THE IMPORTANCE OF TEACHING THE SCIENCE OF SOLVING PROBLEMS AND EXERCISES IN BIOLOGY ON THE BASIS OF AN INTEGRATIVE APPROACH

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ANNOTATION: This article analyzes the theoretical and practical foundations of teaching problem-solving and exercise-solving in biology education based on an integrative approach. Through an integrated approach, students have the opportunity to form interdisciplinary thinking, systematic analysis, problem solving, and elements of scientific research. It is substantiated that it is possible to achieve deep mastery of biology through the use of methodological approaches, STEM education, and modern information technologies.

KEY WORDS: biology education, problem solving, integrative approach, interdisciplinary connection, STEM education, methodology, modern technologies.

INTRODUCTION

One of the main tasks facing the education system in the 21st century is the comprehensive development of a person, forming him as an independent thinker, a critical approach, a creative person who can apply his knowledge in practical life, and who is able to solve modern problems. In this approach, the student becomes an active subject who not only assimilates ready-made knowledge, but also processes it, evaluates it, seeks solutions to problems and puts forward new views. Therefore, improving the content and methodology of education, connecting it with life, increasing interest in science, and ensuring interdisciplinary integration are of great importance.

Natural sciences, in particular, biology, play a special role in this process. Because biology, as a science that studies living nature, forms the skills of observation, analysis, logical conclusions, conducting experiments, and making scientifically based decisions in students. In particular, the science of solving problems and exercises in biology develops important competencies such as deepening students' theoretical knowledge, applying them to real-life situations, independent thinking in problem situations, and developing scientific hypotheses.

In this direction, the integrative approach is recognized as one of the important methods. Interdisciplinary integration, by combining biology with other disciplines such as mathematics, chemistry, physics, and computer science, expands the scope of students' knowledge, increases interest in science, connects theoretical knowledge with practice, and helps to understand logical interdependence. The educational process organized on the basis of an integrative approach serves to form the student's qualities such as critical and analytical thinking, approaching the problem from different angles, and showing interest in scientific research.

Thus, by solving problems and exercises in biology, students develop not only scientific knowledge, but also skills that are important in the 21st century - independent thinking, problem solving, communication, teamwork, creative approach, and information skills. This creates the basis for their formation as active and successful individuals in modern society.

Main part. The role of problems and exercises is extremely important in the in-depth mastery of biology. They serve not only to consolidate theoretical knowledge, but also to develop practical skills in students, such as analyzing and finding creative approaches to problem situations. Biological problems and exercises are used in various chapters and areas:

In the field of genetics - by understanding the processes of heredity based on Mendel's laws, calculating the probabilities of genotype and phenotype, determining the results of monohybrid and dihybrid crosses,

and modeling how traits are passed from generation to generation, students will deeply study the essence of hereditary processes.

In ecology - by creating mathematical models that represent the numerical change of populations, analyzing the energy flow in trophic chains and ecological pyramids, and evaluating the interaction between organisms in biogeocenosis, it is possible to understand the complex balance in nature.

In physiology - by measuring physiological indicators such as metabolism, heart rate, blood pressure, and respiratory rate in humans and animals and determining the causes of their deviation from the normative state, and calculating the rate of enzymatic reactions, it serves to deeply understand the vital activity of the organism[6].

The process of solving such problems and exercises helps to perceive biology not as a science based solely on memorization, but as an activity based on analytical thinking, problem solving, and scientific research. At the same time, these tasks are often closely related to mathematical knowledge (e.g., probability theory, percentages, graphs), statistical analysis (working with tables and diagrams), and physical laws (e.g., diffusion, pressure, conservation of energy), which require interdisciplinary integration.

As a result, the use of problems and exercises in biology expands the scope of students' thinking, teaches them to make decisions on a scientific basis and solve real-life problems with an integrated approach[1].

An integrative approach is a modern method of teaching based on interdisciplinary connections, which aims to equip students with complex knowledge and skills that arise not only within one direction, but also at the intersection of different disciplines. This approach allows for a deeper understanding of biological science and a broader and more systematic way of thinking when solving complex biological, ecological, or technological problems in real life.

The following opportunities arise through an integrative approach:

Mathematical modeling of biological processes - for example, the expression of population growth through logistic or exponential models, the dependence of heart rate on physical activity, the determination of genetic probabilities based on statistical formulas - students learn to apply mathematical knowledge to real biological situations.

In-depth analysis of chemical foundations - through processes such as the importance of the pH environment for enzymatic reactions, the structure of enzyme-substrate complexes, and the balance of ions inside the cell, students understand the molecular foundations of biology. Concepts in chemistry, such as oxidation-reduction reactions or forms of energy binding, have a direct impact on biological processes.

Data analysis using informatics tools - in modern biology, it is necessary to work with large amounts of data. For example, the role of information technologies is significantly increasing through the analysis of DNA sequences using computer programs (bioinformatics), the determination of genetic compatibility, the construction of evolutionary trees of organisms, and the creation of statistical graphs and diagrams.

Connecting environmental issues with geographic information - by using geographic maps and GIS technologies to study global environmental issues such as climate change, biodiversity loss, and natural resource depletion, students learn environmental knowledge by linking it to location and space. This develops their spatial thinking.

Thus, an integrative approach ensures that biology is taught to students based on independent, systematic, and analytical thinking. This not only improves the quality of education, but also creates a foundation for students to be successful in their future professional activities[2].

Today, the STEM (Science, Technology, Engineering, Mathematics) approach in the education system has become an integral part of modern professional training. Through this approach, students acquire not only theoretical knowledge, but also practical skills, as well as analytical thinking, technological literacy and engineering approaches necessary for solving real-life problems. Through the integration of STEM into biology, students' interest in scientific research increases and they develop in the following areas:

Laboratory experiments (biotechnological experiments) - within the framework of the STEM approach, laboratory work such as microscopic observations, DNA isolation, cloning, bacterial culture, and enzymatic reactions are performed in biology lessons. Through this, students acquire scientific research methods,

safety rules, and skills in working with biological equipment. Especially in the field of biotechnology, STEM integration brings students closer to the world of innovative science[6].

Computer modeling (DNA, protein synthesis, cell division) – with the help of modern software tools, the ability to visualize, model and understand biological processes through animations has expanded. For example, complex processes such as DNA replication, RNA transcription, protein synthesis, and the cell cycle are taught using interactive models. This not only facilitates understanding, but also develops computer skills in students.

Statistical analysis (population biology, environmental monitoring) – in biology, many data require statistical analysis. For example, indicators such as population composition, genetic balance, disease prevalence, and environmental pollution levels are analyzed using statistical methods. Students will learn to use Excel, Google Sheets, or special statistical programs and be able to analyze results based on real scientific research.

Through the STEM approach, biology allows students to conduct independent research, work with information, effectively use technological tools, and develop interdisciplinary thinking skills. This will help them become competitive, creative, and inventive individuals of the 21st century. STEM integration paves the way for studying biology not only as a subject, but also as a source of innovative ideas[3].

Information and communication technologies (ICT) play an important role in the successful implementation of an integrative approach in modern education. With the help of ICT tools, it is possible to analyze problems and exercises in biology in more depth, visualize them, and see the results in real time. This not only increases students' interest in science, but also prepares them to work with modern technologies.

The following areas reflect the main advantages of ICT in integrative teaching:

Automatic analysis through online testing systems - there is an opportunity to solve biological problems and exercises online through platforms such as Google Forms, Moodle, Kahoot, Quizizz. These systems automatically evaluate, analyze the results, and help assess the level of students' knowledge based on specific indicators. The teacher, on the other hand, can determine which subjects students are struggling with and establish an individual approach based on statistical reports[4].

Modeling biological processes using simulations – through virtual laboratories, interactive simulations (e.g. PhET, BioMan, Visible Body), complex biological processes such as cell division, genetic inheritance, photosynthesis, and respiration are visually taught. Through this, students are introduced to a safe and realistic alternative form of experimentation and understand abstract concepts much more easily[7].

Performing graphics and data analysis using modern programs – using Power BI, Microsoft Excel, Google Sheets, and the Python programming language, students are taught to analyze biological data, build graphs, work with data such as population changes, enzyme reaction rates, or environmental indicators. In particular, creating interactive visualizations using libraries such as Pandas, Matplotlib, and Seaborn in Python engages students in programming and scientific analysis.

As a result of these processes, students:

acquire digital literacy;

learn to correctly analyze scientific information in digital tools;

develop the skills to apply a technological and systematic approach to the problem[5].

In our opinion, the use of information and communication technologies (ICT) in the process of integrative teaching is taking the teaching of biology to a new level. Digital tools create the opportunity to teach biological concepts in an interactive, demonstrative and practical way. Students master complex processes through virtual experiments, simulations and modeling, connecting the theoretical foundations of biology with their real-life applications.

In addition, ICT tools play an important role in developing students' modern competencies such as critical thinking, problem analysis, working with information, using software and computer literacy. By solving problems and exercises online, analyzing results statistically, creating graphs, and creating models based on algorithmic thinking, students master the skills based on the STEM approach.

This approach also prepares young people for future professions, namely bioinformatics, biotechnology, genetic engineering, environmental monitoring, medical technologies, and scientific research. A student who has mastered ICT will not only understand biology well, but will also be ready to apply it in practice, create new innovative projects, and conduct scientific research.

In general, teaching biology in combination with ICT is not only a key to learning science, but also to forming a generation that is competitive, forward-thinking, and able to use technology in the digital era.

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