METHODOLOGICAL POSSIBILITIES FOR DEVELOPING CREATIVE COMPETENCE IN BIOCHEMISTRY BASED ON DIGITAL TECHNOLOGIES

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Abstract This paper explores the role of digital technologies in fostering creative competence in biochemistry education. As biochemistry is a field that demands both technical knowledge and innovative problem-solving skills, creative competence is essential for students preparing for careers in medical and scientific fields. Digital technologies, including virtual labs, biochemical modeling software, and interactive simulations, provide versatile, scalable tools that enhance active learning, improve comprehension of complex concepts, and enable students to engage in innovative applications of biochemistry. This paper reviews various methodological approaches to integrating these technologies effectively and discusses their implications for biochemistry education.

Keywords: Creative competence, biochemistry education, digital technologies, virtual labs, biochemical modeling, simulation-based learning

Introduction The increasing complexity of biochemistry education, coupled with the rapid advancement of digital technologies, has presented new opportunities for cultivating creativity in students. Creative competence encompasses a range of skills, including analytical thinking, problem-solving, and the ability to approach biochemical challenges from unique perspectives. In biochemistry, where students must understand complex molecular processes and apply this knowledge in real-world contexts, the development of creative skills is critical for success in both research and clinical applications. This paper investigates methodological possibilities for developing creative competence in biochemistry education through digital technologies. These tools allow

students to engage more deeply with material, experiment in virtual environments, and explore interdisciplinary applications of biochemical knowledge.

Theoretical Framework: Digital Technologies and Creative Competence

Creative competence involves cognitive flexibility, the ability to generate new ideas, and the capacity to apply knowledge in novel ways. In the sciences, particularly in biochemistry, these competencies enable students to navigate complex biochemical systems and adapt existing knowledge to innovative research or medical solutions. For instance, understanding metabolic pathways is essential for diagnosing metabolic disorders, which often requires not only scientific rigor but also creative, adaptive problem-solving.

Digital technologies in education include a range of tools such as online simulations, virtual labs, 3D modeling software, and AI-based tutoring systems. These tools provide interactive, adaptive, and experiential learning environments where students can experiment without real-world limitations. In biochemistry, such tools are particularly valuable as they allow for visualization of molecular processes and exploration of biochemical pathways in ways that enhance understanding and stimulate creativity.

Methodological Approaches to Developing Creative Competence through Digital Technologies

Virtual labs have revolutionized biochemistry education by providing students with a safe, flexible environment to conduct experiments, test hypotheses, and learn from mistakes—key elements of creative learning.

For instance, platforms like Labster and BeyondLabz offer biochemistry simulations where students can explore enzyme kinetics, protein folding, and cellular respiration pathways. This approach not only reinforces theoretical knowledge but also encourages students to experiment with different conditions and observe biochemical processes in real time.

Methodological Implementation: Instructors can design virtual lab modules that involve open-ended tasks, prompting students to explore multiple outcomes. Assignments

can involve hypothesizing and testing scenarios, such as the impact of varying pH levels on enzyme activity, thereby enhancing both technical skills and creativity.

Biochemical Modeling Software for Visualization and Analysis

Biochemical modeling software, such as PyMOL, Chimera, and ChemDraw, allows students to visualize complex molecular structures and interactions. This capability is particularly useful in developing creative competence as it helps students think spatially about molecular processes and encourages innovative problem-solving in fields like pharmacology and structural biology.

Methodological Implementation: Instructors can use modeling software to assign projects that require students to model a specific biochemical interaction or pathway. Students could be tasked with modifying molecule structures to test binding affinities or simulating protein folding patterns, enabling them to explore potential applications in drug design.

Methodological Implementation: Educators can incorporate case-based simulations, where students must navigate clinical scenarios, such as diagnosing a metabolic disorder. This approach requires students to synthesize knowledge of biochemical pathways, adapt to dynamic situations, and think creatively about treatment options.

AI and Adaptive Learning Systems for Personalized Creativity Development

Artificial intelligence (AI) tools and adaptive learning platforms can personalize the learning process by adjusting the difficulty of tasks based on students' progress. AI-based tutoring systems, for example, can provide tailored feedback, guiding students through complex biochemical problems and suggesting alternative strategies for problem-solving.

Methodological Implementation: AI-powered platforms like Smart Sparrow or Knewton can be used to develop custom biochemistry modules that adapt to individual students' understanding. By offering varied pathways through biochemical problems, AI systems enable students to explore multiple solutions, fostering an experimental mindset crucial for creativity. Platforms like Google Workspace, Slack, and Miro facilitate collaborative learning by enabling students to work together on biochemistry projects,

share insights, and solve problems collectively. This collaboration simulates real-life scientific research, where teamwork and collective problem-solving are essential.

Methodological Implementation: Educators can create group assignments that require students to collaborate on biochemical research projects, analyze experimental data, or design metabolic pathway models. This collaborative process encourages peer-to-peer learning and sparks creativity through shared perspectives.

Digital tools provide an interactive, hands-on approach to learning that fosters engagement and improves information retention. When students can visualize biochemical processes or simulate experiments, they gain a deeper understanding of concepts and retain knowledge longer. Digital platforms often allow students to experiment independently, encouraging self-directed problem-solving—a key aspect of creative competence. Students can navigate biochemical challenges without the constraints of traditional lab settings, allowing for a freer exploration of ideas.

By engaging with digital technologies, students develop practical skills relevant to modern scientific careers. In fields like biotechnology or pharmaceutical research, familiarity with digital tools for biochemical modeling, data analysis, and simulation is crucial. Developing these skills alongside creative competence prepares students for the interdisciplinary demands of scientific professions.

Conclusion In the context of biochemistry education, digital technologies offer powerful tools for fostering creative competence. Through virtual labs, modeling software, simulation-based learning, and AI, students gain the opportunity to explore biochemical phenomena creatively, engage in independent problem-solving, and develop practical skills for scientific innovation. Future research should continue exploring the integration of digital tools in biochemistry curricula and evaluate their impact on students' creative development, particularly in regions like Uzbekistan where educational technology is evolving to meet the demands of a globalized, knowledge-driven society.

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