RESEARCH ARTICLE

Global Experience In Teaching Biology Using Artificial Intelligence

Pulatova Elnora Kodirovna

Tashkent Region Branch of Astrakhan State Technical University, Uzbekistan

Abstract

This article explores the global experience of using artificial intelligence technologies in teaching biology. It analyzes the effectiveness of СИ-based educational platforms and applications implemented in various countries. The study highlights the importance of personalized learning, visual simulations, and adaptive teaching methods powered by СИ. In conclusion, the article emphasizes that СИ technologies play a crucial role in making biology education more engaging and effective.

K E Y W O R D S

Artificial intelligence, biology education, digital technologies, personalized learning, educational innovations.

INTRODUCTION

Artificial Intelligence (AI) has become one of the most significant innovations in the field of education. In particular, the application of AI technologies in teaching biology makes the learning process more effective and interactive, while ensuring active student participation.

In the modern era, innovations in education play a crucial role, among which Artificial Intelligence and Information and Communication Technologies (ICT) have a significant impact on teaching both theoretical and practical subjects. The use of AI technologies in biology education enhances the effectiveness and interactivity of the learning process and promotes active learner engagement. This article examines the importance of AI in teaching biology, its capabilities, and the contribution of these technologies to the educational process.

Interactive Learning: Virtual Laboratories and Simulations

Virtual laboratories and simulations are important interactive tools in teaching biology. Their advantages include the following:

Virtual models of practical activities and experiments. Biology involves numerous experiments and laboratory activities. Through simulations in virtual laboratories, students can become familiar with real experiments and learn from mistakes without direct physical manipulation or risk;

Models of cells, organs, and biological systems. Through 3D simulations, learners can interactively study the structure and functions of organs and organisms. For example, comprehensive understanding of organisms and their biological systems (such as the nervous system, immune system, and digestive system) can be achieved through various 3D demonstrations and visualizations;

Personalized learning. AI-based methods enable the delivery of adaptive learning materials, tests, and practical tasks tailored to each student's individual level. For instance, AI algorithms analyze learners' study pace and provide lessons customized to their specific needs, allowing students to solve problems more quickly and effectively.

Machine Learning and Data Analysis

Machine learning and data analysis represent another important area of Artificial Intelligence. These technologies are applied in teaching biology in the following ways:

Automatic identification of students' errors and learning difficulties. Machine learning algorithms analyze students' learning processes and automatically detect their mistakes and misconceptions;

Analysis of biological data. AI can be used to quickly and efficiently analyze biological data, including genetic, biochemical, ecological, and other types of data. For example, it enables the rapid identification and analysis of new databases for research in genetics, molecular biology, and evolutionary studies.

Automated Assessment and Feedback

AI-based automated assessment systems ensure high efficiency in evaluating students' knowledge. These systems provide:

Systematic assessment. In biology classes, topic-based questions and tests are commonly used. Through AI, students receive individualized assessment results, which enables timely and effective feedback;

Supportive and interactive learning environment. Automated systems assist students by explaining their mistakes and responding to their questions in a manner similar to a teacher or tutor, even when errors occur, thereby fostering a friendly and interactive learning atmosphere.

Active Engagement and Effectiveness of Learning

The use of Artificial Intelligence in teaching biology significantly increases student engagement and interactivity. Simulations, virtual laboratories, and animations implemented through AI, machines, and robotics enhance students' interest compared to traditional text-based materials and help reinforce the knowledge they acquire.

Thus, AI and Information and Communication Technologies (ICT) make the biology learning process more effective and interactive, ensuring active student participation. Virtual laboratories, 3D models, automated assessment systems, and machine learning methods elevate biology education to a new level. With the integration of these technologies, teaching biology becomes more dynamic and engaging.

Below, advanced practices in AI-based biology education implemented in various countries around the world are reviewed.

Global Practices

Kazakhstan: Virtual Laboratories and Personalized Learning

In the Almaty region of Kazakhstan, at the school named "Altynsarin," AI-based 3D modeling and visualization tools, automated assessment systems, and virtual laboratories are used in teaching biology. These technologies contribute to increasing students' interest in the learning process and improving educational outcomes.

Korea: Integration of AI in Teaching Biological Classification

In a study conducted by Seoul National University of Education in Korea, AI Convergence Education (AICE) was applied in teaching biological classification in primary schools. This approach aims to enhance students' classification skills and improve their understanding of biology.

Ethiopia: AI Programs in STEM Centers

In Ethiopia, AI programs implemented in STEM centers are fostering students' creative abilities in mathematics and science. These programs are designed based on the experiences of developed countries and focus on introducing and implementing AI-based educational initiatives.

India: Symbiosis Institute of Artificial Intelligence

The Symbiosis Institute of Artificial Intelligence (SIAI), established by Symbiosis International University in India, focuses on integrating AI education across various academic disciplines. The institute strives to ensure the responsible and ethical application of Artificial Intelligence for the benefit of society.

United States: DeepMind's AlphaMissense Model

The AlphaMissense model developed by DeepMind uses Artificial Intelligence to predict the likelihood that genetic mutations may lead to diseases. This technology can be applied in biology education to teach students modern scientific methods and approaches.

Russia: AI and Biology Education

In Russia, a number of studies focused on the integration of Artificial Intelligence and biology education are being conducted at scientific institutions. For example, at

Lomonosov Moscow State University and Saint Petersburg State University, research projects and experimental initiatives are being implemented on AI-based biology teaching. These projects emphasize the use of AI algorithms for analyzing biological data, conducting simulations, and personalizing the educational process.

Singapore: Advanced Practices in AI-Based Biology Education

In Singapore, the AI Student Outreach Programme conducted by AI Singapore provides over 15,000 students with opportunities to develop skills in Artificial Intelligence and STEM (Science, Technology, Engineering, and Mathematics) fields. This program helps students enhance their knowledge in AI through online training, certification, and internships. Additionally, as part of the NUS iGEM 2023 project, stories and interactive games were developed to teach synthetic biology to children aged 5–6. This initiative aims to present biology in an engaging and comprehensible manner for young learners.

Thailand: Advanced Practices in AI and Biology Education

At Chulalongkorn University and Mahidol University in Thailand, research is being conducted on integrating AI into biology education. These universities implement projects focused on analyzing biological data, conducting simulations, and personalizing the learning process. For instance, virtual laboratories and interactive simulations provide students with opportunities to study biology in an immersive and practical way.

These experiences demonstrate the global development of new directions in AI-based biology education. By adopting such practices in the education system of Uzbekistan, the quality of biology teaching can be significantly improved. In developed countries such as Germany, Russia, Singapore, and Thailand, the effective use of AI technologies has substantially enhanced the quality of biology education. Analyzing these advanced experiences suggests that integrating AI into the Uzbek education system can elevate the teaching of biology to a higher level.

Why Is This Important?

Biology is not only a theoretical subject but also requires experimentation, analysis, and logical thinking. AI technologies serve as invaluable tools in this context by: supporting students at an individual level; creating a visual, interactive, and immersive learning environment; facilitating practical exercises through simulations and virtual laboratories; and providing automated assessment and rapid feedback.

What Opportunities Are Created?

Personalized Learning. Lessons are automatically tailored to a student's knowledge level, interests, and learning style. Based on AI-analyzed results, teachers can provide an individualized approach to each student.

Virtual Laboratories and Simulations. AI enables the virtual demonstration of biological processes without expensive equipment (e.g., cell mitosis, DNA replication). Through AI-powered platforms, students can conduct independent experiments and gain hands-on experience in a safe, virtual environment.

AI-Assisted Testing and Automated Assessment. Time is saved as AI analyzes student errors, provides suggestions, and grades tests automatically. Accuracy is ensured, and detailed statistics are generated for monitoring learning outcomes.

Strengthening STEM and Cross-Disciplinary Approaches. AI creates opportunities to integrate biology with mathematics, physics, and computer science. By teaching students to analyze genetic data and work with complex datasets, AI prepares them for future careers in biotechnology, genetics, bioinformatics, and other related fields.

Recommendations for the Education System of Uzbekistan

Implement Pilot Projects. Introduce AI technologies in selected schools in Tashkent city and regions. Based on the models of Singapore and Germany, laboratory and simulation courses can be implemented.

Develop a Dedicated Platform. Create AI-powered interactive lessons, 3D models, and automated testing systems for biology on online learning platforms.

Retrain Teachers. Organize short-term courses for teachers on AI and ICT technologies. Implement practice-oriented modules on "Teaching Biology through AI" in pedagogical universities.

Strengthen International Cooperation. Establish scientific and practical partnerships with institutions such as

AI Singapore, Germany's de.NBI network, and Russia's Skolkovo Educational Center.

Thus, the integration of AI technologies into biology education enables personalized learning, the presentation of scientific knowledge in a clear and engaging manner, the development of independent thinking in students, and preparation for STEM fields. For Uzbekistan, these opportunities are of strategic importance, not only for improving biology education but also for enhancing overall educational quality and preparing competitive specialists.

Advantages of AI in Biology Education

Personalized Learning: AI provides a learning process tailored to the individual needs of students.

Interactivity and Visualization: Through 3D models and virtual laboratories, understanding biological processes becomes easier and more engaging.

Automated Assessment: AI systems enable efficient evaluation and analysis of students' knowledge.

Inclusivity: AI allows effective learning even for students who do not speak English, ensuring broader access to education.

The application of AI in education also raises important ethical and social considerations. These include the protection of personal data, identifying biases in algorithms, and ensuring equal opportunities for all students. Therefore, it is essential to uphold ethical standards and social justice when implementing AI in educational contexts.

Thus, Artificial Intelligence plays a crucial role in making the biology learning process more effective and engaging. Global experiences demonstrate the efficiency of AI in education and its significance for the future. In Uzbekistan, the integration of AI into biology education can modernize the learning process and enhance students' interest in the subject.

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