

The Importance of Using Interactive Educational Resources in Teaching Topics Related to Complex Biological Processes in “Biotechnology”

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Abstract

Biotechnology, as a modern science, encompasses knowledge based on complex biological processes in its content. Delivering this knowledge to students in an understandable and simple way can lead to the effective formation of scientific concepts in them. In order to increase the level of students' knowledge in the sciences, the scope of using various methods and tools to explain the content of educational materials in detail and convey them to students is expanding. Among these methods, methodologies related to the use of interactive educational resources occupy a special place. The research work is aimed at assessing the impact of the use of interactive educational resources prepared by visualizing educational materials in higher educational institutions in the subject “Biotechnology” on students' academic performance. The results of experiments conducted in experimental and control groups provided important information for assessing the educational effectiveness of the intervention of interactive educational resources prepared by visualizing educational materials. The statistically significant difference between the two groups confirms that the studied method had a positive effect on the formation of knowledge of complex biotechnological concepts in the experimental groups of students. The extensive use of interactive educational resources in educational activities helps students to study the relevant topic in more depth and increases their enthusiasm for studying the topics.

Keywords

Biotechnology, Biological Processes, Interactive Educational Resources, Level, Efficiency

1. Introduction

Technological development of the educational process is understood as the organization of an effective didactic process in accordance with the established educational goals. In this process, the development of professional and pedagogical skills of teachers requires the organization of their knowledge, skills and competencies on the basis of a modern technological approach (Osorio et al., 2025). For this purpose, pedagogical technologies related to foreign didactics, interactive methods, modern forms and means of teaching are used in pedagogical processes. When designing pedagogical technologies, they are tested in pedagogical experience—the dynamics of the development of teachers' pedagogical skills are studied and scientifically based conclusions are drawn on the improvement of pedagogical technologies. As a result, the educational process is organized on the basis of more effective, systematic and innovative approaches (Allayarova et al., 2020; Djabbarov et al., 2024). Teaching specialized subjects in higher education institutions should expand the possibilities of using new information and pedagogical technologies, based on the specific characteristics of teaching subjects (Liu et al., 2025).

Today, there is no sphere where computers have not penetrated. Education occupies a leading place among these spheres. The effective use of information and communication technologies in educational institutions is becoming an integral part of the organization of modern educational processes. Professors and teachers should have the skills to create educational electronic tools that meet the requirements of the time, to purposefully introduce them into the educational process, and to use electronic textbooks, electronic libraries, digital platforms and other innovative educational resources (Djamirzayev, 2023).

In recent years, one of the important requirements for the organization of modern education is the development and application of methodologies that ensure in-depth mastery of the content of the subjects being taught by students in a short time, without excessive physiological, mental and physical effort. Delivering certain theoretical information to students in a short time and forming their knowledge of certain concepts requires a new approach. A number of studies have shown that the effectiveness of new approaches used in many developed countries directly depends on the types of tools used to convey the content of the subject and the methods of their application (Almara'beh et al., 2015). In this regard, the correct choice of the means and methods of conveying information to students is of great importance in teaching specialized subjects with a rather complex educational content.

In the process of teaching specialized subjects in prestigious universities around

the world, special attention is paid to the virtualization of subject content and its delivery to students in the form of electronic resources (Osin, 2003). Experts note that the attractiveness of using electronic resources is directly related to the following properties:

- 1) Transforming abstract concepts into concrete information;
- 2) Providing a large amount of information in a limited time, that is, in a short time;
- 3) Arousing students' interest in learning;
- 4) Providing the teacher with the opportunity to assess students' knowledge (Haleem et al., 2022).

Multimedia is considered a useful and productive educational technology due to its ability to take into account the individual characteristics of learners and help increase their interest (motivation), as well as the combination of various types of multimedia educational information, interactivity, and flexibility (Guaña-Moya et al., 2022).

Multimedia tools are effective and promising teaching tools that provide the teacher with a wider range of information than traditional sources; they use not only text, graphics, diagrams, but also sound, animations, video, etc. in a visual and integrated manner; and create the opportunity to sequentially select types of information in accordance with the level of perception and logical learning of learners. In order to fully reveal all the possibilities of multimedia technologies and use them effectively, learners need the support of a competent teacher (Churiev et al., 2023).

One of the disciplines that is developing rapidly today and requires precision and practical experience is the science of "Biotechnology", the complex processes of which cannot be explained through traditional teaching. As a solution to this, the use of modern software tools in teaching processes through non-traditional teaching methods is becoming an important factor in improving the quality of education.

In teaching the science of "Biotechnology" using modern software tools, the opportunity to explain complex biological, chemical and technological processes in a visual, interactive and modeled form is created. In this case, the educational process is carried out on the basis of integrating lecture, practical and independent learning activities with the digital environment. Modern software tools are actively used in educational processes such as presenting new knowledge, consolidating knowledge, developing practical skills in students, monitoring and evaluating (Haberbosch et al., 2025).

Informatization of education is of great importance in conducting teaching processes using modern software tools. Today, text-based resources are being replaced by highly interactive, multimedia-rich electronic educational resources. Active interaction between electronic educational resources and the user is the main advantage and strategic task of informatization of education. The level of activity in the use of interactive electronic educational resources is one of the important indicators of their quality (Abdukadirova, 2022).

From a technical point of view, electronic educational resources are a set of programs and data. From a consumer point of view, they are a set of meaningful elements that represent the content, that is, objects, processes, abstractions that are the subject of study (Uspayeva & Gachaev, 2023). In addition, content-independent elements of the graphical user interface of electronic educational resources include elements that allow for personal settings (volume, font size, etc.). In general, the use of navigation and customization elements constitutes the user's interaction with electronic educational resources (Shadmanova et al., 2024).

Based on the above, the aim of this research work was to assess the potential of using interactive educational resources in teaching topics related to complex biological processes in "Biotechnology".

2. Materials and Methods

2.1. Research Objects

During the pilot study conducted within the framework of the research, experimental and control groups were selected in selected higher education institutions and 210 respondent students were involved in the pilot study. Thus, 3 groups were involved in the pilot study at the Samarkand State Pedagogical Institute, the number of students was 75, and 1 group was involved in the control study, the number of students was 27, at the Samarkand State University named after Sharof Rashidov, the number of students was 45, and 1 group was involved in the pilot study at the Samarkand State University of Veterinary Medicine, Animal Husbandry and Biotechnology, the number of students was 20, and 1 group was involved in the control study, the number of students was 19 (Table 1).

Table 1. Information about participants involved in pedagogical experiments.

Name of higher education institution	Total		Including			
			Control group		Experiment group	
	Number of groups	Number of students	Group number (name)	Number of students	Group number (name)	Number of students
Samarkand State Pedagogical Institute	4	102	1 (320)	27	3 (321; 343; 344)	75
Samarkand State University named after Sharof Rashidov	3	69	1 (201)	24	2 (202; 203)	45
Samarkand State University of Veterinary Medicine, Animal Husbandry and Biotechnology	2	39	1 (202)	19	1 (201)	20
Total	9	210	3	70	6	140

2.2. Procedures

Initially, the content of the model Module/subject syllabus of the subject "Biotechnology" taught in higher education institutions was studied. By analyzing this subject syllabus and studying the distribution of topics across the curriculum, it was

considered appropriate to prepare interactive educational resources from 13 science topics. Interactive educational resources were developed based on these topics (Figure 1).

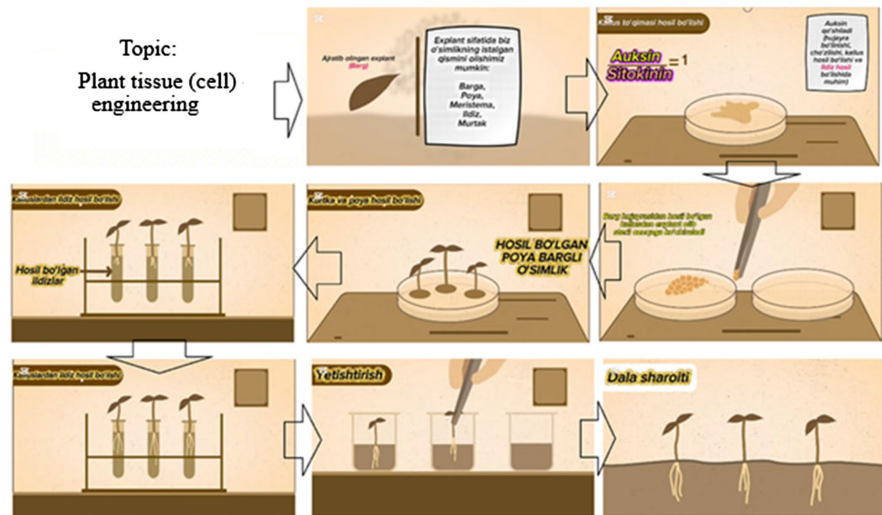


Figure 1. A sample interactive educational resource used in teaching biotechnology (resource on the topic “Cellular Engineering in Plants”).

The interactive educational resources developed on the subject made it possible to develop innovative solutions for implementing training sessions to improve the methodology of teaching the subject “Biotechnology”. Based on the content of the developed lesson plans, a model regulation of the methodology of teaching the subject “Biotechnology” using modern software tools was created (Figure 2).

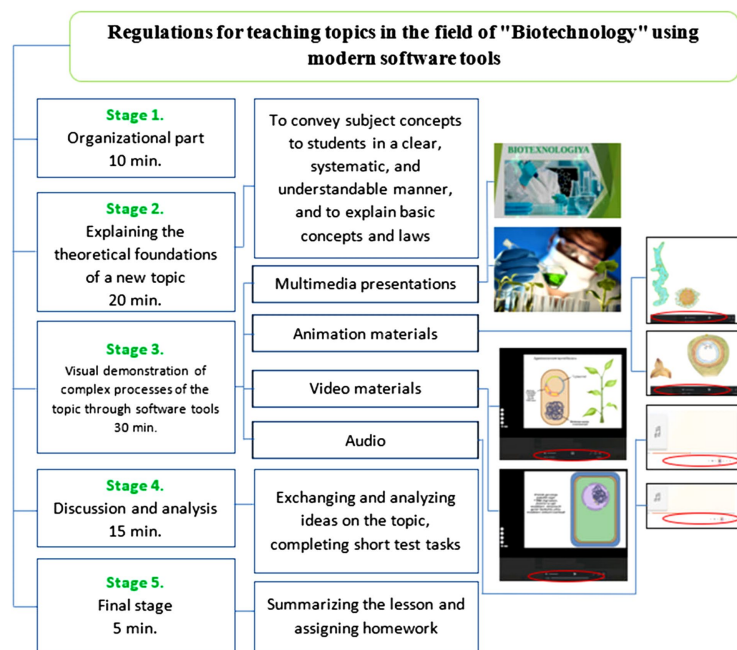


Figure 2. Teaching the subject of “Biotechnology” using modern software tools.

A teaching model based on the use of prepared interactive educational resources was created (Figure 3). Training sessions in experimental groups were conducted based on this model. The learning outcomes of students in the control and experimental groups were compared.

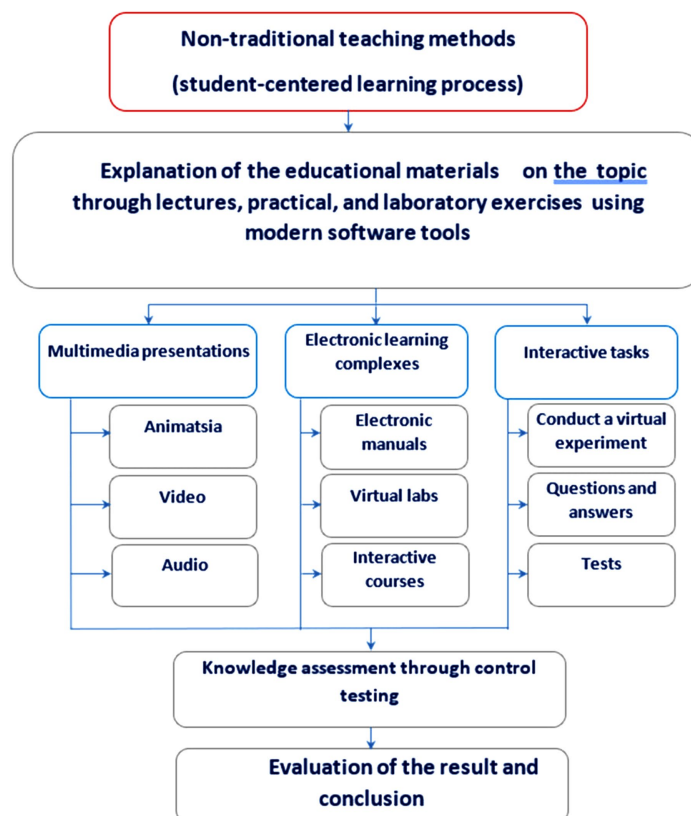


Figure 3. Non-traditional teaching scheme for the subject “Biotechnology”.

2.3. Data Analysis

According to the results of the experiment, the indicators of the experimental and control groups were analyzed mathematically and statistically. The following formulas were used to determine the average value of the share of participants in the cross-section of mastery levels (Lakin, 1990):

$$\bar{X} = \sum_i^n P_i x_i$$

$$i = \frac{X_{\max} - X_{\min}}{K}$$

$$\bar{X}\% = \frac{\bar{X}}{n} * 100\%$$

Here, \bar{X} is the mastery index (in grade); P_i —the statistical probability corresponding to the repetition (frequency) of the number of students in the variation series; x_i —mastery index score; n —number of assessment levels; i —interval; K —degree of freedom; $\bar{X}\%$ —absorption rate (in percent).

The processed values were graphically represented using the Origin Pro (2024) program.

3. Results

A questionnaire was administered to the groups and students who agreed to participate in the experimental groups were selected. Of the students involved in the study, 70 participated in the control groups and 140 in the experimental groups.

The level of students' mastery of the subject was determined based on the analysis of the final control records (**Table 2**).

Table 2. The impact of using improved teaching methods in the subject "Biotechnology" on student learning outcomes (in higher education institutions).

Groups	Number of students	Acquisition indicators								Acquisition rate, %	Quality indicator of mastery, %
		"2"		"3"		"4"		"5"			
		number	%	number	%	number	%	number	%		
Samarkand State Pedagogical Institute											
Control	27	1	3.7	14	51.9	11	40.7	1	3.7	96.3	44.4
Experiment	75	1	1.3	22	29.4	46	61.3	6	8	98.7	69.3
Samarkand State University named after Sharof Rashidov											
Control	24	1	4.2	12	50	10	41.7	1	4.2	95.9	45.9
Experiment	45	1	2.2	14	31.1	27	60	3	6.7	97.8	66.7
Samarkand State University of Veterinary Medicine, Animal Husbandry and Biotechnology											
Control	19	1	5.3	7	36.8	10	52.6	1	5.3	94.7	57.9
Experiment	20	0	0	6	30	11	55	3	15	100	70

69 respondents from Samarkand State University named after Sharof Rashidov participated in the pilot study, 24 students (1 group) participated in the control group, and 45 students (2 groups) participated in the experimental group. According to the results of the final control work taken from the students at the end of the pilot study, in the control group, 1 student (4.2%) received an unsatisfactory (2) grade, 12 students (50%) received a satisfactory (3) grade, 10 students (41.7%) received a good (4) grade, and 1 student (4.2%) received an excellent (5) grade. The level of student mastery was 95.9%, and the quality indicator was 45.9%.

The results of the experimental group were that 1 student (2.2%) received an unsatisfactory (2) grade, 14 students (31.1%) received a satisfactory (3) grade, 27 students (60%) received a good (4) grade, and 3 students (6.7%) received an excellent (5) grade. The student achievement rate was 97.8%, and the quality indicator was 66.7%.

39 students were involved in the experimental tests conducted at Samarkand State University of Veterinary Medicine, Animal Husbandry and Biotechnology, another higher education institution where our study was conducted, and 19 of

them (1 group) were assigned to the control group and 20 (1 group) to the experimental group.

According to the results of the final control work taken from the students at the end of the experimental work, in the control group, 1 student (5.3%) received an unsatisfactory (2) grade, 7 students (36.8%) received a satisfactory (3) grade, 10 students (52.6%) received a good (4) grade, and 1 student (5.3%) received an excellent (5) grade. The level of student mastery was 94.7%, and the quality indicator was 57.9%.

The results of the experimental group showed that there were no students who received an unsatisfactory (2) grade, 6 students who received a satisfactory (3) grade (30%), 11 students who received a good (4) grade (55%), and 3 students who received an excellent (5) grade (15%). The student achievement level was 100%, and the quality indicator was 70%. If we analyze the overall achievement indicators at the end of the experiment in higher education institutions selected for the experimental group, 8.6% of the students in the experimental group received an excellent grade, while 4.3% of the students in the control group received an excellent grade, while 60% of the students in the experimental group received an excellent grade, while 44.3% of the students in the control group received an excellent grade. We can see that the mastery rate of students in the experimental groups is higher than the mastery rate of those in the control groups (**Figure 4**).

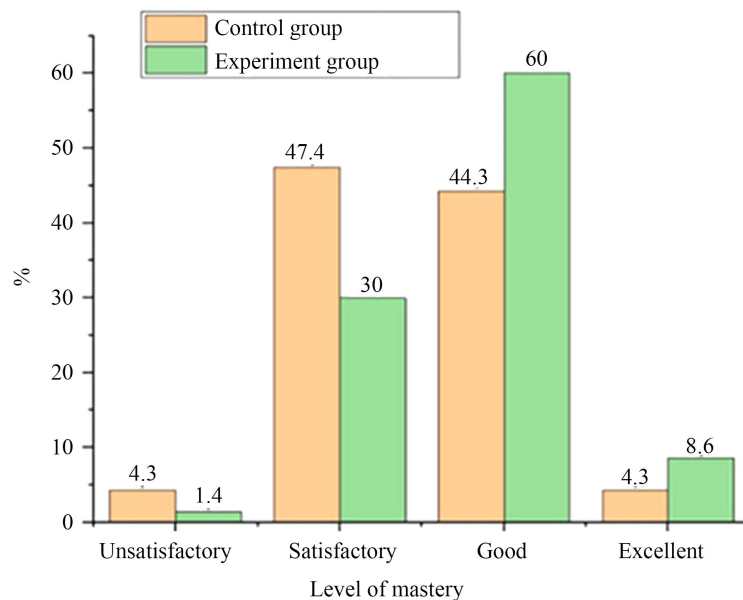


Figure 4. The impact of using improved methods of teaching “Biotechnology” using modern software on students’ mastery of the subject.

In higher education institutions where the experimental test was conducted, the mastery rate of students in the control groups was 95.7%, and the quality indicator was 48.6%, while the mastery rate of students in the experimental test groups was 98.6%, and the quality indicator was 68.6% (**Figure 5**).

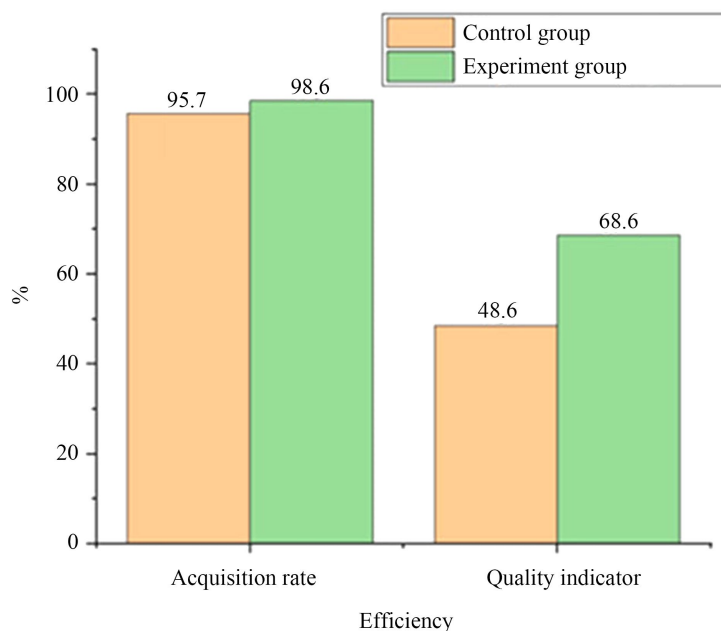


Figure 5. The impact of the use of improved methods of teaching the subject “Biotechnology” using modern software on the effectiveness of groups in mastering the subject.

4. Discussion

In the modern education system, which is being improved on the basis of digital technologies, the effective organization of teaching subjects, including the teaching of “Biotechnology”, clearly shows that the complex biological processes of the subject are directly related to the modeling and experimental properties of the subject. Therefore, it is important to improve and implement teaching methodologies based on the use of modern software tools in teaching the subject “Biotechnology”.

The full use of the capabilities of modern software tools in improving teaching methodologies serves to increase the efficiency of the educational process, ensure the mastery of complex theoretical concepts in a visual and interactive form. In particular, virtual laboratories, multimedia-rich animation, video and audio resources increase the visibility and clarity of the educational process (Abdukadirova, 2022).

The effective use of information and communication technologies in higher education institutions requires strict adherence to certain didactic rules. In particular, the volume of educational materials does not fully correspond to the volume of traditional textbooks or textbooks, which requires the use of various technological solutions, including multimedia technologies. Based on this approach, students will be able to fully and qualitatively master educational information, which creates an opportunity to fill the existing gaps in didactic provision with the help of information and communication technologies (Eltahir, 2015).

Today, in our country, in order to improve the quality of the educational process based on information and communication technologies, special attention is

paid to the development, improvement and introduction of electronic educational resources into the educational process. In particular, multimedia programs are being created that serve to improve the quality of the educational process. Multimedia electronic resources are designed for a specific subject, that is, a specific field or area of education, and provide students with the opportunity to acquire knowledge, independent study and the formation of skills (Staneviciene & Žekienė, 2025).

When analyzing the processes of introducing modern information and communication technologies in teaching specialized subjects in the higher education system, it was shown that they have the following important pedagogical capabilities:

- serve the effective organization of the process of students acquiring knowledge in their specialty;
- create the opportunity for deep, systematic and conscious mastery of the subject area through modeling the studied educational materials;
- direct students to independent learning due to the diversity of forms of organizing the educational process;
- create the necessary pedagogical conditions for ensuring the individualization and differentiation of the educational process through the introduction of interactive communication capabilities;
- use the capabilities of artificial intelligence systems to systematically form effective strategies for students to master educational materials;
- help each individual in the formation and development of information culture in society;
- Presenting the subjects taught in the specialty in a visual, interactive, and understandable form using information and communication technologies is important in increasing students' interest and engagement in the learning process (Kapi et al., 2017).

Modern technological development of the educational process is understood as the organization of an effective didactic process in accordance with educational goals. The development of professional and pedagogical skills of teachers requires the organization of their educational and cognitive activities based on a technological approach (Gonfa et al., 2024). For this purpose, pedagogical technologies related to foreign didactics are designed and tested in pedagogical experience, in which the dynamics of the development of teachers' pedagogical skills are studied and conclusions are drawn. This process serves to ensure the professional development of teachers and improve the quality of the educational process, as well as create a scientific and methodological basis for the introduction of modern pedagogical technologies into the national education system (Huang et al., 2017).

Since teachers first began to use computers and other technologies in educational institutions, researchers have tried to determine whether educational technology has a significant and reliable effect on students' academic achievement or vice versa. In the process, they found that technology cannot be considered as the

only independent developer in the system and that student achievement depends not only on the results achieved in a standardized learning process, but also on the ability to think critically, analyze, draw conclusions, and apply higher-order thinking skills to solve complex problems (Timotheou et al., 2023). Assessing the impact of any modern technology on the learning process requires a deep understanding of how and in what way it is used in lessons, the learning objectives set by the professor and the tools used to assess student achievement, and the level of complexity of new technologies. The use of information and communication technologies in the higher education system leads to a revision of the traditional teaching system of organizing the educational process and serves to increase its effectiveness. Multimedia tools are digital learning resources that incorporate textual information, graphic images, audio materials, videos, animations, and interactive components, allowing students to increase their engagement in the learning process and develop their learning abilities.

5. Conclusion

The results of experimental work conducted with the participation of students of higher education institutions showed that by applying an approach based on the use of interactive educational resources in the lessons of the subject “Biotechnology”, students’ mastery indicators increased by up to 11.3%. This result confirms that the introduction of modern pedagogical and information technologies into the educational process significantly contributes to strengthening students’ knowledge and skills based on complex processes in science and improving their level of knowledge acquisition.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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