

# Neuropedagogy for Improving the Educational Process in Universities

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**Abstract:** *Objective:* This study aims to investigate the problems that neuropedagogy can solve in the context of the educational process.

*Background:* Research in neuropedagogy has been gaining popularity in recent years. This has been driven by advances in technology and the social sciences. Every year more and more scientists approach the subject of neuropedagogy to modernise the educational system and improve the educational process.

*Method:* The main research methods in this scientific article are the comparative method, methods of analysis and data synthesis, the historical method, as well as the theoretical analysis of scientific literature related to the subject matter.

*Results:* The study explored the concept of neuropedagogy and the principles on which it is based. Practical recommendations for teachers of Kazakhstan have been developed. Scientific articles on the subject matter are analysed, the degree of research and the effectiveness of the implementation of neuropedagogy in the educational process is assessed.

*Conclusion:* It was concluded that the use of neuropedagogy would provide an opportunity to improve and modernise the education system.

**Keywords:** Teacher, student, modernisation of education, neuroscience, Kazakhstan.

## INTRODUCTION

Neuropedagogy is a new branch of knowledge. This is the science of technology and parenting theory; it is based on data from modern neurosciences. The name "neuropedagogy" merges the concepts "pedagogy", which means the science of education, and "neuron" – a nerve cell [1]. Neuropedagogy differs from paedology, which presupposes the replacement of all human sciences. Specialists in neuroeducation work closely with a variety of other specialists, especially in neurosciences.

The study and implementation of neurosciences in the educational process and the introduction of neuropedagogy will provide new opportunities for students and teachers [2]. The introduction of neuropedagogy into the educational process will significantly increase students' level of development, unleash their creative potential, and increase labour abilities. Neuropedagogy will help to foster law-abidingness in students, to speed up and improve the process of their adaptation in society, and to improve

their physical and mental health [3]. Neurosciences involve helping society to determine the norms of behaviour and overcome the deviant behaviour of individuals. Neurosciences are also studying other important factors for parenting: gender, age, and genetics. It is impossible to study the concept and essence of genetics without studying the structure of neuron functions [4]. Scientists suggest that the functioning of the human brain can be represented as a system of "modules" that depend on genetics; they develop and work independently. Age also presupposes certain patterns that cannot be cancelled or imposed; however, they can be amenable to social influence. These patterns can be both positive and negative [5].

The purpose of this study is to analyse the concept and principles of neuropedagogy. This paper discusses examples of the application of neuropedagogy in practice. The experience of the introduction of neuropedagogy is analysed, and an objective assessment of methods and profitability of the introduction of this science into the educational process and the education system is developed. The advantages and disadvantages of this system are assessed, the possibilities of introducing neuropedagogy into higher educational institutions of

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Kazakhstan are considered. Opportunities for improving the education system by introducing neuropedagogy techniques have been assessed. Practical recommendations have been developed for teachers, facilitating communication with students, motivating them, and increasing their academic performance. Scientific articles of foreign researchers were also considered and analysed.

## **MATERIALS AND METHODS**

Theoretical methods of cognition, as well as the analysis of scientific articles, became the methodological basis for conducting this study and studying neuropedagogy and its influence on the educational process. This study was based on theoretical methods of scientific cognition. The following methods were used: historical method, methods of synthesis and analysis, comparative method. The comparative research method is based on the consideration of individual mechanisms of behaviour and psychological acts compared to similar phenomena in other organisms. The comparison method is one of the most common methods of scientific cognition. It provides an opportunity for the researcher to study similar and distinctive features for certain objects and phenomena. In the context of this study, a comparative analysis of the classical techniques of pedagogy and innovations, namely neuropedagogy, was carried out. The comparative research method formed the basis for comparing and defining the distinctive features of neuropedagogy. Positive factors and techniques in neuropedagogy were identified to improve the education system, specifically the educational process in universities and other higher educational institutions.

The historical research method is based on the study of historical documents and facts. It involves the study of material, with a reliable study of events and facts. This method allowed to study the origin and development of the concept of neuropedagogy, to explore the components of neuropedagogy. It allowed studying the process of the emergence of this term, namely, the emergence of neuropedagogy as a result of the merger of three sciences. Neuropedagogy arose through the fusion of psychology, pedagogy, and neuroscience. Also, the principles underlying the concept of neuropedagogy and on which this science is based are analysed. The principles of neuropedagogy are considered and analysed in detail, as well as the foreign experience of introducing neuropedagogy into the educational process. The practical application and

the positive and negative aspects of introducing neuropedagogy into the educational process are analysed.

Methods of synthesis and analysis are used to study the concept of neuropedagogy and its influence on the educational process. The method of analysis allowed us to assess the concept of neuropedagogy and all its components qualitatively, also allowed us to consider the emergence and implementation of neuropedagogy in the educational process. The emergence of neuropedagogy and how this scientific industry can improve educational institutions' educational process, particularly in Kazakhstan, are analysed. The synthesis method allowed us to systematise and structure information about neuropedagogy. It also allowed us to study the concept of neuropedagogy to assess the positive and negative factors of influence on the educational process. This method helped to track similar and different aspects of neuropedagogy and classical approaches to education. The existing practical methods and recommendations for the introduction of neuropedagogy into the education system are analysed. Highlighted and analysed practical recommendations for teachers. Techniques have been developed that teachers can apply in practice during the educational process.

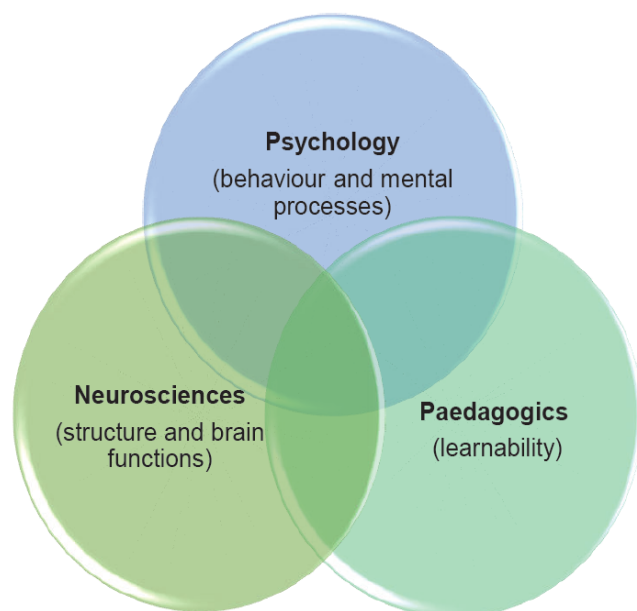
Scientific articles of authors from different countries were analysed. Various theories about the prospects and possibilities of introducing neurosciences into the education system are considered. At this stage, researchers in neuropedagogy are not inclined to agree. Scientists believe that neuroscience is still underdeveloped, and the human brain is still understudied. Scientists have yet to study the positive and negative aspects of introducing neuropedagogy techniques into the educational process. However, some of them have already developed a definite opinion and are inclined to believe that at this stage of development, neuropedagogy cannot provide the educational system with innovations for modernisation and improvement. Smeyers calls neuropedagogy a new sub-discipline and is quite critical of it. Cuthbert notes that currently, there are few resources and neuroeducation-related material in the public domain and believes that this industry needs development and new research. Bowers is convinced that educational neuroscience is heading in the wrong direction. After analysing the available work, it can be concluded that all researchers note an insufficient amount of resources for the study of neuropedagogy and the need for further research. However, it is impossible not to mention the

positive factors of the introduction of neuropedagogy. The introduction of neuropedagogy into the educational process implies that students and teachers establish communication, introduce diversity, and other positive changes.

## RESULTS

### The Concept and Principles of Neuropedagogy

Neuropedagogy is a science that has combined other sciences, namely neuroscience, psychology, and pedagogy (Figure 1). The key role in neuropedagogy is given to educational psychology. Neuroeducation implies the development of certain educational skills in students. Neuropedagogy is a new field of research; it involves scientists and teachers' cooperation to develop and improve this science. This area uses the latest advances in psychology, education, cognitive science, and neuroscience to improve teaching techniques and methods and improve the educational process [6]. Neuropedagogy and the educational process in its context involve the use of neuroscience. The basic task of neuroscience is to provide students with knowledge about how the human brain works, stimulate it, and activate cognitive and other brain functions, stimulating its development. Neuropedagogy, as a separate branch of pedagogy, has only recently received its definition [7]. The opportunity to single out neuropedagogy as a separate branch appeared only in the last decade. Accordingly, this scientific branch is at the initial stage and requires the development and further study.



**Figure 1:** Components of neuropedagogy.

The emergence of neuropedagogy provoked scientists to highlight the basic principles on which this branch of knowledge is based. The study considers the basic principles of neuropedagogy. The first principle of neuropedagogy is based on the assertion that the brain is a parallel processor. This means that the human brain is capable of performing several functions simultaneously. Such complex processes as thinking, emotions, and imagination can occur simultaneously with the processes of processing and studying information. Also, the human brain can process information while simultaneously socially and culturally interacting with other people. Guided by this principle, the teacher is recommended to provide a variety of opportunities for the full involvement of students in a variety of activities [8]. For example, use different forms, content, different methods, and techniques.

The second principle of neuropedagogy is based on learning and cognition being natural processes for the human brain. This principle says that the human brain needs to acquire new knowledge constantly. The third principle is based on the assertion that the human brain can rely on previous experience and search for meaning [9]. This means that the brain is always looking for the interrelation between the current task and previous experience. Also, scientists are inclined to think that comprehension and understanding of new situations are based on previous ideas and experience. In the context of this principle, the updating of previous knowledge is an important factor for obtaining new ones. The fourth principle is the constant search for meaning through the establishment of certain patterns. There is a claim that disorder and chaos slow down and complicate the human brain's productive activity. Thus, the nature of the human brain tends to seek patterns and meaning in any messy situations. Consequently, the learning process is effective in the development of the brain by overcoming difficult intellectual tasks, namely, searching for meaning by establishing patterns in the problem under study [10].

The fifth principle is based on the assertion that emotions are necessary for the human brain's productive functioning. Neuropsychologists argue that human emotions and the cognition process are inseparable and occur in parallel. Consequently, there is a need to create a favourable environment and emotional background for students in the learning process. Scientists tend to believe that the material covered will be better remembered in a favourable emotional atmosphere; emotions also stimulate the thinking process and creativity. The sixth principle of

neuropedagogy is based on the fact that the human brain is capable of synthesising and analysing incoming information simultaneously.

The seventh principle of neuropedagogy is the natural ability of the human brain to perceive information simultaneously under conditions of peripheral perception and focused attention. The human brain's ability to perceive information beyond the immediate attention of a person has been scientifically proven. This means that the student simultaneously perceives both the teacher's words and the sounds of the environment, for example, the sounds of cars outside the window, noise from the corridor, and other extraneous sounds. Provided the professional use of peripheral perception of the brain, teachers will be capable of using this feature of the brain to improve learning. During the brain functioning, the processes of consciousness and subconsciousness occur simultaneously. This is the basis of the eighth principle of neuropedagogy. During the educational process, students receive a massive amount of information. Some peripheral signals, such as sounds, words, gestures, or images, unconsciously enter the brain. This feature can be taken into account and used by teachers. The ninth principle of neuropedagogy is the principle of visualisation. Students will better understand and remember the material covered with the use of the visual-spatial memory system. Consequently, the use of images and other visual materials helps the teacher ensure better absorption of information for students.

### **Neuropedagogy in the Educational Process**

The main fields of application of neuropedagogy are schools. At this stage of development, neuropedagogy was more common in schools and private educational institutions for children. However, this science and its advantages can be highly appreciated by teachers of higher educational institutions and students. Neuropedagogy can help solve several key problems of the educational process and improve it. Neuropedagogy can contribute to solving such problems of the educational process: to study and develop the potential of each student, to improve the methodology and didactics of the educational process, to prevent poor student performance. Below is a closer look at each task of neuropedagogy.

The first and foremost task of neuroeducation is to explore and develop the potential for each individual

student and group of students. Neuropedagogy is designed to study the behavioural processes that occur in study groups. A separate task is the study of subjective and personal interrelations in groups of students. Also, neuropedagogy solves the problem of studying the principles according to which a common neuropedagogical space is established in groups. Developing the potential of each individual student, neuropedagogy studies the processes of the human brain that are responsible for the learning and development of the student's nervous system [11]. The second task is to improve teaching methodology and didactics. The educational process methodology includes a set of methods, techniques, and operations of practical and theoretical development of information. The concept of didactics means the art of teaching, namely, practical application. The task of neuropedagogy is to integrate scientific cognition into the educational process. This can contribute to improving the quality of teaching, as well as developing new educational strategies. The final goal of neuroeducation is to prevent poor student achievement. Neuroeducation helps to anticipate and find possible risks and difficulties that may arise in the learning process. Through the use of scientific methods, it is possible to identify students who have problems and disorders. Neuroeducation provides an opportunity to study the cognitive impairments that can lead to poor student performance and also helps to train the student to overcome problems and difficulties. Teachers' main goal is to make the educational process as effective as possible for students, to provide them with the opportunity to receive and master the curriculum of a particular discipline in a quality manner. In the context of neuropedagogy, teachers should study how the human brain works, how the processes of memorising, processing, recording, storing and recalling information occur. Scientists tend to believe that neuroeducation programmes provide educators with an opportunity to improve student performance.

Teachers should study the theory of neuropedagogy, as well as further apply theoretical knowledge in practice during lectures and seminars with students. The key recommendations for the application of neuropedagogy in practice are: to create a positive emotional atmosphere during the lesson, to apply emotional teaching methods, to use different teaching methods and styles, to maintain optimal environmental conditions, to use different methods of repetition of the material studied, to explain to students

the usefulness of the information under study, to give students feedback.

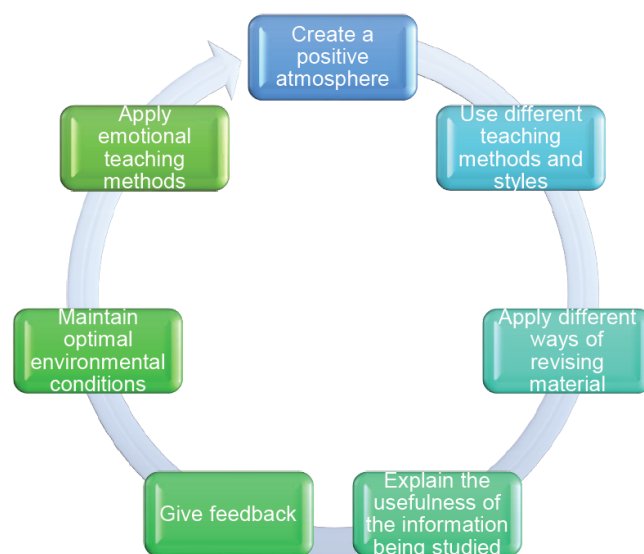
The introduction of practical methods of neuropedagogy will help improve the educational process and improve the performance of Kazakh students. The key is to create a positive emotional atmosphere for students. An important task facing the teacher is to create and constantly maintain a positive atmosphere in the classroom. It is important to build a friendly and trusting relationship with students. The teacher must keep emotions under control, create a favourable atmosphere, as well as be positive, and, if possible, avoid unnecessarily stressful situations and conflicts with students. A small stress factor can positively affect students, motivate them, and keep them active. On the other hand, too stressful situations negatively affect productivity and, consequently, the academic performance of students.

Another task of the teacher, by their example, is to teach students to control negative emotions, including stress. The use of emotional teaching methods is conditioned by the close interrelation between emotions and memory. Scientists have proven that a person is more likely to remember information or events that provoked certain emotions. The educator must adhere to this neuroeducational strategy by creating an emotional connection with a particular discipline. To create emotional connections, teachers are encouraged to use certain techniques and exercises to involve students in the material of the discipline. An emotional connection can be established in the following ways: a teacher can tell a story, use challenging images (pictures) during the lesson, mix and combine different types of emotions during the lesson [12]. Student performance can be improved by different learning styles. Also, teachers are encouraged to use a variety of assignments and teaching materials during class. It is recommended to use a variety of techniques because each student remembers information and educational material in their way. For example, some students can be attributed to visual learners, others to kinaesthetic learners. It is recommended to use audio, photo, and video materials. This will increase the efficiency of the learning process for all students.

Scientists have developed a theory that people tend to perceive information better under certain conditions. By creating a dynamic lesson structure, the teacher will manage to include all students in the process, as well as increase their level of attentiveness. Another

effective technique is to maintain order and an aesthetically pleasing atmosphere in the classroom, as well as daylight. Thus, students will feel comfortable [13]. It is not recommended to use fluorescent lighting in classrooms or lamps that do not provide enough light. The most effective and common way to memorise information is a regular revision of the learned material. However, teachers note that students are often bored of revising information in the same way.

Neuropedagogy provides students and teachers with the opportunity to diversify this process through different exercises and tasks. An important factor in optimising the educational process is student motivation. Teachers can motivate students to study disciplines by explaining to them the applied value of studying a given subject. With the help of the key strategy of neuroeducation, teachers will be able to create metaphors and analogies in real exercises, research, setting up experiments, studying causality, analysing the possibilities and prospects of students in the context of the practical application of a given discipline (Figure 2) [14]. Feedback for students plays a key role in neuroeducation. Feedback implies that the educator will complement the student and point out opportunities for improvement. The correct explanation of student's mistakes and regular motivation is crucial.



**Figure 2:** Practical methods of neuropedagogy.

Over the last decade, many countries have already started introducing neuropedagogy into the educational process. Neuropedagogy is rapidly being researched and introduced into the educational process in France. At the beginning of the 21st century, the Centre for Research and Innovation in Training of the

Organisation for Economic Cooperation and Development was established. It was created to bring together neuroscientists, neurophysiologists, educators, psychologists, medical professionals, sociologists, and other professionals from more than 30 countries. The main purpose of this Centre is to study neuroscience and make it accessible to teachers and students, as well as improve the educational process with its help. French scientists have been investigating issues related to neuroscience for several years and are looking for ways to introduce it into the learning process for schoolchildren and students.

## DISCUSSION

Neuropedagogy is a new science; it has not yet been fully researched. At present, scientists have yet to study all the positive and negative aspects of introducing neuropedagogy techniques into the educational process. In his scientific article, Smeyers examines a new scientific area, namely neuropedagogy and neuroeducation [15]. He calls neuropedagogy a new sub-discipline. The author is rather sceptical of neuroeducation. His opinion is that neurobiology should not be sold for the educational sphere as a miraculous solution to all the problems of the modern education system. The author considers some principles and methods of neuropedagogy to be worthy of attention, and the authors of this study concur with his opinion. Furthermore, the author insists that neurosciences are a very interesting subject matter, and discoveries in these areas will continue to amaze scientists around the world for decades to come.

In Cuthbert's article *Teaching & Learning Guide for "Neuroscience and Education – an Incompatible Relationship"*, the author examines the process of popularising neurosciences, particularly neuropedagogy [16]. He believes that the popularity of neurosciences in recent years is conditioned by the fact that science has the public authority and is viewed as something that can provide certainty. In this aspect, neuroeducational discourse is consistent with the pre-existing discourse of fear and risk aversion. Cuthbert notes that currently, there is a limited amount of resources and material in the public domain that are directly related to neuroeducation and discusses that this industry requires the development and new research. Having reviewed Cuthbert's works, the authors of this study support the conclusion that neuroeducation has been understudied so far.

The article *"The Next 50 Years of Neuroscience"* presents the achievements of neurosciences over the

past fifty years and considers possible paths for the development of neurosciences in the future [17]. The authors of the article suggest that over the next fifty years, society may see a broader application of neuroeducational strategies depending on the age and educational environment of students. The authors noted the outstanding contribution of neurosciences to understanding how students with dyslexia, attention deficit hyperactivity disorder, and other disorders learn. The authors of this study agree with the author's assertion that despite progress, cognitive psychology and neuroscience have not found widespread use in teachers' standard educational practice in both primary and higher education. At this stage in the development of neuroeducation, it is important to note that the basic principle of neuropedagogy, namely the interweaving of art and science education, has allowed students who study through neuropedagogy programmes to find more creative and innovative approaches to problem-solving. The authors note that the development of the neuroscience industry continues to strengthen its considerable potential.

In his study *"The Practical and Principled Problems with Educational Neuroscience"*, Bowers is inclined to a different opinion in neuroeducation matters [18]. The author is convinced that educational neuroscience is heading in the wrong direction. The author of the article believes that currently strong claims about the success of educational neuroscience are trivial, or unfounded in the meaning that the recommendations are based on misconceptions of neurobiology, or the conclusions do not follow from neurobiology. Bowers believes there are no examples yet of new and useful neuroscience-based learning proposals. In part, the authors of this study agree with the above convictions since there have been no new and revolutionary discoveries in neuropedagogy in recent years. The author believes that the only way to study and introduce neurosciences into the educational process is to conduct behavioural research in psychology. The author emphasises the need for neuroscience to characterise how the brain functions change during learning, including classroom learning. Hence, the author is convinced that although neuroscientists cannot help teachers in the classroom, teachers can help neuroscientists by changing the brain functions of their students. However, there is another opinion regarding neuroeducation.

In the article *"The emerging role of educational neuroscience in education reform"*, Janet Zadina examines educational neuroscience from the standpoint of a key factor in the modernisation of the



educational process [19]. The author is inclined to believe that neurosciences are capable of revolutionising the educational system. She says that currently, society is on the verge of new discoveries and views on education, according to which scientists and teachers can work together on educational reform. The author emphasises that despite the reform of education in the context of neuropedagogy currently seems to be a distant future, and changes are already close. And with fruitful joint work, this process will only accelerate. Another author who agrees with Zadina is Manuel Martín-Loeches [20]. Moreover, the author claims that neuroeducation looks extremely promising and fruitful shortly. Martín-Loeches believes there is no need to wait to see the benefits that neuroeducation can bring to education today. He also believes that neuroscientists, along with other qualified specialists, should become part of the groups that make decisions about the education system since they are significantly ahead of the political and economic interests of states. The author believes that there is no need to hesitate; enough useful knowledge has already been accumulated to introduce neuropedagogy into schools and universities. While supporting the author in his statements about the benefits that neuropedagogy can bring, it is important not to forget that this science is still imperfect and requires further study.

## CONCLUSIONS

Having analysed and studied all the available information regarding neuroeducation, some conclusions and statements can be made about the degree of research of this science, the principles on which it is based, and possible implementation methods in the education system and the educational process. In the context of this study, the concept of neuropedagogy was analysed. Neuropedagogy constitutes a scientific branch that emerged in the process of combining other sciences. Neuropedagogy includes psychology, pedagogy, and neuroscience. The development of neuropedagogy provoked scientists to highlight the basic principles on which this branch of knowledge is based. The study considered the problems that neuropedagogy can solve. The main recommendations for the application of neuropedagogy in practice are: to create a positive emotional atmosphere during the lesson, to apply emotional teaching methods, to use different methods and styles of learning, to maintain optimal environmental conditions, to use different methods of repeating the material studied, to explain to students the usefulness of the information under study, and to give students feedback.

The information that was investigated within the framework of this study suggests the cost-effectiveness of introducing neuropedagogy into higher educational institutions. At present, the influence of neuropedagogy on the educational process has been understudied. However, the principles and techniques of neuropedagogy cannot harm students. These innovations will be capable of improving communication between students and teachers, improving educational methods by providing teachers with different methods of presenting the information. Also, teachers will be capable of involving more students in the educational process. Consequently, despite the lack of in-depth research of neuropedagogy and contradictory opinions of scientists, the authors of this study are inclined to believe that the introduction of neuropedagogy into higher educational institutions of Kazakhstan is expedient. The applied value of the material lies in the possibility of developing a system for the implementation of neuropedagogy in higher educational institutions of Kazakhstan.

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## REFERENCES

- [1] Williamson B. Coding the biodigital child: The biopolitics and pedagogic strategies of educational data science. *Pedagogy, Culture & Society* 2016; 24(3): 401-416. <https://doi.org/10.1080/14681366.2016.1175499>
- [2] Taguchi H. "The concept as method": Tracing-and-mapping the problem of the neuro(n) in the field of education. *Cultural Studies. Critical Methodologies* 2016; 16(2): 213-223. <https://doi.org/10.1177/1532708616634726>
- [3] Aronsson L. Reconsidering the concept of difference: A proposal to connect education and neuroscience in new ways. *Policy Futures in Education* 2019; 18(2): 275-293. <https://doi.org/10.1177/1478210319850437>
- [4] Cuthbert A. Neuroscience and education – An incompatible relationship. *Sociology Compass* 2015; 9(1): 49-61. <https://doi.org/10.1111/soc4.12233>
- [5] Kraft V. Neuroscience and education: Blind spots in a strange relationship. *Journal of Philosophy of Education* 2012; 46(3): 386-396. <https://doi.org/10.1111/j.1467-9752.2012.00868.x>
- [6] Rueda C. Neuroeducation: Teaching with the brain. *Journal of Neuroeducation* 2020; 1(1): 108-113. <https://doi.org/10.1344/joned.v1i1.31657>
- [7] Kumar S. Neuroeducation and learning. *Research Nebula* 2016; 5(2): 155-158.
- [8] Di Jorio D. Synaptic plasticity and learning processes: A neuroeducation perspective. *OBM Neurobiology* 2020; 4(2): article number 7. <https://doi.org/10.21926/obm.neurobiol.2002063>
- [9] Nouri A. The basic principles of research in neuroeducation studies. *International Journal of Cognitive Research in Science Engineering and Education* 2016; 4(1): 59-66. <https://doi.org/10.5937/IJRSEE1601059N>

- [10] Doukakis S. Exploring brain activity and transforming knowledge in visual and textual programming using neuroeducation approaches. *AIMS Neuroscience* 2019; 6(3): 175-190.  
<https://doi.org/10.3934/Neuroscience.2019.3.175>
- [11] Miller R. Neuroeducation: Integrating brain-based psychoeducation into clinical practice. *Journal of Mental Health Counseling* 2016; 38(2): 103-115.  
<https://doi.org/10.17744/mehc.38.2.02>
- [12] Smyrnaïou Z, Riopel M, Sotiriou M. Recent advances in science and technology education, ranging from modern pedagogies to neuroeducation and assessment. Newcastle: Cambridge Scholars Publishing 2016.  
<https://doi.org/10.1007/978-3-319-22933-1>
- [13] Pastena N, Minichiello G. Neuro-phenomenology and neuro-physiology of learning in education. *Procedia – Social and Behavioral Sciences* 2015; 174(1): 2368-2373.  
<https://doi.org/10.1016/j.sbspro.2015.01.902>
- [14] Thomas M, Ansari D, Knowland V. Annual research review: Educational neuroscience: progress and prospects. *Journal of Child Psychology and Psychiatry, and Allied Disciplines* 2019; 60(4): 477-492.  
<https://doi.org/10.1111/jcpp.12973>
- [15] Smeyers P. Neurophilia: Guiding educational research and the educational field? *Journal of Philosophy of Education* 2016; 50(1): 62-75.  
<https://doi.org/10.1111/1467-9752.12173>
- [16] Cuthbert A. Teaching & learning guide for “Neuroscience and education – An incompatible relationship”. *Sociology Compass* 2015; 9(2): 156-160.  
<https://doi.org/10.1111/soc4.12239>
- [17] Altimus C, Jones Marlin B, Ekavi Charalambakis N, Colón-Rodríguez A, Glover E, Izbicki P, Johnson A, Lourenco M, Makinson R, McQuail J, Obeso I, Padilla-Coreano N, Wells M. The next 50 years of neuroscience. *Journal of Neuroscience* 2020; 40(1): 101-106.  
<https://doi.org/10.1523/JNEUROSCI.0744-19.2019>
- [18] Bowers JS. The practical and principled problems with educational neuroscience. *Psychological Review* 2016; 123(5): 600-612.  
<https://doi.org/10.1037/rev0000025>
- [19] Zadina J. The emerging role of educational neuroscience in education reform. *Psicología Educativa* 2015; 21(2): 71-77.  
<https://doi.org/10.1016/j.pse.2015.08.005>
- [20] Martín-Loeches M. Neuroscience and education: We already reached the tipping point. *Psicología Educativa* 2015; 21(2): 67-70.  
<https://doi.org/10.1016/j.pse.2015.09.001>

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