



DEVELOPING 21ST-CENTURY SKILLS AMONG STUDENTS THROUGH DIGITAL TECHNOLOGIES IN BIOLOGY LESSONS

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Abstract

This article analyzes the methodology of developing 21st-century skills among students in biology lessons through digital technologies. The study examines methods and practices aimed at fostering critical thinking, creativity, teamwork, and effective use of technology among students with the help of digital tools. Experimental results show that interactive programs, mobile applications, and online resources can effectively enhance students' learning processes in biology. The article highlights the importance of digital technologies in pedagogical practice and their role in the education system.

Keywords: Biology, Digital technologies, Interactive programs, Online platforms, Critical thinking, Creativity, Teaching methodology, Educational technologies.



**ФОРМИРОВАНИЕ НАВЫКОВ XXI ВЕКА У УЧАЩИХСЯ НА
ОСНОВЕ ЦИФРОВЫХ ТЕХНОЛОГИЙ НА УРОКАХ БИОЛОГИИ**

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Аннотация:

В статье анализируется методика формирования умений учащихся XXI века на основе цифровых технологий на уроках биологии. В статье рассматриваются методы и практики, направленные на развитие у студентов таких навыков XXI века, как критическое мышление, креативность, работа в команде и эффективное использование технологий с помощью цифровых технологий. Результаты эксперимента показали, что интерактивные программы, мобильные приложения и онлайн-ресурсы позволяют эффективно развивать процесс обучения учащихся при преподавании биологии. В статье подчеркивается значение цифровых технологий в педагогической практике и их роль в системе образования.

Ключевые слова: Биология, Цифровые технологии, Интерактивные программы, Онлайн-платформы, Критическое мышление, Креативность, Методика обучения, Технологии обучения.



Introduction

The modern education system requires constant renewal and the development of skills necessary for successful living in the 21st century. Today, it is not enough to merely transmit knowledge; education must also cultivate competencies such as communication, critical thinking, problem-solving, creativity, and effective use of technology. These skills represent the core goals of 21st-century education, and the integration of technology into the learning process serves as a vital tool for their formation [1–3].

In the context of rapid globalization, the education of a creative and well-rounded younger generation with broad horizons and critical thinking becomes particularly significant. To achieve this goal, new innovative approaches — internationally tested and proven to be effective — are being introduced into the education system. When organizing the learning process based on innovative methodologies, the experiences of countries with highly developed education systems such as Singapore, China, the United Kingdom, Finland, and Estonia were studied.

Research has shown that in these countries, the primary focus is on developing 21st-century skills, represented by the “4Cs” principle: critical thinking, creativity, communication, and collaboration. As a result, these nations consistently rank highly in international assessments such as PISA and PIRLS [6].

When preparing textbooks and teaching materials for publication, increasing attention is paid to how well their content and quality meet international standards. In designing these textbooks, developers take into account students’ age-related and psychophysiological characteristics, ensure cross-curricular connections, and maintain continuity between grade levels.

In developing a new generation of textbooks and instructional resources, special emphasis is placed on incorporating the requirements of international education quality assessment programs — TIMSS and PIRLS — adapted to the cognitive and developmental characteristics of schoolchildren.



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Across various national education systems, a strong focus is placed on developing students' skills within the framework of the "4Cs" concept — communication, collaboration, creativity, and critical thinking. The emphasis is on cultivating logical reasoning, creative approaches, and communication abilities. Students not only study academic disciplines but also acquire life skills that are essential in the 21st century.

During the teaching of each subject, students develop a range of key competencies. The development of these competencies contributes to communicative growth. Within the innovative "4C" model, particular attention is given to the enhancement of communication skills. The formation of communicative competence enables students to develop the following abilities:

- not to fear communication and to organize it effectively, being ready to ask and answer questions;
- to adapt to the purpose and content of communication as well as to their interlocutor;
- to use verbal and non-verbal means to achieve communicative goals;
- to understand the meaning of communicative norms and build trust;
- to learn how to listen attentively to others;
- to form a positive self-image;
- to practice expressing thoughts and emotions clearly;
- to develop skills of presentation, perception, and feedback;
- to support and justify one's own opinions and judgments;
- to gain experience in interacting within both large and small groups.

As a result, students learn to express their thoughts clearly and precisely, to listen and understand others, and to use language effectively in communication. Alongside these abilities, they develop **pragmatic competence** — the capacity to use different styles of speech (colloquial, academic, artistic, or journalistic) appropriately and effectively according to the communicative context and social situation [4].

Students' interest in lessons and their desire to gain knowledge largely depend on the forms of encouragement applied during the educational process.



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Encouragement serves as an important source of motivation for learners. Typically, students receive praise or positive reinforcement for correct answers during class, while mistakes are often met with criticism or restrictions. Such an approach, however, may create barriers to active participation and communication in the classroom.

It is essential to encourage students to ask questions during lessons. The more questions a student asks, the more confident they become and the less they fear communication. In many ways, the quality of communication depends on how a question is formulated. The ability to think critically is determined not only by the capacity to answer questions but also by the ability to formulate them. Therefore, developing students' skill in asking logical, purposeful questions is of great importance. This practice plays a significant role in nurturing independent and critically minded individuals who are capable of making sound decisions in the future.

Today, the world is changing so rapidly that education systems often struggle to adapt to these transformations. Increasingly, it is argued that excellent academic results no longer guarantee professional success. Personal, flexible, and transferable skills have become key criteria in the modern labor market [2].

Over the past few decades, the importance of human intelligence has significantly increased, and economies are gradually shifting toward knowledge-based industries. New technologies and digital networks accelerate the flow of information, enable deeper analysis, and facilitate the large-scale dissemination of knowledge.

While many schools around the world still prepare students for the realities of the industrial age, society already lives in the era of information technologies. Training specialists who meet the demands of this time requires comprehensive educational reform.

Given the time, resources, and effort involved, cultivating highly qualified professionals has become a major challenge for every nation. In intellectual fields, the ability to understand, process, and apply information has acquired paramount importance. The necessity of developing such skills from early



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childhood makes school education a matter of national significance, directly linked to the country's future [7].

In the past, when the number of professions was limited and the boundaries of human capability were not fully explored, the main task of schooling was literacy and the transmission of knowledge. Today, however, we are witnessing a technological revolution that has fundamentally transformed our way of life, methods of work, and forms of human interaction. The scope, purpose, and complexity of this process are unprecedented in human history.

Consequently, basic literacy alone is no longer sufficient for adapting to or driving modern change. In the contemporary conception of education, special attention is paid to transforming the school from an institution of literacy into an institution of **skills formation**.

Thus, the school becomes a key environment where competencies essential for 21st-century professionals are developed. The effectiveness of unified educational programs — including standards that allow teachers to monitor student progress and provide methodological support — has been confirmed by the experiences of several leading countries [6–12].

Creative thinking is one of the most essential competencies required for an individual's successful participation in 21st-century society. These competencies — often referred to as 21st-century skills — hold particular importance in a constantly changing, globalized, and digitalized world where traditional professions are disappearing, new ones are emerging, and the amount of accessible information grows with every second.

To adapt and self-realize in such conditions, individuals must possess highly developed cognitive abilities, including logical reasoning, comparison, analysis, and synthesis, as well as the capacity to find unconventional solutions to problems — both individually and collaboratively [8].

Critical thinking is a key cognitive skill that enables individuals to meet the challenges of the 21st century successfully. It helps them gain a deeper understanding of what they study and do. Critical thinking is a complex process in which ideas and possibilities are combined with creativity; concepts and



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information are reinterpreted and reconstructed. This process occurs simultaneously on multiple levels of active and interactive cognition.

Individuals who think critically have their own system of beliefs, making them less vulnerable to bias and misinformation. In critical thinking, ideas and their significance are examined from multiple perspectives and compared with other viewpoints. It represents the highest form of mental activity, emphasizing analysis, comparison, interpretation, application, reasoning, innovation, problem-solving, and self-evaluation [5–10].

Critical thinking also develops communication and teamwork skills. Creating an environment conducive to the growth of critical thinking is one of the central tasks of modern education. Today, one of the key goals of schooling is to teach students how to learn — to help them acquire the ability to think critically. When encountering new information, students should be able to evaluate it independently, view it from different angles, and decide how to apply it to their own needs and goals.

To truly become critical thinkers, students must be encouraged to act creatively, experiment, and master specific intellectual strategies.

Developing critical thinking requires the following:

- the formation of a personal point of view;
- the ability to justify one opinion over another;
- problem-solving skills in complex situations;
- the capacity for reasoned discussion;
- rationality, skepticism, objective analysis, and fact-checking;
- the ability to collaborate in order to reach consensus;
- understanding how life experience influences perspectives and beliefs.

The most effective teaching methods are those that engage students quickly in active thinking and encourage them to apply it in practice. Critical thinking develops most effectively when learners discuss issues that genuinely interest them and when the initiative comes from within the group itself.



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The elements of critical thinking include:

- independence of thought;
- reliance on information as a starting point, not as an end;
- the habit of identifying problems and asking meaningful questions;
- the pursuit of reliable evidence;
- the social nature of thought.
- **1. Independent Thinking.** Critical thinking is, first and foremost, independent thinking. When a lesson is structured on the principles of critical thinking, each participant develops their own ideas, assessments, and beliefs that differ from those of others. No one can think critically on someone else's behalf — this process belongs solely to the individual. Therefore, only when thought is personal and self-directed can it truly be called critical.
 - Students must possess intellectual freedom, the ability to reason independently, and the courage to seek correct answers even to the most complex questions. Each learner determines how to think and what conclusions to draw. Thus, independence is one of the most essential aspects of critical thinking.
- **2. Information as the Beginning, Not the End.** Information is not the result of critical thinking — it is its starting point. Knowledge serves as the stimulus that motivates a person to think critically. As the saying goes, “It is difficult to think with an empty mind.” For complex reasoning to occur, one needs a substantial base of raw material — facts, ideas, texts, theories, data, and concepts — to analyze and process.
 - Critical thinking is possible at any age. Not only university students but even first-graders already possess certain life experiences and knowledge. As children learn, their cognitive abilities evolve, and even at a young age they are capable of thinking critically and independently. It is through critical thinking that the process of learning gains meaning, coherence, and effectiveness.
- **3. Asking Questions and Defining Problems.** Critical thinking begins with questioning and identifying problems that require solutions. Human beings are naturally curious. When we encounter something new, we instinctively seek to



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understand its essence — upon seeing a historical monument, for instance, we wish to know what lies inside and what story it tells.

- Curiosity is an inherent quality of all living beings and is especially strong in children. True learning at any educational stage is characterized by the learner's independent engagement with problems — the desire to seek answers arising from personal interests and needs.

- The American philosopher and educator **John Dewey** emphasized that critical thinking in students arises only when they begin working on a specific problem. He wrote: "The starting point of the learning process is a question concerning a concrete situation or phenomenon that helps us understand what kind of problem it creates." He further stated: "Only when a learner struggles with a problem and seeks their own path to resolve it do they truly begin to think."

- From this, we can infer that in preparing lessons, teachers should identify potential problem areas students might encounter and guide them toward formulating these problems independently. Through critical thinking, learning becomes a meaningful process in which students engage in genuine intellectual work and address real-life challenges. They collect facts, analyze texts, compare multiple viewpoints, and, through collaboration, find answers to questions that genuinely interest them.

4. The Pursuit of Reliable Evidence. A person who thinks critically seeks reliable evidence to support their ideas and conclusions. Such a person approaches problem-solving independently, substantiating their choices with logical and well-grounded arguments. While acknowledging that alternative solutions may exist, they strive to demonstrate that their selected approach is the most rational and justified among possible options.

Any sound argument is composed of three essential parts: a **claim**, **reasons**, and **evidence**.

- The claim forms the core of reasoning — it is the central statement or thesis of the argument.
- The reasons provide explanations that support the claim.



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- The evidence reinforces these reasons, lending them credibility. Evidence can take many forms — statistical data, textual excerpts, personal experiences, or any ideas that substantiate reasoning and can be accepted by others.

All of these components rest on a **foundation**, which serves as the fourth crucial element of reasoning. The foundation represents the shared ground between speaker and audience — a set of common understandings or assumptions that give meaning to the argument.

Reliable arguments become especially persuasive when they consider opposing viewpoints. Recognizing counterarguments does not weaken one's position — on the contrary, it strengthens it by showing openness to alternative perspectives. A critically minded individual with strong, evidence-based reasoning can challenge even authoritative opinions, remaining intellectually independent and resistant to manipulation.

5. The Social Nature of Thinking. Critical thinking is also inherently social — for every human being is a social creature. Thought becomes clearer and more precise when it is shared with others. As the philosopher **Hannah Arendt** wrote: "The presence of another makes me more complete."

In dialogue, debate, reading, and discussion — through the exchange of ideas and arguments — individuals refine, clarify, and deepen their own perspectives. This is why educators who aim to develop critical thinking actively use pair and group work in their teaching practices. They effectively employ **debate** and **discussion** methods, as well as diverse forms of presenting written assignments.

Ultimately, any critically thinking individual operates within a collective framework, solving not only personal intellectual tasks but also contributing to broader social and cultural development [9–11].

Thus, critical thinking is an integral component of successful education and personal development in the 21st century. It nurtures independence, responsibility, analytical reasoning, and the ability to make well-founded decisions. Critical thinking enables learners not only to understand academic



material more deeply but also to apply acquired knowledge effectively in real-life contexts.

Developing critical thinking requires educators to create an active, open, and creative learning environment in which students can freely express their thoughts, discuss differing viewpoints, defend their opinions with evidence, and show respect for the perspectives of others. The effective use of group work, debates, discussions, and written reflections makes the educational process more meaningful and engaging.

Therefore, the formation of critical thinking is a **strategic goal of modern pedagogy** — one aimed at preparing independent, thoughtful, and socially active citizens capable of adapting to and thriving in a rapidly changing world.

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