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# Educational Neuroscience, Educational Psychology, and Classroom Pedagogy as a System

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**Abstract** This paper introduces a view of educational process as a 3-layer system comprising human brain, personality psychology, and classroom pedagogy. It aims to present a classroom as a place where educational neuroscience and educational psychology meet to result in effective pedagogy. The paper demonstrates the advantages of such approach for mathematics education. Among them are understanding of mathematical anxiety as a defensive reaction of the brain on operating memory overflow, finding gifted and talented students objectively, assertion of possible limitations on the educational goals given unfavorable conditions, restricted time of information perception, limited liability of teachers and instructors for the success of their students, and opportunities for better outcomes when group learning, peer leadership, or cross-discipline teaching and learning are implemented. As examples of applications, a technology - based teaching technique MARTA and Virtual/Augmented Reality are discussed.

***Keywords:*** *pedagogy of mathematics education, educational neuroscience, educational psychology, systemic approach, educational technology, AR/VR teaching and learning*

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## 1. Introduction

This paper aims to present a classroom, tangible or virtual, as a place where educational neuroscience and educational psychology meet. These two areas, in spite of differences in theory and methodology time and again mentioned in the literature, share pedagogy as a common field of applications. From the educational neuroscience - educational psychology point of view, some important indicators of effective teaching and learning, such as retention and graduation rates and success rates on tests - are just proximate indicators. They are determined by the fundamentals, namely the mass, volume and structure of brain tissues and the ability of the brain to absorb, accumulate, and store the flows of biopotentials. At the lower level, the fundamentals are the subject of the educational neuroscience study, while at the higher level it is the educational psychology that explores the functionality and the outcomes of the brain activity.

This research field is an area of intensive study in the recent years, as demonstrated, for example, by publications of [1,6,7,10,11,22,27-32,37,40,41,44,45,48,56,57], to name just a few. The specific objective of this paper is to provide a systemic view of their results and map the theoretical findings onto classroom settings.

An intensity and scope of knowledge transfer result from the quality of educational processes. From the educational neuroscience point of view, these processes initiate and govern the flow of the biopotentials aimed to form specific domains in the brain that allow one to achieve the desired educational results. Educational psychology, in turn, studies the functionality of the human brain and the roles of its specific zones in the educational processes. In other words, it explores the ways of action of the brain in the process of performing educational functions.

Practical pedagogy, to be successful, should implement the findings of both educational neuroscience and educational psychology to find out the ways of optimization of the educational processes. Understanding of the interrelations among these three areas allows us to objectively evaluate the opportunities and efficiency of specific educational strategies and practices. In particular, the suggested approach states that school teachers should have limited liability for the success of their students because the latter may or may not be able to achieve the stated educational goals due to insufficient development of specific brain zones. On the other hand, consideration of the educational process from the educational neuroscience - educational psychology point of view allows for the optimization of teaching and learning based on the right estimation of the learning characteristics of the median student. These may be, in particular, the determination of the dominant "learning style" of a particular group of students, estimation of the average capacity of working and long-term memory, evaluation of the typical time-related characteristics concerning the ability to store information for a long period of time, and the capability of critical analysis of new information attained from different sources at different moments in time.

Understanding the basics of the educational neuroscience and educational psychology allows the pedagogy practitioners to perceive the mathematical anxiety as a natural defensive reaction of the brain aimed at avoiding the operating memory overflow. On the other hand, educators should understand that the inability of the brain to store the biopotentials for a long period of time may form the natural threshold to knowledge accumulation. This phenomenon, if present, may limit the highest level of education available to a particular student.

The necessity for close cooperation of the educational neuroscientists and psychologists was mentioned in the literature, for example, in [40], but this paper develops this idea further, aiming its practical use in the classroom settings. Educational neuroscience, educational psychology, and classroom pedagogy are considered as three layers of a unified system. The main focus of this paper is mathematics education.

It should be mentioned that the human brain may be improved by special types of training or medications that may affect the educational process. This particular topic falls beyond the scope of this paper, but educators, students, parents, and guardians should keep it in mind and act correspondingly when needed.

The paper is organized as follows. Sections 2 and 3 provide brief reviews of the educational neuroscience and educational psychology, respectively, from the point of view of the objectives of this paper. Section 4 considers practical pedagogical outcomes that follow from the proposed approach, and section 5 contains concluding remarks.

## 2. System Layer One - Educational Neuroscience

Educational neuroscience is a scientific discipline that studies the neural mechanisms of education. As [42] points out, educational neuroscience is potentially able to resolve the core problems of education. From the information processing theory perspective, educational neuroscience may be considered as the study of the "educational hardware", based on the perception that the human brain is a system comprising about 100 billion neurons (neuron cells) passing signals to each other via approximately 1,000 trillion synaptic connections. This “brain computer” eventually is responsible for the learning processes and outcomes. The outer layer of the neural tissue is referred to as the cerebral cortex. It is divided into two cortices, left and right, and into five lobes: frontal, parietal, occipital, and two temporal; see, for example, http://serendip.brynmawr.edu/bb/kinser/Structure1.html for detail. It is commonly accepted and supported by experimental studies that particular brain zones are responsible for specific brain functions as pointed out, for example, at http://cognitrn.psych.indiana.edu/busey/Q301/BrainStructure.html, where the brain zones are shown at the brain cross section. It is commonly believed that the parietal cortex plays the most important role in the acquisition and storage of mathematical knowledge though the location and functioning of the mathematics - related domains are still in need of further exploration. Also, different points of view of brain functioning exist as well, as mentioned, for example, in [21].

Publication [33] presents one of the most popular models of the mathematics subject cognition, namely the triple-code model proposed in [17]. This model states that the number sense "quality" subsystem comprises the bilateral horizontal intraparietal part of the brain. It is responsible for the nonverbal semantic representations of size and distance relations between the numbers on a mental number line in connection with the performance of the magnitude comparison of the numbers together with the estimation tasks. Another "verbal" subsystem represents numbers in a verbal format. It engages a region of the left angular gyrus. This subsystem is used when the well-learned arithmetic facts, for example, addition and multiplication tables, are reclaimed. Finally, the "visual" subsystem that operates with the numbers in Arabic format, number comparison, subtraction and counting, and approximation uses the posterior superior parietal lobe. The correspondent brain areas were experimentally found in the fMRI - based research reported in [17].

Educational neuroscience studies the processes that occur during the study of mathematics by using the means of contemporary technology. They include magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI), electroencephalography (EEG), and near-infrared spectroscopy (NIRS). Magnetic resonance imaging (MRI) is an imaging technique aimed to visualize the internal structures in detail. It makes use of the property of nuclear magnetic resonance (NMR) to image nuclei of atoms. An MRI scanner is a device in which the patient lies within a large, powerful magnet where the magnetic field is applied, and radio frequency fields systematically alter the alignment of the magnetization. The MRI is a means of the brain tissue research. The functional magnetic resonance imaging (fMRI) measures brain activity by detecting associated changes in blood flow. The primary form of fMRI uses the blood-oxygen-level-dependent (BOLD) contrast. This technique can detect the spatial activity within millimeters though its time window is limited to just a few seconds. Publication [35] presents an example of the fMRI image aimed at the investigation of the patterns of the brain activation in the process of problem solving. Electroencephalography (EEG) is recording of electrical activity along the scalp aimed to measure the voltage fluctuations in the brain in the process of problem solving. Typical EEG procedures measure electrical activity over a time period of 20 to 40 minutes with millisecond - range temporal resolution not possible with fMRI. However, its spatial resolution is limited. A snapshot of an experimental situation using the electroencephalography may be found in [39].

Near-infrared spectroscopy (NIRS) is a spectroscopic method of the brain activity research that uses the electromagnetic spectrum from 800 nm to 2500 nm. When a specific brain zone is activated, the localized blood volume in that area changes and this activity may be detected by the optical imaging devices.

Neuroscience suggests a lower neuron-level description of the brain processes. The brain processes are viewed as the neurons potentiation and biopotentials structuring. At the next system level - that of educational psychology – the neuron clusters are viewed as working and the long-term memory, intelligence, types of learners, etc. In relation to educational psychology, the educational neuroscience studies reveal that the main location of the working memory is the prefrontal cortex, while the long-term memory related neurons are spread throughout the brain. The transition from working to the long-term memory is made via the hippocampus. Thus, from the educational neuroscience perspective, the learning process is regarded as forming new domains in the memory and setting up connections among them. At some moment the learning process reaches the stage when a new brain structure is having been formed - a new construct, in terms of educational psychology. This point in time is referred to in educational psychology and pedagogy as the “Aha!moment, eureka moment, or eureka effect,” per [7]. With time, the newly created structure is transferred to the part of the brain corresponding to the long-term memory and becomes a pattern. One of the common goals of the educational neuroscience and educational psychology is to make this moment to occur as quickly as possible and with least possible efforts on both sides - the student's and the instructor's.

In this way, educational neuroscience is able to suggest alternative opportunities of teaching and learning, based on direct impact on the human brain, resulting in neurons potentiation and forming the desired brain domains.

## 3. System Layer Two - Educational Psychology

Educational psychology is the study of learning processes from cognitive and behavioral perspectives. It provides a higher, than that of the educational neuroscience, layer of study of teaching and learning processes. Educational psychology is based on the fundamental research by [8,9,18,25,43,53,54], just to name a few. It operates with the notions of memory, intelligence, information processing, level of comprehension, etc. To some extent, educational psychology may be considered as the study of the "brain operating system" that runs the functional modules of "pedagogical applications" in the environment of the "brain hardware". Educational psychology studies the brain zones responsible for acquisition, processing, storage, and retrieval of educational information. The level of the ability of the brain to respond adequately to a claim to solve a problem is considered by the educational psychology as proximity to the educational goals.

For the objectives of this paper, the most important dimensions of the educational psychology are the theory of multiple intelligences, information processing theory, and constructivism. The information processing theory is the study of how the human brain attains, stores, and structures the new information during the learning process. The constructivism emphasizes that it is the prior knowledge and experience of the learner that underlies the learning process. The difference in the abilities to acquire and process the information of different nature is interpreted in [20] as the existence of the learners of different types. The following main learning styles are mentioned in the literature: visual, auditory, read-write, and kinesthetic. Another way of the study of different abilities of the human brain is the statement of multiple intelligences, [25]. This approach actually may be traced back to the work of Plato some 2,500 years earlier as mentioned in publication [26]. Literature sources point out the musical–rhythmic and harmonic, visual–spatial, verbal–linguistic, logical–mathematical, bodily–kinesthetic, and some other types of intelligence. It may be mentioned that from the educational neuroscience perspective, differences in the learning types or in the level of the development of diverse intelligence is due to the fact that some parts of the brain are better developed than other parts as well as to the individual differences in the brain structure and the distribution of biopotentials.

Human memory - its activity and performance in the process of learning - are among the cornerstones of educational psychology. The long-term memory is viewed by some educational psychologists as one of the central elements of human cognition. When a specific problem is posed, the brain attempts to find a similar pattern in the long-term memory and use it to find a solution, [14]. On the other hand, the working memory is crucial for solving the problems that do not have patterns. Publications [3,14], and [36] stress the relationship between complexity of the mathematics problems and the amount of working memory involved in the process. Publication [14] states that the working memory can hold information for about 30 seconds and can allocate it to up to seven different objects. As a matter of practical applications, it should be mentioned that some students may have even lower working memory capacity limited to just four elements and can keep the information for shorter periods of time. If this is the dominate type of students in a classroom, the teaching style should be adjusted appropriately.

From the perspective of this paper, the learning process is the acquisition and processing of the new information and pushing it deeper into the long-term memory. This process is not as straightforward as it may seem to be. The ways of the information transfer are not fully investigated. Examples are known when students cannot acquire all of the facts presented during a classroom period or even later in the semester, but reconstruct it much later in situations that may seem just marginally related to the original study. This observation should be kept in mind when a particular teaching technique is implemented and specific educational goals set up.

In this paper below, we follow [34] and [51] in the description of the relationships between educational psychology and educational neuroscience. From the point of view proposed in these publications, the neuroscience of mathematical cognition and learning of mathematics are the creation of active or potentially active zones in the human brain and memory structuring. As mentioned in the literature, the brain always tries to connect new information to that already stored in the memory and related to the same or a related area of knowledge. From this perspective, the success of a learning process depends on a variety of factors: the conductivity of the verbal, visual, and spatial channels through which new information is delivered to the brain, the level of informational noise in the channels, the amount of working memory available, the conductivity of the channels connecting working and long-term memory, the level of general development of the brain tissues, etc. This observation explains, in particular, the importance of multi

- channel delivery of information and significance of using several teaching tools simultaneously. This phenomenon is well-known in conventional pedagogy: using several information delivery methods for teaching is more advantageous than any one alone. Also, the right way to start a classroom period may be of crucial importance - it makes the students focused on the subject by diminishing the level of informational noise.

Publication [49] underlines the fact that the brain has limited capability of information processing. In particular, students' attention cannot be quickly and easily relocated among different parts of an object or from a big picture of the object to the details of its components. The brain has limited capacity and tends to deliver faster detection of global details than the structure of smaller parts - the "global precedence effect" mentioned in [38]. It was also mentioned in [3] and [12] that students may have difficulties in the perception of mathematics concepts and performing computations and thus, experience mathematics anxiety simply because of the deficit of the working memory.

From the educational psychology point of view, an instructor should try to make as many connections among the existing zones in the human memory as possible, [14]. In particular, making connections to real-life situations is a useful way to improve the perception of mathematics. In this way, the new information is automatically related to a broader set of memory domains and therefore has a higher opportunity to be successfully saved in the long-term memory. In certain cases all standard teaching techniques may be ineffective. Such cases include deficit of working memory that may result in mathematics anxiety, weak long-term memory that precludes the storage of the new facts for a reasonably long time, and excessive information noise in the channels that makes a barrier to the information acquisition, [3]. In such cases, only substantial memory improvement may help. If this situation is not appropriately recognized and managed, the mathematics instructors assigned to teach classes with many students of this type may suffer poor performance evaluations.

Literature sources stress the importance of providing assignments of progressive difficulty, so as to cause the brain zones be trained to work appropriately. It is important that the assignments would vary in complexity, wording, and applications in order to activate broader regions of memory. By just increasing the volume of similar assignments, an instructor cannot achieve the goal of improved student perception or achievement. An appropriate use of technology may help to resolve some issues. By using educational technology, an instructor can simultaneously satisfy the different needs of the learners of different types, teach the students having different levels of preparation, and adequately address the students with essentially different volumes of working and long – term memory. These findings of educational psychology form the basis of some essential issues of classroom pedagogy considered in the next section.

## 4. System Layer Three - Classroom Pedagogy

A classroom is a place where educational neuroscience meets educational psychology to form a foundation of effective teaching and learning. In this paper below, we follow [51] to present a connection between them able to improve the practice of classroom pedagogy. In the framework of the suggested approach, teaching and learning mathematics is viewed as an interactive process of creation of mathematics-related domains in the human brain. These domains act as mathematics knowledge centers. Learning mathematics is regarded as the process of strengthening the existing domains, forming new ones, and establishing or developing the connections among them. We refer to this approach in this paper below as neuro-mathematics education (NME).

The NME approach allows for a new insight into the mathematical abilities and paves the way for development of new teaching tools, strategies, and techniques. In particular, it stresses the principal importance of elimination of mathematics anxiety – the main barrier to success in mathematics. Among the new tools for teaching mathematics are active development of mathematical intuition, which is a skill of finding solutions to the problems without following formal rules, using hypnopedia and hypnosis, and instruction delivery in the multifaceted interactive environment, just to name a few. The goal of the NME is the creation of a positive mental environment for perception and storage of mathematical information: concepts, notions, rules, techniques, etc. Literature sources and our personal teaching experience present evidence that the assertion of the neuroscientific nature of mathematics education has positive impact on teaching techniques.

Professional mathematicians and mathematics educators tend to underestimate mental challenges related to learning mathematics. The following evidence may serve as an example, [19]: "… In spite of trying a myriad of popular methods (modified Socratic, self-paced instruction, mastery learning, etc.), what I produced … was ineffective teaching. I was a good lecturer, enthusiastic about teaching, serious in my attempt to do it well, and I cared about my students. They liked me and my courses, but from everything I could see, they were not learning much more than students of other teachers, and that was woefully inadequate." A possible reason for such relative lack of success may be the fact that this particular mathematics instructor was unable to break through the mental barrier of a median student. It is worth mentioning that the same authors suggest a possible explanation of this observation. Their publication reads: "… As a young student of functional analysis, I had considerable difficulty with the idea of the duality of a locally convex space. I was fine with the notion of a linear functional that acted on elements … to produce numbers… But the idea of applying actions to these transformations, …equipping <them> with arithmetic and …topologies, was really tough for me." It may be mentioned that for a functional analysis student (that is an individual having passed the courses in calculus, mathematical analysis, linear and abstract algebra, and differential equations, to name just a few) the situation was completely standard. A student was just required to equip an abstract space with algebraic and topology structures, which are the operations that are quite ordinary at the level of the functional analysis study. However, as the authors mention, it was a challenge. Acting later as a mathematics professor, this same student was unable to recognize and overcome the same type of problems that faced him previously. Thus, it was the lack of knowledge of the neuroscientific component of mathematics education that was the actual reason. It was incumbent on this professor to recall his own problems and try to deliver the new knowledge in the most acceptable way, namely in the way able to form the corresponding domain in the brain at the pace relevant to the median student.

As another example, consider teaching fractions in a slightly more rigorous than usual way - by using the equivalence classes. This way of teaching may be needed in the elementary mathematics courses taught for the pre-service teachers. Publication [55] puts a question in this regard: "What is so hard about equivalence classes of ordered pairs of integers?" - that is the suggested way of teaching fractions. The author avoids consideration of the problem of how difficult such way of teaching fractions may be if corresponding brain domains have not been properly formed and trained. This way of presentation, while very convenient for the trained mathematicians, may pose significant difficulty in perception when presented to unprepared audience. Many of us are familiar with the same problem that occurs in school geometry. When introducing the notion of congruent triangles - equivalence classes - instead of equal triangles, the problem occurs if the notion of equivalence was not presented and ingrained to the level of comprehension well in advance.

From the educational neuroscience perspective, the problem of teaching technique optimization may be stated as finding the preeminent way to develop domains in brain and the interconnections among them able to allow a free flow of the biopotentials. Considering classroom pedagogy from this perspective, a TIER principle may be proposed. It states that the learning process should be thoughtful (T), interesting (I), encouraging (E), and rewarding (R). The T-component requires that in the process of learning a student should use his intelligence rather than just the ability to memorize. Another point, the I-component, states that the process should be of interest to the student. This does not necessarily mean the relationship to real-life problems, but the student should clearly understand why this problem is set up, what its solution means, and how it could be used. As stated by the E-component, the solution, when found, should inspire the student to investigate further. Lastly, the R-component states that every student should be rewarded after each class period. It may be done as a verbal praise, a credit towards the final grade, or a small present. From the educational neuroscience perspective, this means that a path should be paved from the domain just formed to the pleasure center in the brain. No matter how weak this path may be at this time, it will be strengthened later after several repetitions.

This paper also claims that the brain of the students revealing high level capabilities in mathematics may have some specifics with regard to the tissue structure and biopotentials distribution similar to those mentioned for geniuses like Einstein; see [23] for detail. This observation may explain the fact that some financial firms tend to hire trained mathematicians for the positions that actually require little or even no math. The reason is that the mathematics graduates may be genetically inclined and college-trained to acquire large amounts of information, sort and structure it, and to process step-wise using complicated algorithms. This observation, in its turn, fosters a question: how may mathematical abilities be recognized objectively and as early as possible? One of the probable solutions of this problem is suggested in [50], based on the findings presented in [2] and [16]. The proposed approach is based on using contemporary technology of neuroscience (functional magnetic resonance imaging (fMRI) or electroencephalography (EEG) to find individuals having exceptionally well- developed mathematics – related brain zones leading to exceptional abilities to solve 'untrained' problems. Such an approach is test-free and provides fully objective results, thus eliminating race- or gender - related selection problems and any disadvantages for youngsters from families with lower socioeconomic status.

Publications [13] and [51] present another example of practical application of the suggested approach in a computer-intensive classroom environment. The corresponding teaching technique was named MARTA - the Multilevel Alternating Recursive Teaching and Assessment approach. In the framework of MARTA, each course is conveniently divided into sections, topics, and units as shown in Figure 1. In this figure, symbols T and A stand for teaching and assessment, respectively. This structure suggests that the classroom contact time (the innermost element in this scheme) is a building block of the teaching and learning process. It is developing further by embracing the outer blocks related to topics, sections, and the course as a whole. The T-block brings the bio-potentials to the desired part of the brain, while the A-block reactivates them thus aiming to form or strengthen a domain. By using an educational computer system, a student may proceed on his own in a classroom or at home. The process continues to the following unit until a group of them forming a topic is covered. At each step, a new domain is formed, and after a series of domains has been formed, an assessment process combines them into a domain of the higher level. Cyclicity and recursiveness of the suggested process allow for the information delivery to the working memory repeatedly and its transfer to the long-term memory, at an optimal pace.

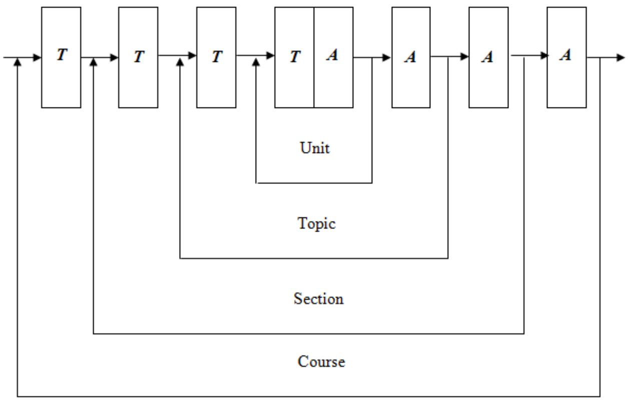


**Figure 1.** MARTA functional structure. T stands for teaching, A - for assessment. Source: [13]

Instructional technology plays a crucial role in this process. It allows facilitating the resolution of many of the learning problems. Thus, it provides an individualized pace of learning and places stress on flipped courses and independent study. By using technology, a student has access to a practically unlimited number of similar problems for guided or independent practice. When conveniently organized, the process of teaching is student-oriented, activity-based, and reminiscent of a computer game. Potentially, it allows one to achieve significantly better results with less personal communication between an instructor and students. On top of that, the assessment process is permanent.

New opportunities for the implementation of the suggested approach are provided by the means of Augmented (AR) and Virtual (VR) Reality, as presented, for example, in publications [24,46,47], and [52], to name just a few. Augmented reality is integration of digital information with the user's environment in real time, while in virtual reality artificial environment is presented in a way that the user accepts as actual reality. Both provide the learning-by-doing environment. AR/VR environment allows for making learning mathematics interesting, attractive, interactive, and efficient. Tangible means of the AR/VR environment include goggles, hearables (smart headphones) and sensors aimed at reception of voice, handwriting, and body language. Educators and psychologists should work together to make this way of education the mainstream and to prevent unintended consequences caused by the extensive use of technology.

Viewing mathematics education from the educational neuroscience - educational psychology perspective allows for suggestion of alternative teaching tools for the future. Among them are meditation aimed at better concentration and focus on material presented in a classroom, medication aimed to promote memory development and improvement, hypnosis leading to the desired knowledge acquisition without overwhelming efforts, and hypnopedia or sleep learning that allows avoidance of using valuable active day time. It should be stressed, however, that practical implementation of all these non-standard teaching tools requires further research concerning their effectiveness and long-term effects. Also, a series of moral, ethical, and other considerations should be resolved, especially in cases when these tools are intended for use for children and youngsters.

## 5. Conclusion

This paper suggests a unified systemic approach to educational neuroscience, educational psychology, and classroom pedagogy. The suggested systemic view assumes that each component is related to different aspects of the teaching and learning processes. Their union results in the synergy leading to the improvement in student learning outcomes as measured by the amount of acquired knowledge and the abilities to use the new information. Educational neuroscience deals with the "brain hardware" that we assume in this study to be a union of brain tissues, structures, and biopotentials. From the educational neuroscience point of view, learning is the accumulation of new and redistribution of the existing biopotentials governed by the teaching process. Selected studies of the brains of the recognized geniuses show that their brains were different from that of the ordinary people with regard to the brain tissues or structure.

Educational psychology studies the teaching and learning process from the point of view of working and long-term memory, intelligence, information processing, level of comprehension, etc. Using a computer analogy, it deals with the "brain operating system" that is the ability of the human brain to manage new information resulting from the teaching process and to form functional structures aimed at solving problems. From this perspective, the multiple intelligences and types of learners theories may be viewed as the preexistence of a set of brain zones responsible for different types of human activity.

Pedagogy is the theory and practice of education. From the point of view presented in this paper, it suggests the tools for the development of useful "brain applications" dealing with different aspects of human life. The TIER principle (Thoughtfulness, Interest, Encouragement, and Rewarding) is suggested as a basis for the successful teaching and learning.

The suggested approach allows for optimization of the teaching and learning process and, on the other hand, for better understanding of its limitations. Thus, if the brain tissues of a median student are not sufficiently developed, due, for example, to age or specific sickness, it is not possible to successfully teach such student community complex disciplines like that of STEM (Science, Technology, Engineering, and Mathematics). The same is true about the insufficient ability of the median student to accumulate biopotentials and store them for a long period of time. In such cases, the sustainable long term progress seems hardly possible.

This paper outlines some practical issues stemming from the suggested approach. Firstly, it opposes the mainstreaming in education that is the practice of placement of underprepared students or those with special needs in regular classrooms. Such approach increases the variance of mental abilities in a classroom and, thus, works against efficient knowledge transfer. In other words, it states that a median student in a classroom will be more successful if the student body is uniform with respect to the brain development rather than from any other perspectives. Secondly, it opposes the consideration of teachers as the individuals deemed fully responsible for student progress and success. For example, two teachers assigned to teach classes populated with rather differently developed students are destined to achieve quite different results. Thirdly, a method of finding STEM genius is proposed. It is suggested that the well-established mathematicians and other STEM-scientists would voluntarily participate in a brain imaging aiming to a database creation. With the help of such a database, any youngster could be investigated for potentially great abilities in the field. Such an approach is fully objective: it is test-free, race-free, gender-free, and socioeconomically neutral. Fourthly, this paper states a new role of educational technology. When viewing the learning process as the formation of the new domains in the brain, the educational technology allows for making it less “painful” and excludes an instructor from micromanaging the memorization procedures.

The MARTA approach (Multilevel Alternating Recursive Teaching and Assessment) is suggested as a teaching technique suitable for a computer-intensive classroom able to combine neuroscience, psychology, and classroom pedagogy. Also discussed are the perspectives, opportunities, and possible problems related to teaching and learning in augmented or virtual reality.

It falls beyond the scope of this paper to consider the efficiency of non-traditional methods of education, such as medication aimed at memory improvement, meditation serving to strengthen the ability to concentrate attention, hypnosis, sleep-learning (hypnopedia), etc. They may be suggestive of the next steps of this research.

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