

## WAYS OF FORMING STUDENTS' RESEARCH COMPETENCE IN THE COURSE «MICROBIOLOGY AND VIROLOGY»

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**Annotation.** This article discusses the ways of forming the research competence of students in the process of teaching the course "Microbiology and Virology" at the university. The purpose of the research work is to develop the scientific thinking, experimental skills and analytical abilities of students by introducing elements of research into the process of teaching microbiology. In the course of the study, the content of microbiological experiments, methods of organizing laboratory work were analyzed. The research work was carried out with the aim of developing the scientific thinking of future biologists, improving the skills of microbiological research and conducting experiments, identifying the problem and considering ways to solve it. The effectiveness of research and teaching technologies was also described, and models for developing research competencies through microbiological experiments were presented.

During the experimental work, students improved their research skills by completing tasks related to the isolation, cultivation, and morphological analysis of microorganisms. As a result, students developed a greater interest in research activities and improved their abilities to analyze, observe, and draw conclusions independently. The proposed methodological approaches contribute to enhancing the quality of professional training for future biology teachers.

**Keywords:** microbiology, virology, research competence, research work, laboratory practice, higher education institution, microorganisms, nutrient medium, microscopy.

**Introduction.** In the higher education system, it is important not only to limit the professional training of future specialists to theoretical knowledge, but also to develop their research competence. The main goal of teaching biological disciplines in modern universities is to form a scientific worldview and develop students' research abilities. In this context, the concept of research competence is particularly important. It describes a student's ability to identify scientific problems, form hypotheses, and conduct experiments to prove and analyze the results. In other words, research competence reflects the level of a student's ability to organize practical work based on scientific thinking.

Biological disciplines, including the course "Microbiology and Virology," allow students to develop their research skills. This is because microbiology is a science that requires not only the mastery of existing theories, but also the use of experimental evidence and methods. Additionally, since microbes are ubiquitous in nature, it is easy to conduct research. This process fosters scientific thinking, logical analysis, and the ability to provide evidence. During the course, students not only study the morphology and physiology of microorganisms, but also conduct actual experiments in the laboratory, learn methods of sterile work, cultivation and observation of bacteria, and various research methods [7].

Practices such as studying the properties of microorganisms, working with sterile equipment, and isolating and culturing bacteria increase students' research interest and provide opportunities for practical application of scientific methods. In today's era of increasing concerns about biological safety, environmental sustainability, and antibiotic resistance, the importance of microbiological research is becoming increasingly significant [9]. As future biology teachers, it is crucial for them to not only possess the necessary skills to work with microorganisms but also to develop scientific thinking and research abilities. In addition, the course on microbiology and virology plays a special role in shaping students' scientific worldview. This is because microorganisms are essential participants in the cycle of matter and energy in nature. By studying

microorganisms, students gain a deeper understanding of the unity of life, the interconnectedness of ecosystems, and the role of humans in the biosphere. This level of knowledge enhances students' environmental awareness and provides a more comprehensive understanding of biological principles. The scientific activity of students is increased by purposefully introducing research elements into the content of the microbiology course. For example, observing the growth of microorganisms under the influence of various factors, conducting experiments to change the composition of the nutrient medium, and comparing the morphology of bacteria under a microscope develop the student's research abilities by applying their theoretical knowledge in practice [10]. These activities not only enhance the understanding of biology for future teachers but also provide opportunities for students to engage in research-based activities.

In the context of modern globalization, biological sciences, including microbiology and virology, are becoming increasingly important in society. The spread of infectious diseases, the emergence of antibiotic-resistant microorganisms, the discovery of new viruses, and the growing importance of biosecurity issues are fundamentally changing the requirements for the training of future specialists in universities. This situation requires students to go beyond theoretical knowledge and acquire research skills, scientific thinking, and the ability to make independent decisions in laboratory settings [11].

In traditional approaches to education, courses in microbiology and virology are often focused on the acquisition of ready-made information, while independent research activities by students take a backseat. In such circumstances, students do not develop a sufficient interest in scientific thinking, analysis, and experimental activities. However, the modern job market and scientific environment require future professionals to be more than just executors of standard instructions; they must be capable of conducting research, making scientific discoveries, and thinking creatively.

In this context, an urgent problem is to strengthen the research focus in teaching the course of microbiology and virology, and to systematically introduce elements of research activities into the educational process. The organization of laboratory work of a research nature, the presentation of problem assignments, the implementation of small-scale scientific projects, and the scientific analysis of experimental results allow to improve the professional training of students [12]. At the same time, these approaches increase the students' interest in the subject and create conditions for their involvement in research activities.

Currently, the introduction of research elements into the educational process at universities is one of the most effective ways to improve the quality of education. The use of research methods, especially in the teaching of microbiology and virology, not only increases students' interest in the subject, but also helps them develop their ability to conduct scientific research as future professionals. Therefore, methodological research and pedagogical solutions in this area are currently relevant. In this sense, the study of microbiology is considered not only an academic goal, but also important for professional and personal development. Through microbiological experiments, students improve their ability to provide scientific evidence, analyze results, compare, and draw conclusions.

Thus, determining the ways of forming students' research competence in the course "Microbiology and Virology" is one of the current problems of the modern higher education system. Solving this problem will not only increase the professional competitiveness of future specialists, but also contribute to the development of the country's scientific potential [13].

**Research materials and methods.** The research was aimed at determining the ways of forming students' research competence when studying the course "Microbiology and Virology". In accordance with this goal, the following methods were used:

**Theoretical methods:** the analysis of pedagogical and methodological literature, domestic and foreign research revealed the essence, structure and ways of forming research competence.

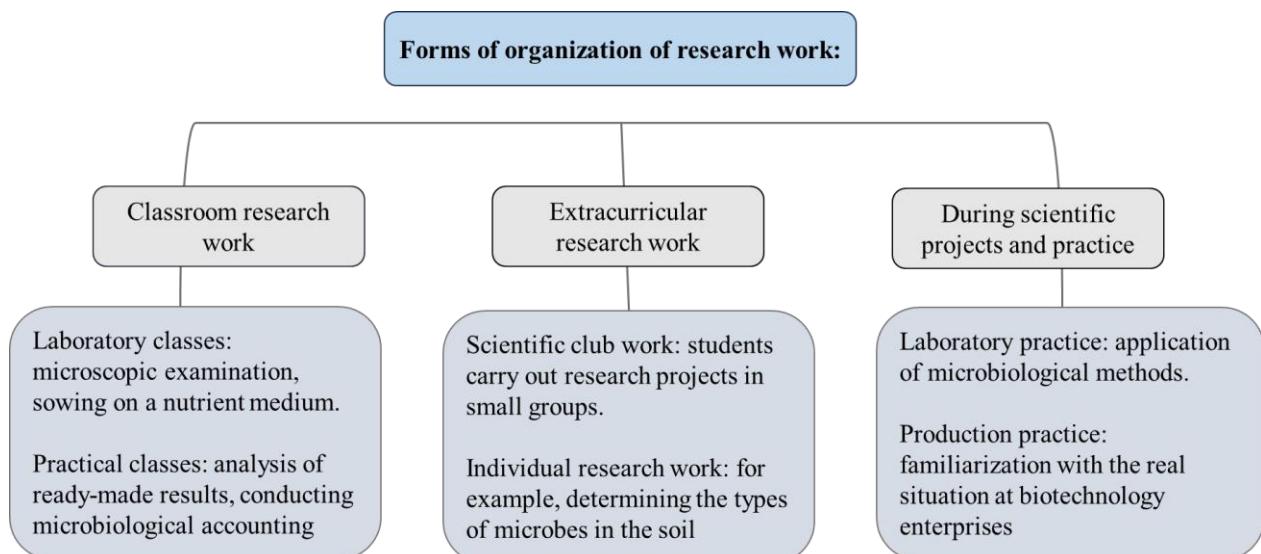
1. The curriculum and the content of the discipline "Microbiology and Virology" are analyzed, the scientific and methodological foundations of the introduction of research elements are systematized;

2. Innovative technologies and methodological approaches to laboratory work are compared and analyzed, which can be used in the learning process.

**Empirical methods:** observation method: analyzed by systematically monitoring the activity, independence, and creativity of students during laboratory classes and research assignments; questionnaires and interviews: conducted to identify students' interest in the microbiology course, their readiness to participate in research activities, and their difficulties; pedagogical experiment: aimed at developing research competencies in the process of teaching microbiology and virology, implemented using a specific methodology. The results obtained during the experiment were compared between the control and experimental groups.

**Statistical methods:** the results of the experiment were processed quantitatively and qualitatively, the effectiveness was proven, and conclusions were drawn.

Independent completion of laboratory work by a student helps to acquire practical skills for conducting microbiological research, analyze the results obtained, and gain a deeper understanding of the role of microorganisms in nature and human life. The skills acquired through laboratory experiments will enable students who hold positions in scientific institutions to organize research work in microbiology [14]. When teaching the course of microbiology and virology, various forms of research can be used. The main mechanism for developing students' research competence is the effective organization of research work [6]. This work is carried out in accordance with the content of the educational process and the interests of students, as well as the equipment of the university's research laboratory. The figure shows the forms of research that are organized during the lesson (Fig. 1).



**Figure 1 – Scheme for organizing research work**

By conducting such experiments, the student independently designs the experiment and learns how to process the results. The content of the Microbiology subject provides students with a unique opportunity to master research methods. The course's main topics cover various subjects, ranging from safety guidelines for working in a microbiology laboratory to methods for quantifying microorganisms. During the laboratory classes, students will have the opportunity to study the morphological and cultural properties of microorganisms, prepare nutrient media, obtain pure cultures of microorganisms, perform microbiological control of air and soil, determine the sensitivity of bacteria to antibiotics, study enzyme activity, and familiarize themselves with the applications of microorganisms. For example, when isolating a strain of *Bacillus subtilis* from soil and studying its growth dynamics, students will learn the entire process of the microbiological method. This process fosters research thinking and enhances accuracy, responsibility, and analytical skills [15].

**1. Laboratory research.** Laboratory classes-the basis of the course of microbiology. Here students solve specific scientific tasks: isolate microorganisms, master the methods of staining, make vaccinations in a nutrient medium, control the growth dynamics. Laboratory and practical works of research orientation in the discipline of Microbiology not only improve the practical skills of students, but also form a scientific vision. In such classes, the student acts not only as a learner, but also as a small researcher [3]. As a result, the efficiency of mastering the microbiology course increases, and the abilities for scientific thinking, observation, and analysis develop. Students participate in research work in groups of 3-4 people. This table systematizes the relationship between each research topic and the learning goal, as well as the methods and tools used. By incorporating research elements into the learning process, the structure and content of each laboratory assignment allow students to conduct independent research [5]. Students develop their scientific research skills by studying the structure of microorganisms, growth patterns, and development in a nutrient medium. Table-1 below shows examples of lessons aimed at developing students' research skills:

**Table 1 – Research Topics and Methods in Microbiology**

No.	Lesson Topic	Research Content	Methods and Tools Used
1	Study of the morphology of microorganisms	Identification of bacterial shapes (cocci, bacilli, spirilla)	Microscopy, staining methods (Gram staining, etc.)
2	Preparation of nutrient media and cultivation	Cultivation of bacteria on nutrient media	EPA, EPG, Petri dishes, incubation
3	Effect of temperature and pH	Study of bacterial growth depending on physical factors	Incubation, observation, counting methods
4	Effect of antibiotics	Investigation of the effect of various solutions on bacterial growth	Disk diffusion method
5	Observation of mold and yeast fungi	Study of the microscopic structure of prepared fungal specimens	Sabouraud medium, microscopy

**2. In practical classes**, students analyze the theoretical material and then develop and summarize the results of their practice. For example:

- plotting the growth curve of bacteria and describing each phase;
- assessing air pollution based on microbiological indicators;
- conducting statistical analysis of the results obtained.

**Effective ways to introduce a research element in practical classes:**

- analysis of a microbiological problem caused by a real-life situation (e.g. causes of an eating disorder, mold cases);
- Individual report or small study (each student is provided with their own subject);
- Mutual comparison of observation results and group discussion.

**3. Problem-solving tasks and situations:** The use of problem-solving tasks and situations in teaching microbiology and virology plays an important role in developing students' research thinking, analytical, and evidence-based abilities. The problem-solving method helps students to become not just recipients of ready-made knowledge, but researchers who strive to solve scientific problems independently. In microbiology, problem-solving situations are often based on specific biological phenomena and laboratory experiments. For example, students can be given the following tasks:

- Why is *Bacillus subtilis* resistant to high temperatures, but *Escherichia coli* is not? How is this difference related to cell construction?
- The growth of microbes was observed in some nutrient media during the sterilization process. What could be the reason, and how can this problem be solved?:
- Why do antibiotic-resistant bacterial strains form? Analyze the biological and ecological significance of this phenomenon.

These problem situations not only increase students' interest in the subject, but also improve their skills in scientific analysis, experimentation, and conclusion-making.

**Discussion of Results.** As part of the course in microbiology and virology, in order to develop the research competencies of students, a workshop was held to identify morphological features. During the practice, students study microorganisms *E. coli*, *Staphylococcus sp.*, *Bacillus sp.*, *Lactobacillus sp.* examined under a microscope and described their shape, grouping and features of the colony. The purpose of the laboratory session is to familiarize students with the main morphological forms of bacteria and to conduct research using microscopic methods.

The objectives of the laboratory session are as follows:

- Studying the main forms of bacteria (cocci, rods, spirals, etc.).
- Preparing infections from bacterial cultures.
- Determining the shape, size, and arrangement of bacteria under a microscope.

Morphological characteristics include features such as cell shape and size, and the presence of endospores and exospores. Preparations were used to study morphological characteristics. The morphological characteristics of a culture depend on the composition of the environment and the growing conditions. Bacterial cells can be spherical (cocci), rod-shaped, or spiral [2]. The grown colonies are first examined with the naked eye, and then examined using a magnifying glass or a small microscope. Morphological features are described according to the following scheme: cell shape and size, cell connection, motility, filament arrangement and number, spore formation, type of spore formation, capsule formation, auxiliary substances, and color in grams. Cultural properties are characteristic of each species of microorganisms, and therefore they are an important diagnostic feature of microorganisms [4].

**Microscopic preparation:** students are introduced to the microscope and the principles of its operation. Students, following the rules of sterile technique, took samples from the culture, then placed them on a slide and prepared a dried, stained preparation according to the instructions [1].

**Morphological study:** the cell shape, size, grouping pattern, and colony shape of each microorganism were examined under the microscope. Students compared the morphology of different bacteria and identified their characteristics:

- *E. coli* are rod-shaped and arranged individually or in pairs;
- *Staphylococcus sp.* - spherical, in clusters;
- *Bacillus sp.* - long rod, sometimes spores are formed;
- *Lactobacillus sp.* - short rod, characteristic group arrangement.

During the practice, students studied the morphological features of microorganisms, determined the shapes, sizes and group characteristics of various bacteria. Such practical work allows combining theoretical knowledge with practice, forms the research competence of students.

In the experimental part, the students completed a practical task based on the results obtained (Fig.2).

Type of sign	Description
Shape, color	
Size	
Side view, edge	
Consistency	
Structure	
Morphological features	
Gram coloring	
Mobility	

**Figure 2 – Scheme for describing microorganisms based on their cultural properties**

The students completed a task to identify the morphological features of microorganisms. During this task, each student or group recorded the characteristics of the colonies, such as shape,

color, edge shape, and surface texture. This activity allowed the students to observe the diversity and characteristics of microorganisms in practice, creating an opportunity to combine theoretical knowledge with practical skills [8]. Additionally, the practical work encouraged independent learning and the correct use of scientific terminology.

**Conclusion.** The systematic use of experimental and research elements in the process of developing students' research competencies in the course of microbiology and virology has significantly improved their professional training. Practical work, microscopic observations, and methods of cultivating and identifying microorganisms allowed students to combine theoretical knowledge with real-world experience. These methods have developed students' analytical thinking, scientific reasoning skills, and the ability to plan and execute experimental activities.

During the practical classes, students performed specific research activities, such as determining the morphological features of microorganisms, cultivating and observing cultures, which strengthened their experimental skills and formed a scientific mindset. Additionally, the systematic organization of research work fostered a research culture among students and enhanced their professional competence.

Thus, the introduction of research elements into the course "Microbiology and Virology" is an important tool in developing students' research competencies. These comprehensive methods allow students to combine their theoretical knowledge with practice, improve their scientific thinking, and develop their professional skills. In the future, the widespread use of practical and research approaches will further enhance the quality of microbiology teaching, make the educational process more innovative, and elevate students' professional training to a higher level.

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## «МИКРОБИОЛОГИЯ ЖӘНЕ ВИРУСОЛОГИЯ» КУРСЫН ОҚЫТУДА СТУДЕНТТЕРДІҢ ЗЕРТТЕУШІЛІК ҚҰЗЫРЕТТІЛІГІН ҚАЛЫПТАСТАЫРУ ЖОЛДАРЫ

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**Андатпа.** Бұл мақала оқу орнында «Микробиология және вирусология» курсын оқыту барысында студенттердің зерттеушилік құзыреттілігін қалыптастыру жолдарын қарастырады. Зерттеу жұмысының мақсаты – микробиологияны оқыту үдерісіне зерттеу элементтерін енгізу арқылы білім алушылардың ғылыми ойлаудың, эксперименттік дағдыларын және талдау қабілеттерін дамытуға негізделген. Зерттеу барысында микробиологиялық тәжірибелердің мазмұны, зертханалық

жұмыстарды ұйымдастыру әдістері талданды. Зерттеу жұмысы болашақ биолог мамандардың ғылыми ойлаудың дамытуға, микробиологиялық зерттеуде дағдыларын жетілдіруге және тәжірибе жүргізу арқылы мәселені анықтап, оны шешу жолдарын қарастыруға бағытталды. Сондай-ақ, зерттеу және оқыту технологияларының тиімділігі сипатталып, микробиологиялық тәжірибелер арқылы зерттеушілік құзыреттілікті дамыту үлгілері ұсынылды. Эксперименттік жұмыс барысында студенттер микроорганизмдерді бөліп алу, өсіру және олардың морфологиялық қасиеттерін зерттеу тапсырмаларын орындау арқылы зерттеушілік дағдыларын жетілдірді. Нәтижесінде студенттердің ғылыми-зерттеу іс-әрекетіне қызығушылығы артып, дербес талдау, бақылау және қорытынды жасау қабілеттері дамыды. Ұсынылған әдістемелік тәсілдер болашақ биология пәні мұғалімдерін қарастырып, күрделі биологиялық үдерістерді терең түсінүіне ықпал ететінін көрсетті.

**Тірек сөздер:** микробиология, вирусология, зерттеушілік құзыреттілік, ғылыми-зерттеу жұмысы, зертханалық тәжірибе, жоғары оқу орны, микроорганизмдер, қоректік орта, микроскопия.

## **ПУТИ ФОРМИРОВАНИЯ ИССЛЕДОВАТЕЛЬСКОЙ КОМПЕТЕНТНОСТИ СТУДЕНТОВ ПРИ ИЗУЧЕНИИ КУРСА «МИКРОБИОЛОГИЯ И ВИРУСОЛОГИЯ»**

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**Аннотация.** В данной статье рассматриваются пути формирования исследовательской компетентности студентов в процессе преподавания курса «Микробиология и вирусология» в вузе. Цель исследовательской работы – развитие научного мышления, экспериментальных навыков и аналитических способностей обучающихся путем внедрения элементов исследования в процесс обучения микробиологии. В ходе исследования проанализировано содержание микробиологических опытов, методы организации лабораторных работ. Исследовательская работа проводилась с целью развития научного мышления будущих специалистов-биологов, совершенствования навыков микробиологических исследований и проведения экспериментов, выявления проблемы и способы пути ее решения. Также была описана эффективность исследовательских и обучающих технологий и представлены модели развития исследовательских компетенций с помощью микробиологических экспериментов. В ходе экспериментальной работы студенты совершенствовали свои исследовательские навыки, выполняя задания по выделению, культивированию микроорганизмов и изучению их морфологических свойств. В результате у студентов вырос интерес к научно-исследовательской деятельности, развились способности к самостоятельному анализу, наблюдению и подведению итогов. Предлагаемые методические подходы позволяют повысить качество профессиональной подготовки будущих учителей биологии. Результаты исследования показали, что системное применение исследовательских подходов в обучении микробиологии формирует научную культуру обучающихся и способствует более глубокому пониманию сложных биологических процессов.

**Ключевые слова:** микробиология, вирусология, исследовательская компетенция, исследовательская работа, лабораторная практика, высшее учебное заведение, микроорганизмы, питательная среда, микроскопия.