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**IRSTI 14.35.09** https://doi.org/10.51889/2959-5762.2025.87.3.026

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# INNOVATIVE APPROACHES TO THE DEVELOPMENT OF PRACTICAL COMPETENCIES OF FUTURE BIOLOGY TEACHERS

*Abstract*

The article is devoted to the study of innovative approaches to the development of practical competencies of future biology teachers. The relevance of the research topic is determined by the need to equip students at pedagogical universities with the skills necessary for the successful implementation of modern educational standards and the effective teaching of biology. The study analyzed various teaching methods and technologies that contribute to the development of practical competencies, including project-based learning, the use of information technologies in the educational process, the introduction of research-oriented teaching methods, as well as the application of multimedia and interactive tools, virtual laboratories and augmented reality (AR) technologies. The research methods included questionnaires, testing practical skills, observation, and statistical analysis. The results demonstrated that the integration of innovative technologies into the training of future biology teachers increased the level of their practical competencies by 20-30%. The most significant progress was recorded in teamwork skills and the ability to conduct experiments. Furthermore, the use of project-based assignments contributed to the development of critical thinking, independence, and a creative approach among students. The implementation of such approaches made it possible to substantially improve the level of independent work of future teachers and to prepare them for the application of innovative teaching methods in real educational settings. The conclusion of the study emphasizes the importance of further advancing innovative teaching methods in teacher education with a focus on practice-oriented mastery of disciplines and provides recommendations for improving curricula and pedagogical technologies in the context of training future biology teachers.

**Keywords:** pedagogical approaches, innovative approaches, practical competencies, teacher training, biology education.

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## БОЛАШАҚ БИОЛОГИЯ ПӘНІ МҰҒАЛІМДЕРІНІҢ ПРАКТИКАЛЫҚ ҚҰЗЫРЕТТІЛІКТЕРІН ДАМЫТУДЫҢ ИННОВАЦИЯЛЫҚ ТӘСІЛДЕРІ

*Аңдатпа*

Бұл мақалада болашақ биология пәні мұғалімдерінің практикалық құзыреттіліктерін дамытудағы инновациялық тәсілдер қарастырылған. Зерттеу жұмысы тақырыбының өзектілігі педагогикалық жоғары оқу орындары студенттерінің заманауи білім беру стандарттарын сәтті енгізуді және биологияны тиімді оқытуды қамтамасыз ететін дағдыларды дамыту қажеттілігімен байланысты. Зерттеу барысында жобалық іс-әрекет, оқу процесінде ақпараттық технологияларды қолдану, сонымен қатар ғылыми-зерттеу әдістерін енгізу сияқты практикалық құзыреттіліктерді дамытуға ықпал ететін әр түрлі әдістер мен оқыту технологиялары қарастырылды. Зерттеу әдістері ретінде сауалнама, практикалық дағдыларды тестілеу, бақылау және статистикалық талдау қолданылды. Зерттеу нәтижелері болашақ биология пәні мұғалімдерін даярлау процесіне инновациялық технологияларды енгізу олардың практикалық дайындығын жетілдіруге, сыни тұрғыдан ойлауды дамытуға және теориялық білімдерін практикада қолдана білуге ықпал ететіндігін көрсетті. Мультимедиялық және интерактивті әдістерді, сондай-ақ виртуалды зертханалар мен AR-технологияларын қолдану, жобалық тапсырмаларды пайдалану тиімді болып шықты, бұл студенттердің практикалық дағдыларын тереңдетуге және шығармашылық көзқарасын дамытуға оң әсер етті. Инновациялық әдіс-тәсілдерді интеграциялау студенттердің практикалық құзыреттілік деңгейін 20-30%-ға арттырды, ең үлкен ілгерілеу топтық жұмыс және эксперимент жүргізу дағдыларында байқалды. Мұндай тәсілдерді енгізу болашақ мұғалімдердің өзіндік жұмысының деңгейін едәуір арттыруға, оларды білім беру ұйымдарының нақты жағдайында оқытудың инновациялық әдістерін қолдануға дайындауға мүмкіндік берді. Зерттеу қорытындысы болашақ биология пәні мұғалімдерінің практикалық дамуына баса назар аудара отырып, мұғалімдерді даярлауда оқытудың инновациялық әдістерін одан әрі дамытудың маңыздылығын көрсетеді және болашақ биология пәні мұғалімдерін даярлау жағдайында оқу жоспарлары мен педагогикалық технологияларды жетілдіру бойынша ұсыныстар берілді.

**Түйін сөздер:** педагогикалық тәсілдер, инновациялық тәсілдер, практикалық құзыреттілік, мұғалімдерді даярлау, биологияны оқыту.

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## ОСОБЕННОСТИ ФОРМИРОВАНИЯ ПРАКТИЧЕСКОЙ КОМПЕТЕНТНОСТИ У СТУДЕНТОВ В ПРОЦЕССЕ БИОЛОГИЧЕСКОГО ОБРАЗОВАНИЯ

*Аннотация*

В данной статье рассматриваются инновационные подходы к развитию практических компетенций будущих учителей биологии. Актуальность темы исследования обусловлена необходимостью формирования у студентов педагогических вузов навыков, обеспечивающих успешное внедрение современных образовательных стандартов и эффективное преподавание биологии. В рамках исследования были проанализированы различные методы и технологии обучения, способствующие развитию практических компетенций, такие как проектная деятельность, использование информационных технологий в учебном процессе, внедрение научно-исследовательских методов, также применение мультимедийных и интерактивных средств обучения, виртуальных лабораторий и AR-технологий. Методы исследования включали анкетирование, тестирование практических навыков, наблюдение и статистический анализ. Результаты показали, что интеграция инновационных технологий в процесс подготовки будущих учителей биологии повысила уровень их практических компетенций на 20-30%. Наибольший прогресс был зафиксирован в навыках командной работы и умении проводить эксперименты. Кроме того, использование проектных заданий способствовало развитию критического мышления, самостоятельности и творческого подхода у студентов. Внедрение таких подходов позволило существенно повысить уровень самостоятельной работы будущих педагогов и подготовить их к применению инновационных методов обучения в условиях реальных образовательных учреждений. Заключение исследования подчеркивает важность дальнейшего развития инновационных методов обучения в системе подготовки учителей с акцентом на практико-ориентированное освоение дисциплин, а также содержит рекомендации по совершенствованию учебных программ и педагогических технологий в контексте подготовки будущих учителей биологии.

**Ключевые слова:** педагогические подходы, инновационные подходы, практическая компетентность, подготовка учителей, обучение биологии.

**Introduction**. In pedagogical science, competence is construed as an integrative characteristic of the individual encompassing knowledge, skills, abilities, value orientations and the readiness for their practical implementation. Within the field of pedagogical science, the notion of *practical competence* is subject to a broad and multidimensional interpretation. Thus, in our view [1], practical competence encompasses «abilities, skills and the readiness to apply knowledge in real and professional contexts». According to the Russian scholar V.A. Slastenin [2], practical competence is interpreted as «the willingness and ability of an individual to perform professional activities in conditions approximating real work environments». The Dutch scholar, Professor M. Mulder [3], emphasizes its multidimensional nature, noting that competence comprises cognitive, functional, personal and ethical components manifested in the process of task performance. In turn, the Russian pedagogue, Professor V.V. Serikov [4], argues that competence is not only a combination of knowledge and skills but also the readiness to apply them in changing circumstances.

Based on these definitions, the practical competence of students in biological fields should be understood as the integration of cognitive (knowledge), functional (skills), personal (motivation and attitudes) and ethical components that ensure the ability to act effectively in educational and professional contexts. This includes conducting experiments, operating laboratory and field equipment, applying theoretical knowledge in practice, as well as demonstrating flexibility and readiness to address new tasks within a team.

In the modern world, biological education is undergoing a transformation driven by the need to prepare specialists capable of applying acquired knowledge in real professional and research contexts. Traditional forms of instruction are increasingly complemented by experimental and research practices, project-based assignments, group projects and the use of digital technologies. In international practice (the United States of America, the United Kingdom, Finland, Turkey, South Korea), growing emphasis is placed on practice-oriented learning, where the theoretical foundation is closely integrated with experimental work, project tasks, field research and digital technologies, including virtual laboratories and augmented/virtual reality (AR/VR). Recent studies [5] demonstrate that such approaches foster not only subject-specific knowledge, but also critical thinking, research skills, the ability to collaborate effectively and the application of the scientific method to solving really biological and environmental challenges.

For Kazakhstan, the issue of developing practical competence among students in biological specializations is of particular relevance. National strategic documents – *Kazakhstan-2050* [6] and the State Program for the Development of Education and Science for 2020-2025 [7] – emphasize the necessity of training competitive specialists equipped with applied skills. Supplementary state programs, such as *Rukhani Zhangyru* and *Education 2023-2027*, play a signaling and supervisory role in this process. In leading universities of the country, including Abai Kazakh National Pedagogical University and al-Farabi Kazakh National University, educational programs incorporate modules focused on laboratory research, biological data analysis and field practice. Nevertheless, traditional forms of instruction still predominate, while the implementation of innovative technologies – such as CLIL, AR/VR-based modules, case methods and virtual laboratories – remains fragmented.

Thus, the study of the peculiarities of developing practical competence among students in the process of biological education in Kazakhstan acquires both theoretical and applied significance. On the one hand, it draws upon best international practices, while on the other, it addresses the demands of state policy and society for preparing a new generation of specialists capable of tackling the challenges of sustainable development and scientifically grounded environmental management. In this regard, the purpose of this article is to analyze the potential of applying innovative methodologies for fostering practical competencies in future biology teachers. Within this objective, the following tasks are defined: to examine existing approaches to the training of biology students, to assess their effectiveness in the development of practical competencies, and to identify the problems and prospects of implementing innovative technologies into the educational process. The scientific novelty of the research lies in the development of an integrated approach that combines project-based learning, the use of augmented reality technologies, and the conduct of field studies, thereby ensuring active student engagement in the educational process and promoting deeper assimilation of the material.

*Basic provisions.* The State of Nations People of the President of the Republic of Kazakhstan dated September 1, 2023, outlined key priorities in the field of education, such as the introduction of digital technologies and the development of critical thinking among students. This is aimed at creating new educational standards that require teachers to be willing to work with innovative teaching methods. In this regard, the idea of the research is to develop and implement innovative approaches to the development of practical competencies of future biology teachers, considering the current requirements of the educational system. To implement this idea, the following main objectives were set:

- Analysis of the current state of biology teacher training in the context of new educational standards and legislative initiatives, such as "Modernization of the education system of the Republic of Kazakhstan" and the concept of "Digital Kazakhstan", to identify gaps in teacher training.
- Development and implementation of innovative teaching methods (project activities, research training, use of information technologies) aimed at developing practical skills and the ability of future biology teachers to effectively apply modern pedagogical technologies.

**Materials and Methods.** The study was conducted during the 2024-2025 academic year at Abai Kazakh National Pedagogical University (Almaty). A total of 30 undergraduate students ($1^{st}$-$4^{th}$ year) majoring in Biology participated in the research. The purpose of the experiment was to determine the effectiveness of implementing innovative teaching methods in the formation of students' practical competence. As a result of the study, and based on the effectiveness evaluation, the developed lesson plans will be validated and approved for further implementation in the educational process.

To achieve the stated objective, a pedagogical experiment was conducted, which included both diagnostic and formative stages. At the diagnostic stage, the initial level of students' competencies was identified according to key indicators (knowledge of biology, ability to conduct experiments, skills in handling equipment, application of theory in practice, and teamwork). At the formative stage, innovative teaching methods, consolidated in specially designed lesson plans, were introduced into the educational process.

The methodological framework of the experiment was based on the integration of the following approaches:

- *Lesson Study (Lesson Planning and Design).* Three types of lessons were developed: project-based learning (*topic: Biodiversity of Animals in Kazakhstan*), the use of augmented reality technologies (*topic: Animal Anatomy*), and field research (*topic: Wildlife Observation*). Each lesson was focused on practical student activities and the development of research skills.
- *CLIL (Content and Language Integrated Learning).* Cross-curricular integration of language and subject teaching was applied in the study of biology in Kazakh and English. This approach simultaneously deepened subject knowledge and enhanced students' universal linguistic competencies. It strengthened the interdisciplinary nature of tasks and increased students' readiness to use biological terminology in the international academic environment.
- *Virtual Laboratories.* Platforms such as *Virtual Biology Lab* were employed, providing opportunities to conduct online experiments in an interactive environment. This method helped to compensate for the limited access to real laboratory classes and gave students practical experience with models of biological processes.
- *Case Method.* The educational process included real-life cases from biological education and ecology (e.g., the decline of biodiversity in Kazakhstan's steppe ecosystems). Case analysis enabled students to apply their knowledge to solving current problems while developing critical thinking and group discussion skills.

To diagnose the level of competence formation, questionnaires, observation, knowledge testing, and expert evaluation of project and practical task performance were applied. Comparative data analysis was carried out using descriptive statistics and pre-/post-intervention charts. The reliability of differences was verified with Student's $t$-test at a significance level of $p < 0.05$.

Thus, the study combined a pedagogical experiment, lesson study, and the introduction of innovative teaching methods (CLIL, virtual laboratories, and the case method), which made it possible to comprehensively assess their impact on the formation of practical competence among biology students. In addition, detailed lesson plans were developed as part of the research design, using a design-based research (DBR) methodology, which ensured the scientific rigor, systematic structure, and replicability of the proposed pedagogical interventions.

**Results.** The research results are presented in the form of a table and a diagram illustrating the level of development of students' practical competencies before and after the introduction of innovative approaches.

- Sample: 30 undergraduate students majoring in Biology at Abai University.
- Methods: questionnaires, observation, analysis of learning materials, and testing of practical skills (Table 1).

*Table 1 – The Level of Development of Students' Practical Competencies Before and After the Introduction of Innovative Approaches*

| *Indicator* | *Before (%)* | *After (%)* |
|---|---|---|
| Biological knowledge | 60 | 85 |
| Ability to conduct experiments | 50 | 80 |
| Skills in handling equipment | 55 | 75 |
| Application of theory in practice | 65 | 90 |
| Teamwork | 40 | 70 |

The results demonstrate that the implementation of innovative approaches significantly enhanced the level of practical competencies among future biology teachers. As shown in Figure 1, the most substantial improvements were revealed in teamwork, which demonstrated a significant gain of 30% (from 40% to 70%), and in the ability to conduct experiments, which increased by 30% (from 50% to 80%). Moreover, the application of theory in practice exhibited a considerable improvement of 25% (from 65% to 90%), indicating a higher level of integration between theoretical knowledge and practical application. Overall, the findings suggest that the incorporation of innovative teaching approaches not only enhanced specific competencies but also contributed to creating a more engaging and pedagogically relevant learning environment, as confirmed by students' feedback on the use of digital technologies and field research (Figure 1).

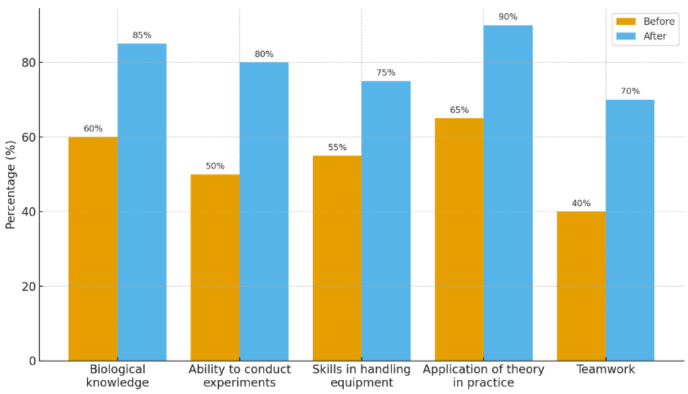



*Figure 1 – Comparative Analysis of Practical Competence Levels*

To further substantiate these findings, a series of lesson plans was developed and implemented, serving as the experimental foundation for evaluating the effectiveness of innovative teaching methods. These lesson plans integrated project-based learning, augmented reality technologies, field studies, and gamification, providing a structured framework for the development of students' practical competencies. By aligning specific topics (such as animal biodiversity in Kazakhstan, animal anatomy, wildlife observation, and zoology) with clear objectives, textbooks, and lesson stages, the plans ensured consistency and comparability of outcomes. The following tables present the detailed structure of these lesson plans, which were used as the pedagogical basis for assessing academic performance, language competence, and motivation among biology students (Table 2) [8].

*Table 2 – Lesson Plan Structure*

| *Lesson Plan* | 1. Project-Based Learning | 2. Use of Augmented Reality Technologies | 3. Field Studies | 4. Gamification |
|---|---|---|---|---|
| *Topic* | Study of animal biodiversity in Kazakhstan | Animal Anatomy | Wildlife Observation | Zoology |
| *Objective* | To explore various species of animals in Kazakhstan and their ecosystems. | To study the structure and functions of different animals using augmented reality (AR) technologies. | To investigate the behavior and ecosystem of local animals through field research. | To examine animal diversity and classification through gamified learning elements. |
| *Textbook* | «Biology», authors: M.S. Isakov, G.A. Nurpeisov. | «Human and animal anatomy», authors: E.S. Yesin, A.A. Tazhimov. | «Ecology», authors: A.A. Beisembaev, S.B. Beketov. | «Zoology», authors: N.N. Solovyev, D.D. Dosmukhambetov |
| *Lesson Stages* | *Introduction (10 min).*<br>• Discussion of the importance of biodiversity. Use textbook data indicating that Kazakhstan ranks 9th in the world by territory and its ecosystems include forests, steppes, mountains, and water bodies.<br>• Presentation: *"Unique Animals of Kazakhstan"* (e.g., snow leopard, saiga antelope, black stork).<br>*Group Formation (5 min).* Students are divided into groups of 4-5. Each group selects an animal species for investigation. Use the textbook to provide brief background information on the chosen species.<br>*Research (20 min).* Each group conducts research on their selected species, focusing on:<br>• Habitat (e.g., the snow leopard inhabits mountainous regions).<br>• Diet (omnivorous, herbivorous, carnivorous).<br>• Reproduction (breeding seasons and number of offspring).<br>• Threats (poaching, climate change).<br>Use internet resources and textbooks for reference.<br>*Project Development (10 min).* | *Introduction (5 min).* Overview of animal anatomy and its importance for understanding their behavior and ecology. Use textbook examples of the structure of different animal classes (mammals, birds, fish).<br>*Work with Augmented Reality (20 min).* Students use augmented reality applications (e.g., *Zookazam* or *Google Expeditions*) to visualize the anatomy of different animals.<br>They study organs and systems, observing their functions (e.g., comparing the respiratory systems of mammals and birds).<br>*Group Work (15 min).* Students create posters illustrating the anatomy of selected animals (e.g., horse, tiger). Use textbook data to | *Introduction (5 min).* Discussion of ecosystems and the behavior of local animals. Use textbook data on how ecosystems influence animal behavior (e.g., the impact of habitat on social behavior).<br>*Field Trip (90 min).* Students go to a nearby natural area (park, reserve) for direct observations.<br>They complete an observation sheet documenting animal behavior and habitat. For example, observing birds, their behavior, and interactions with the environment.<br>*Data Collection (20 min).* Students use mobile applications (e.g., *iNaturalist*) to record observations. They take photographs of animals and document their characteristics, referring to textbook information about each observed species.<br>*Data Analysis (30 min).* Students present the | *Introduction (5 min).* Overview of the main classes of animals (mammals, birds, reptiles, etc.).<br>*Game "Animal Classification" (20 min).* Students are divided into teams. Each team receives a set of cards with images of animals. Teams classify the animals into appropriate classes and explain their choices, referring to the textbook.<br>*Interactive Quizzes (15 min).* Use applications for creating interactive quizzes (e.g., *Kahoot*) on zoology.<br>Students answer questions about animals and earn points for correct answers.<br>*Discussion of Results (5 min).* Review of mistakes and explanation of difficult questions. |

| | | | | |
|---|---|---|---|---|
| | Groups create multimedia presentations about their animals, including photographs, videos, and distribution maps. *Project Presentations (5 min).* Each group presents their work and discusses possible conservation measures, referring to textbook information on environmental protection strategies. | provide deeper analysis. *Discussion and Reflection (10 min).* How did AR technologies change students' perception of animals and their anatomy? Reflection on what new insights were gained. | collected data and exchange observations. Discussion focuses on the importance of studying animal behavior. *Conclusion (5 min).* Reflection on the significance of field studies in understanding animals and their ecosystems. | Summarizing the outcomes of the game. *Conclusion (5 min).* Reflection on how gamification made the learning process more engaging. |
| *Methods* | Project-based learning, teamwork, and use of digital technologies. | Augmented reality technologies, visualization, group work. | Field studies, practice-based learning, data analysis. | Gamification, interactive learning, teamwork. |

Innovative Approaches Proposed for Implementation:

1. CLIL (Content and Language Integrated Learning): CLIL enables students to simultaneously improve their knowledge in biology and develop universal language skills. The methodology involves bilingual instruction in biological disciplines, with a focus on interdisciplinary tasks.

2. Virtual Laboratories: The use of platforms such as *Virtual Biology Lab* provides students with opportunities for practice-oriented learning in an interactive environment.

3. Case Method (Case Analysis): This methodology incorporates the analysis of real-life cases from educational practice, allowing teachers to facilitate the application of skills in real-world contexts.

Within the framework of Kazakhstan's Education Development Program, the introduction of innovative methods into the training of future biology teachers has demonstrated the following results:

1. Improved Academic Performance: in groups using CLIL and virtual laboratories, the average level of practical task completion increased by 18% compared to traditional methods.

2. Enhanced Language Competence: the use of CLIL contributed to a 15% improvement in students' English proficiency through the implementation of a bilingual approach.

3. Increased Motivation: 90% of students noted that working with case studies and computer-based modeling enhanced their interest in the subject (Table 3).

*Table 3 – Comparative Data on Achievement and Engagement Levels*

| *Methodology* | *Achievement (%)* | *Engagement (%)* |
|---|---|---|
| Traditional Method | 72 | 65 |
| Use of CLIL | 85 | 80 |
| Virtual Laboratories | 90 | 88 |

Example from the «Virtual Lab». In this virtual simulation, students explore Connell's classic 1961 experiment on interspecific competition between two barnacle species – *Chthamalus* and *Balanus*. The interface allows manipulation of parameters such as *sea level* and *predator density.* Real-time outputs include *population graphs,* showing changes in abundance across different intertidal elevations, and a *visual representation* of barnacle distributions on the rock surface IHMC Public Cmaps+10Virtual Biology Lab+10BIOL 123 Lab Manual+10 (Figure 2).

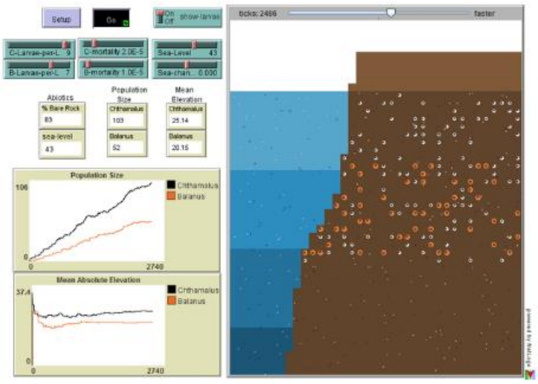



*Figure 2 – Illustrative Screenshot from the Virtual Biology Laboratory Environment*

Screenshot Description:

• Panels displaying *population size vs. time* and *mean elevation* for each species (distinguishing *Chthamalus* and *Balanus*).

• A *visual simulation area* depicting barnacles at different tide levels.

• Control enabling *modulation of sea level*, which simulates environmental change such as global warming.

To illustrate the practical application of these approaches, the following lesson plan is presented, which was used as the basis for evaluating the effectiveness of innovative teaching methods. The plan integrates CLIL, virtual laboratory simulations, and case-based learning, enabling a comprehensive assessment of students' academic performance, language competence and motivation.

LESSON PLAN.

Lesson Topic: The Use of Virtual Laboratories for Studying Animals

Target Audience: Students of pedagogical universities (future biology teachers)

Duration: 50 minutes

Objective: To develop practical competencies in the study of animal biology through the use of virtual laboratories (Table 4-5).

*Table 4 – Lesson Instructions*

| *Virtual Laboratories for Studying Animals* | *Description* | *Materials (Screenshots)* |
|---|---|---|
| *Virtual Biology Lab* | An online platform that offers a wide range of biological simulations, including experiments with animal anatomy, physiology, and ecology. It allows students to conduct experiments virtually, repeat procedures multiple times without material costs, and visualize biological processes in real time. |  |
| *Labster* | A globally recognized platform providing high-quality virtual biology laboratories with 3D animations and realistic scenarios. For animal studies, it includes simulations on dissection, animal cell biology, genetics, and ecological interactions, enabling immersive and safe experimentation. |   |

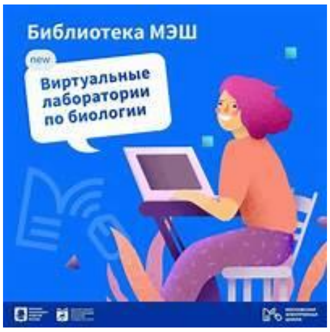
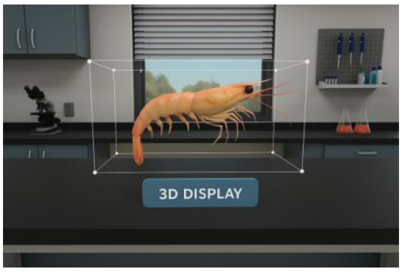
| | | |
|---|---|---|
| *PhET Interactive Simulations* | The University of Colorado provides free interactive simulations, including biology. An educational resource offering interactive simulations in biology, physics, and chemistry. In the context of animal studies, PhET provides models of ecosystems, population dynamics, and physiological processes that make abstract concepts more accessible. |   |
| *Moscow Electronic School (MES)* | An educational library containing a collection of digital resources, including virtual biology laboratories. It covers topics such as zoology, anatomy, and ecology of animals, and integrates interactive tasks that help reinforce knowledge within the Russian school curriculum. |   |
| *PraxiLabs* | A modern platform that provides virtual biology laboratories with 3D-models and interactive experiments. It focuses on zoology, physiology, and molecular biology, allowing learners to explore animal-related experiments in a controlled and engaging digital environment. |   |

*Table 5 – Lesson Stages with Methods and Technologies*

| *Lesson Stages* | *Time* | *Objective* | *Teacher's Activities* | *Students' Activities* | *Methods and Technologies* |
|---|---|---|---|---|---|
| *Introductory Stage* | 5 min | Introduction to the topic, student motivation | – Explains lesson objectives. – Demonstrates key terms in English (CLIL). | – Listen to the introductory material. – Answer questions about animal diversity. | CLIL, multimedia presentation, short video |
| *Main Stage* | 35 min | Reinforcing theory through practice | – Demonstrates the use of Virtual Biology Lab. – Provides guidance on tasks. | – Explore models. – Complete tasks: study animal anatomy, observe behavior. | Virtual laboratory, case method |
| *Stage 1: Working with the Virtual Laboratory* | 15 min | Mastering skills in using the laboratory | – Sets task parameters. – Explains instructions. | – Select an animal for study. – Explore anatomical structures or behavioral simulations. | Independent work, interaction with platform |
| *Stage 2: Data Analysis* | 15 min | Interpreting results obtained | – Demonstrates an example of data analysis. – Organizes group discussion. | – Compare data from different animals. – Fill in the results table. | Group work, data analysis, graphs |
| *Stage 3: Presentation of Findings* | 5 min | Drawing conclusions | – Organizes presentation of data. | – Present results of their research. | Presentation of findings, discussion |

| | | | | | |
|---|---|---|---|---|---|
| *Final Stage* | 10 min | Reflection, application of knowledge | – Leads discussion on the advantages of virtual technologies.<br>– Assigns task to design a lesson. | – Discuss experiment results.<br>– Develop a mini-lesson on animal studies. | Reflection, development of a mini-lesson plan |

Student Assignments. *a) Main Part:* Virtual Laboratory Task. Instructions:
1. Select an animal from those provided in the virtual laboratory (e.g., reptile, bird, mammal).
2. Examine the structure of internal organs or behavior.
3. Set environmental parameters (temperature, humidity) and observe the animal's response.

*Table for Completion:*

| *Animal* | *Environmental Parameters* | *Observed Changes* | *Conclusions* |
|---|---|---|---|
| Example: Turtle | Increased temperature | Reduced activity | Reptiles prefer moderate temperatures |

*b) Final Part:* Case-Based Task. Situation: You are conducting a lesson for school students on the topic *«Animal Adaptations to Environmental Conditions»*. Using data from the virtual laboratory:

1. Design an assignment for school students to compare the behavior of two animal species under different conditions.
2. Prepare a graph to illustrate the dynamics of changes.

*Example of a Graph:*

| *Environmental Temperature (°C)* | *Reptile Activity (units)* | *Mammal Activity (units)* |
|---|---|---|
| 15 | 2 | 8 |
| 25 | 6 | 10 |
| 35 | 4 | 12 |

Homework:

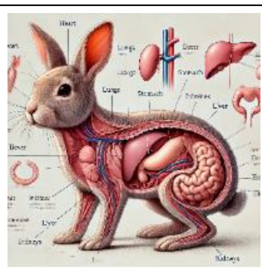
1. Prepare a presentation (5–7 slides) on the topic *«How Virtual Laboratories Support the Study of Animal Biology»*.
2. Design a lesson for school students that includes an experiment in a virtual laboratory (description of objectives, stages, and expected outcomes).

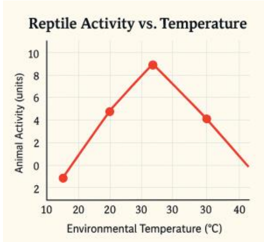
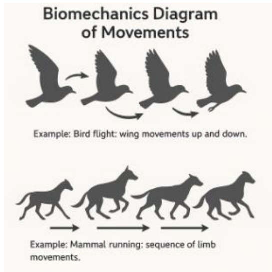
Now, let us present examples of illustrations for the assignment:

- 3D-model of an animal with labeled anatomical structures.
- Graph showing the relationship between animal activity and temperature.

Schemes for Visualization are graphic or structural representations that help better understand complex concepts, illustrate interconnections, or analyze data. In Table 6, examples of schemes that can be used in a lesson on animal studies (Table 6).

*Table 6 – Examples of Visualization Schemes for Animal Studies Lessons*

| *Schemes for Visualization* | *Description* | *Example* | *Screenshots for Example* |
|---|---|---|---|
| *Anatomical Diagram of an Animal* | Schematic image of an animal highlighting major organs or body parts. | • For a mammal: location of the heart, lungs, stomach, kidneys.<br>• For an insect: diagram of body structure with head, thorax, abdomen, wings, and limbs labeled. |  |

<table>
<tr><td>Ecological Pyramid</td><td>A diagram illustrating the levels of animals in the food chain:</td><td>• Producers (plants)<br>• Primary consumers (herbivores)<br>• Secondary consumers (predators)</td><td></td></tr>
<tr><td>Graph or Diagram of Activity</td><td>Graphical representation of data obtained from the experiment.</td><td>Graph of reptile activity vs. temperature:<br>• X-axis: Environmental Temperature (°C)<br>• Y-axis: Animal Activity (units)</td><td>
</td></tr>
<tr><td>Biomechanics Diagram of Movements</td><td>Step-by-step images show how an animal moves.</td><td>• Bird flight: wing movements up and down.<br>• Mammal running: sequence of limb movements.</td><td>
</td></tr>
<tr><td>Habitat Range Map</td><td>A map highlighting regions where a particular animal species is distributed.</td><td>A world map marking the ranges of tigers, penguins, or koalas.</td><td>
</td></tr>
<tr><td>Comparative Table or Diagram</td><td>For visualizing data on animal adaptations to different environments.</td><td colspan="2">Example Table:
<table>
<tr><th>Animal Species</th><th>Environmental Temperature</th><th>Adaptations</th></tr>
<tr><td>Camel</td><td>+50°C</td><td>Water storage in humps</td></tr>
<tr><td>Penguin</td><td>-20°C</td><td>Thick layer of subcutaneous fat</td></tr>
</table></td></tr>
</table>

The integration of innovative teaching methods – such as CLIL, virtual laboratories, case-based learning, field studies and gamification – demonstrates a significant potential for the development of practical competencies among future biology teachers. The lesson plans and student assignments presented above illustrate how theoretical knowledge can be effectively combined with practice through interactive and technology-enhanced learning. These approaches not only strengthen students' academic performance and language competence but also foster motivation and engagement in the learning process. Moreover, the incorporation of visual aids, biomechanical diagrams, ecological pyramids and habitat range maps ensures a deeper understanding of biological concepts and their application in real-world contexts. Overall, the proposed framework highlights the importance of integrating modern digital tools and active learning strategies into teacher training programs, thereby contributing to the preparation of a new generation of biology educators capable of addressing contemporary educational and ecological challenges.

The pedagogical experiment demonstrated that the introduction of innovative methods into the training of biology students led to a significant increase in the level of their practical competencies. The most pronounced progress was recorded in the indicators of *teamwork* (+30%) and *ability to conduct experiments* (+30%), which confirms the effectiveness of active learning formats such as project-based tasks, case analysis, and field studies.

A distinctive feature of this study is the comprehensive implementation of several innovative methodologies simultaneously: CLIL, virtual laboratories, AR-technologies, the case method and lesson study lesson plans. This integrative approach ensured sustainable growth in students' competencies and increased their motivation to learn.

At the same time, one problematic area was identified – the indicator *skills in handling equipment* improved by only +20%. This is primarily due to limited access to modern laboratory facilities. While virtual laboratories partially compensate for this deficiency, further improvement requires the renewal of universities' material and technical base.

Thus, the study confirmed that the use of a set of innovative methods in the educational process is an effective tool for developing the practical competencies of future biology teachers and contributes to the modernization of their professional training.

**Discussion.** The relevance of this study is determined by the current trends in the modernization of higher education in Kazakhstan, which are aimed at training specialists capable of applying knowledge in real professional contexts. This is particularly important in the field of biology education, where the integration of theoretical knowledge with practical skills – such as conducting experiments, working with laboratory equipment, and participating in field research – is a key condition for shaping the professional readiness of future teachers, ecologists, and researchers. Recent studies (Kozhabayeva & Sarsembayeva, 2022; Nurpeisov, 2023) confirm that traditional forms of teaching are gradually giving way to innovative, practice-oriented methods. In this regard, addressing the issue of developing practical competence among biology students in Kazakhstan has both theoretical and applied significance.

The distinctive feature of this study lies in the simultaneous integration of several approaches. In international literature (García-González et al., 2021; Chen et al., 2022) [9-10], the focus is often placed on a single method (for example, exclusively virtual laboratories). In Kazakhstani biology textbooks (Isakov & Nurpeisov, 2019) [11], practice-oriented tasks are included but limited to school-based laboratory work. Our study for the first time integrates project-based learning, AR, CLIL and field studies into a unified system for developing biology students' practical competencies.

International experience also confirms the necessity of such an integrative approach. In Japan, where the *lesson study* method is widely applied, biology education is built around joint lesson analysis: teachers design a lesson, conduct it and then collectively analyze the results to refine the methodology (Fujii, 2016) [12]. This approach is comparable to our use of lesson study plans, which enhance both practical orientation and reflection within the educational process.

Finland, in contrast, emphasizes STEM-oriented education, where biology is integrated with chemistry, physics, and technology. Research (Holbrook & Rannikmäe, 2017) [13] demonstrates that project tasks, field studies, and work with digital simulations develop sustainable practical skills among students and foster the ability to apply knowledge in interdisciplinary contexts. Our findings regarding the use of CLIL and virtual laboratories are largely consistent with Finnish practices, confirming the effectiveness of such integration.

The Kazakhstani context also deserves particular attention. Studies by Tuktassinova et al. (2024) and Satayev et al. (2022) demonstrate the effectiveness of CLIL in training biology teachers: students simultaneously master subject knowledge and improve their English proficiency, which is particularly important for international academic mobility. Our data confirm these results: the inclusion of CLIL in the educational process strengthened interdisciplinarity and increased students' readiness to use scientific terminology in English.

Of special interest is the experience of Turkey, which, like Kazakhstan, is modernizing teacher education through the integration of innovative technologies and bilingual instruction. Research indicates that Turkish universities are actively implementing CLIL and EMI (English Medium Instruction) in teaching science disciplines, including biology. Studies by Akin & Kutluca (2020) [14] confirm that the use of CLIL in biology education fosters the development of academic language proficiency in English and enhances the quality of material acquisition. Furthermore, in Turkey, the role of STEM approaches has been expanding in recent years, involving students in project-based research related to ecology, biodiversity conservation and the use of digital technologies in education (Demirbaş & Yağbasan, 2021) [15].

Field studies in Turkey are also considered an essential component in building practical skills. For example, outdoor classes in natural reserves or coastal areas are applied as a method of ecological education and the development of students' research abilities (Yildirim, 2019) [16]. This approach closely aligns with our experiment, where special attention was given to field tasks and wildlife observation in Kazakhstan.

Thus, the Turkish experience confirms that the combination of CLIL, STEM and field studies effectively enhances the level of practical training of future teachers. For Kazakhstan, this experience is particularly relevant, as both countries are adapting their educational systems to international standards while preserving national specificities.

Despite the positive outcomes, certain problematic areas remain: the least significant growth was observed in the indicator «skills in handling equipment» (+20%). This is explained by limited access to modern laboratories, a challenge faced not only in Kazakhstan but also in Turkey, where the quality of practical training also depends heavily on the material and technical resources of universities. A possible solution lies in a closer integration of real and virtual laboratories, as well as state-supported infrastructure upgrades.

Overall, our study confirms that the comprehensive use of innovative methods, adapted to national contexts, is the most effective way of developing practical competencies. Unlike Japan, Finland and Turkey, where individual elements (lesson study, STEM, or CLIL) are applied systematically, our study integrates them into a unified model, which makes it a unique contribution to the modernization of biology teacher education in Kazakhstan.

**Conclusion.** The study confirmed that the integration of innovative teaching methods into biology education significantly enhances the development of practical competencies among future teachers. The pedagogical experiment revealed the greatest improvements in teamwork (+30%) and the ability to conduct experiments (+30%), highlighting the effectiveness of active learning methods such as project-based tasks, case analysis and field research. The comprehensive application of CLIL, virtual laboratories, AR technologies, the case method and lesson study provided a sustainable increase in students' competencies and strengthened their motivation to learn.

The findings also indicate that the development of practical competencies among biology students requires a comprehensive approach that combines traditional teaching methods with innovative technologies. Specifically:

- the use of project-based learning, AR, and CLIL increased competencies by 20–30%;
- the most notable improvements were observed in teamwork and experimental skills;
- the proposed lesson plans can be successfully implemented into the teaching practices of universities in Kazakhstan.

At the same time, a limitation was identified: the relatively modest improvement in skills in handling laboratory equipment (+20%), which is largely due to insufficient access to modern laboratory infrastructure. While virtual laboratories partially compensate for this gap, achieving higher outcomes requires the modernization of the material and technical resources of universities.

Looking ahead, a promising direction is participation in a startup project aimed at developing a mobile application for biology education. This application is envisioned to integrate virtual laboratories, AR-based anatomy modules, a biodiversity database of Kazakhstan and case studies for students, thereby extending the impact of innovative teaching beyond the classroom.

Overall, the results demonstrate that the integrated use of innovative methods, adapted to Kazakhstan's educational context, represents an effective model for fostering practical competencies and modernizing teacher education. The unique combination of lesson study, CLIL and digital learning tools positions this research as an important contribution to advancing biology education methodology and preparing a new generation of teachers capable of addressing contemporary educational and ecological challenges. In conclusion, the following recommendations are proposed:

*1. Curriculum Renewal.* Incorporate mandatory practice-oriented modules into biology education programs, such as virtual laboratories, CLIL, AR/VR technologies, and the case method. This will consolidate the positive outcomes of the experiment, where students' competencies increased by 20–30%.

*2. Enhancement of Laboratory Infrastructure.* Since the smallest improvement (+20%) was observed in equipment-handling skills, it is necessary to gradually modernize biological laboratories and equip universities with up-to-date instruments. This will ensure a balance between virtual and real experiments.

*3. Professional Development of Teachers.* Organize courses and training programs for biology teachers on the application of innovative methods (CLIL, project-based learning, virtual laboratories, AR technologies). This will improve the quality of implementing new approaches in the educational process.

*4. Expansion of Student Academic Mobility.* Develop joint projects with foreign universities and short-term internships, particularly in STEM and CLIL fields, to strengthen the interdisciplinary and international dimension of teacher training.

*5. Development of Digital Resources.* Create multimedia content, online courses, and interactive platforms to enhance students' independent learning and to compensate for the limited availability of practical classes under real conditions.

*6. Systematization of Field Studies.* Integrate regular expeditions and field-based classes into the mandatory components of the curriculum. On their basis, develop teaching and methodological materials on Kazakhstan's biodiversity, which will strengthen practical training and foster ecological thinking among students.

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**МРНТИ 14.37.27** https://doi.org/10.51889/2959-5762.2025.87.3.027

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## ФОЛЬКЛОРДЫ ЖОҒАРЫ МЕКТЕПТЕ ОҚЫТУДЫҢ ЗАМАНАУИ ТЕХНОЛОГИЯЛАРЫ МЕН ӘДІСНАМАЛЫҚ АСПЕКТІЛЕРІ

*Аңдатпа*

Қазақ фольклоры – мәліметтерді ауызша таратуға негізделген біртұтас коммуникативтік жүйені құрайды. Фольклор мәтіндерінің жанрлық өлшемдері оның тұрмыста пайда болуы және тұрақты қолданыс формалары арқылы анықталады. Сонымен қатар, фольклорды ауызша халық шығармашылығы жанрларының жиынтығы деп қана түсінбеу керек, оны қоршаған ортаға деген көзқарастар жиынтығы, дәстүрлі мәдениеттің әртүрлі қырларынан көрініс табуы деп бағалаған жөн. Сондықтан, ауызша халық шығармашылығы жанрларымен қатар халықтық мәдениеттің мифология, әдет-ғұрып, болмыс, тіл секілді өзге де қырларына ерекше мән беріледі.

Қазақстанда фольклорды жоғары мектепте оқыту мәселелері өткір тұр. Оны заманауи технологиялар мен әдіснамалық тәсілдер арқылы оқыту мәселесіне жіті көңіл бөлінбеуде. Қазақстанның қазіргі білім және ғылым жөніндегі стратегиялық бағдарламаларына сәйкес жоғары оқу орындарында фольклорды студент жастарға оқыту жалпыұлттық мәселеге айналып отыр. Студент жастардың бойында отансүйгіштік қасиетті арттыру үшін фольклор мұраларының тигізер септігі орасан. Ал фольклорлық шығармалардың ұлттық бірегейлікті қалыптастырудағы маңызы өте зор болмақ.