and it was concluded that students who used virtual laboratories were able to answer most of the questions related to all technical and theoretical processes related to laboratory work correctly and fully understood the essence of the experiment [9]. In this pedagogical study, in order to assess the knowledge of students in chemistry and to develop skills in students before performing laboratory exercises, 4 groups of 15 students each studying in the MBBS direction of a foreign faculty were selected as a test. In two of the groups, practical training was organized through an online virtual laboratory, and in the other two, the lesson process was organized in a traditional way. The following virtual laboratories were used for the study:

Royal Society of Chemistry's Virtual laboratory (https://virtual.edu.rsc.org/titration/experiment/2/5) va PraxiLab (https://praxilabs.com).

a b

Figure 1. Interface window of virtual laboratories: a- PraxiLab b – RSC

Since these types of programs are mainly in English, a foreign group of students was taken as a test for pedagogical research. In terms of virtual reality, programs such as PraxiLab have several advantages. After all, the equipment and tools are depicted in 3D so that the user feels like he is in a real laboratory environment. When the program user window opens, the virtual assistant guides the student through the procedure for completing each stage of each task. Questionnaires were anonymously created in a telegram group for online classes from the group of students who used the program in the lesson. In addition, in order to compare the effectiveness of the method used, control questions on the subject were given to the group of students who received traditional practical training and the group of students who used an online virtual laboratory before and after practical training, and their mastery indicators were obtained. During the experiment, students performed the determination of the amount of acetic acid by determining the equivalent point on the topic of acid-base titration, one of the titrimetric analysis methods in the chemistry module. They had the opportunity to consolidate their knowledge by answering questions in the control question sections of the program. MS Excel 2019 was used to process statistical data on students' assessments.

The introduction of virtual software tools opens up great opportunities for the formation of professional competencies in students. Interactive laboratory programs not only increase the visibility of the process, but also provide students with information that is easy to understand. They also play an important role in solving didactic problems related to the formation of relevant competencies and reducing the number of hours of teaching the subject, organizing independent learning, evaluating, and reinforcing.[10] The relevance of using virtual laboratory work is also that it does not require the construction of complex devices, storage and replacement of devices and reagents to organize laboratory experiments, as well as the need to carry out repairs, washing chemical dishes, etc. All laboratory work is stored in computer memory or external memory in electronic form and in one place. The computer device is safe, not difficult to use, and at the same time requires the user only to have skills in working with specific programs. The students were conditionally divided into 2 groups: a control group and an experimental group. The control group studied the subject in the traditional way. The experimental group was trained using virtual laboratories and short animated videos.

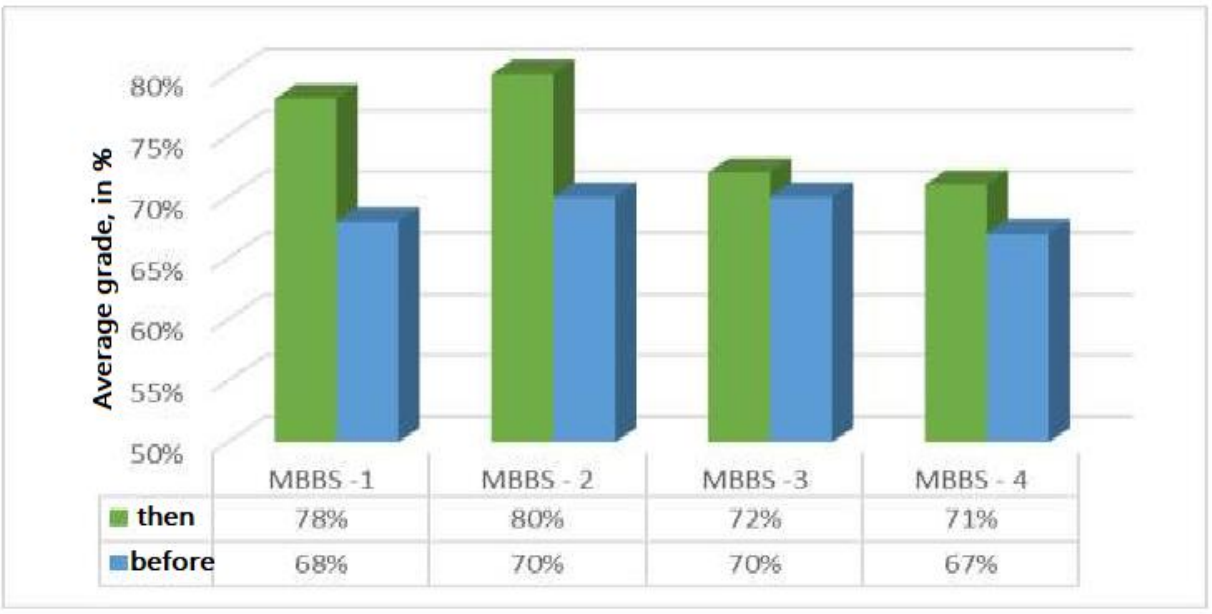

Figure 2. Average number of correct answers to control questions before and after the Laboratory exercise by group

It is clear from this diagram that the correct answers to the "pre-lab" control questions in the groups were approximately the same when compared to the general groups (68%, 70%, 70% and 67%). The control questions included questions related to the topic, theoretical information and questions related to the implementation of the work. In the next parts of the study, students from the MBBS -1 and MBBS -2 groups, which were taken as the experimental group, entered the practical training in the virtual laboratory via their mobile phones. In the remaining 2 MBBS -3 and MBBS -4 groups, the teacher demonstrated the real experiment in a traditional way for everyone and repeated the work with 2-3 students. At the end of the practical training, written "post-lab" control questions were taken from both groups. The results obtained were positive, and it turned out that the indicators of the students in the research group (78% and 80%) were slightly higher than the indicators of the students in the control group (71% and 72%). In addition, according to the results of the questionnaire, the students who participated in the questionnaire also expressed their opinion that "the Virtual Laboratory made the process of mastering the subject much easier" and that it would be appropriate to use such interactive tools during future practical classes. Based on this, it can be recommended to use the Virtual Laboratory in the following cases:

- To familiarize students with the experimental technique being performed;
- To familiarize themselves with the equipment used during the experiment;
- To develop reporting and observation skills;

Such work is carried out using three-dimensional animations and images. They are specially programmed and provided with sound. In this case, the content of the same topic will consist of information, control questions and various illustrations.

The possibilities of a virtual laboratory

- No need to purchase expensive laboratory equipment
- The possibility of modeling processes that are impossible to perform in principle in laboratory conditions
- Safety
- Saving time and resources
- Automatic calculation of the results of the performed laboratory
- The possibility of using virtual laboratories in distance learning
- Given that the control of the virtual process is assumed by the computer, the possibility of conducting a series of experiments by changing the input parameters
- The possibility of observing the laboratory experiment being conducted on other time scales.

• In addition, in the context of a virtual information and educational laboratory, learning new areas of knowledge through educational modeling allows students to gain a comprehensive understanding of the biological, pharmacological, biochemical mechanisms of action of substances such as polyfunctional, heterocyclic compounds as metabolites, which are covered within the scope of chemistry. [11-12] As a result, readiness is formed to apply the acquired knowledge in practice.

CONCLUSION

Based on the results of this small study, as well as the results of research conducted by foreign and domestic scientists, the following conclusions can be drawn about the effectiveness of using virtual laboratories in chemistry classes.

1. These innovations in education can be used in the fields of exact and natural sciences. Identifying new opportunities in the use of computers and consistently implementing them in practice is one of the important factors in the modern stage of development of educational processes.

2. In turn, the rapid development of computer technologies creates favorable conditions for their widespread use in educational processes. The implementation of the Internet as one of the leading factors of social development in all aspects of human activity, including in the education system, and the consistent solution of issues related to the formation of learners' skills to perceive existence on the basis of virtual tools are urgent problems. In particular, the problem of creating educational resources based on virtual reality is of particular introduction to researchers.

3. Virtual reality is an artificially created information environment, which is aimed at replacing the usual perception of the environment with information generated on the basis of various technical means. The creation of information visualization tools aimed at developing virtual reality tools for educational purposes can provide a pedagogical effect that cannot be achieved using other technical means.

4. The use of virtual laboratories in the process of chemistry education helps to conduct experiments with chemicals that are harmful to human health and to create an idea of such experiments.

5. It allows you to virtually perform laboratory work related to the insufficient material and technical base or rare, expensive reagents.

6. The use of information-controlled types of virtual laboratories in controlling the knowledge of students prevents the teacher from spending excessive time and resources, and also leads to the objectivity of the assessment process. Interactive pedagogical technologies are necessary teaching tools to improve the quality of education.

REFERENCES

1. O‘zbekiston Respublikasi Prezidentining ““Raqamli O‘zbekiston — 2030” strategiyasini tasdiqlash va uni samarali amalga oshirish chora-tadbirlari” to‘g‘risida 05.10.2020 yildagi PF-6079-son farmoni,
2. Georgiou, J., Dimitropoulos, K., & Manitsaris, A. (2007). A virtual reality laboratory for distance education in chemistry. International Journal of Social Sciences, 2(1), 34-41.
3. Safarova N. S., G‘afurov U. U., Omonov X. T. Venn grafik uslubidan kimyo darslarida foydalanish //Oriental renaissance: Innovative, educational, natural and social sciences. – 2022. – T. 2. – №. 1. – C. 134-138.(Use of venn graphic method in chemistry classes)
4. Sulaymonovna, S. N., & Sobirzoda, K. J. (2022). Generality and differences between situation problems and case methods. International journal of social science & interdisciplinary research ISSN: 2277-3630 Impact factor: 7.429, 11(03), 155-159.
5. 5. Sadullayeva, G. G., & Rakhmatov, S. B. (2022). Amperometric method of analysis and its advantages over other methods. International journal of research in commerce, it, engineering and social sciences ISSN: 2349-7793 Impact Factor: 6.876, 16(2), 4-8.
6. Sadullayeva, G., & Karimova, S. A. (2022). Eritmalar konsentratsiyasini ifodalash bo‘yicha masalalar yechish usullari. Oriental renaissance: Innovative, educational, natural and social sciences, 2(3), 909-915.
7. Гапуров У. У., Ниязов Л. Н. Исследование некоторых квантово-химических параметров соединения салициловой кислоты с глицином //Universum: химия и биология. – 2020. – №. 3-2

(69).

8. Каримов, Ж. С. (2022). Влияние природы катализатора и температуры на уход продукта в реакции аминометилирования. Pedagogs jurnali, 4(1), 357-361.

9. Бахромов Ҳ.Қ., Ниязов Л.Н.Синтез производных гидроксибензойных кислот и их антибактериальная активность .//Наманган давлат университети: Илмий ахборотномасиилмий- журн.–2021, – №12. – С. 69-73.

10. Tatli, Z., & Ayas, A. (2010). Virtual laboratory applications in chemistry education. Procedia-Social and behavioral sciences, 9, 938-942.

11. Xamidova, M. X. Q. (2021). Kimyo fanini virtual laboratoriyalardan va kompyuter dasturlaridan foydalanib o ‘qitishning ahamiyati. Academic research in educational sciences, 2(8), 133-139.

12. Джумаева М. К. Механизм основных химических процессов в азотсодержащих соединениях при синтезе биологически активных веществ //Zamonaviy dunyoda tabiiy fanlar: Nazariy va amaliy izlanishlar. – 2022. – Т. 1. – №. 9. – С. 1-6.