

# BENEFITS AND OBSTACLES IN IMPLEMENTATION OF NEUROSCIENTIFIC APPROACH IN EDUCATION

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**Abstract:** *Although relation between brain and education is known for long time, facts known about brain organization and functioning were not found to be useful in the process of education till recently. New field named as Neuroeducation, or Mind, Brain and Education is interdisciplinary scientific field that merge Neuroscience and Education in order to implement knowledge from brain science into process of education. The main scope of Neuroeducation is to investigate relations between biology of cognitive processes on one side, and learning and education on the other side. Birth of Neuroeducation as a “child” from “unnatural marriage” between Neuroscience and Education as parents, opened many questions but also great expectations. In this paper we summarize benefits and obstacles in the relatively new field of Neuroeducation trying to predict its further development and outcomes.*

**Keywords:** *neuroscience, neuroeducation, education, brain*

## 1. INTRODUCTION

Neuroeducation or Educational Neuroscience, also known as “Mind Brain and Education” is a new interdisciplinary scientific field that brings together two traditionally different and nonfamiliar areas of Neurosciences and Educational Sciences [1]. Learning is common issue for both scientific areas. Education is about enhancing learning, and neuroscience is about understanding the mental processes involved in learning. In a broad view, researchers from several different domains as cognitive neuroscience, developmental cognitive neuroscience, pedagogy, educational psychology, educational technology, and other related disciplines joined their efforts in order to investigate the relationship between the biological basis of mental processes and the process of education. There are many important issues concerning this “unnatural marriage”, for example, in education, biology is an aspect of the child, whereas in neuroscience, the child is an aspect of biology.

Although relation between brain and education is known for long time, facts known about brain organization and functioning were not found to be useful in the process of education till recently. It is well known that it is not absolutely necessary for someone involved in the process of education to acquire knowledge about brain organization and functioning in order to be able to teach or to learn. Nevertheless, knowing how brain works might be helpful in designing learning techniques and learning tools. In practical terms, the research results obtained in Neurosciences will be implemented in the formation of curricula for individual educational subjects. Also, this knowledge will influence the design of teaching strategies, as well as the design of teaching tools. Knowing that for example some of the students suffer from neurological developmental disease that affects brain functions is most obvious case in which syllabus of certain teaching subject must be acquired to this specific student.

Neuroeducation has great potential in improving the learning capabilities of students with ADHD, dyslexia, and dyscalculia. In addition to being explicitly supportive for students with learning disorders, the neuroscience learning theory offers effective learning strategies for all students. At large, in order to meet the needs of learners, educators must have a foundational understanding of their brain organization and functioning.

Generally, Neuroeducation integrates classical behavioral approaches from educational sciences and modern methods from the area of Neuroscience with the aim of examining the process of acquiring knowledge and other topics relevant to the process of education [2]. On the one hand, Neuroeducation is based on the statements and experiences of the respondents, ie. recording their behavioral effects in solving certain tasks, while, on the other hand, combines them with neuroscience methods which primarily include functional brain imaging and electrophysiological signal recording. Obviously, the main scope of Neuroeducation is to investigate relations between biology of cognitive processes on one side, and learning and education process on the other side. Thus, investigators from the field of neuroeducation require skills and knowledge from these two quite different and unfamiliar sciences.

One of two key drivers behind the neuroeducation initiative is understanding how neuroscience can inform education strategies. The second is finding out what teachers want and need to know about the way in which students learn since each individual learns their own way. As a final result, neuroeducation has the potential to ease the process of studying as well as the process of teaching bringing benefits for both students and teachers. Therefore, Neuroeducation has the potential not only to inform but also to transform processes of teaching and learning.

## 2. NEUROSCIENTIFIC APPROACH IN EDUCATION

It is evident that curriculum in schools and at universities has transformed in response to changes in society, pedagogy and technology. As technology and especially computers became an asset in classrooms, all schools appropriately encompassed that instruction in the syllabus. Many schools and universities depending on the states in they are situated made similar education program curriculum alterations in response to changes in society such as multiculturalism, languages that are spoken, attitudes towards specific social and science issues, etc. Nowadays when the neuroscience research implications for teaching are also a precious classroom benefit, it is time for instruction in the neuroscience of learning to be encompassed as well in professional teacher education [3].

Even before neuroscientific approach in education, it was known that motivation and challenges are able to activate certain areas of the brain that help to learning process. We also knew that we learn more and better in interaction with other people than individually. Nowadays, within neuroeducation new or partially modified classical research paradigms of educational sciences are applied, which examine topics such as: learning; attention; development of verbal expression; reading and writing; acquisition of mathematical knowledge; the importance of emotions, motivation and environment for the learning process, etc.

*Learning* is the ability possessed by humans, animals, and some machines, and it is defined as process of acquiring new understanding, knowledge, behaviors, skills, values, attitudes, and preferences [4]. This process is tightly linked to the feature of the brain well known in neuroscience as “brain plasticity” or “neuroplasticity”. *Attention* refers to the brain processes allowing us to focus on some aspects of our environment, excluding others. Process of learning as a basic process in education acquires focusing on some specific stimuli for prolonged period of time, excluding other stimuli that are not important for learning. *Verbal expression* is one of the milestones of each individual motor, cognitive and social development and important prerequisite in the process of education. *Reading and writing* are basic skills necessary in order to expand knowledge during long period of formal education, but also during education as life long process. Acquisition of *mathematical knowledge* is important in order to understand quantitative relations and for further implementation in technology. The importance of *emotions, motivation and environment* for learning process is more than evident. Designing the environment with positive emotional and motivational stimuli together with social interactions might significantly improve process of education, therefore there are often labeled as cognitive enhancers [5]. Learning can be a solo or a group experience, and neuroscience can inform which approaches are the best depending on the learning goals.

Researchers in the area of Neuroeducation use knowledge in the field of cognitive neuroscience to develop new technologically advanced tools for learning to read, mathematics, foreign languages, etc. The methodology of combining the behavioral approach of monitoring the achievements of the subjects and recording brain activity enables research of various problems in the field of education, such as: learning efficiency of different types of materials, influence of positive and negative stimulation on knowledge acquisition, influence of developmental disorders on learning process, etc. Finally, in order to apply neuroscientific approach in education some fundamental facts should be noticed. Although all human brains have the same pattern of organization and functioning, each brain is unique and therefore reacts in its own way to stimuli, and that changes it. Without a doubt learning depends on environmental influences and positive influences might strongly improve it, but learning is also strongly determined with genetic predispositions and individual mental processes.

Several academic institutions around the world are beginning to devote resources and energy to the establishment of research centers focused on educational neuroscience research. The Johns Hopkins University School of Education’s Neuro-Education Initiative (NEI) was founded in 2008 through a cooperative effort of the School of Education and the School of Medicine’s Brain Science Institute. It links research and practice through the subsequent initiatives [6]:

- connecting the gap among research from the science of learning and educational practice through regional and national conferences and institutes;
- providing courses of study through the Mind, Brain, and Teaching graduate certificate EdD doctoral specialization;

- giving online professional development modules that provide Continuing Education Units, micro badging, and competency-based assessments;
- growing innovative research in the learning sciences to inform educational practice, policies, and products
- expanding, piloting, and prototyping NEI innovations through school and non-profit partnerships, and collaboration with various entrepreneurial organizations.

It is important to notice that Neuroeducation studies should be totally distinguished from previous initiatives such as “brain-based learning” or “brain-based education” [7]. Brain – based education has been strongly criticized for propagating misunderstood, misconnected, oversimplified, and or overgeneralized conceptions regarding neuroscientific facts resulting in ‘neuromyths’. Using knowledge about brain function in the educational process should results in:

- identification of student’s personal requirements;
- more stimulative teaching methodologies;
- profounder assimilation of information;
- respect for each individual’s cognitive potential.

### **3. BENEFITS IN IMPLEMENTATION OF NEUROSCIENTIFIC APPROACH IN EDUCATION**

Neuroeducation is already showing an impact on educational theories and practice although it is a relatively new scientific discipline, with a limited number of experimental studies so far, Teachers pay more and more attention in their work to education based on knowledge about the development and functioning of the brain. In one recent survey of teachers, almost 90 % thought that a knowledge of the brain was important, or very important, in the design of educational programs [8]. Evidently, classroom teachers show great enthusiasm for neuroscience as well as a strong desire to learn about the mind and brain Thus, knowledge of the differences in the functioning of the child, adolescent, and adult brain can significantly contribute to the planning of educational interventions in each of these groups [9]. For example, in accordance with this knowledge, learning foreign languages is appropriate before puberty, ie already in kindergarten or early primary school age [10] More precisely, extensive research shows that there are sensitive periods, but not critical periods, during which an individual can acquire certain aspects of language with greater ease than at other times [11].

Apparently, there is extensive difference in learning capacity among various people. Some persons struggle to learn in all domains, while others have specific problems as language, literacy, numeracy or self-control. These individuals are at increased hazard of poor social adaptation and unemployment. The costs to society are thus substantial and there is an urgent need to find educational approaches that will work. Could application of research in the field of neuroeducation determine the difference in the acquisition of knowledge between students who literally remember the facts (learn by heart) and those who acquire new knowledge with a certain algorithmic strategy? Does the brain make a difference when applying these two ways of learning?

One study examined differences in brain region activation when solving new arithmetic operations using previously mentioned two approaches [12]. Students were shown arithmetic problems in which it was necessary to apply a new fictional arithmetic operation with which they were just introduced. The first group of students learned to solve tasks using a memorization learning approach, so that they remembered which values from the task needed to be combined in order to get a result. Another group of students solved the same arithmetic problems strategically, by learning an algorithm for converting given values into a final result. Using magnetic resonance imaging brains of students from both groups were monitored during task solving. The students who learned to solve tasks by heart showed greater activity of parts of the brain involved in remembering verbal information and the use of verbal repetition strategies. The group that strategically solved tasks showed greater activity in parts of the brain involved in executive processes and visual-spatial processing of information. This investigation showed that different approaches in the strategy of solving the same arithmetic tasks lead to the activation of different brain structures and imply different cognitive mechanisms. Different cognitive mechanisms used in learning between students further imply that in order to improve this process teacher need to present facts in a module that favorize learning that is not based on simple visualization and remembering the facts without their deep understanding. By studying this type of research, teachers will also be able to distinguish those practices that are least effective. It is also clear that it is crucial for learning and memory to organize and link information that is adopted with other relevant or previously learned knowledge in order to be more persistent. Previous research in the field of neuroeducation shows that the left inferior prefrontal cortex is primarily involved in such design [13].

Recent research in the field of neuroeducation is devoted to examination of topics such as: individual differences in learning, learning strategies, understanding mathematical concepts, evaluating programs to help students with learning difficulties or adaptive technologies to help learning [2]. Particular importance for the field of special education and rehabilitation is the fact that neuroeducation is increasingly turning to the examination of cognitive and neural mechanisms that underlie various forms of learning difficulties. Much neuroscientific research has focused on more specific learning difficulties, such as developmental dyslexia and developmental dyscalculia, where mastery of reading or mathematics pose unusual difficulties for the child. Based on such studies, education and teaching strategies that are

adapted to different forms of individual differences are developed. Neuroscience techniques can potentially be used in education to differentiate between delayed and atypical development in learning disorders or to monitor progress in the application of a particular program in such individuals [14].

In recent years, early learning "neural markers" for certain learning disorders have been identified. For example, neural markers for dyslexia indicate an increased risk of newborn to develop disorder later during school age [15]. Even though study has shown there are brain correlates, or markers, for learning difficulties, these markers are delicate and composite. Therefore, it is not possible to forecast or assess an individual's specific learning disability from a brain scan. This is because even within a diagnostic category, such as developmental dyslexia, there is substantial anatomical variation from one individual to another [16]. Besides, even when a genetic risk or neurological base for a learning disability can be recognized, this does not mean the individual is unteachable. Rather, it means that it is required to recognize the precise barriers to learning for that person, and eventually find alternative ways. The research of dyslexia, by means of a combination of behavioural and neuroimaging methods, demonstrates that it is imaginable to define neuro-cognitive barriers to learning and to make propositions for appropriate teaching methods.

Neuroscientific discoveries can often recognize a precise locus for a specific kind of learning difficulty. Although they may not determine the precise method of intervention that should be taken, they may propose the nature of the concept or skill to be targeted, and the kind of cognitive activity that needs to be reinforced [16]. Definitively, one of the main challenges in the field of neuroeducation is to translate discoveries from neuroscience into practical tools that teachers can use in their daily work.

In short line, there are evident benefits of neuroscience approach in education. There is necessity for teachers to be prepared with foundational knowledge of brain functioning in order to understand, evaluate, and apply the neuroscience of learning. Knowing how certain apparatus (in this case brain) works could be of great help in teaching other people how to effectively use it. This will increase the effectiveness of their teaching and build and sustain students' joy of learning. Teachers should be armed with the knowledge and tools that will prepare their students for the future changing and globalized world that acquire long life learning and constant learning of new skills. These skillsets are those pronounced in the neurology literature for long time, and they remain the brain networks that can be strengthened so all students can participate in the opportunities and challenges in higher education. Till application of neuroscience in education research only behavioral studies and measurements were accessible. Functional brain imaging helps in mapping brain regions that are active during process of learning. Teachers need to understand "the why" and not just "the how" of the most effective teaching strategies in order to have the motivation and positive expectations and to best utilize these strategies. Teachers' awareness of the vast potentials of neuroplasticity increases their opportunities to influence the development of their students' brain networks.

#### **4. OBSTACLES IN IMPLEMENTATION OF NEUROSCIENTIFIC APPROACH IN EDUCATION**

As with any innovative initiative, there are intrinsic barriers to implementation of neuroscientific approach in education. Joining theory and practice can be quite difficult. This difficulty is present especially during transfer of neuroscience research to the classroom. Moreover, there is a systemic challenge in amalgamation dissimilar fields of study as neuroscience and education are. Finally, additional perpetuation of neuromyths may stymie labors to endorse neuroeducational approaches.

There are opinions that neuroscience and education represent so different areas that a relationship between them which will result in practical results will never be established. Varma and associates believe that all criticisms of neuroeducation can be classified into two groups: the so-called. theoretical, or scientific and pragmatic [17]

Probably the strongest of the theoretical critiques is the one that refers to the presumed impossibility of researching the most important issues within the educational sciences using the methods of neuroscience. Neuroscience methods require some simplification of the studied phenomena, while excessive control in educational research may reduce the value and applicability of the collected data. Neuroscience is characterized by a certain reductionist approach, which is not considered appropriate to the educational context. Therefore, a multidisciplinary approach and a combination of different research approaches are required for the educational field [18]. In addition, theoretical criticisms refer to the fact that the very localization of cognitive functions has no direct significance for the work of teachers working in the education system. The fact that it is known location does not say anything directly about the function, its development, potentials, factors that affect it, etc. The methodological approach cultivated by neuroscience itself is questionable, because according to some researchers, education and neuroscience are irreconcilable areas: education deals with behavioral and neuroscience with physical phenomena [17].

Pragmatic critiques state that the methods of neuroscience are too expensive and too complicated to apply within the educational context, as well as that the results obtained by such research are not practically applicable in educational institutions. More conservative researchers in the field of education believe that neuroscience threatens the independence of educational sciences, as well as that certain knowledge from neuroscience is often misinterpreted and turned into a kind of "neuromyth". For example, the media often reports "how most people use only 10% of their brain capacity" and offers various programs that will allow them to "improve their cognitive abilities to full 100% efficiency." There is also the neuromyth of the visual, auditory, and kinaesthetic (VAK) learning styles, suggesting that every child

has a dominant learning style, which should be identified to teach each of them more precisely according to their preferences. Actually, some researchers classified all neuromyths in to a core group of 7 "classic" neuromyths including: items related to learning styles, dyslexia, the Mozart effect, the impact of sugar on attention, right-brain/left-brain learners, and using 10% of the brain [19]. For these reasons, one of the main tasks of neuroeducation is to enable the direct exchange of knowledge between neuroscience and education professionals, avoiding intermediaries from the teaching aid industry, who have a commercial interest in selling funds based on such "neuromyths" [20] .

## 5. CONCLUSION

Although achievements of Neuroeducation are growing, the partnership between Neuroscience and Education have not been as successful as first hopes suggested it should be. Like in most marriages, in order to have full partnership two partners in the relationship should be willing to work closely with each other and to share resources. The problem can only be overcome by neuroscientists and educators working together to find mutual goals upon which they can both agree. Solution for overcoming practical barriers in implementation of neuroscientific approach in education is most probably in appropriate training in suitable areas and shared experience, through which neuroeducation can reach its full potential. Neuroscientists should be skilled in science communication and stimulated to produce rudimentary reports on research, while educators should obtain elementary neuroscience training and training in research methods. Taking all mentioned before, it is too early to give final answer to the question is Neuroeducation applicable in the classroom.

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