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EDUCATIONAL NEUROSCIENCE: THE RISE OF A NEW RESEARCH FIELD IN EDUCATIONAL SCIENCES

Educational neuroscience is an emerging research field aiming to bridge neuroscience's discoveries with educational research and practice. Our paper aims to explore the short history of this new field, to define its disciplinary boundaries and relations with other domains such as educational psychology or cognitive neuroscience, and to identify its potential contribution to the educational theory and practice.

A literature review was conducted including the most relevant international academic papers defining educational neuroscience research field. We found that the majority of relevant papers are no older than two decades, given the domain's relative infancy. In our analysis, this new discipline seems to be rather a bridge between brain research and educational psychology in a quest for better learning, even if there are some other disciplines such as cognitive sciences, ethics or social psychology that are offering consistent input to a larger educational conversation in this context.

Concerning the applied nature of this new scientific field, the authors discussing about the foundations of educational neuroscience mainly consider that it is still too early to talk about this but that there are some important initiatives and predictions to be taken into account. Educational neuroscience seems to be a promising source of evidence to feedback educational practice and shape educational policy in the future to come. Therefore, there is a need to delve further into the heated debate and growing conflict on the identification and acknowledgement of problems in this new research field.

Keywords: educational neuroscience, neuropedagogy, neuromyths, evidence-based research.

Introduction

Currently considered as a “bridge” (Bruer, 1997) between the knowledge about learning coming from basic cognitive and neuroscience on the one hand, and the possibilities to apply that knowledge into the educational practice on the other hand (Butterworth & Tolmie, 2013), educational neuroscience brings as much hope as questions to educational researchers, policy-makers and practitioners.

This paper comes to meet their needs aiming to define educational neuroscience and identify its main disciplinary boundaries as well as its potential to help education to provide better learning. Therefore, the questions guiding our review are as follows:

- In this study we conducted *What can history help us reveal about this new emerging field of educational neuroscience?*
- *What other disciplines contribute to this new science and how are these interacting in building a new body of knowledge?*
- *Is there such a thing as applied educational neuroscience? If so, what are its promises and current or future limits and concerns?*

a comprehensive review of the literature defining the educational neuroscience new research discipline, mainly including the most relevant peer-reviewed research found either in books authored and edited by reputable researchers (as for example, the *Educational Neuroscience* book edited by D. Mareschal, B. Butterworth, and A. Tolmie, and *The learning Brain. Lessons for Education*, edited by Sarah-Jayne Blakemore and Uta Frith), or in the most consecrated journals for this field such as *Mind, Brain, and Education* (published by Wiley), *Trends in Neuroscience and Education* (published by Elsevier), *Nature Neuroscience* (published by Springer Nature), *Educational Research Review* (published by Elsevier), *Educational Researcher* (published by SAGE Journals), *NeuroImage* (published by Elsevier), *Educational Psychology Review* (published by Springer), *Learning and Individual Differences* (published by Elsevier), *Educational Philosophy and Theory* (published by Taylor & Francis Group), and *Journal of Philosophy of Education* (published by Wiley).

The article was structured based on the three main questions of our review, starting with historical overview and disciplinary framing, continuing with aspects regarding the applied features of this discipline, and ending with some concluding remarks regarding some limits and concerns that educational neuroscience could bring to education sciences arena and mainly to the educational practice.

The Emergence of Educational Neuroscience: Historical overview and disciplinary connections

In an effort to construct new knowledge, attempts to advance thinking in education as a result of findings in neuroscience could pose serious challenges.

Historical accounts indicate that there have been efforts to combine education and neuroscience since the 1890s. Theodoridou and Triarhou (2009) report the efforts of neurologist Henry Herbert Donaldson and educator Reuben Post Halleck in studying the applicability of neurobiological research findings to education. Moreover, E.L. Thorndike observed in 1926 the importance of brain physiology for educational psychology (Mayer, 1998).

Since the 1990s, the idea of linking these fields has gained substantial attention, as many researchers been devoted to bridging the gap between education and neuroscience (Howard-Jones, 2008; Prudy and Morrison, 2009; Mason, 2009; Coch and Ansari, 2009; Fischer et al., 2010; Baker et al., 2012; Beauchamp and Beauchamp, 2013). The cognitive scientific theories of embodied cognition translated into learning and education research contributed a lot to this (Kieffer and Trumpp, 2012). But nevertheless, there were still considerable hurdles to be overcome. Bruer (1997) advocated for regular and systematic dialogue between researchers from the two distinct domains of education and neuroscience. But it soon became clear that the distance was too considerable at that time. Thus, it became apparent that there was an existing need for a more solid and coherent process of linking the two fields of research.

Several years ahead, Byrnes (2001) brought to light a strong link between many influential theories of psychology and education, such as memory, emotions or attention, and the evidences from the field of neuroscience. To support this view, he wrote the book “Minds, Brains, and Learning: Understanding the

Psychological and Educational Relevance of Neuroscientific Research" in which he further emphasized the need for the education domains to employ in neuroscience research.

Recently, there has been thorough, wide-ranging debate about educational neuroscience as an emergent discipline that addresses in depth "the integration of the diverse disciplines that investigate human learning and development" (Fisher et al. 2007, p. 1). Concepts such as "neuroeducation" (Theodoridou and Triarhou, 2009), "neuropedagogy" (Patten, 2011) or "mind, brain and education" (Fischer et al, 2007) have been used to some extent synonymously with "educational neuroscience".

Szücs and Goswani (2007, p. 114) proposed defining this new field as the "combination of cognitive neuroscience and behavioral methods to investigate the development of mental representations". This definition suggests that the authors plead for a multi-disciplinary approach to educational neuroscience. In order to create usable knowledge that has practical value, a stronger infrastructure for educational research needs to be designed. The multifaceted linking of various disciplines (e.g. biology, cognitive science, developmental science, psychology, and others) has created a multi-way dialogue for the creation of a strong research foundation (Fischer et al, 2010). More definitions appeared (see Table 1), ranging from a more multi-disciplinary to a more inter-disciplinary perspective, and all suggesting a rather applied orientation of this new research discipline (as for example, Campbell, 2011).

The potential utility of neuroscience within the field of education is indisputable. The so-called *mindbrain*, considered the primary object of study in educational neuroscience (Campbell, 2011, p. 12) is very complex. However, the lack of proper communication has given rise to ideas, which are poorly justified, outdated or misinterpreted (Geake, 2008). And these widespread beliefs, the so-called "neuromyths", create problems by building barriers in effectively connecting neuroscience to education. In 2002, OECD defined this concept through its project entitled "Brain and Learning", as a "misconception generated by a misunderstanding, a misreading or a misquoting of facts scientifically established (by brain research) to make a case for use of brain research, in education and other contexts" (OECD, 2002, p.111). Examples of such "neuromyths" comprise of ideas about the assumption that we only use 10% of our brains, left versus right brain thinking and learning, etc. It is a strenuous task to dispel such myths, because, at face value, they appear as an accurate translation of neuroscientific findings. Therefore, it is imperative that communication difficulties should be lessened so that the "bridge" between education and neuroscience to eventually become redundant (Pincham, 2014).

Table 1. List of definitions of educational neuroscience found in the literature

Source	Definition
Sűzcs & Goswami (2007, p. 114)	"... *educational neuroscience* as the combination of cognitive neuroscience and behavioral methods to investigate the development of mental representations."
Fischer et al. (2010, p. 68)	"*Educational neuroscience* is emerging as a new field that brings together biology, cognitive science, developmental science, and education to investigate brain and genetic bases of learning and teaching."
Campbell (2011, p. 8)	"... *educational neuroscience* [is] an area of educational research that draws on, as being informed by, theories, methods, and results from the neuroscience, but unlike an applied cognitive neuroscience, is not restricted to them."
Report by The Royal Society UK, (2011) apud Butterworth & Tolmie (2013)	"Education is about enhancing learning, and neuroscience is about understanding the mental processes involved in learning. This common ground suggests a future in which educational practice can be transformed by science, just as medical practice was transformed by science about a century ago."

Vander Wyk & Pelphrey (2011, p. 633)	"... *educational neuroscience* can be conceived of as the multidisciplinary process of mapping knowledge from the domain of brain science to education."
Patten (2011, p. 94)	"*Educational neuroscience* is seen as a bridge to connect the significant differences between knowledge of neuronal function and how these functions operate and actuate in teacher/learners."
Hruby (2012, p. 2)	"Into the excitement of this neuro-revolution has emerged the promise of an applications-oriented field of educational inquiry increasingly referred to as *educational neuroscience*."
Gayle (2016, p. 95)	"The term *neuroeducation* or *educational neuroscience* refers to how educators use the findings of neuroscience to shape their educational practices."
Bruer (2016, p. 1)	"*Educational neuroscience* is a relatively new and highly interdisciplinary research front. Its objective is to improve educational practice by applying findings from brain research."
Palghat, Horvath, & Lodge (2017, p. 6)	"The Science of Learning (SoL) is an interdisciplinary field (also known as *educational neuroscience*; mind, brain and education; learning sciences, etc.), which is an effort to translate insights about the brain and mind to enhance practices in the classroom."

Educational Neuroscience Contribution to Educational Research, Practice and Policy: The First Steps and Some Further Promises

The Trends in Neuroscience and Education journal (published by Elsevier) is one of the major consecrated journals promoting publications of researchers identifying themselves as educational neuroscientists. We will further use this study case to briefly describe what are the "hot" topics in the field and who and what is researching in the domain.

First of all, it is important to mention that the purpose for which the editors created this publication is "to bridge the gap between our increasing basic cognitive and neuroscience understanding of learning and the application of this knowledge in educational settings" (Sosic-Vasic, Z. & Spitzer, M., n.d.). Therefore, this is seen as a "forum" where researchers from a wide area of research fields with an interest in educational neuroscience publish their original research, reviews or opinion papers, in order to improve educational outcomes and promote evidence based educational policies and practice. Furthermore, the editors are confident that this could help moving further the education science from a "merely field of ideology" to an applied science similar to what medicine became in the last 200 years since the natural sciences offered it a richer understanding of the human body (Sosic-Vasic, Z. & Spitzer, M., n.d.). Concluding, the journal's editors pledge for a more effective translational research, encouraging neuroscientists from all sectors to contribute, and especially those from the developmental cognitive neuroscience.

The journal was founded no more than five years ago. The first number was issued in December 2012 and has been published since (last number launched on June 2017) in over 16 issues totaling 83 publications, of which over 58% are original research articles, 31% are review papers and the rest of approximately 11% are mostly opinion articles such as editorial articles.

Most of the approached research subjects are within one of the following category: (1) the special or normal development of literacy and numeracy skills (i.e. the effect of handwriting on future reading skills of preschoolers or better understanding dyscalculia), (2) the testing of various experimental programs to support better academic achievement in students, or (3) more accurate definitions of what educational neuroscience actually is and how this can really help educational policies and improve practice.

Regarding the research methods used in experimental studies included in the Trends in Neuroscience and Education journal, these vary from more *educational* ones - experimental observation, or cognitive and behavioral tests, to more *neuroscientific* ones - functional RMI, electroencephalography (EEG) and event related potentials analysis (ERP) or the more rarely used, the near-infrared spectroscopy (NIRS), the transcranial direct current stimulation (tDCS), and mathematical modeling.

As about the origin of the authors of these studies (see Figure 1 and Table 2), they are usually coming from research centers and universities specialized mainly in psychology, education, cognitive sciences, neuroscience and psychiatry. Their specialties vary from developmental psychology, to general and special education, from cognitive neuroscience to pediatrics, from neurobiology to pharmacology and medicine, from behavioral sciences to computer science, from didactics to nursing or engineering. Geographically, we can observe the dominance of US, Germany, UK, and Canada.

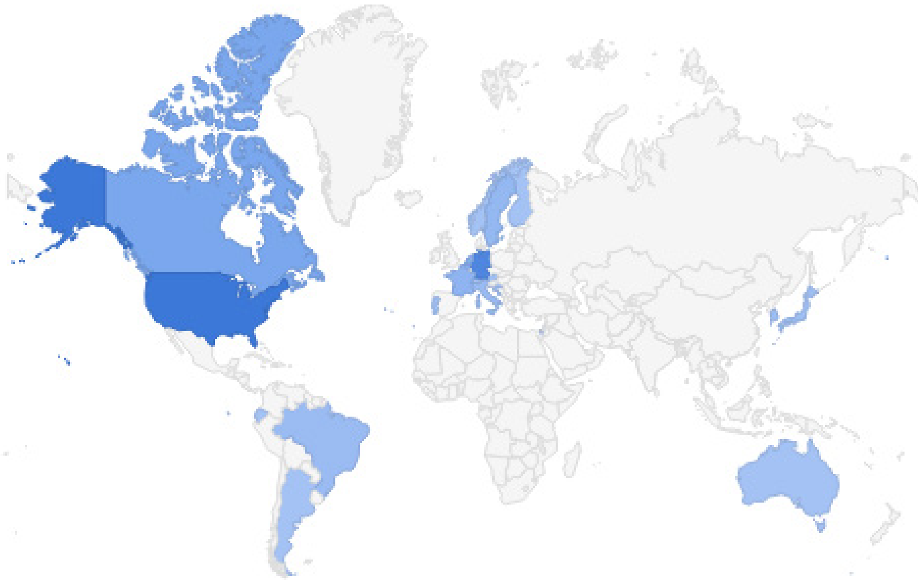

Figure 1. Map of authorship per country of origin in Trends in Neuroscience and Education (from December 2012 until June 2017)

Table 2. Distribution of authorship per articles published in Trends in Neuroscience and Education (from December 2012 until June 2017)

Country	Number of articles	Number of authors
Argentina	1	6
Australia	1	3
Austria	2	3
Belgium	6	14
Brazil	3	6
Canada	9	19
Croatia	1	1
Ecuador	1	5
Finland	1	1

France	5	13
Germany	18	37
Israel	2	5
Italy	3	6
Japan	2	3
Netherlands	6	21
Norway	1	2
Portugal	2	4
Republic of Korea	2	2
Singapore	1	4
Sweden	4	12
Switzerland	1	1
UK	10	27
US	22	49

In the following, we will present four educational neuroscientific studies, three of them representing experimental studies and one being a review paper. The articles were selected as being considered representative for the interests and specific of the research field discussed.

Educational neuroscience study example 1 - The effects of handwriting on preliterate children's brain development

In a study investigating the effects of handwriting on brain development in preschoolers, James and Engelhardt (2012) indicated that for the pre-literate children this experience has a crucial impact on letters recognition ability later in life and thus on their reading skills. The authors suggested that the mechanism behind this correlation is the fact that learning through perceiving variable instances of each letter can further lead to better abstraction of that letter (p. 33). To test this hypothesis, the researchers invited five-year old preliterate children to print, type or trace letters and shapes and then watch images of these stimuli while undergoing an fRMI scanning. As the scans indicated, without any practice, letters and shapes were not processed differently in the children's brains. Although, after the letters printing practice, their brain activated the network usually used in reading and writing, which is correlated with our motor experience determined activation and is also reactivated during visual perception. The results thus indicate that the normal "reading circuit" is recruited during letter perception only after the handwriting experience and not after those of simply typing or tracing letters and shapes. The study supports the general idea that the visual and sensorimotor letters representations are associated to one another both during learning and also during subsequent letter processing as a functional network for reading and writing. As the authors eventually suggest, practitioners should consider the fact that preliterate children are more prone to develop good reading skills if they are taught to write letters by hand before learning how to type them. This would allow them to gain an understanding of the most important perceptual properties of letters and be able to distinguish between those that are crucial for their identity and those that are not (James & Engelhardt, 2012, p.33).

Educational neuroscience study example 2 - The impact of mindfulness training to metacognitive skills and inhibition of irrelevant stimuli of adolescents

In a recent study (2016), Sanger and Dorjee, from Bangor University (UK) used event related potentials (ERPs) to measure the impact on brain indexes of attention processing in 16 to 18 years old adolescents after a school-based mindfulness training. The effects of the training programme on ERPs was measured based on participants' response to irrelevant frequent stimuli and color-deviant non-target oddball stimuli (visual oddball paradigm). Results (based on N=47 self-reports and N=40 ERPs data) indicated improvements in negative thought controllability post-training but no group differences on task performance. Although, regression analysis indicated that the variance of improved target accuracy was explained to a degree of 16% by the satisfaction towards the programme. Therefore, this suggests that a school-based mindfulness curriculum can enhance task-relevant inhibitory control of attention and perceived mental competency for the students of that age by helping them reduce their hypercritical self-beliefs.

Experimental study example 3 - The impact of mathematical education on adult learners' capacity to process large numbers

Another study published in Trends in Neuroscience and Education tried to tackle the impact of math education in number approximation capacity of adult learners (Nys et all, 2013). The researchers conducted two behavioral experiments with three groups of Western adults (a schooled group N=15, an unschooled but instructed group N=15, and an unschooled and uninstructed group N=13). In the first experiment - the number-comparison task, all unschooled groups were slower and made more errors compared to the schooled group when asked to compare numerical symbols and non-symbolic dot collections. Also, the second experiment - the forced-choice mapping task, was experienced as more difficult for these adults, specifically in linking large non-symbolic and symbolic quantities, and in matching purely non-symbolic quantities. Therefore, the adults that did not receive math education had lower number approximation capacities than those that had a form of instruction to help with this capacity. These findings indicate that the acquisition of culturally determined skills can modify core cognitive competences such as numeracy skills.

Educational neuroscience study example 4 - The beneficial effects of physical exercise in education

Published in 2016, the article "Translating the neuroscience of physical activity (PA) to education" authored by Brian M. Gearin and Hank Fien, mainly focuses on the body of research emerged in the past two decades approaching the beneficial effects of physical activity on the brain's structure and function. The benefits are analyzed from a double perspective within the educational setting - that of combating child obesity, which is a mounting concern nowadays, and that of improving academic achievement. The authors are drawing attention that since schools have been called for supporting both above-mentioned matters, it is yet unclear why they are not exploiting more the research on physical activity cognitive effects. Therefore, their review indicated major gaps in understanding how neuroscientific findings can be better translated into practice with the collaboration between educators and neuroscientists preoccupied about how PA programs can be implemented at a reasonable cost. Authors are also indicating important subjects to be further investigated such as the ways mobile technology, differentiated pedagogy, and systematic support structures could be used to support these ends. More longitudinal and large-scale datasets research is called in order to shift the current perspective on PA as a rather "non-academic" class with less "cognitive" stakes. Besides the benefits on changing educator's perceptions about PA's impact on students' health and cognition, Gearin and Fien (2016) are seeing this focus also as a good mean for a better bridging between neuroscience and education.

These were three experimental studies and a review presented with the intention to showcase educational neuroscientific research approach. They were selected as to illustrate different types of research of this new research domain. Thus, the first article, the one presenting the effect of handwriting for students' development is considered as to bring clarifications about the normal functioning of the reading-writing mechanisms. The second article, presenting an experimental training program and its impact for developing adolescents' metacognitive skills, is considered as to introduce innovative approaches to the educational practice. The third experimental study, researching the impact of previous mathematical education experiences for adult learners' numbers processing skills, is considered as to validate current conceptions about the education system and bring proves about its actual benefits. Least but not last, the review included in the above presented series of educational neuroscientific studies, is drawing the attention to some important aspects of the educational system that need to be better regulated by further policies as to integrate existing scientific proves data and. It also reports on the need for more exploration both from education researchers and policy-makers in initiating this type of evidence based research.

Returning to our initial question about the existence of an applied side of educational neuroscience, we can only ascertain that this is in fact meant to be the ultimate goal of this new discipline, as Butterworth and Tolmie (2013) formulated it: "*The goal of educational neuroscience is to work out how all learners can be helped to achieve their learning potentials and to make learning more effective for all learners.*" (p. 2).

However, considering the main contributions of this new discipline to educational practice identified by the literature reviewed, we can only state that this is still in its infancy and initiatives such as using electrical or electromagnetic brain stimulation techniques for boosting mathematical abilities (Cohen Kadosh et al, 2013) or providing personalized education based on full genotyping of students (Thomas, 2013), are still purely experimental or seen as a sci-fi by the teachers or by other educational stakeholders.

Taking this further into the future, M.S.C. Thomas (2013) made some predictions about the evolution of educational neuroscience and its impact on educational practice based on the comparison with the similar impact that science had on medical practice in the last two hundred years. His main predictions are synthesized in the table below as an invitation to reflection for the reader.

Table 3. Predictions about the impact of neuroscience in education (according to M. S. C. Thomas, 2013, pp. 24-25)

Near Future	**Far Future**
(1) Educational neuroscience will be about understanding the reasons why some educational methods that work indeed and why some don't.	(1) We should expect to some "educational placebo effect" similar to the medical practice.
(2) The impact of educational neuroscience will be about small effects aiming to optimize learning.	(2) Possible findings to expect: a. Good teaching can result in more different students; b. Optimal teaching could require students' genotyping; c. Some interventions could lead to side effects; d. Not all abilities can be manipulable as hoped.
(3) Findings will rather be broad than specific, at the level of the curriculum.	(3) Teachers training could be the greatest practical consequence of placing education on a neuroscientific foundation.

Limits and Concerns Regarding Educational Neuroscience

As we have seen so far, the results of educational neuroscience provide useful information about the brain processes involved in learning. They also inform us about different learning difficulties and their connection to brain functioning.

In the literature devoted to the subject, there are some issues that are addressed as important to deal with in order to have a more "objective" view on the results from educational neuroscience and their use for learning improvement.

The first one is that most of the results are obtained in laboratory studies, in which the subject's brains are monitored in order to identify the neural networks involved/activated in different learning processes. But, in these situations, the subjects are insulated from their usual learning contexts from within class/school, so a lot of elements, which are influencing learning, are missing from the laboratory situation. For example, such elements are: human relationships as between students themselves and between students and teachers; peer pressure/conformity issues; obedience to authority; competition and/or cooperation between students; the physical school environment (space, light, temperature, school space design and so on). All this aspects, as shown in many studies of social psychology, anthropology, sociology, cognitive psychology, are having a certain influence on the learning process within each student, either facilitating or inhibiting it (Ansari, de Smedt, & Grabner, 2012).

The second concern regarding the educational neuroscience research is that in order to have a more accurate understanding of the results obtained from studying the brains involved in different learning processes, we must enforce a multi/inter/trans-disciplinary perspective. We need to bring together specialists from different scientific domains, as for example, experts from education, psychology, neurosciences, sociology, anthropology, in such a way that a multi-disciplinary team analyze the results and make sense of them, from a theoretical and practical point of view. As such, we need not only to know what parts/networks of the brain are activated in certain learning situations, but also what elements (social/physical environment, emotional/cognitive issues, etc.) contribute to that activation (OECD, 2007).

The third concern is that the brain, being plastic, is influenced, in his functioning/organization, by behavior and elements of surrounding context. These elements act upon internal personal appraisals of different learning situations and can modify the personal students' input into aspects as: perseverance, retreat, effort, time invested and so on. Also, as studies from social and cognitive psychology show, different non-cognitive abilities, such as self-efficacy, motivation, mindset, self-regulation, are orienting/influencing the learning process, making it more or less efficient towards reaching the target goals. So, there is a tight and reciprocal connection between brain functioning and learning context, the two domains feeding each other. The point to get from here is that we need the results from neuroscience be infused/mixed with insight from social sciences, in order to have a more comprehensive view of brain learning in different contexts (OECD, 2002; OECD, 2007; Immordino-Yang, 2011).

Fourth, the educational neuroscience informs us regarding different learning difficulties, bringing to light different potential causes related to brain structure and functioning. There are two main points to address on this issue: stimulating learning and avoiding stigmatization and learning inhibition. Therefore, we need to know what neural networks are influencing different learning difficulties in order to enhance the learning contexts, methods, in such a way as to supplement from the outside what is missing inside the brain and/ or to make use of other brain networks to supplement the missing links. Also, we need to be aware of the possibility of sustaining the learning inequalities through students grouping by different criteria, including learning difficulties. We have to be cautious not to make the situation of students with learning difficulties even more difficult, by placing them in the wrong/ non-supportive educational contexts and/ or by stigmatizing them (Billington, 2017).

Given the above arguments, we bring forward the last issue, which is teacher training. We need a comprehensive system, in such a way that teachers can use information gathered by sciences in order to better act as learning facilitators. There is a recent trend, which could be a promising beginning: especially in the UK and USA, students are trained in both education and neuroscience, in order to increase the communication and reciprocal inputs between the two domains. Also, the work of different centers that connect/integrate classroom educational practice with neuroscience research on learning is of great importance for a better understanding of the connections between learning, brain and educational contexts (Ansari, de Smedt, & Grabner, 2012; OECD, 2002).

Conclusions

As discussed above, educational neuroscience is a rapidly growing research field that is opening up new innovative conversations about how to facilitate better learning in the educational setting.

As such, it is important to consider the very short history of this new discipline. Basically, this is no longer than a decade, considering the birth of its official naming - "mind, brain and education" (Fischer et al, 2007), "neuroeducation" (Theodoridou & Triarhou, 2009), or the more newly used "educational neuroscience" (Butterworth & Tolmie, 2013). Yet, we can already identify some major elements substantiating it, such as rapidly developing graduate programmes that are training educational neuroscientists around the globe, research centers initiated within the most reputable higher education institutions, and dedicated journals that already published few hundred of specialized articles in the last decade.

When exploring the possibilities of educational neuroscience, one should be aware of its diversity and complexity. As such, the subjects researched are ranging from understanding the very general physiological aspects that influence human learning as sleep, nutrition or exercise, to comprehending brain architectures explaining fundamental processes such as language or reading, and the innovative tools allowing us an early detection of the cognitive deficits in children (Sigman et al, 2014).

Therefore, another important aspect to consider when referring to this new research field should also be the great "epistemological pluralism" of the researchers contributing to its body of knowledge (Palghat, Horvath, & Lodge, 2017). Therefore, as educational neuroscience findings could not be possible without the joint efforts of psychologists, educators, psychiatrists, neuroscientists, computer scientists, philosophers and many other researcher profiles, a knowledge "brokering" should be considered and provided by those coordinating research projects in this area (Palghat, Horvath, & Lodge, 2017).

Lastly, when considering the application of this new knowledge directly to educational practice, one should also take into account several aspects. First, education needs to ensure the safety of the students as so many ethical issues derive from this. Second, teachers and other education professionals involved must be trained as to better understand the implications of the new knowledge they intend to apply to the educational setting. Moreover, the experts coming from outside of education and are interested in developing educational neuroscience research projects, should consider attracting in their teams education specialist to provide enough inside input for their projects.

Looking forward to the future we can only conclude that educational neuroscience is a promising source of evidence for educational practice and policy and that its starting momentum presented in this article should be supported with enthusiasm and openness for collaboration on behalf of the education researchers community.

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ОСВІТНЯ НЕЙРОНАУКА: ВИНИКНЕННЯ НОВОЇ НАУКОВОЇ СФЕРИ В ОСВІТНІХ НАУКАХ

Освітня нейронаука - це нова дослідницька область, спрямована на те, щоб об'єднати відкриття нейронауки з освітніми дослідженнями та практикою. Наша дослідницька праця спрямована на вивчення короткої історії цієї нової галузі, визначення її дисциплінарних кордонів та відносин з іншими областями, такими як педагогічна психологія або когнітивна нейронаука, а також визначити її потенційний внесок в освітню теорію та практику.

На основі аналізу літератури, включаючи найактуальніші міжнародні наукові праці, що визначають напрямки дослідження неврологічної освіти, нами виявлено, що більшість відповідних документів не старші за два десятиліття, що становлять період відносного зародження цієї наукової області. У нашому дослідженні ця нова дисципліна, скоріше за все, являє собою міст між вивченням мозку та психологією навчальних закладів у пошуках кращого навчання, навіть якщо існують інші дисципліни, такі як когнітивні науки, етика або соціальна психологія, які пропонують послідовний внесок у потужнішу освітню дискусію в цьому контексті. Що стосується прикладного характеру цієї нової наукової області, то автори, які обговорюють основи освітньої нейронауки, в основному вважають, що ще зарано говорити про це, але існують деякі важливі ініціативи та прогнози, які варто враховувати. Освітня нейронаука, як видається, є перспективним джерелом доказів, що живлять освітню практику та формує освітню політику на майбутнє. Тому існує потреба інтенсифікувати гострі дебати та поглиблювати зростаючий конфлікт щодо ідентифікації та визнання існуючих проблем у цій новій галузі досліджень.

Ключові слова: освітня нейронаука, нейропедагогіка, нейроміти, доказові дослідження.

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ОБРАЗОВАТЕЛЬНАЯ НЕЙРОНАУКА: ВОЗНИКНОВЕНИЕ НОВОЙ ОБЛАСТИ ИССЛЕДОВАНИЙ В ОБРАЗОВАТЕЛЬНЫХ НАУКАХ

Образовательная нейронаука - это новая исследовательская область, целью которой является преодоление открытий нейронауки с помощью образовательных исследований и практики. Наша статья направлена на изучение короткой истории этой новой области, определение ее дисциплинарных границ и отношений с другими областями, такими как педагогическая психология или когнитивная нейронаука, и определение ее потенциального вклада в теорию образования и практику. Был проведен обзор литературы, включающий наиболее актуальные международные научные документы, определяющие научную область исследований в области нейробиологии. Мы обнаружили, что большинство соответствующих документов не старше двух десятилетий, составляющих период относительного зарождения этой научной области. В нашем анализе эта новая дисциплина представляется скорее мостом между исследованиями мозга и педагогической психологией в поисках лучшего обучения, даже если есть некоторые другие дисциплины, такие как когнитивные науки, этика или социальная психология, которые предлагают последовательный вклад в более крупную образовательную дискуссию в этом контексте. Что касается прикладного характера этой новой научной области, авторы, обсуждающие основы образовательной неврологии, в основном считают, что еще слишком рано говорить об этом, но есть некоторые важные инициативы и прогнозы, которые необходимо учитывать. Образовательная нейронаука представляется многообещающим источником доказательств для обратной связи образовательной практики и формирования образовательной политики в будущем. Поэтому необходимо углубиться в жаркие споры и растущий конфликт в отношении выявления и признания проблем в этой новой области исследований.

Ключевые слова: образовательная неврология, нейропедагогика, нейромиты, научно обоснованные исследования.