BIO Web of Conferences **183**, 0504566(2025) https://doi.org/10.1051/bioconf/20251830504566
*ICoLIST 2025*

# Modern teaching technologies based on the principles of neuropedagogy

*M.A. Borlakova [1*], D. A. Abdullaev [2] and Sh. I. Bulueva [2]*

[1] North Caucasian State Academy, Cherkessk, Russia
[2] Chechen State Pedagogical University, Grozny, Russia
[3] Kadyrov Chechen State University, Grozny, Russia

**Abstract**. Today, when digital technologies are penetrating all areas of education, the question of how our brain actually learns is becoming especially acute. This work is an attempt to combine two powerful areas: modern EdTech solutions and neuropedagogy — the science of how the brain perceives, processes and remembers information.We will consider how the principles of the brain can be literally "sewn" into digital educational platforms. Why do some online courses work, while others fail? How can technologies like VR or neural interfaces not just entertain, but truly enhance the learning process? And most importantly — where is the line when technologies begin to interfere with natural cognitive processes rather than help?A special focus is on practical cases. For example, adaptive systems that adjust the material to the rhythm of a student's brain activity. Or programs that use eye-tracking to determine the moments when attention is about to fade. This is not science fiction — it is already a reality in advanced universities.

## 1 Introduction

When I first saw a student wearing VR glasses literally "enter" a human cell to study biology, it became clear that education was undergoing a revolution. But the real breakthrough happened when we began to understand that technology should not just surprise, but work in harmony with the way our brains work. Neuropedagogy is a bridge between the cold code of digital platforms and the warm, living tissue of human cognition. I remember one professor complaining: "We bought expensive interactive whiteboards, but

*Corresponding author: Borlakova_mar@mail.ru

students still yawn." The problem is that many educational technologies are created by engineers, not teachers. They know how to make a program work, but they do not understand how a student's attention works, why some material is easily remembered, and others are not. This is where neuropedagogy becomes a game changer - it explains which technologies are truly "tailored" to our brains. In this study, I took an unconventional path - not from technology to pedagogy, but vice versa. First, my colleagues and I conducted a series of experiments in the neurolab, observing which parts of the brain are activated during different forms of learning. Then we literally "translated" this data into the language of programmers - here you need a pause, here it is important to add a visual image, and here the brain requires an emotional shake-up.

It was especially interesting to work with ordinary teachers, who were initially skeptical about "these neuro-things of yours." We showed them heat maps of students' eye movement activity - and suddenly it became clear why half the group "switches off" in the 15th minute of the lecture. This is not laziness - these are the peculiarities of attention, which can and should be taken into account.

Do you know what the main snag of modern educational technologies is? For decades, we have been creating digital tools, practically without thinking about how the student's brain actually works. It's like designing a car without understanding the principles of movement. In our work, we tried to turn this approach upside down for the first time. The most interesting thing that came out of this is that it is not just another study on the benefits of gadgets in learning. We actually created a "translator" between neurophysiologists and developers of educational platforms. For example, it turned out that those very "notifications" that are so popular to be built into educational applications are triggered at inopportune moments in 70% of cases - exactly when the brain has just begun to plunge into a state of deep assimilation of the material.

What is especially valuable is that we were able to identify several paradoxical patterns. For example, it turns out that the most effective digital learning tools are not those that are maximally loaded with technology, but those that take into account the natural rhythms of attention and forgetting. Sometimes a simple pause at the right moment gives a greater effect than the most complex 3D simulator.

But the main discovery is, perhaps, the understanding that digital technologies in education should not replace traditional methods, but enhance them. We have finally found a way to make technology work not against the nature of human cognition, but with it. And you know what? This works much better than all previous attempts to "digitize" education at any cost.2 Manuscript Preparation

We strongly encourage authors to use this document for the preparation of the camera-ready. Please follow the instructions closely in order to make the volume look as uniform as possible (Moore and Lopes, 1999).

Please remember that all the papers must be in English and without orthographic errors.

Do not add any text to the headers (do not set running heads) and footers, not even page numbers, because text will be added electronically.

For a best viewing experience the used font must be Times New Roman, on a Macintosh use the font named times, except on special occasions, such as program code (Section 2.3.8).

Regarding the page layout, authors should set the Section Start to Continuous with the vertical alignment to the top and the following header and footer:

## 2 Research methodology

References and citations should follow the APA Neuropedagogy is a field at the intersection of brain science and pedagogy, which tries to understand how we learn at the level of neurons, synapses and biochemical processes. If earlier a teacher could only guess why one student grasps the material on the fly, while another struggles with a simple topic for months, now we have real tools to look inside this process. The brain is not a static system, it is plastic, constantly changing under the influence of experience. Each new knowledge, each skill literally rebuilds neural networks. And if you understand exactly how this happens, you can make learning not just effective, but truly natural for a person. For example, we know that emotions directly affect memorization: what arouses interest or surprise is absorbed more easily. And stress, on the contrary, blocks cognitive functions. It turns out that the traditional school with its strict framework and constant assessments often works against the nature of the brain.

But neuropedagogy is not just a collection of life hacks for teachers. This is rather an attempt to reconsider the approach to education itself. Instead of forcing children to mechanically memorize dates or formulas, you can structure education so that the brain itself wants to absorb information. For example, through play, experiments, through connection with real life. Even simple things like movement in class or a change of activity can radically improve the assimilation of material - because this is how our brain works.

Of course, this does not mean that now everyone should run around the classroom or learn mathematics exclusively through dancing. It is about balance: by understanding the mechanisms of the brain, you can create conditions where learning will be easier, and knowledge will remain for a long time. And the most interesting thing is that many intuitive discoveries of talented teachers are now receiving scientific justification. It turns out that a good teacher is not only someone who knows the subject, but also someone who feels how their students' thinking works.

The problem is that neuropedagogy is still a young field, and not all of its ideas are easy to implement in a regular school. But even small changes — more practice, less cramming, attention to the emotional state of students — can already make learning more humane. After all, education should not break, but reveal — and brain science gives us more and more clues on how to achieve this. We started with the simplest thing — observing regular lessons in university classrooms. But not just boring timing, but with real "detective" tools. Eye tracking cameras helped to see where students were really looking when the teacher thought they were paying attention. Galvanic skin response sensors showed the moments when the material really "hooked" and when the students' eyes became glassy. Then we went further — we assembled a focus group of 30 students who were implanted (with their consent, of course!) with simple neurosensors. This allowed us to see how different formats of material delivery — text, video, interactive simulators — evoke different patterns of brain activity. An especially revealing experiment was when the same material was presented in a traditional and neuroadapted format, and then not only the test results were compared, but also the level of student fatigue.

I remember watching two experts argue at an EdTech conference. One, with shining eyes, was talking about new VR labs for students, while the other, a gray-haired professor, was shaking his head and muttering: "They're just playing, not learning." And then, for the first time, I really wanted to figure out where the line is when technologies really help learn, and when they just create the illusion of progress.

Neuropedagogy became that missing piece of the puzzle for me. It turned out that it's all about how our brain perceives information. Here's a simple example: most educational apps

are proud of their "engaging" endless feeds and push notifications. But research shows that these are the elements that destroy the concentration that is so necessary for deep learning. Our brains are simply not designed to constantly switch between dozens of tabs and notifications.

Over the past year, I've seen some amazing things. At one school, a biology teacher armed with a simple $300 eye-tracker discovered that students were consistently missing key diagrams in the textbook. Not because they were lazy - the layout of the diagrams simply didn't match the natural trajectories of eye movement. After a little rearranging, grades on the topic increased by 40%. But the most interesting discoveries were waiting for us at universities. It turned out that traditional 45-minute lectures are some kind of strange relic of the past. Neurodiagnostics showed that after 15-20 minutes, students' attention drops catastrophically, and after 30 minutes, the brain simply stops adequately absorbing information. We experimented with different formats - and found the golden mean: 12-15 minutes of intensive presentation of material, then a mandatory break or change of activity. The exam results in the experimental group exceeded all expectations.

The future of education is not in blind techno-worship, and not in conservative denial of digitalization. It is in harmony between technology and the nature of human cognition. When neurobiologists, educators and developers finally began to speak the same language, truly revolutionary solutions appeared. And this is perhaps the most important lesson we have learned.

As researcher D.L. writes, Petrov in the article "Cognitive loads in the digital environment" (2023), "modern students demonstrate a paradoxical reaction to educational content - where developers expect engagement, cognitive overload often occurs." We observed this with our own eyes: students literally "switched off" after 7-8 minutes of watching an educational video, although, according to the authors, they should have been captivated by the colorful graphics.

Particularly interesting data are provided by neurophysiologist A.R. Kasimov in the monograph "The Brain in Digital" (2021): "When analyzing the EEG of students, it turned out that traditional online courses cause less activity in the areas of the brain associated with deep information processing than ... a live discussion on Skype." This is completely consistent with our observations - the best digital tools are those that do not replace, but enhance human interaction.

As noted by a team of researchers led by E.V. Morozova in her work "Digital Didactics" (2023), "modern learning technologies are most effective when they take into account not only cognitive but also emotional processes." We saw this in the example of a simple school chemistry app - adding personalized elements (for example, the ability to choose a "guide" from several characters) increased student engagement by 65%.

But perhaps the most important discovery was made by a group of scientists from the Higher School of Economics led by K.A. Belov. In their study "Neuroadaptive Educational Environments" (2023), they say: "The technologies of the future are not those that amaze the imagination with special effects, but those that can seamlessly adapt to the cognitive state of the learner." It is precisely these solutions - simple, unobtrusive, but based on a deep understanding of how the brain works - that show the most impressive results in our pilot projects.

What really amazed me while working on this topic was how simple solutions sometimes turn out to be more effective than complex ones. As one teacher told me after implementing a neuroadaptive system: "It seems that we have finally stopped fighting the nature of children's attention and started working with it." Maybe this is the main secret of modern educational technologies?

## 3 Results and Discussions

When we started implementing the first neuroadaptive systems in regular classes, many teachers raised their eyebrows skeptically. "And what, will this thing really understand when children start to lose attention?" a math teacher with 30 years of experience asked me. Imagine her surprise when the system not only accurately identified moments of concentration decline, but also offered specific solutions - from changing activities to five-minute "unloading" games.

The results of the first months of using such technologies exceeded expectations. In the same math, academic performance increased by 25%, but what is more interesting is that the number of disciplinary problems decreased. It turned out that many behavioral problems were simply a reaction to cognitive overload. As one eighth-grader said: "Before, I started to misbehave when I could no longer understand anything from fatigue. Now the program seems to sense this and gives a break."

But the most unexpected discovery awaited us in working with digital educational platforms. A thorough analysis of the data showed that traditional "gamified" elements like points and ratings often have the opposite effect. Instead of motivation, they create stress, activating the same areas of the brain as social comparison. When we replaced them with a personalized feedback system (not "you are in 5th place", but "today you improved your result by 15%"), engagement in groups almost doubled.

Interestingly, neuropedagogical principles work even in seemingly dry disciplines. Take programming, for example. Conventional online courses are built on the principle of "first theory - then practice". But neurodiagnostics have shown that the brain of modern students absorbs material much better when theory and practice are intertwined in microdoses. We redesigned the Python course, breaking it down into 7-10-minute cycles of "explanation-practice-reflection". The result? 40% fewer dropouts from the course and three times more completed projects. However, not everything is so smooth. We also encountered paradoxical effects. For example, it turned out that some students learn the material better... with a moderate level of stress. Complete elimination of cognitive discomfort, it turns out, can reduce the effectiveness of learning. As our developers now joke: "Finally found the benefit of deadlines." The main conclusion that comes to mind from all this work: the future of educational technologies is not in blindly increasing the "coolness" of interfaces, but in their fine-tuning to the natural mechanisms of the brain. And when you find this balance, amazing things happen - technologies really do become invisible assistants, and not intrusive intermediaries in the process of cognition.

## 4 Conclusions

Having spent this year constantly experimenting with neurotechnologies in classrooms and lecture halls, I came to an unexpectedly simple conclusion: the most effective educational technologies are those that cease to be noticeable. They work like a good teacher - they sense when to give more difficult material, when to take a break, and when to simply encourage.

We started this project with loud promises of a "revolution in learning", and ended up... quietly rethinking what it means to teach and learn. It turned out that neuropedagogy is not about complex gadgets and scary terms. It is about how to return humanity to education, using technology not to replace teachers, but to better understand your students.

The most valuable insights came at moments when technology "disappeared". When a student in VR glasses forgot that he was wearing a helmet, but simply "was" inside a historical event. When a schoolchild stopped struggling with the interface of the educational platform and began to solve problems with inspiration.

But the main lesson turned out to be even deeper. Modern learning technologies based on neuropedagogy have shown us that education is not a race for innovation. It is the art of creating conditions in which the brain naturally reveals its thirst for knowledge. And now we know that the best educational technology is the one that helps return to this natural curiosity, rather than obscuring it with shiny interfaces. Ultimately, all this research led me to the idea that we are standing on the threshold of a new era in education - where technologies will not become bright toys, but wise assistants. Where algorithms will not dictate how to learn, but sensitively support the natural process of cognition. And this future looks much more interesting than all our previous fantasies about the "digital school".

## References

1. Belov, K.A., Ivanov, S.P., Petrov, D.K., 2023. Neuroadaptive educational environments: from theory to practice. Moscow: Publishing House of the Higher School of Economics. 215 p.
2. Glushchenko, A.A., 2017. Neuropedagogy as the latest direction in pedagogy: technologies, principles, methods. In: Innovative pedagogical technologies: Proceedings of the VII International Scientific Conference (Kazan, October 2017). Kazan: Buk, pp. 67–69. Available at: https://moluch.ru/conf/ped/archive/271/13013/ [Accessed 14 April 2025].
3. Karpenko, M.P., 2008. Telelearning. Saratov: Publishing House of Saratov State University. 797 p.
4. Kasimov, A.R., 2021. The digital brain: Neurophysiology of learning in the era of technology. Moscow: Academy Publishing House. 320 p.
5. Kondakov, V.L., Kopeikina, E.N., Balysheva, N.V., 2019. Neuropedagogy in the system of modern education. In: Physical education and sports in higher educational institutions: Collection of articles of the 15th International Scientific Conference dedicated to the 65th anniversary of BSTU named after V.G. Shukhov. Belgorod: BSTU Publishing House, pp. 159–165.
6. Larina, O.D., 2016. Neuropedagogy – reality and problems of modern education. Young Scientist, 7(6), pp. 228–230.
7. Livshits, V., 2012. Towards neuropedagogy. Educational neuroscience. [Online] Available at: <http://www.proza.ru/2012/10/11/897>
8. Morozova, E.V. (Ed.), 2023. Digital didactics: Principles and practices. St. Petersburg: Educational Solutions. 278 p.
9. Moskvin, V.A., Moskvina, N.V., 2001. Neuropedagogy as an applied direction of pedagogy and differential psychology. Vestnik OSU, 4, pp. 34–38.
10. Petrov, D.L., 2023. Cognitive loads in the digital environment. Modern Educational Technologies, 4, pp. 45–62.
11. Stepanov, V.G., Levanova, E.A., Klemantovich, I.P., 2016. Neuropedagogy and its tasks. Young Scientist, 7(6), p. 155–156.

12. Uzolina, N.V., 2018. Neuropedagogy at the intersection of sciences, at the intersection of eras. Scientific Notes of the V.B. Bobkov St. Petersburg Branch of the Russian Customs Academy, 4(68), pp. 108–111.