



APPLICATION OF NEUROFEEDBACK TECHNOLOGIES IN INDIVIDUAL TEACHING: THEORETICAL BASIS AND PRACTICAL APPROACH

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Abstract

This article examines the theoretical foundations and practical aspects of applying neurofeedback technologies in the individualized learning process. Neurofeedback technology uses electroencephalography (EEG) to monitor brain bioelectrical activity in real time, providing feedback that teaches learners to regulate their cognitive states. The article covers the psychological-pedagogical foundations of individualized instruction, the neurofeedback mechanism, international meta-analyses, and implementation possibilities in Uzbekistan schools.

Keywords: Neurofeedback, individualized learning, EEG, attention index, cognitive development.

Introduction

INDIVIDUAL O'QITISHDA NEYROFEEDBACK TEXNOLOGIYALARINI QO'LLASH: NAZARIY ASOS VA AMALIY YONDASHUV

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Annotatsiya

Ushbu maqolada individual o'qitish jarayonida neyrofeedback texnologiyalarini qo'llashning nazariy asoslari va amaliy jihatlari ko'rib chiqiladi. Neyrofeedback texnologiyasi elektroensefalografiya (EEG) yordamida miya bioelektrik faolligini real vaqt rejimida kuzatib, o'quvchiga qayta aloqa berish orqali uning



kognitiv holatini boshqarishga o'rgatadi. Maqolada individual o'qitishning psixologik-pedagogik asoslari, neurofeedback mexanizmi, xalqaro meta-tahlillar tahlili va O'zbekiston maktablarida qo'llash imkoniyatlari yoritiladi. Tadqiqot natijasida O'zbekiston ta'lim tizimiga moslashtirilgan besh bosqichli model taklif etiladi.

Kalit so'zlar: neurofeedback, individual o'qitish, EEG, diqqat indeksi, kognitiv rivojlanish, miya to'lqinlari.

Аннотация

В данной статье рассматриваются теоретические основы и практические аспекты применения технологий нейрoфидбека в процессе индивидуального обучения. Технология нейрoфидбека с помощью электроэнцефалографии (ЭЭГ) в режиме реального времени контролирует биоэлектрическую активность мозга и обучает учащегося управлять своим когнитивным состоянием посредством обратной связи. В статье освещаются психолого-педагогические основы индивидуального обучения, механизм нейрoфидбека, анализ международных мета-анализов и возможности применения в школах Узбекистана.

Ключевые слова: нейрoфидбек, индивидуальное обучение, ЭЭГ, индекс внимания, когнитивное развитие.

INTRODUCTION

In the modern education system, the organization of the educational process with individual examination of students has become one of the important pedagogical productions. According to the World Health Organization, the number of school-age children with attention deficit disorder at the rate of 5-7 years, without a clinical diagnosis, but with attention-related assistance, can be from 20 to 30 [1]. A qualitative survey in Uzbekistan (2026) also confirmed this trend: 60% of respondents assessed the problem of attention as a serious pedagogical problem in 20 teachers.

Neural feedback technology — an innovative method that transfers the bioelectrical activity of the brain to the management of cognitive states through real-time and feedback — has been actively studied in education over the past



decade. A number of studies have been conducted in the USA, the Netherlands and other countries on testing neurofeedback programs in school settings.[2] However, the issue of introducing this technology into the education system in Uzbekistan has not yet been sufficiently studied.

The purpose of this article is to review the theoretical foundations of neurofeedback technology, analyze international scientific sources on the basis of its school proposal in education, and the practical implementation model of Uzbekistan.

INDIVIDUAL TRAINING AND NEUROFEEDBACK: THEORETICAL BASIS

Individual training, according to the stable direction of modern pedagogy, requires both the material knowledge of the student and his cognitive, physical and neurophysiological support. L.S. According to the theory of the "Zone of Performance" (ZPD), learning is not something that a student can do independently, but is most effective with assistance [3]. It is in this area that neurofeedback operates — it objectively measures the cognitive state of the student and brings him to an optimal learning state.

The Baddeley model of performance suggests that cognitive capacity is a state of load, which reduces the learning process to the extent that it is loaded [4]. J. Sweller's (1988) cognitive load theory is also developed and applied: learning increases when the educational material is adapted to the physical condition of the student [5]. Neurofeedback technology serves precisely this purpose — it monitors the cognitive state of the student in real time, providing the teacher with objective information for adaptive control.

Neurofeedback is a special type of biofeedback, which records the bioelectrical activity of the brain through electroencephalography (EEG) and returns this information to the student as a visual or auditory signal. The brain There are five types of brain waves: delta (0.5-4 Hz) — deep sleep; theta (4-8 Hz) — memory and creativity; alpha (8-13 Hz) — alertness; beta (13-30 Hz) — active attention; gamma (30-100 Hz) — high cognitive integration [6]. Neurofeedback training mainly involves correcting beta waves and reducing the theta/beta ratio — that is, adding protocols to enhance attention.

The mechanism of operation of the technology is based on the principle of operant conditioning (B.F. Skinner, 1953): when the student achieves the target cognitive

state — improved attention — he receives a positive signal, and this state is reinforced [7]. Over time, the brain learns to maintain this state, as a result of which attention stabilizes and the effectiveness of learning activities increases.

ANALYSIS OF INTERNATIONAL META-ANALYSES

Meta-analyses are the most reliable scientific source for assessing the effectiveness of neurofeedback. The table below presents a comparative overview of major meta-analyses from the last decade.

Table 1. Major international meta-analyses on the effectiveness of neurofeedback

Author, year	RCT	Research Area	Effect size	Key findings
Cortese et al., 2016	13	ADHD	Medium	Individual adaptation increases effectiveness
Bussalib et al., 2019	16	ADHD	Medium–low	Blind assessment results decrease, protocol is important
Jackson et al., 2023	22	Memory	Small–medium	Positive effect on working memory is observed
Kimura et al., 2024	18	Attention	Medium	Attention scores increase in healthy individuals
Westwood et al., 2025	30+	ADHD	Low–medium	A systematic approach is necessary for sustainable effectiveness

Table analysis shows that neurofeedback has shown some positive effect in all major meta-analyses. However, the effect size often remains moderate or low. This makes it necessary to view neurofeedback not as a universal solution, but as part of a systematic pedagogical approach. In particular, individual diagnostics and an adapted protocol are emphasized as key factors for effectiveness [8].

A noteworthy aspect from the perspective of the Uzbek context is that international studies have mainly studied children with a clinical diagnosis. In local schools, students without a clinical diagnosis but with attention-related difficulties are more common. This indicates the possibility of using neurofeedback not only in clinical settings, but also in general education settings.

IMPLEMENTATION MODEL FOR SCHOOLS IN UZBEKISTAN

As part of the study, a survey was conducted in May 2026 with the participation of 20 teachers in general education schools in the city of Chirchik. The results

showed the following picture: 60% of respondents considered attention problems in their students to be a serious pedagogical problem; 65% did not know about neurofeedback at all; 70% indicated that they were ready or likely to use the technology; 80% indicated the need for special training for teachers as the main obstacle.

Based on these results and an analysis of international scientific sources, a five-stage model adapted to the Uzbek education system was developed. The main advantage of the model is that it takes into account the specifics of local conditions, in particular, financial constraints, the level of personnel training and technical capabilities.

Table 2. Five-stage model for the use of neurofeedback in individual training

№	Stage	Content	Expected result
1	Diagnostics	The attention index (AI = θ/β) is determined by EEG, an individual cognitive profile is created	Initial AI indicator and individual training plan
2	Goal Setting	A training protocol is selected based on Vygotsky's ZPD, a session schedule is created	Adapted protocol and individual schedule
3	Neurofeedback Training	2-3 times a week, 20-30 minutes; attention is stabilized through operant conditioning	AI indicator increases, attention stabilizes
4	Pedagogical Integration	The results of the training are applied to the lesson process, tasks are adapted to AI	Transfer effect — training results are transferred to educational activities
5	Monitoring	Cognitive, behavioral and academic indicators are monitored weekly	Stable result, dynamic adaptation of the strategy

To ensure the financial feasibility of the model, it is recommended to use portable EEG devices such as the Muse 3 (costing \$200-300) and the free MindMonitor application at the initial stage. A study by Debener et al. (2012) confirmed that portable EEG devices provide satisfactory information for initial educational programs [9].

The following recommendations were developed to overcome the main obstacles identified in the questionnaire: first, starting with a small group as a pilot program; second, a special 7-10 hour training course for teachers; third,



information sessions with parents; fourth, integrating neurofeedback organically into the teaching process, rather than as a separate session.

CONCLUSION

The following conclusions were drawn from the study.

First conclusion. Neurofeedback technology fully complies with the scientific and pedagogical foundations of individual learning — Vygotsky's ZPD theory, Baddeley's working memory model, Sweller's cognitive load theory — and allows for objective measurement of the student's cognitive state.

Second conclusion. International meta-analyses confirm that neurofeedback has a certain positive effect, but its effectiveness directly depends on the quality of individual diagnostics, adapted protocol and pedagogical integration.

Third conclusion. A survey conducted in schools in the city of Chirchik empirically confirmed the relevance of the problem of attention in local schools (60%) and the positive attitude of teachers to technology (70%).

Fourth conclusion. The proposed five-stage model was developed taking into account the current conditions of Uzbek schools and can be practically applied using the Muse 3 portable device.

In future studies, it is recommended to conduct a comparative experiment with a control group, expand the number of respondents and test the model in different regions.

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