The Implementation of the Innovation Platform "Educational Potential of Hardware-Software Complexes Based on the Study and Interpretation of Brain Activity Patterns"

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***Abstract*—The article describes the main objectives and features of realization of the innovation platform "Educational potential of hardware-software complexes based on the study and interpretation of brain activity patterns". Standard volumetric test is used in order to obtain objective data about the characteristics of the child for building individual learning paths. The prototype of the brain-computer system will be tested in the course of the innovation platform. It will allow to assess the condition of children in the learning process based on the analysis of brain signals. The regional innovation platform was established on the basis of the Yuri Gagarin SSTU, lecturers of N.G. Chernyshevsky SSU are working on pedagogical fundamentals and methods of application of this technology. Cooperation is necessary because such developments should be created in accordance with pedagogical and ergonomic requirements for information systems providing automation of information and methodological support of the educational process.**

Keywords— robotics device;, neuropedagogy; cognitive activity; innovative platform; brain-computer interface

I. INTRODUCTION

The current generation of students this is the phenomenon of education without any geographical and political boundaries. This generation of "digital natives" is initially in collaboration with a variety of technical and operating devices (personal computers, mobile phones, smartphones, tablets, etc.). Consequently, all their mental processes, such as sensation, perception, thinking, imagination, and memory, appear and develop very differently. Attention is a kind of "trigger mechanism" of cognition and it also works differently. It is necessary to add that the variability of the attention process is also determined by the increased number of students with disabilities, including children with autistic spectrum disorder, and, at the same time, there is a high number of pupils in classes, that objectively reduces the attention of the teacher to the individual student.

On the one hand, at the moment, a significant challenge is the identification and systematization of attention features and cognitive patterns as the psychological characteristics of the current students' generation members. On the other hand, the development of specific management methods of students' cognitive activity, including through the modern technology involvement, taking into account the complexity (the individuality, variability, ambiguity) of received signals, as well as the necessity of situational and prolonged transformation of the basic attention characteristics. Innovative scientific and technical solutions in the form of neural interfaces will help to advance objective diagnosis (including real time) of psycho-physiological conditions of students (such as fatigue, ability to concentrate, adaptability to the changing external conditions, resistance to external stimuli, etc.) and to increase the efficiency of basic cognitive processes.

In the education system of the Russian Federation the solution of this problem is significant for any level, from preschool education to higher education institutions. But of course it is more important at the stage of primary education, the efficiency of which largely depends on the productivity of cognitive control processes in the future. Therefore, the scientists face the problem of identifying the psychological and pedagogical features and relationships between the experimental EEG data based on the attention processes study of specific age students groups (7-9 years), stage of learning (primary school), category ("normal/abnormal") and parameters, mechanisms and logic of constructing

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individualized educational trajectories taking into account the educational needs of the student as an individual, and typical and/or atypical of the group fixed pattern (matrix) of cognitive pattern.

For this purpose, at the level of the Saratov region on the basis of the Yuri Gagarin SSTU was developed and approved by the regional innovation platform "Educational potential of hardware-software complexes based on the study and interpretation of brain activity patterns", the main idea of which is to study the dynamics of concentration based on decoding patterns of neural activity in the brain and determining how to use hardware-software complex of the robotic assistant of anthropomorphic type for optimization of cognitive processes in elementary school students, including the disabled.

The possibility of implementing the project is determined by the Federal law of the Russian Federation "On education in Russian Federation" and is part of a Strategic development project "Breakthrough neuro-technology" of the Yuri Gagarin SSTU, and the project "Development of research laboratory and polygon design of software and hardware complex of the robotic anthropomorphic type assistant for the teacher with the use of learning control based on decoding brain activity patterns" (unique project identifier RFMEFI57717X0282) of the Federal target program "Research and development on priority directions of advancement of scientific-technological complex of Russia for 2014-2020 years"

II. The Conditions Necessary For the Platform Implementation

The theoretical basis was the patterns formation concept of brain activity during the stimulus effects related to synchronization/desynchronization (ERS/ERD) of neural activity in different frequency bands and the provisions of neuropedagogy and neuropsychology about building a system of learning that is optimally tailored to individual neuropsychological characteristics of students (individual lateral students' profile; gender differences; type of temperament; sensory-perceptual organization (modality of internal experience); the level of higher mental functions development) [1-4].

For solving problems related to recording of the brain neural activity signals, we use a modern complex of neurophysiological equipment licensed by the Federal service of the Russian Federation for supervision in the sphere of health care that includes the following units:

1. Electroencephalograph-recorder "Encephalan-EEGR-19/26" for record EEG up to 32 derivations with synchronized video monitoring in a stationary variant;

2. Electroencephalograph-recorder "Encephalan-EEGR-19/26" for most tasks associated with control and diagnostics of the brain state at different neurophysiological studies and related fields;

3. Electroencephalograph-recorder "Encephalan-EEGR-19/26" "Mini" used for carrying out various experimental works aimed at multichannel registration of a person's EEG signals. Number of channels: 10;

4. Software supplied with the Electroencephalograph-recorder "Encephalan-EEGR-19/26" that provides basic functions for recording, viewing and processing of experimental EEG signals;

5. Additional software for "Encephalan-EEGR-19/26", enabling studies of long-latency evoked potentials (EP) of the brain to different modalities stimuli (visual, auditory, somatosensory) in the presence of stimulants;

6. Additional software of "Encephalan-EEGR-19/26" that provides flexible forming and playback of cognitive stimulation scenarios using such stimulus as images, sound files, and sign-alphabetic information;

7. A set of electroencephalographs-recorders "Encephalan-EEGR-19/26" connected in one network and enabling experiments with simultaneous recording of EEG signals from a group of people, for example, in the case of a joint perception of the stimuli or joint decision-making;

8. Psychophysiological training complex with biological feedback (BFB) "Rehacor", designed for training self-regulation skills and self-assessment of the psychophysiological state of the individual/group entity, and for correction with using a wide range of physiological parameters and their combinations revealed violations;

9. System for neurophysiological investigations "BE Plus", including amplifier "BE Plus LTM" (AC 64 monopolar channels, 4 bipolar AC/DC channels) for the EEG with a sampling rate up to 1000 Hz;

10. Additional amplifier "BE Plus LTM" system neurophysiological studies in expanding the number of channels from 64+4 to 128+8.

To obtain reliable results, allowing to estimate the degree of concentration of the student for a specific period of study time, we plan to use the neural interface "NeuroFocus" that implements the allocation of attention patterns during the solution of cognitive tasks based on EEG brain signals derived from a particular subject (the student) using surface electrodes and the analysis of these signals using techniques developed in the Yuri Gagarin SSTU. At the same time, to control results in relation to the systematization of the cognitive patterns of students, modern methods will be used based on the technology of artificial intelligence and machine learning previously approved in the organization-applicant.

III. The Implementation Plan Of Innovation Platform

Direct implementation of the project implies solution of problems complex:

1. The carrying out of works on registration of neural activity (EEG data) of students when performing specialized tests related to cognitive activity, the accumulation of knowledge about specific brain states in learning process;

2. Collection, systematization, analysis and objective assessment data on the impact of the concentration dynamics to the efficiency of the students' cognitive activity, including those with disabilities, and identifying of typical and atypical cognitive patterns;

3. Development of methodologies and guidelines for the concentration mechanism training, including using the anthropomorphic type robotic assistant increase the efficiency of cognitive activity organization based on the student's individual pattern;

4. The possibility of using a hardware-software complex of the anthropomorphic type robotic assistant to optimize the students' cognitive processes in different types of educational institutions;

5. Dissemination of the project results in the context of the implementation of the Strategic project "Breakthrough neuro-technology" of the Yuri Gagarin SSTU, as well as the implementation of the project "Development of research laboratory and polygon design of software and hardware complex of the robotic anthropomorphic type assistant for the teacher with the use of learning control based on decoding brain activity patterns" (unique project identifier RFMEFI57717X0282) of the Federal target program "Research and development on priority directions of advancement of scientific-technological complex of Russia for 2014-2020 years".

Implementation of regional innovation platforms "Educational potential of hardware-software complexes on the basis of studying and decoding patterns of brain activity" takes place in stages. In the preparatory phase (June 2018 – June 2019) regulatory documents were developed and approved, that were the admission to the beginning of the study. We evaluated the interest of educational institutions in the project, developed the design of the psycho - and neurophysiological investigations including plan, script, Protocol, and complex learning tasks.

The practical phase (July 2019 – December 2021) will be conducted to record neural activity of students while performing specialized tests related to cognitive activities, as well as data analysis and highlights the dynamic characteristic of a specific age group student' brain states (7-9 years), stage of learning (primary school), and category ("normal/abnormal"). The result of these works can be the creation of a vast database anonymous experimental data of neuronal activity and scientific results relating to the analysis of brain dynamic states, and the typical and atypical patterns of cognitive activities; we will conduct assessment and classification of the received data. A feature of this phase will be the development of individual methods of concentration of attention, increase the efficiency of cognitive activity organization based on the student's individual pattern, including using the anthropomorphic type robotic assistant. Will be provided a real opportunity for the development and implementation of individual educational trajectories, enhancing the personification of cognitive processes, especially in the context of "special educational needs".

At the final stage (January 2022 – December 2024) it is planned to provide interpretation of the data obtained in the project course, summarized results of the study, scientific and practical recommendations for the educational process subjects.

IV. Prospects And Conclusions

Developed during the implementation of the innovative project methodologies on the use of neural interfaces "NeuroFocus" and anthropomorphic robotics in education will be tested in educational establishments of city and region in the course of work with different categories of students.

It is expected that methods using techniques of biological feedback through the analysis of EEG signals, will clarify the emotional and psychological state of the student with disabilities, the focus of its attention, and, consequently, to determine the strategy in the context of expanding social skills.

It is expected that the results of the project can be used not only in the field of school education.

Developed methods that provides flexible forming and playback of cognitive stimulation scenarios using such stimulus as images, sound files, and sign-alphabetic information, as well as the inclusion in the educational process of the anthropomorphic type robotic assistant will find application in other levels of education (preschool, basic general, secondary, higher, additional, including professional), taking into account their immediate needs, and can serve as one of the factors of integration and at the same time optimize the education system in Russia.

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