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CONDITIONS FOR IMPROVING THE EFFECTIVENESS OF BIOTECHNOLOGY EDUCATION IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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ABSTRACT

The study explores the influence of scientific and technological progress on societal structures and the growing inclination towards religion and mysticism over scientific solutions to global crises. The study aims to evaluate the effectiveness of biotechnology education within the framework of sustainable development, recognizing the pivotal role of scientific education in steering the direction and pace of societal evolution. Utilizing theoretical and practical approaches, the study analyzes current scientific methodologies, statistical data, and both local and global experiences in sustainable development. The findings underscore the necessity for biotechnological education to evolve in response to the digital age's demands, focusing on critical thinking, problem-solving, and the practical application of scientific knowledge. It highlights the emergence of new high-tech professions and the critical need for specialized education to prepare students for future challenges. Biotechnology education must adhere to fundamental pedagogical principles while focusing on the detailed examination of production techniques and the significance of biotechnology in addressing global challenges. The modernization of biotechnology education should be prioritized within each country's education policy and supported through international collaboration. This approach will facilitate the creation of a global system for biotechnological training and contribute to the resolution of worldwide challenges, ensuring technological independence and sustainable development.

Keywords: Biotechnology education; Sustainable development; Global challenges of our time; Digitalization; Scientific and technological progress.

INTRODUCTION

One of the primary challenges confronting contemporary society is the competition for resources. These include not only tangible assets such as minerals, freshwater, and forests but also intangible resources such as financial, human, and informational commodities. The scarcity is not solely attributable to perceived

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overpopulation; rather, it stems from the vast and diverse needs of humans and their spiritual pursuits, which have reached an overwhelming scale and variety (Clark & Harley, 2020; Johnson et al., 2023; Robert et al., 2005). In this era, individuals have significantly expanded their comfort zones, becoming highly sensitive to even minor deviations from their typical consumption patterns. This sensitivity has resulted in profound discomfort for some and led to enduring deprivation for others. Such experiences often engender a persistent sense of discontent, motivating individuals to seek equilibrium within themselves and their environment (Kiknadze & Leary, 2021; Suppiah & Govind, 2018).

Currently, humanity has acknowledged that its existence is not confined to apartments, cities, or states, but extends to the planet itself. Earth constitutes the entirety of what humanity possesses, serving everyone and expected to do so indefinitely, at least in the foreseeable future. The discovery of planets with conditions potentially suitable for human life in distant regions of space offers little immediate hope, given the vast distances of thousands or millions of light-years involved. Moreover, the data regarding these planets are largely inferential, rather than based on direct observation (Feng et al., 2020; Lammer et al., 2009).

The shift towards a market-based economy has intensified competition among businesses, pushing them to increase production, broaden their influence, and explore new market opportunities to ensure profitability. Such profit expansion is inherently tied to increased production volume, necessitating greater consumption of critical resources like freshwater, electricity, and raw materials. This dynamic has led to resource depletion and exacerbated the impoverishment of the planet, threatening both its developmental prospects and its very survival (Taylor & Buttel, 1992).

The increasing complexity of these challenges has prompted the adoption of the sustainable development concept globally. This approach is designed to tackle the 17 global goals established in response to the growing challenges and systemic issues brought about by contemporary global crises (Johnson et al., 2023; Mensah & Ricart Casadevall, 2019).

In the midst of these developments, the contemporary world, described by American futurist Jamais Cascio with the BANI (brittle, anxious, nonlinear, incomprehensible) paradigm, contrasts with the earlier VUCA (volatility, uncertainty, complexity, ambiguity) model, indicating a shift towards seeking moral guidance in religion and mysticism rather than in scientific inquiry. The year 2023 has highlighted

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the severe threat of a global conflict, perceived by experts as already underway, marking a regression to earlier societal conditions reminiscent of the Middle Ages.

Following 2022, Cascio introduced the SHIVA acronym (split, horrible, inconceivable, vicious, arising) to capture the zeitgeist, while Sergey Deryabin proposed the TACI (turbulent, accidental, chaotic, inimical) model as an alternative in May 2022. These acronyms, though seemingly playful, aim to articulate contemporary reality's nuances and suggest that underlying trends should be addressed constructively.

Along with more abstract models of modern society, the failure of the educational reform on the planet may be explained by the now widely accepted theory of generations (N. Howe, W. Strauss (1991), then M. McCrindle (2023), etc.). This theory convincingly demonstrates how historical events influence the mentalities and behaviors of different age groups, including the Hero Generation, the Silent Generation, the Baby Boomers, X, Y, Z, and Alpha (α).

The advancement of science and technology has not reduced the influence of religious beliefs on shaping individuals' consciousness and worldviews, despite the global "crisis of humanitarian knowledge." This crisis is marked by a stagnation in humanities and social sciences amidst rapid developments in technologies such as cloud computing, augmented reality, and cybersecurity (Bai et al., 2020; Wormald, 2015). Although biomedical innovations have extended lifespans, this has led to prolonged adolescence and a delay in maturation, contributing to a rise in infantilism and a decline in young people's independence and career prospects. Concurrently, there is a noticeable increase in religious affiliation, with billions identifying with major religions or choosing non-religious beliefs, indicating a preference for idealism over materialism despite scientific progress.

Scientific achievements have reached unprecedented levels, merging the understanding of living and non-living nature. Innovations have driven the economy towards a new technological era, while global economic and social trends are analyzed through the lens of significant economic cycles and civilizational theories (Henry, 2016; Schumpeter, 1954). The application of behavioral economics, neuromarketing, and artificial intelligence has become widespread due to the rapid pace of information exchange.

The growing number of religious institutions and the extended definition of adolescence by the WHO reflect societal changes against increased life expectancy.

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The reluctance of youth to assume responsibility and unanswered philosophical questions underscore the complexity of modern life. The survival of the planet and the progress of states hinge on achieving breakthroughs through activities aligned with global standards and based on objective knowledge, emphasizing the laws of nature.

The inclusion of ecology as an independent subject in educational curricula worldwide is advocated, recognizing its critical role in shaping future societal development. The environmental state varies globally, with certain countries exhibiting superior conditions and others facing severe challenges. Environmental factors significantly impact health, underscoring the urgency of shifting towards sustainable development and a "green" economy (Artamonova et al., 2021; Brega & Erokhina, 2022). Thus, biotechnological education demands comprehensive reform to meet the demands of the sixth technological order, requiring updates in principles, content, and methodologies.

Objectives of the study contains assessment of the current state and challenges of biotechnology education in the context of sustainable development and identification and proposal of methods for improving the efficiency and effectiveness of biotechnology education. In addition, the study aimed to explore the integration of biotechnology education into global and national education policies.

METHODS

The study employed theoretical and practical approaches. Existing scientific approaches and statistical data were analyzed. Russian, foreign, and global experiences in implementing the sustainable development concept were tracked and compared. Key challenges in the development of bio-technological education were synthesized and organized. Conditions for enhancing the effectiveness of bio-technical education in a sustainable development context were identified.

RESULTS

Speaking about teaching biology at school, it is impossible not to pay attention to the obvious need to divide this subject into four completely different independent disciplines: general biology (the principles of biochemistry, biophysics and bioinformatics, as well as morphology, anatomy and physiology of organisms, genetics, cytology, etc.); fundamentals of medical knowledge (structural and functional organization of the human body, prevention and diagnosis of the most common

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diseases, first aid, formation of a healthy lifestyle, etc.); biotechnology (environmental management, green economy, lean manufacturing, environmental entrepreneurship, etc.); natural history (evolution of views on the development of nature, society and consciousness, geochronology, origin of species, origin and transformation of consciousness, etc.). Biology should defend its right to independence, its research subjects should be isolated, isolated, and not blurred by faceless natural science, biotechnology should be studied separately, in the broad theoretical context of NBIC convergence and in the narrow scientific and applied aspect of developing technologies and techniques.

In addition to inorganic and organic chemistry, the teaching of nanotechnology should be organized as a separate discipline in schools, so that students gain a comprehensive understanding of the contemporary production of significant substances, materials, and medicines, etc., as well as their properties, purposes, storage conditions, and effective use. The interconnection between nanotechnology and biotechnology will enhance our understanding of crucial processes and contribute to a more complete understanding of life phenomena at the cellular, molecular, and atomic levels. Students no longer perceive the knowledge of natural science regarding the micro- and nanoworlds as abstract.

It is very important that general education make the transition from the formation of superficial ideas and abstract concepts to a deep and lasting mastery of knowledge about the mechanisms of functioning and interrelation in nature, society and consciousness. The logic of "problem-solution-tools" should be traced in the study of most applied topics in the biotechnology course. Today it is not enough to see problems and pass off one's private opinion as objective scientific knowledge, it is necessary to critically rethink existing approaches to solving the problems under consideration, and even better — to master a variety of tools for implementing optimally selected solutions. Children are the heirs of the planet and civilization, they must be ready for their mission. To prepare them for it is the main task of education.

In the context of the transformation to the information age, the rate of data transfer has increased by a multiple. This development has brought about a drastic change in the way civilization functions: people now receive a significantly larger amount of information, with the volume and frequency increasing. If previously there was a challenge in finding information, now it is necessary to evaluate it in terms of relevance, reliability, utility and completeness. Augmented reality and 3D modelling

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and animation can have a significant impact on the field of biotechnology; they will enable us to elevate consistency, visibility, scientific accuracy, accessibility and other educational principles to an unprecedented level.

Today we see that humanity is at the stage of transition to a new system of social, including economic, relations, within which some social institutions sometimes consistently, and sometimes not, replace others, the role of information and the value of the person himself, which determine the main competitive advantages of almost all economic entities, is radically changing. The influence of traditional institutions is significantly decreasing, state borders are becoming largely conditional, the freedom of movement of the world's population is increasing, most spheres of human life and society are experiencing significant, if not fateful, global influences. Against the background of these changes, competition is intensifying between globalists calling for total "equalization" and anti-globalists defending the rights of the community to self-determination and self-identity. Of course, all people on the planet are similar and everyone is different, so both points of view are justified and logical, and this underlines the importance of their coexistence and dialectical struggle. The resolution of this contradiction is largely possible through the rational use of biotechnologies (Semenova & Fridman, 2020).

As previously noted, society is increasingly aware that everyone does not reside in an apartment, city, or country, but rather, above all else, on the planet – our shared home. Given the rapid expansion of human economic activity, and the fact that we no longer have the right to disregard the anthropogenic impact on the biosphere, individuals become the sole entities fully responsible for preserving not only cultural but also natural biodiversity on earth, which cannot be achieved without the implementation of relevant biological technologies (Semenova & Fridman, 2020).

It is this situation that demonstrates the significance, relevance, and importance of the theoretical research and practical development of biotechnological knowledge among contemporary students, both at the general and professional levels of education.

The development of scientific and technological progress and the transformation of the system of public relations have led to the emergence of new high-tech professions (Artamonova et al., 2020; Semenova & Fridman, 2020). For instance, professions such as bioethicists, genetic consultants, clinical bioinformatics specialists, R&D managers in healthcare, molecular nutritionists, operators of medical robots,

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information technology geneticists, developers of cyber prosthetics and implants, tissue engineers, designers of medical institution life, experts in personalized medicine, consultants on healthy aging, etc., will be featured in the Atlas of New Projects 3.0 for nanomaterials and nanotechnology. Additionally, biomimetists, safety specialists in the nano-industry, designers of smart materials, glass makers, recycling technology specialists, designers of nanotechnology-based materials, system engineers of composite materials, translational nanotechnologists, designers of micro- and nano-electronics, sensor engineers, and diagnostic system engineers will also be featured. At the same time, in the biotechnology sector, Atlas developers anticipate the need to recruit such specialists as developers of biocompatible and biodegradable materials; system biologists; developers of microfuel cells; biochemical engineers; safety engineers in biotechnological manufacturing; synthetic biologists; architects of living systems; and biopharmacologists. In abundance, specialists whose qualifications are directly dependent on the natural sciences base will be required in agriculture, spaceflight, aviation, robotics, electricity, metallurgy, neurotechnology, etc. The question arises naturally, where do these come from? The school should reinforce the natural science education of the younger generation. In addition to focusing on so-called “soft skills”, it is essential to concentrate efforts on the basics of education, based on the development of basic biological knowledge (such as cells, tissues, biochemical and biophysical processes, genetic information, etc.). This situation places a high responsibility on colleges and universities responsible for providing the biotechnological industry with appropriately qualified personnel. Leadership in biotechnological education is a necessary prerequisite for the technological independence of any state in the future.

CONCLUSION

In relation to the modernization of methods for improving the efficiency of biotechnology education in today's context, it is essential to note that the influence of science education is significant, and this will determine the direction and speed of social development for the foreseeable future.

Of course, biotechnological education should be based on fundamental pedagogical principles: scientific integrity, accessibility and manageable difficulty, consistency and systemic organization, historicism, clarity, and the connection between theory and practice. Special attention should be given to a detailed

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examination of specific production techniques, the analysis of vital processes, the role and significance of biotechnology in addressing the global challenges of our time. At the same time, it is crucial and even essential to include the modernization of biotechnological education within the priorities of each country's state education policy by organizing international collaboration on this matter. This will enable the creation of a global system for biotechnological training, the sharing of best practices, and the joint resolution of challenges affecting the populations of the entire world (Wormald, 2015).

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