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RESEARCH ARTICLE OPEN ACCESS

Neurodidactic Methods for Activating Cognitive Activity in The Learning Process of Future Teachers

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ABSTRACT

This article scientifically and theoretically elucidates neurodidactic methods for activating cognitive activity in the learning process of future teachers. Neurodidactic methods that activate cognitive processes, as well as their role in increasing the effectiveness of education, are revealed. Also, scientific and practical recommendations have been developed regarding the integrative neurodidactic model created by the author for the use of neurodidactic methods in teaching, as well as its description, possibilities, and advantages.

Keywords: Neurodidactic methods, cognitive activity, brain neuroplasticity, future teachers, educational process, reflection, cerebral cortices, spaced repetition, individual cognitive profile, multisensory teaching, repetition, emotional-cognitive integration.

INTRODUCTION

One of the main requirements imposed on the education system in the context of today's globalization and digital transformation is the thorough, conscious, and stable formation of the professional competencies of future teachers. In particular, in the process of mastering subjects that equip them with the most necessary knowledge and skills during their professional activity, it is important not only for students to acquire knowledge, but also to develop their thinking, creative approach, and ability to make quick and effective decisions in problematic situations. In this process, the issue of activating cognitive activity is emerging as one of the urgent problems of modern pedagogy.

In traditional educational practice, teaching subjects is often focused on transmitting theoretical knowledge, while insufficient attention is paid to students' brain activity, perception, memory, attention, and thinking mechanisms. As a result, students' retention of knowledge in long-term memory, its application in real pedagogical situations, and reflection are weakened in the learning process. Therefore, the need arises to organize the educational process in accordance with the laws of human brain activity.

In recent years, the field of neurodidactics, which has been developing at the intersection of education and neurophysiology, has emerged precisely from this need. Neurodidactics envisages designing the educational process on the basis of human brain activity, cognitive processes, and psychophysiological characteristics. This approach scientifically explains how pupils and students perceive, process, and consolidate knowledge and creates opportunities to increase the effectiveness of education. In particular, Tokuhama-Espinosa considers neurodidactics as a scientifically grounded educational model and relates the activation of cognitive activity to brain activity [1].

The use of neurodidactic methods in the learning process of future teachers is important for increasing their cognitive activity, strengthening their motivation, and developing their critical and creative thinking. The neurodidactic approach makes it possible to apply effective methods in developing these competencies by relying on

the natural mechanisms of brain activity. After all, the learning materials and methods selected for instruction should be within the cognitive capabilities of learners [2].

From this point of view, the scientific substantiation of neurodidactic methods aimed at activating cognitive activity in teaching, the identification of their didactic possibilities, and their introduction into practice constitute an urgent scientific and pedagogical task facing researchers in the field. This article focuses precisely on this issue and highlights the importance of the neurodidactic approach in the process of pedagogical education, the mechanisms of activating cognitive activity, and the possibilities of its application in practical activity.

The purpose of the article logically follows from this, namely, in this research we defined for ourselves the main purpose as theoretically and practically substantiating neurodidactic methods that serve to activate the cognitive activity of future teachers in the learning process and analytically examining their impact on the effectiveness of education. In order to achieve the stated purpose, the following tasks were identified during the research process:

- to determine the content, structure, and pedagogical significance of the concept of cognitive activity;
- to identify the mechanisms for activating cognitive processes (perception, memory, attention, thinking, and reflection) in mastering subjects;
- to systematize neurodidactic methods and techniques aimed at developing cognitive activity;
- to substantiate the effectiveness of these methods in pedagogical practice;
- to develop practical recommendations based on the research results.

By implementing the above purpose and tasks, it is possible to achieve indicators of easy and effective learning of subjects by students.

LITERATURE REVIEW AND METHODS

In recent years, the issue of organizing the educational process on the basis of the laws of human brain activity has become one of the important directions in the scientific research of scholars in the field of pedagogy. In particular, in the studies of A.R. Luria, recognized as the founder of neuropsychology and cognitive science, the functional blocks of brain activity and their significance in the educational process were scientifically substantiated. His works served as a theoretical fundamental basis for subsequent neurodidactic research. The American scholar E. Jensen, in his studies, developed the concept of "brain-based learning" and explained the influence of emotion, motivation, and environment on cognitive activity in the educational process. In his opinion, educational content yields effective results only when it is organized in accordance with the natural needs of brain activity. Also, such scholars as J. Zull and H. Gardner analyzed cognitive processes and the influence of neural mechanisms on learning activity [3]. In his studies, S. Dehaene emphasizes that cognitive activity operates through brain neural networks and the neuronal workspace, and puts forward the idea that consciousness and learning are connected with the functioning of neural networks [4]. The effects of cerebral hemispheric asymmetry on the development of children's speech and thinking in the educational process, as well as the differing consequences of damage to the left and right hemispheres, and the possibilities of applying knowledge about the human brain in the educational process, are reflected in the scientific studies of L.S. Basser, J.E. Bogen, B.T. Woods, E. Lenneberg, A. Smith, P. Wolfe, E. Jensen, and B. Given [5].

In Uzbek pedagogical science, no serious research has yet been conducted by any scholar on presenting neurodidactic solutions for a learner-centered approach in the educational process, designing the pedagogical process, and activating students' cognitive activity. This, in turn, increases the theoretical and practical significance of our research. Nevertheless, scholars such as N. Saidahmedov, B. Xodjayev, R. Mavlonova, and Sh. Sharipov studied the problems of innovative methods, interactive approaches, and the development of reflective activity in pedagogical education. Also, in her scientific article, F. Jo'rayeva interprets the activation of cognitive activity as the harmony of pedagogical management and the learner's internal activity [6].

However, the analysis of existing research shows that the issue of activating cognitive activity on the basis of the neurodidactic approach in teaching has not been sufficiently studied in a comprehensive and systematic manner. In particular, there are almost no scientific

developments aimed at improving the methodology of teaching subjects based on the laws of brain activity.

For this reason, this research is aimed at scientifically substantiating neurodidactic methods for activating cognitive activity in the learning process, and it serves to some extent to fill the existing scientific gap. In the course of the research, wide use was made of theoretical analysis and synthesis, comparison and systematization of the literature related to the topic, a number of scientific articles by foreign and Uzbek scholars, as well as pedagogical observation and interview methods.

RESULTS

In accordance with the tasks defined at the beginning of our research, let us first dwell on the concept of cognitive activity. Cognitive activity is the mental activity of a person that includes the processes of perceiving, understanding, remembering, and thinking about the surrounding environment. It encompasses all processes related to acquiring knowledge and processing it. Cognitive activity consists of such basic processes as perception (receiving the external world through the senses), attention (concentrating on a particular object), memory (storing and retrieving information), thinking (solving problems, analyzing and synthesizing), imagination (creating new images), and speech (expressing thoughts and exchanging them with others). In terms of content, cognitive activity serves a person in acquiring knowledge, understanding it, and applying it in practice.

Cognitive activity is considered the central element of the educational process and has high pedagogical significance in carrying out educational activity and achieving results. Through cognitive activity, the child consciously assimilates knowledge, develops independent thinking, becomes not a passive but an active participant in the learning process, learns to make decisions in problematic situations, and achieves personal development.

The research results showed that high effectiveness is achieved when the activation of cognitive activity in the learning process of future teachers is effectively organized on the basis of neurodidactic approaches. In particular, we distinguish the following main neurodidactic methods:

I. Brain-based learning significantly increases cognitive activity. As James E. Zull emphasizes, the learning process is connected with the reorganization of neural networks, and knowledge is consolidated through sensory, associative, and motor zones. This ensures deep assimilation through the active processing of learning material [7]. James E. Zull divides the learning process into four main parts of the cerebral cortex:

1. Sensory and postsensory cortex. The posterior part of the brain. It receives information. It performs the function of obtaining information from the external world (seeing, hearing, touching).

2. Temporal integrative cortex. The lower/lateral part of the brain. It gives meaning to information and processes it. It analyzes the received information and compares it with the information already existing in memory.

3. Frontal integrative cortex. The front part of the brain (prefrontal). It is considered the center of planning, logic, and idea generation. It is the center responsible for creating new ideas, making plans, and making decisions.

4. Premotor and motor cortex. The upper-middle part of the brain. It carries out the control of body movements, the practical application of ideas, taking action, and checking the result.

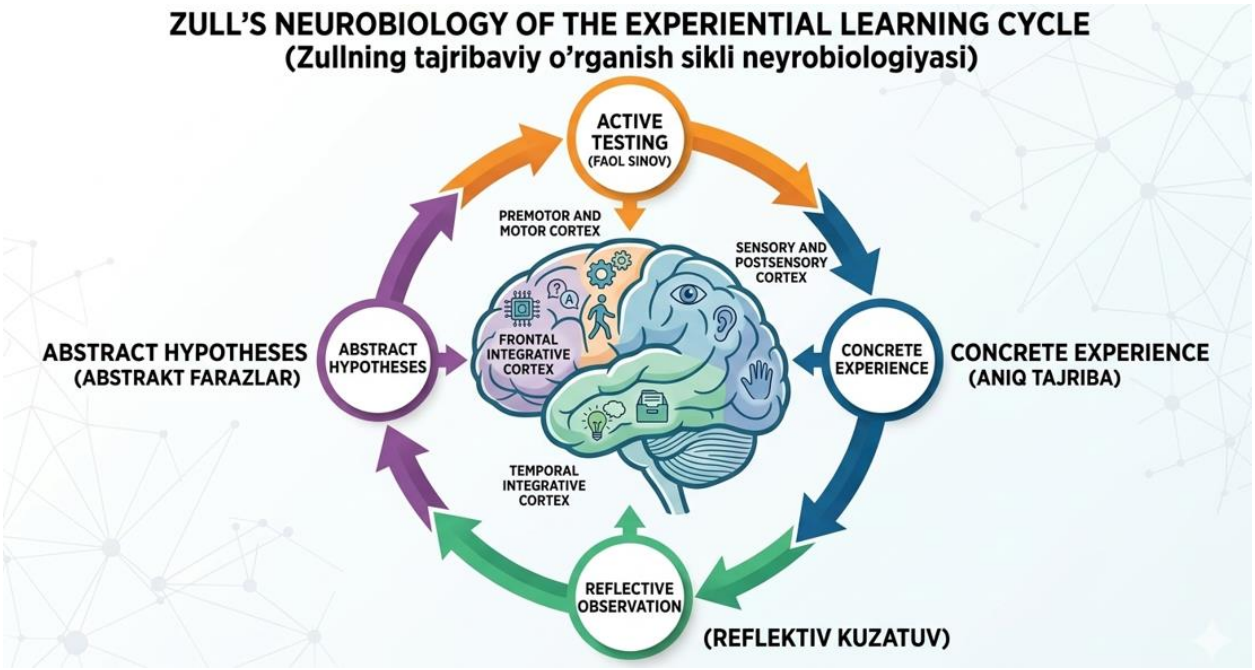

Figure 1.

II. Active engagement and attention management are important factors in activating cognitive processes. In his studies, Stanislas Dehaene identifies four main pillars of learning (attention, active engagement, learning through errors, and consolidation). In the educational process organized on the basis of this model, students do not passively receive knowledge, but actively construct it [8]. If we pay attention to the practical structure of this model, through attention the learner consciously focuses on important information. Beginning the lesson with a clear goal and reducing distracting factors are important factors in directing the child's attention to the main process. If the child's personality is actively engaged in pedagogical activity, the learner does not remain passive, but thinks actively, makes assumptions, and acts. This activity can be achieved through mini-exercises, discussions, and interactive tasks. This, in turn, ensures better understanding. In the educational process, it should not be forgotten that making mistakes in some cases is normal for the learner, and that errors are an important part of learning. It is advisable not to punish the error, but rather to analyze it and provide quick and accurate feedback. The fourth stage of the model proposed by S. Dehaene is consolidation, and at this stage the acquired knowledge passes into long-term memory. Here, it is recommended to use the mechanism of spaced repetition. Spaced repetition is a learning technique based on reviewing information at certain time intervals in order to retain it in long-term memory. In the traditional method, we study everything in one day before the exam (this is called "cramming" and is quickly forgotten). In spaced repetition, however, the repetition intervals gradually become longer. For example:

1. First repetition: Immediately after learning or a few hours later.
2. Second repetition: After 1 day.
3. Third repetition: After 3–4 days.
4. Fourth repetition: After 1 week.
5. Fifth repetition: After 2 weeks or 1 month.

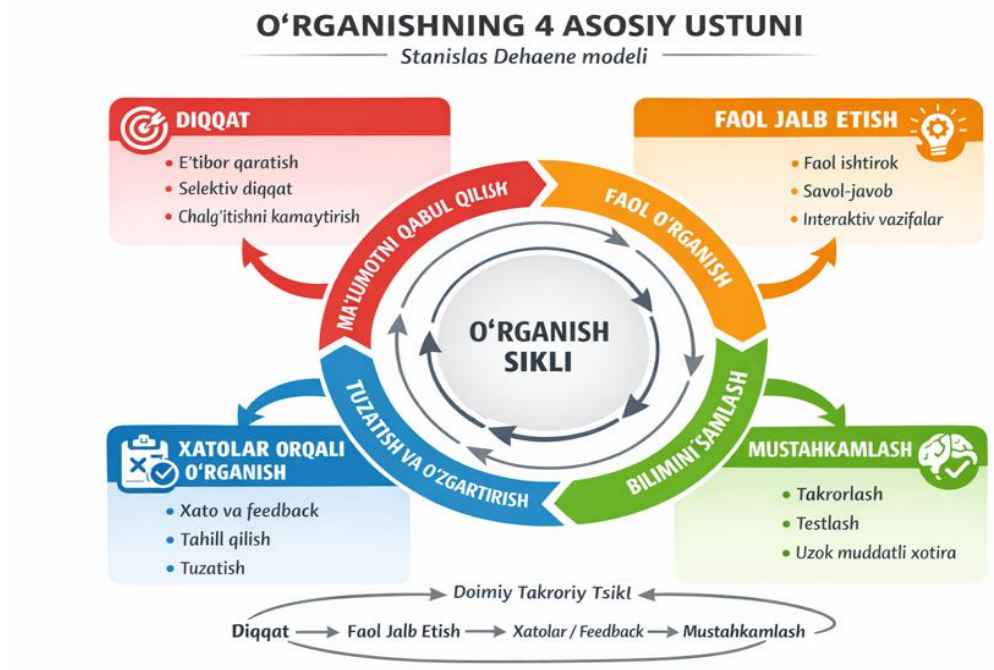

Figure 2.

III. In the learning process of students, multisensory teaching and taking into account individual cognitive styles also produce effective results. According to the theory of multiple intelligences developed by Howard Gardner, each person has a unique cognitive profile, and individualizing the educational process on this basis increases cognitive activity. Also, Evgenia Gkintoni, Stephanos P. Vassilopoulos, and Georgios Nikolaou systematically studied the effect of multisensory teaching on brain neuroplasticity. In their studies, it was proven that teaching through the integration of visual, auditory, and kinesthetic elements leads to an increase in cortical thickness in the frontal-temporal parts of the brain and to an improvement in cognitive flexibility. They call the multisensory approach “biologically aligned education” [9]. In addition, Ioanna Porfyri and Evangelos Paraskevopoulos analyzed the difference between multisensory and unisensory (one-sided) teaching at the level of neural networks. The studies showed that multisensory training causes changes in beta rhythms in the brain and strengthens effective connections between cortical networks. This, in turn, accelerates cognitive activity in the learning process several times [10].

IV. In neurodidactics, emotional-cognitive integration (the harmony of emotion and thinking) is considered the main factor accelerating the learning process. Modern studies show that emotions not only provide motivation, but also directly serve as a neurobiological mechanism in memory consolidation and attention management. Amanda Matias and Nuno Dorotea analyzed the relationship between the amygdala (the center of emotion) and higher cognitive functions from a neurodidactic point of view. The study examined how the amygdala imprints memory traces (engram) not only through fear, but also through emotional engagement. They proved how a positive emotional environment increases lesson effectiveness at the neural level [11]. Likewise, Jelle Jolles and Dietsje D. Jolles developed the concept of “Neuro-guidance,” in which they studied the “top-down” modulation between the prefrontal cortex (mental control) and the limbic system (emotions). Their work is aimed at improving cognitive outcomes by teaching students emotional regulation [12].

V. In neurodidactics, repetition and reflection are considered the main mechanisms that not only consolidate knowledge, but also regulate the process of neuroplasticity that changes the physical structure of the brain. Recent studies deeply analyze these processes from the point of view of synaptic plasticity and functional connectivity. This method is considered extremely effective for activating cognitive activity in the learning process of future teachers. The neurobiologist and educator Judy

Willis is considered one of the most authoritative scholars in applying neuroplasticity in classroom conditions. In her recent works, the concepts of "Synaptic Pruning" and "Long-term Potentiation" are analyzed. According to Willis, repetition insulates the electrochemical pathways between neurons "like electric wires" (myelination), while reflection ensures the connection of these pathways with "meaning."

If we analyze the obtained results in general, cognitive activity increases in the educational process organized on the basis of neurodidactic approaches, knowledge is assimilated more deeply, and independent thinking and reflection develop. This, in turn, makes it possible to create a favorable environment for the brain capacities of learners and thereby achieve high learning outcomes.

DISCUSSION

The analysis of the obtained results shows that the activation of cognitive activity in the learning process of future teachers can be effectively organized through neurodidactic approaches. Although these approaches are theoretically substantiated differently by various scholars, the common feature that unites them is the interpretation of the learning process as being inseparably connected with brain activity and cognitive mechanisms.

First of all, an important similarity is observed between the views of James E. Zull and Stanislas Dehaene. Both scholars explain learning through the activity of neural networks and their changes. Zull explains the learning process step by step through the functional parts of the cerebral cortex, substantiating the transition of knowledge from sensation to action. Dehaene systematizes this process further, distinguishing such universal mechanisms as attention, active engagement, learning through errors, and consolidation. Accordingly, Dehaene's model is considered more adaptable to pedagogical practice and methodologically clearer, whereas Zull's approach reveals the biological basis more deeply.

However, when comparing these two approaches, some of their limitations also become apparent. In particular, Zull's model is more theoretical and biological in nature, and it is difficult to implement it directly in the classroom process. Although Dehaene's model is convenient from a practical point of view, it does not sufficiently take individual differences into account. From this point of view, the theory of multiple intelligences proposed by Howard Gardner partially compensates for this shortcoming. Gardner links cognitive activity with the individual characteristics of the person and substantiates the need to individualize education. At the same time, an important weakness of Gardner's theory is that it is not sufficiently connected with neurobiological mechanisms. That is, the exact relationship of the types of intelligence with brain structures has not been fully empirically proven. This creates a certain limitation in relation to the requirements of modern neurodidactics.

The studies conducted by Evgenia Gkintoni, Stephanos P. Vassilopoulos, and Georgios Nikolaou on multisensory teaching experimentally strengthen the neurodidactic approach. Their work proved that multisensory integration activates different parts of the brain simultaneously and increases cognitive flexibility. The advantage of this approach lies in its biological grounding and high effectiveness. However, in practice, the development and implementation of multisensory methods for all academic subjects require certain resources and methodological preparation.

In the issue of emotional-cognitive integration, the views of Amanda Matias and Nuno Dorotea, as well as Jelle Jolles, are of particular importance. They explain the role of emotions in the learning process on a neurobiological basis and reveal the interaction between the amygdala and the prefrontal cortex. The strong point of this approach is that it offers an effective mechanism for managing learners' motivation and attention. At the same time, managing the emotional environment requires a high level of psychological competence from the teacher, which creates certain difficulties in practice.

In the approach based on repetition and reflection, the views of Judy Willis deserve special attention. She explains neuroplasticity at the synaptic level and substantiates that the consolidation of knowledge occurs through repetition and reflection. The advantage of this approach is its scientific grounding and the possibility of wide application in pedagogical practice. However, excessive repetition may lead to a decrease in learners' motivation, which indicates the need for balanced application of the method.

In our opinion, although each of the approaches considered above is of great importance in activating cognitive activity, it is not possible to achieve full effectiveness when each of them is applied separately. The most optimal

solution is to develop an integrative neurodidactic model. In this case:

- Zull provides the neurobiological basis
- Dehaene systematizes the cognitive mechanisms
- Gardner ensures individualization
- The multisensory approach activates complex perception
- Emotional integration increases motivation
- Willis consolidates knowledge.

Taking into account each of the above separate aspects, we present the integrative neurodidactic model below:

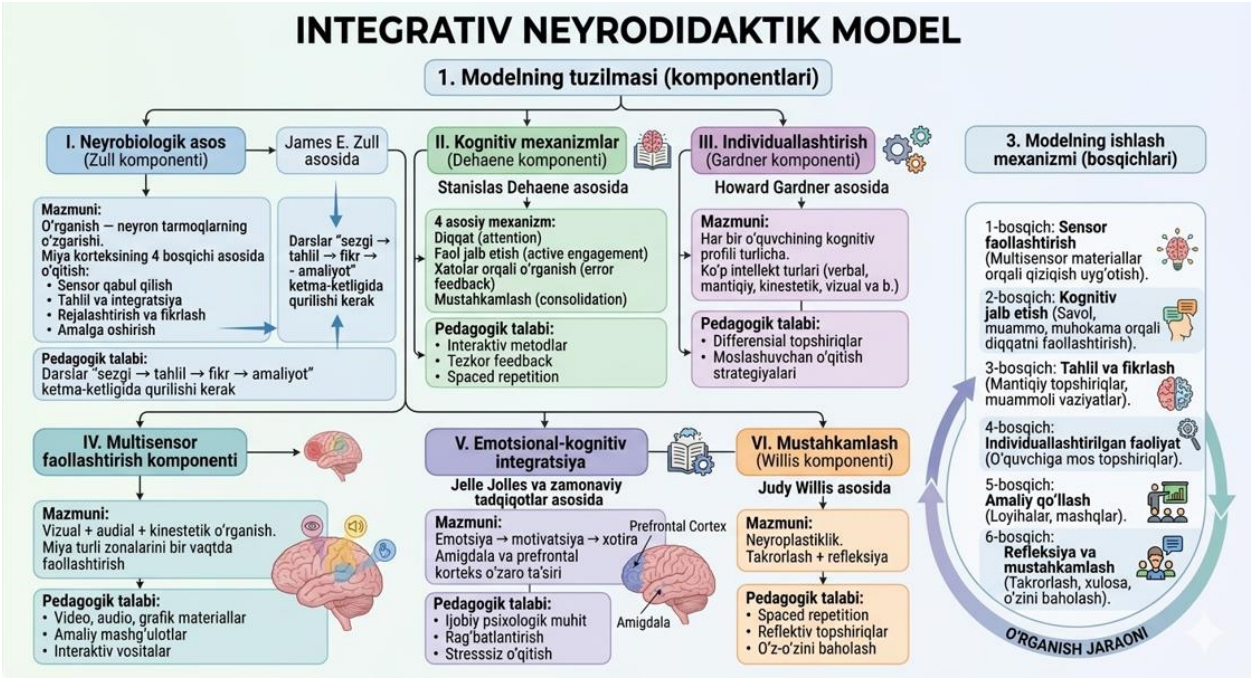

Figure 2.

The proposed integrative neurodidactic model is considered one of the effective approaches in activating cognitive activity. Its main advantage is the integration of various scientific theories into a single system. At the same time, the gradual implementation of the model in practice and the special training of teachers are necessary. Among the advantages of this model are its comprehensive development of cognitive activity, its adaptation to brain activity, its support for individualized education, its increase of motivation, and its strengthening of long-term memory.

Also, based on the research results, it can be noted that the following scientific problems have not yet found a complete solution:

- the lack of a special neurodidactic methodological system for future teachers;
- the insufficient study of teaching mechanisms based on individual neuroprofiles;
- the insufficiency of empirical studies on the long-term effectiveness of neurodidactic methods.

In general, neurodidactic approaches have high scientific and practical potential in activating cognitive activity. Their comprehensive and systematic implementation serves as an important factor in increasing the professional competence of future teachers.

CONCLUSION

Within the framework of this research, the neurodidactic foundations of activating cognitive activity in the learning

process of future teachers were comprehensively analyzed. The research results showed that organizing the educational process in accordance with the laws of human brain activity significantly increases the effectiveness of cognitive processes.

In particular, the neurobiological approach substantiated by James E. Zull demonstrated the inextricable connection of the learning process with brain structures. The cognitive mechanisms proposed by Stanislas Dehaene serve as an important methodological basis for managing learners' attention, ensuring active engagement, and consolidating knowledge. At the same time, along with Howard Gardner's theory, the application of an individualized approach on the basis of the scientific and theoretical works of a number of scholars in the field makes it possible to take into account the individual cognitive characteristics of learners.

The research also scientifically substantiated the significance of such neurodidactic methods as the multisensory approach, emotional-cognitive integration, and repetition and reflection in the learning process. These approaches serve to develop learners' abilities not only to receive knowledge, but also to understand it deeply, process it, and apply it in practice. In particular, the integration of emotional factors into the learning process increases motivation and has a positive effect on the formation of long-term memory.

The use of separate approaches alone is not sufficient for the effective activation of cognitive activity. In addition to the above, in order to achieve effective results through a number of proposals within the framework of our research, it is necessary to apply an integrative model that embodies various components of neurodidactics. Such a model makes it possible to organize the educational process in a systematic, flexible, and scientifically grounded manner.

It should also be added that there are certain problems in implementing neurodidactic approaches in practice. In particular, teachers' insufficient knowledge of neuroscience, the limited methodological support, and the insufficient development of teaching technologies based on individual neuroprofiles complicate this process. Taking this into account, the fact that pedagogical staff themselves should first possess sufficient neurodidactic competencies makes it possible in practice to make broader use of the possibilities of this approach.

In general, the educational process organized on the basis of neurodidactic approaches has important scientific and practical significance in activating cognitive activity, increasing the effectiveness of learning, and developing the professional competence of future teachers.

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