THE ROLE OF NEURODIDACTIC PRINCIPLES IN IMPROVING BIOLOGY EDUCATION

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Abstract. *The development of professional skills in future biology teachers requires the integration of modern pedagogical, psychological and neurodidactic approaches. Biology as a school subject is closely connected with observation, experimentation, visualization and analytical thinking. Therefore, future biology teachers should be prepared not only to explain biological concepts, but also to organize learning activities in accordance with students' cognitive, emotional and sensory characteristics. This article examines neurodidactic principles as an important theoretical and methodological basis for developing professional skills of future biology teachers. The study focuses on such principles as visualization, multisensory learning, emotional activation, attention activation, motivational orientation, short-block teaching and reflective reinforcement. The article argues that these principles help future teachers design biology lessons more effectively, reduce cognitive overload, increase students' interest in biological phenomena and strengthen the connection between theoretical knowledge and practical activity. The results of the study show that the application of neurodidactic principles contributes to the formation of cognitive, methodological, practical and reflective skills in future biology teachers. The article concludes that neurodidactic principles may serve as a key component of a broader model for developing professional skills in biology teacher education.*

Keywords: *neurodidactics, biology education, future biology teachers, professional skills, visualization, multisensory learning, cognitive activity, teacher training.*

Introduction. Modern teacher education is increasingly focused on preparing specialists who are able to organize the educational process in accordance with the cognitive, psychological and individual characteristics of learners. In this context, the training of future biology teachers has a special significance, because biology is a science that requires the integration of theoretical knowledge, practical observation, experimentation, visualization and scientific reasoning. A biology teacher must be able not only to transfer knowledge, but also to create conditions for students' active perception, understanding, analysis and application of biological concepts.

Traditional approaches to teacher training often emphasize the acquisition of subject knowledge and general pedagogical methods. However, in many cases, insufficient attention is paid to the mechanisms through which students perceive, process, store and reproduce information. As a result, future teachers may know the content of biology, but may experience difficulties in adapting this content to the cognitive capabilities of students. This problem becomes particularly important when teaching complex biological topics such as cell structure, genetics, human physiology, ecological systems and evolutionary processes.

Neurodidactics offers a promising direction for overcoming this problem. Neurodidactics is an interdisciplinary field that combines pedagogy, psychology, didactics and knowledge about the functioning of the human brain. It studies how educational content can be organized in

accordance with the cognitive and emotional mechanisms of learning. From this point of view, neurodidactic principles can help future biology teachers design lessons that are more visual, emotionally engaging, cognitively accessible and practically meaningful.

In the professional training of future biology teachers, neurodidactic principles can perform several important functions. First, they help future teachers understand how students perceive and process biological information. Second, they guide the selection of teaching methods, visual materials, practical tasks and reflective activities. Third, they contribute to the development of professional skills related to lesson planning, classroom interaction, student motivation and assessment of learning outcomes.

The purpose of this article is to analyze neurodidactic principles as a theoretical and methodological basis for developing professional skills of future biology teachers. The article focuses on the role of visualization, multisensory learning, emotional activation, attention activation, motivational orientation, short-block teaching and reflective reinforcement in biology teacher education.

Materials and Methods. This study is based on theoretical and analytical research methods. The main materials of the study include pedagogical, psychological and neurodidactic literature related to teacher education, biology teaching methodology and the development of professional skills. The research also relies on the conceptual analysis of the model aimed at developing professional skills of future biology teachers on the basis of neurodidactic approaches.

The following methods were used in the study:

First, the method of theoretical analysis was applied to study the essence of neurodidactics and its relevance to biology teacher education. This method made it possible to identify the main principles that are important for organizing biology lessons in accordance with students' cognitive and emotional characteristics.

Second, the method of classification was used to systematize neurodidactic principles according to their pedagogical functions. As a result, the following principles were selected as the main elements of the study: visualization, multisensory learning, emotional activation, attention activation, motivational orientation, short-block teaching and reflective reinforcement.

Third, the method of pedagogical generalization was used to explain how each neurodidactic principle contributes to the development of professional skills in future biology teachers. In this process, attention was paid to the connection between theoretical knowledge, methodological preparation and practical teaching skills.

Fourth, the modeling approach was used to determine the place of neurodidactic principles in the general system of professional skill formation. Within this approach, neurodidactic principles were considered not as separate didactic recommendations, but as interconnected elements of a broader pedagogical model.

The research logic was organized in the following sequence: analysis of the problem, identification of neurodidactic principles, explanation of their pedagogical content, determination of their influence on professional skills and formulation of theoretical conclusions.

Results. The results of the theoretical analysis show that neurodidactic principles play an important role in developing the professional skills of future biology teachers. These principles

provide a methodological basis for transforming biological content into a form that is understandable, engaging and cognitively appropriate for learners.

The principle of visualization is one of the most important principles in biology education. Biology contains many abstract, microscopic and complex processes that are difficult to understand through verbal explanation alone. For example, cell division, DNA structure, photosynthesis, blood circulation and ecological interactions require visual representation. Therefore, future biology teachers must learn to use diagrams, models, pictures, videos, animations and concept maps effectively. The use of visualization develops the teacher's ability to explain complex concepts clearly and helps students form stable mental images of biological processes.

The principle of multisensory learning is also significant. It means involving different sensory channels in the learning process, including vision, hearing, movement and practical action. In biology lessons, multisensory learning may include observing a model, listening to an explanation, performing an experiment, drawing a diagram and discussing the result. This principle helps future teachers organize lessons in a way that activates several cognitive channels at the same time. As a result, students understand and remember biological information more effectively.

The principle of emotional activation is connected with the idea that emotions influence learning. If a biology lesson arouses curiosity, surprise, interest or personal relevance, students are more likely to participate actively and remember the material. For future biology teachers, this principle develops the skill of creating emotionally meaningful learning situations. For example, a lesson about the human heart may begin with a short activity in which students feel their pulse and connect their own body experience with the scientific explanation of blood circulation.

The principle of attention activation is particularly important because students' attention is not stable throughout the whole lesson. Complex biological information may quickly overload learners if it is presented in a monotonous form. Therefore, future teachers should be able to use attention-focusing strategies such as problem questions, visual signals, short tasks, changes in activity and interactive discussion. This principle develops the teacher's ability to manage the rhythm of the lesson and maintain students' cognitive engagement.

The principle of motivational orientation helps connect the learning content with students' interests, needs and real-life experience. Biology provides many opportunities for motivation because it is directly connected with health, environment, plants, animals and human life. Future biology teachers should be able to show the practical importance of biological knowledge. For example, topics related to nutrition, ecology, immunity or genetics may be explained through real-life situations. This increases students' internal motivation and makes learning more meaningful.

The principle of short-block teaching is based on the idea that complex material should be divided into smaller, logically connected parts. This is especially important in biology because many topics contain several levels of organization and many scientific terms. Future biology teachers should learn to divide the lesson into short conceptual blocks: introduction, visual explanation, practical task, discussion and reflection. This reduces cognitive overload and helps students gradually construct knowledge.

The principle of reflective reinforcement completes the learning process. Reflection allows students to analyze what they have understood, what difficulties they faced and how they can apply the new knowledge. For future teachers, this principle develops the skill of organizing feedback, self-assessment and lesson analysis. Reflective activities may include short questions, concept summaries, “what I learned” tasks, exit tickets or group discussions.

The analysis shows that each neurodidactic principle contributes to a specific group of professional skills. Visualization and multisensory learning develop methodological and practical skills. Emotional activation and motivational orientation develop communicative and motivational skills. Attention activation and short-block teaching develop lesson management skills. Reflective reinforcement develops analytical and evaluative skills.

Thus, neurodidactic principles are not only teaching recommendations. They are important elements of professional teacher training because they help future biology teachers connect subject knowledge with students’ cognitive development and real classroom practice.

Discussion. The findings of this study confirm that the development of professional skills in future biology teachers should be based on an integrative approach. It is not sufficient for a future teacher to know biological content or general pedagogical methods separately. Professional readiness appears when biological knowledge, teaching methodology, psychological understanding and neurodidactic principles are combined into a single system.

In the context of biology education, neurodidactic principles have particular value because biological content is often complex, dynamic and visual in nature. Many biological phenomena cannot be directly observed in ordinary classroom conditions. For example, molecular processes, physiological mechanisms and ecosystem interactions require special forms of representation. Therefore, the ability to visualize and model biological content becomes an essential professional skill of the biology teacher.

Another important issue is the connection between neurodidactic principles and students’ cognitive load. If a teacher presents too much information at once, students may fail to understand the main idea. Short-block teaching and attention activation help solve this problem. These principles allow the teacher to organize the lesson step by step and prevent mental overload. For future biology teachers, this means learning how to structure the content logically and choose the appropriate pace of instruction.

The principle of multisensory learning is also closely related to the practical nature of biology. Biology is not only a theoretical subject; it requires observation, experimentation and interaction with natural objects. Therefore, future teachers should be able to combine explanation with practical activity. This approach helps students move from passive listening to active learning.

Emotional activation and motivation are equally important. Many students may perceive biology as difficult because of scientific terminology and abstract concepts. However, when the teacher connects biological topics with students’ personal experience, nature, health and everyday life, the subject becomes more accessible and interesting. This requires the teacher to develop communicative and creative skills.

Reflective reinforcement is especially important for teacher training itself. Future biology teachers should not only conduct lessons but also analyze their own pedagogical decisions.

Reflection helps them understand whether the selected methods were effective, whether students were active and what should be improved in the next lesson. Therefore, reflection is a professional growth mechanism.

The discussion also shows that neurodidactic principles may serve as a bridge between the first theoretical stage of teacher training and the second practical stage, where a methodological model is developed and implemented. In the first stage, these principles form the theoretical foundation. In the second stage, they can be used to design specific methods, technologies, lesson models and assessment criteria.

Conclusion. Neurodidactic principles represent an important theoretical and methodological basis for developing professional skills of future biology teachers. The principles of visualization, multisensory learning, emotional activation, attention activation, motivational orientation, short-block teaching and reflective reinforcement help organize biology lessons in accordance with students' cognitive, emotional and sensory characteristics.

The study shows that these principles contribute to the development of several important professional skills: the ability to explain complex biological concepts clearly, select appropriate methods, activate students' attention, motivate learners, organize practical activities and analyze lesson outcomes. Therefore, neurodidactic principles should be considered an essential component of biology teacher education.

The results of the study may be used in developing a broader model for forming professional skills of future biology teachers on the basis of neurodidactic approaches. In future research, these principles should be tested in pedagogical practice and connected with assessment criteria, lesson design technologies and experimental results.

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