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The QEEG Research as an Example of an Alternative Method of Evaluation of Didactic Activity – Popularization of the Concept and Effects of Own Research

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Abstract

The article presents the concept of applying QEEG research in the assessment of didactic activity in polytechnic education. In addition, the promotion of EEG research in the field of therapeutic activities and as an innovative research method in didactics will be shown.

Keywords: simulation programs, electroencephalographic tests, QEEG, cognitive process, modeling, brain and education

Introduction

The concept of neuroeducation or neurodidactics is more and more often cited in the category of novelty in pedagogical literature. Neurodidactics seems to be a concept strictly related to didactics it self, soitcan be concluded that the area of its interest is not all education, but only refers to a narrower scope, didactics it self. Other concepts functioning in Polish and foreign literature are: *neuroedukacja*, *brain and education*, *educational neuroscience*. The thematic scope of these concepts is extremely extensive, but there is no doubt that it brings together knowledge from various fields of science, in this case neuroscience, cognitive psychology, pedagogy (didactics), and cognitive science. Neurodidactics, as a new trend in the development of the humanities, uses the known knowledge about the work of the brain in the teaching-learning process. It indicates the correlation of brain activity with the human cognitive process. Information processing processes that take place in the nervous system, consisting in receiving information from the environment, their storage and transformation, reflect the attitude of human behavior and its cog-

nitive activity. Simply put, the more we know about the activity of our brain, its activity under the influence of external stimuli, the greater our knowledge about the possibilities of organizing the educational process. With regard to teaching methodology, we have an impact on the targeted and individualized practice of upbringing and education. No wonder that the more and more frequently emerging possibilities of using specialized information technology encourage research on content. One of the possibilities offered by current technology is EEG electroencephalography. The idea of EEG research and its use in research on didactic effectiveness is one of the main activities to promote science. An exampleis the cyclical participation of the author in activities promoting the latest scientific achievements as part of the Silesian Science Festival Katowice (Figure 1, 2).

Figure 1. The place of promoting EEG research at the Laboratory of Experimental Research Biofeedback at Jan Dlugosz University in Częstochowa (own source)

Figure 2. The place of promoting QEEG research – a method of bioelectrical activity of the cerebral cortex (own source)

The subject matter of the study

In the Experimental Research Laboratory of Biofeedback in Jan Długosz University, EEG and QEEG research has been carried out for many years. QEEG tests (Quantitative electroencephalography) are a type of EEG tests that enable the so-called mapping brain activity (Prauzner, 2019–2021). For this purpose, specialized measuring equipment is used in the research, including a device called Mitsar 202. The operation of the apparatus consists largely in reading electrical impulses read on the scalp thanks to sensors placed in the so-called a bonnet (Figure 3). These are electrodes made of low impedance materials connected with recording equipment located on the head according to a specific pattern (Oostenveld, Praamstra, 2001; Olejniczak, 2006).

Figure 3. The QEEG research (own source)

Research methodologies and tools

In the years 2020–2022, complementary QEEG research was carried out among students in the field of engineering. A total of 34 people participated in the research, and their small number resulted from pandemic restrictions. The aim of the research was to evaluate the activity of the brain while working at the computer. Students were tasked with making a project in the form of a virtual model in a simulation program. During their work, brain activity was recorded.

The implementation of the engineering project was associated with several stages of work, such as: reading the documentation of the exercise, getting to know the software environment, developing the model in a simulation program, simulating the operation of the model, substantive evaluation of the work. At each of these stages of work, the activity of the brain was recorded and the results obtained in the form of frequency waveforms of the brain's work were used to perform the graphic activity of the brain's work QEEG. It is worth mentioning at this point that the activity of the brain is visualized in the form of specific frequencies of electrical potential impulses. In addition, the occurrence of these frequencies, the so-called waves of activity is related to their location, these are the waves: Alpha, Beta, Gamma and Theta. The most important in terms of didactic activity are Beta waves (Beta1 and Beta2, SMR). Beta1 waves with a waveform frequency of 16–20 Hz are associated with concentration on one issue, with an external orientation. If a person is faced with the need to solve, for example, a mathematical problem (intense mental effort), we will notice that first the amplitude of the activities will increase around 17 Hz and at exactly the same time the amplitude of Theta and Alpha (8–10 Hz) will decrease. This bandwidth correlates with the cognitive activity characteristic of active problem solving (intense mental effort). Low Beta1 level accompanies intellectual deficits as well as disturbances in concentration and attention. Too high Beta wave in the non-dominant (genetically non-dominant) hemisphere disturbs the emission of the SMR wave, which in turn is associated with emotional disturbance and attention deficit. Waves 18–36 Hz, the so-called Beta2 – a stressful wave of anxiety, accompanies us during intense mental work. It is associated with increased emotional tension, because its emission accompanies the release of adrenaline responsible for the state of readiness of the body. For the above studies, it was assessed as undesirable (Thompson, Thompson, 2012). The higher the frequency, the greater the creative stimulation and abstract thinking. We are aware of external stimuli. The main research goal was to determine the didactic activity among students of technical studies during practical work with the use of simulation software. The simulation software allows you to conduct classes in the IT laboratory thanks to the use of the most modern computer programs, in this case computer simulation determinists (abbr. DSK). The general (initial) hypothesis was with high probability that the use of DSK in the course of didactic activities increases the level of cognitive activity in the didactic process. Computer software was adopted as an independent variable, its features determining its attractiveness as a teaching means, while an increase in knowledge and skills of using this software in the implementation of an engineering project was assumed as a dependent variable. The method of the research was the ob-

servation and measurement of the results obtained from the Mitsar 202 research apparatus. The indicator of the dependent variable is the analysis of the occurrence of specific waves accompanying the activity of the brain during the student's work. The presence or absence of specific waves indicates a greater or lesser activity of specific brain structures characteristic of a human's creative work. The effects of individual work in the form of technical solutions in the construction and the course of simulating the operation of a virtual model were also assessed.

Review of author's research

In the course of the research, in each of the examined persons, a series of frequency wave forms, proving the activity of the brain, was recorded. Figure 4 shows an example of the course of one person at different stages of his work. Figure 5 shows a graphic illustration of the activity of the brain with the division into the activity of brainwaves. Due to the large number of such runs, the data of the entire group are presented in the form of Graph 1 and Table 1.

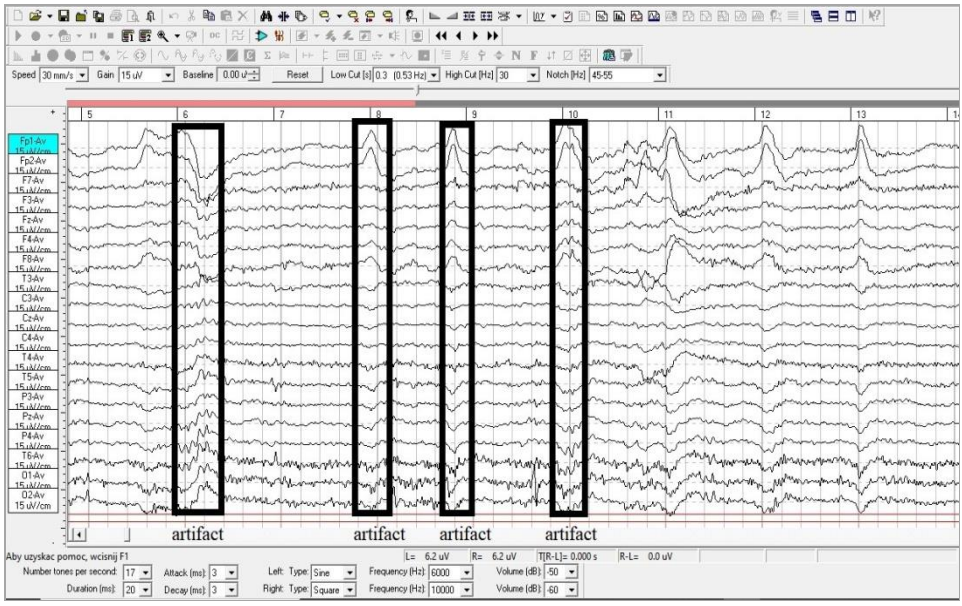


Figure 4. Frequency waveform of EEG waves

The figure also shows the so-called artifacts, i.e. disturbances in the operation of the apparatus, which should be removed after registration and then the results should be graphically interpreted (Figure 5) (Prauzner et al., 2019–2021; Robbins, Touryan, Mullen, Kothe, 2020)

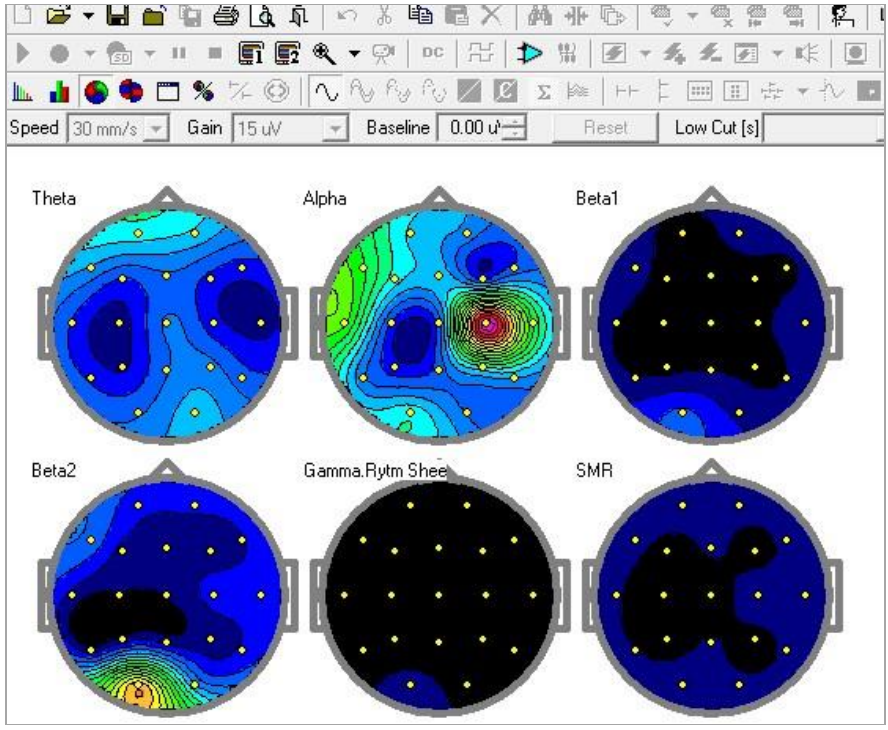
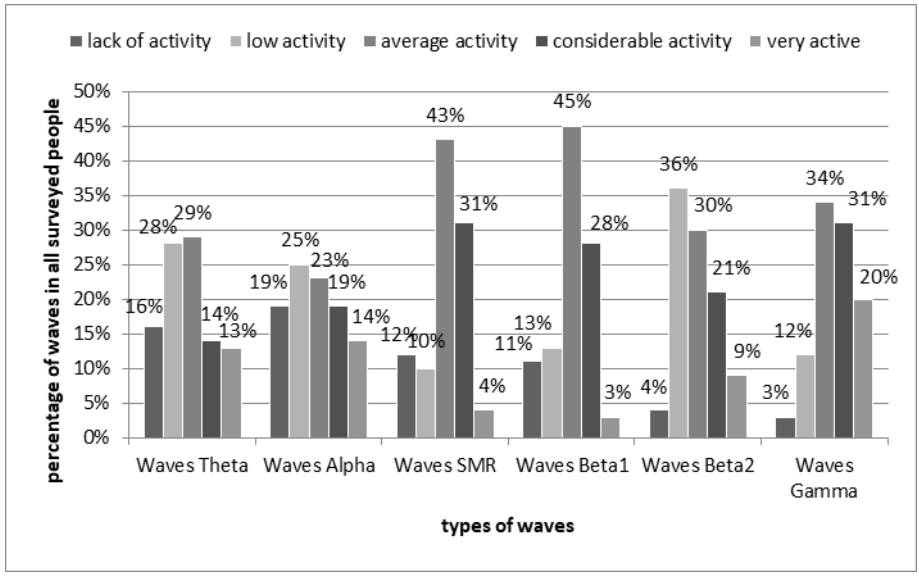


Figure 5. Graphical analysis of brain activity (own source)



Graph 1. Percentage of waves in all surveyed people (own source)

Table 1. Percentage share of individual waves and their intensity in the studied group (own source)

	lack of activity	lowactivity	averageactivity	considerableactivity	veryactive
WavesTheta	16%	28%	29%	14%	13%
WavesAlpha	19%	25%	23%	19%	14%
Waves SMR	12%	10%	43%	31%	4%
Waves Beta1	11%	13%	45%	28%	3%
Waves Beta2	4%	36%	30%	21%	9%
Waves Gamma	3%	12%	34%	31%	20%

Conclusions

The analysis of the results shows that all waves (Theta, Alpha, SMR, Beta1, Beta2, Gamma) occurred in 34 subjects. Of course, as expected, the percentage of dominant frequencies is different. This condition is influenced by many factors, including individual and biological predispositions, medical history, medications taken, etc. However, the quantitative analysis of the data shows that there is a significant correlation with the occurrence of certain waves (especially Beta1, Beta2, SMR) with mental activity in during work. The average and significant activity of Beta1 and SMR waves proves the involvement of all senses simultaneously and the state of attention, so in didactic terms it was the moment when the student was extremely focused on what he was doing. Beta1 waves appear very often when the student is doing mathematical or physical calculations. They are related to concentration on one issue, with an external orientation. Emotional states are related to arousal and alertness, the mind is focused on solving a task. Beta2 waves also occur frequently and are usually associated with Beta1 waves, but although they are characteristic of the active state of attention, they indicate increased emotional tension, and thus stress. Of course, stress accompanies creative work because it is often an experimental stage of work, the obtained results are not certain and raise concerns about their accuracy. They are related to the secretion of adrenaline in humans, so their excess determines the state of stress, which in didactic terms may be a destructive factor. Gamma waves are also frequently observed frequencies. Their occurrence is always related to the active and cognitive state in humans. It accompanies very active mental work of a person. We are dealing here with a high concentration in humans, creative work. The remaining types of waves, although their occurrence was also noticed, are dominant in a smaller number of people. They are associated with a state of calm, often lack of concentration and information processing, which does not mean that a person does not learn at this moment. However, they are not so important in active creative work at the computer. We must remember that working with a computer is primarily a static and moving image, so the organ of sight is the basic organ responsible for the information reaching the mind. Added to this is the problem of using software and computer skills. This conclusion can be

used for further research related to the usefulness of computer applications in didactics due to their architecture, data visualization side, difficulty in using software and many other factors. However, this is a topic for further research and joint discussion.

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