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Essays

Neuromitos: desconexión entre la neurociencia y la educación

Neuromyths: disconnection between neuroscience and education

Neuromitos: a desconexão entre a neurociência e a educação

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Resumen

La sociedad experimenta un creciente interés en el funcionamiento del cerebro y la mente humanos, dando origen a la neurociencia. Sin embargo, los hallazgos neurocientíficos, particularmente los relacionados con la *neuroeducación*, han desarrollado un encanto seductor promoviendo versiones distorsionadas, desinformadas, diluidas, exageradas o simplificadas, dando origen a los *neuromitos*. Estas versiones erróneas de resultados científicos validados se han abierto camino hacia las aulas de todo el mundo, trascendiendo la barrera teórica y derivando en acciones que se proponen mejorar el proceso de enseñanza-aprendizaje, adoptando estrategias con escasa base científica.

El propósito de este trabajo es reflexionar en torno a los *neuromitos* educativos, su generación, persistencia y consecuencias. Se presenta un compendio de *neuromitos* vigentes que han encontrado difusión en el mundo mediático masivo a través de influenciadores. Finalmente, se propone el fortalecimiento de la comunicación multidisciplinaria como método de defensa y ataque contra los *neuromitos* difundidos masivamente en el mundo de internet y las redes sociales, con el objetivo final de propiciar ambientes educativos eficaces que aprovechen los avances científicos en neurociencia.

Palabras clave: neurociencia, neuroeducación, neuromitos

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Abstract

Society is experiencing a growing interest in understanding the functioning of the human brain and mind, giving rise to *neuroscience*. However, *neuroscientific findings*, particularly those related to *neuroeducation*, have developed a seductive allure that has popularized misinformed, diluted, exaggerated, or simplified versions, giving rise to *neuromyths*. These erroneous versions of proven scientific results have made their way into classrooms worldwide, surpassing the theoretical barrier and leading to actions intended to improve the teaching-learning process by adopting strategies with little scientific basis. This essay examines educational *neuromyths*, their generation, persistence, and consequences. A compendium of current *neuromyths* that have been disseminated through mass media by *influencers* is presented. Finally, strengthening multidisciplinary communication as a method of defense and attack against *neuromyths* massively disseminated in the world of the Internet and social networks is proposed, with the ultimate goal of promoting effective educational environments that take advantage of advances in neuroscience.

Keywords: neuroscience, neuroeducation, neuromyths.

Resumo

A sociedade vivencia um interesse crescente no funcionamento do cérebro e da mente humana, dando origem à neurociência. Entretanto, descobertas neurocientíficas, particularmente aquelas relacionadas à neuroeducação, desenvolveram um charme sedutor, promovendo versões distorcidas, desinformadas, diluídas, exageradas ou simplificadas, dando origem aos neuromitos. Essas versões errôneas de resultados científicos validados têm chegado às salas de aula do mundo todo, transcendendo a barreira teórica e levando a ações que visam melhorar o processo de ensino-aprendizagem, adotando estratégias com pouca base científica.

O objetivo deste trabalho é refletir sobre os neuromitos educacionais, sua geração, persistência e consequências. É apresentado um compêndio de neuromitos atuais que encontraram difusão no mundo da mídia de massa por meio de influenciadores. Por fim, propõe-se o fortalecimento da comunicação multidisciplinar como método de defesa e ataque aos neuromitos massivamente disseminados no mundo da Internet e das redes sociais, com o objetivo final de promover ambientes educacionais eficazes que aproveitem os avanços científicos da neurociência.

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Palavras-chave: neurociência, neuroeducação, neuromitos.

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Introduction

In recent years, neuroscience and the neurological basis of individual and collective human behavior have given rise to the creation of *neurologisms*. These are novel terminology to differentiate the complex and varied terms born from the interaction of neuroscience and society, such as *neuroethics*, *neuromyth*, *neurorealism*, *neuromarketing*, and *neurobabble* (Illes *et al.*, 2010). The present reflective paper focuses on neuromyths, the allure of contemporary neuroscientific explanations surrounding them, and their relation to the educational field. Its main contribution is the insight that the lack of effective communication of scientific results and commercial greed results in the adoption of activities that negatively impact classroom work worldwide and lead to sterile investments of time and money.

Genesis of the concept

The origin of the term *neuromyth* is attributed to the neurosurgeon Alan Crockard, who devised it in the 1980s to refer to conceptions of the brain with little scientific basis (Crockard, 1996). About twenty years later, in 2002, the term was taken up and modified by the Organization for Economic Cooperation and Development (*OECD*) of the United Kingdom through the Brain and Learning project, which states that a *neuromyth* is a "*misconception generated by a misunderstanding, misreading or misquotation of scientifically demonstrated facts (by neuroscience) to defend the use of brain research in education and other contexts*" (*OECD*, 2002).

According to Newton & Salvi (2020), *neuromyths* come from various sources, such as misinformation by the media, lack of understanding of the specialized language of neuroscience, and limitations of access to reliable sources such as scientific publications, which are practically unattainable for the public sphere in contrast to the information presented by various media, loaded with distortions, simplifications or exaggerations about neuroscientific findings (Zhang *et al.*, 2019).

The aforementioned situations expose neuroscience as a scientific discipline that is particularly prone to misinformation and the dissemination of inaccurate information; a clear example of the spread of *neuromyths* is the case studied by Beyerstein (1999). The author states that the myth that we only use 10% of the brain originated at the beginning of the 20th

century and was marketed through so-called *popular science and self-help books, i.e., self-help books*. This myth, persistent until the 21st century (Gleichgerrcht *et al.*, 2015), is an example of the popularization of misleading information that has been attractive to the public, in general, due to the sensationalism provided by the media for commercial purposes. We are, therefore, faced with two types of distortions of neuroscientific information, one intentional for economic purposes and the other unintentional due to poor communication.

As with pseudoscience, *neuromyths* permeate the collective when accompanied by images perceived as scientific, in this case, brain images. *Neuromyths* are particularly attractive to society because they are endowed with meaning and based on friendly and intuitive explanations of everyday issues, enhanced with sensationalist headlines that evoke the possibility of mind reading or posit a neurogenetic basis *for fidelity*, miraculous cures for motor and sensory afflictions, and memory enhancers among many others (Weisberg *et al.*, 2008; McCabe & Castel, 2008; Dekker et al., 2012; Pasquinelli, 2012). Not surprisingly, they receive widespread media attention, spreading at a notorious and persistent rate, but, above all, worrying, mainly because citizens are accumulating mythical knowledge that potentially derives from behavioral changes (Beck, 2010; Lilienfeld *et al.*, 2012; Howard-Jones, 2014; Cho & Yeh, 2024).

Defining *neuroeducation*

Because *neuroscience research* is primarily aimed at understanding the capacity and mechanism of learning, scientific advances about the brain and its functioning have been particularly welcome in the educational field, where those involved seek more effective ways to achieve knowledge transmission, giving rise to *neuroeducation*, a concept that can be interchanged with *brain-based learning, educational neuroscience, brain-based teaching, "mind, brain and education"* and even, *brain-based parenting* (Frith *et al.*, 2013; Howard-Jones, P. 2016; Bhargava & Ramadas, 2022). According to Bhargava and Ramadas (2022), *educational neuroscience* is a budding interdisciplinary field geared toward impacting student learning outcomes by connecting neuroscientific data on the brain's learning power with pedagogical practices brought to the classroom. This *neurologism* was defined in 2010 by Carew and Magsamen (2010) as an inter-discipline between neuroscience, psychology, cognitive science, and education (Howard-Jones, 2016). However, Howard-Jones (2016) is credited with incorporating biology into the fabric of the disciplines involved in neuroeducation, giving rise to the biological perspective of learning, which has been

integrated into the design of teaching methods, educational policies, and curricula.

While neuroscientists focus their work on "*the air traffic control system*" of the brain, *i.e.*, working memory, cognitive flexibility, and inhibitory control (Allee-Herndon & Roberts, 2018; Wilkinson et al., 2019); educational decision-makers around the world, but mainly teachers, have drawn on advances in *neuroeducation* to devise strategies to improve the teaching-learning process and remedy the adverse outcomes of the traditional educational system such as low academic performance, lack of innovation, poor creative thinking, higher failure and dropout rates.

Neuromyths *in* education

Neuroscience has been enthusiastically embraced by educators and educational researchers, who have generated great expectations about how it can foster a more complete understanding of the brain and mind (Cho & Yeh, 2024). This enthusiasm responds to the fascination and mystery surrounding the human brain and mind and their intervention in teaching-learning, enhanced by the media and turning them into concepts of fashion and public interest, propitiating attention to brain training games and activities to skyrocket (van Dijk & Lane, 2018). This trend has favored the proliferation of advertising campaigns for commercial educational programs created based on biased or simplified neuroscientific research results. It has motivated the generation of neuromyths in education.

From the *OECD* (2012) perspective, *neuromyths* are distortions or misconceptions of neuroscientific knowledge that make their way into the classroom. The scientific community has studied their creation and persistence since the 1990s, when it was declared *The Decade of the Brain* in the United States (*OECD*, 2012). One of the works that has received the most attention is the one published by Dekker *et al.* (2012), which lists 15 *neuromyths* generally accepted by educators in the United Kingdom and the Netherlands -in the study- and the world (Howard-Jones, 2012; Sullivan *et al.*, 2021; van Dijk & Lane, 2018) (Table 1). The original listing has been modified with the diversity of research conducted worldwide, adding new misperceptions and demystifying others.

Table 1. *Neuromyths* reported in the scientific literature with the purpose of measuring their credibility.

Neuromyth	Reference				
	[1]	[2]	[3]	[4]	[5]
	Studio location				
	United Kingdom and Netherlands	Latin America	USA	Türkiye	Hong Kong
People learn best when they receive information in their preferred learning style (auditory, visual, kinesthetic).	X	X	X	X	X
There are different types of intelligence: verbal, mathematical, spatial, rhythmic, kinesthetic, introverted and extroverted.	-	-	-	X	-
Differences in hemispheric dominance (left brain, right brain) may help explain individual differences among students.	X	X	X	X	X
Students who use the right hemisphere of their brain dominantly are creative, while students who use the left hemisphere of their brain dominantly are more successful in rational-academic tasks.	-	-	-	X	-
Brief coordination exercises can improve the integration of left and right brain functions.	X	X	X	X	X
Exercises that practice coordination of perceptual-motor skills can improve literacy skills.	X	X	X	X	X
Stimulation-rich environments improve the brains of preschool-aged children.	X	X	X	X	-
Children are less attentive after consuming sugary drinks and/or snacks.	X	X	X	X	-
It has been scientifically proven that fatty acid supplements (omega-3 and omega-6) have a positive effect on academic performance.	X	X	-	X	X
Following a specific diet can help overcome certain neurological disabilities, such as ADHD, dyslexia, and autism spectrum disorders.	-	-	X	-	-
Regular consumption of caffeinated beverages (more than 5 cups of coffee, cans of soda or energy drinks) increases alertness.	-	-	X	-	-
There are critical periods in childhood after which certain things can no longer be learned.	X	X	X	X	X
We only use 10% of our brain.	X	X	X	-	-
We only use a certain percentage of our brain.	-	-	-	X	-
Regular consumption of caffeinated beverages reduces alertness.	X	*	-	X	-
Brain gymnastics helps students learn to read and use language better.	-	-	X	-	-
Children must acquire their native language before acquiring a second language. If they do not, neither language will be fully acquired.	X	X	X	X	X
Learning problems associated with differences in the development of brain functions cannot be remedied with education.	X	X	X	X	X
If students do not drink enough water (6-8 glasses a day), their brain shrinks.	X	X	X	X	
Prolonged rehearsal of some mental processes can change the shape and structure of some parts of the brain.	X	*	X	X	*

Each student shows preferences for the way in which he or she receives information (for example, visual, auditory, kinesthetic).	X	*	-	X	*
A common sign of dyslexia is seeing letters backwards.	-	-	-	X	-
Listening to classical music increases children's reasoning ability.	-	-	-	X	-
During sleep, complex skills can be acquired, such as learning a foreign language, by listening to instructional audio.	-	-	-	X	-
The brains of today's children, who have been intensely exposed to digital technology from the moment they were born, have been changed to multitask.	-	-	-	X	-

Note: [1]: Dekker , 2012; [2]: Gleichgerrcht *et al.*, 2015; [3]: Van Dijk & Lane, 2018; [4]: Tunga & Çağıltay , 2023; [5]: Tsang *et al.*, 20204; X: studied *neuromyth ; -: neuromyth* excluded from the study; green cells: most accepted *neuromyth* , yellow cells: least accepted *neuromyth* ; *: statements considered *neuromyths* that have been scientifically proven.

Of the most recent works, the one by Romero-Naranjo (2024) stands out, in which the author exposes some of the general neuromyths in education in force in 2023, among which are: a) the Mozart effect, i.e., the beneficial effect that classical music has on brain development and its ability to learn; b) the need to acquire the mother tongue during early childhood, exclusively and before a second language; c) some things cannot be learned after infancy; d) the cerebral hemispheres are independent and determine essential traits of our personality; e) listening to reggaeton is beneficial for the brain; f) we can learn while we sleep, and we can learn while we are sleeping; g) we can learn while we are sleeping, and we can learn while we are sleeping; h) we can learn while we are sleeping, and we can learn while we are sleeping; f) we can learn while we sleep; g) we only use 10% of the brain; h) the bigger the brain, the more intelligent one is; i) the female brain is multitasking; j) language is controlled by only one cerebral hemisphere; k) there are people with right hemispheres and others with left hemispheres; l) the brain shrinks due to lack of water; and m) sugar reduces attention span.

In particular, his work recovers seven neuromyths related to movement: *i*) the existence of kinesthetic intelligence; *ii*) crossed laterality is related to learning problems; *iii*) coordination exercises, particularly brain gymnastics, improve the connection between the cerebral hemispheres; *iv*) walking 10,000 steps a day is necessary for good -mental- health; *v*) body percussions cure ADHD, autism, Alzheimer's, Parkinson's...; *vi*) any type of exercise is beneficial for the brain and the formation of new neurons; *vii*) neuromotor skills and

psychomotor skills are the same thing; *vi*) any type of exercise is beneficial for the brain and the formation of new neurons; vii) neuromotor skills and psychomotor skills are the same.

The studies cited, and the diversity of the audiences studied in them demonstrate that many *neuromyths* are echoed by teachers, students, their parents, and academic decision-makers. In the work of Weisberg et al. (2008), and more recently in that of Bennett and McLaughlin (2024), the *SANE* phenomenon arises, which refers to *the seductive allure of neuroscientific explanations* based on the prevalent tendency to support information with neuroscientific overtones and a certain level of sophistication, even though there is no hard evidence to back it up. This phenomenon reveals the need to strengthen and, in critical cases, generate critical thinking and media literacy in education. It makes teachers particularly aware of the *seductive charm of neuromyths* and the speed of their dissemination fostered by advances in communication and information technology.

Consequences of believing in *neuromyths* in education

Horvath *et al.* (2018) determined that in a group of internationally relevant teachers whose teaching quality had been recognized and awarded by the educational guild, belief in *neuromyths* prevailed on par with the bulk of their colleagues. In this context, it is indirectly recognized that belief in *neuromyths* does not represent any disadvantage in teaching performance. However, although in light of the research cited above, it would seem that belief in *neuromyths* is innocuous or that their application in the classroom does not attract relevant consequences, the scientific community has taken on the task of offering rigorous explanations supported by irrefutable evidence on the importance of debunking educational neuromyths and monitoring their generation.

Bennett and McLaughlin (2024) determined that students' belief in *neuromyths* has a potentially harmful and profound effect on their learning. For their part, Hughes *et al.* (2020) demonstrated that *neuromyths* not only affect understanding at the conceptual level but also influence decision-making and the behavior of teachers and learners in the classroom and outside the classroom when attending to extra-class work, indirectly criticizing the work of Horvath *et al.* (2018). The authors argue that students or their parents may make wrong decisions about learning, health, or educational strategies based on misconceptions, *i.e.*, the adoption of *neuromyths* is carried into the field of educational action and, therefore, influences the behavior of individuals who take actions aimed at improving learning outcomes. An example of this is when parents accept as true the *neuromyths* related to the

optimization of brain functions, such as children's memory, through certain products such as self-help tapes and even food supplements such as omegas (Table 1), which result in the inefficient application of economic resources and represent a significant expense for families.

Undoubtedly, teachers' roles are highly significant; class time in the classroom and student learning depends on their accuracy in teaching techniques. In the work of Blanchette Sarrasin *et al.* (2019) and Lethaby & Harries (2016), it is evident that teachers' belief in *neuromyths* about learning styles and hemispheric dominance was brought to classroom teaching practice through didactic strategies focused on students.

On the other hand, Howard-Jones (2014) states that the effects of actions based on *neuromyths* can be perceived in the decision-making of key actors responsible for the formulation of educational public policies and teaching strategies for the bulk of the school population, impacting the application of valuable and limited economic resources and time in activities that may be of little benefit or even sterile, when it comes to strengthening or improving the teaching-learning process. Therefore, understanding the impact of *neuromyths* is essential to strengthen or formulate efficient and scientifically sound public policies.

The challenges of *neuroeducation*

According to Park and Chen (2012), educational science researchers significantly translate neuroscientific advances into practical teaching strategies. Collaboration between teachers, educational researchers, and neuroscientists represents one of the challenges when designing educational programs for students. An even more significant challenge is to design professional development programs for teachers that promote effective communication of neuroscientific advances and reduce the prevalence of *neuromyths* and their repercussions.
Educators should consider the interactions between brain, cultural background, and language in educational practice, which is highly beneficial to students (Cho & Yeh, 2024). From this perspective, *neuroeducation* faces the challenge of interdisciplinary communication, in which the knowledge gap should be narrowed by including formal and non-formal education for all involved in the teaching and learning process, *i.e.*, teachers, learners, and parents.

The education received in the family, and the educational decisions made within the family are as relevant as formal school education in shaping students' learning. For this reason, eradicating neuromyths in parents favors informed decision-making. Combating the generation and permanence of *neuromyths*, in general, is crucial to discourage lacerating behaviors in the educational system; demystifying education is the same as defending it.

This fight directs attention to the media's need for more excellent permeability among ordinary citizens and to make reliable scientific communication programs in a common language available, away from sensationalism, exaggerations, or simplifications. About this point, the works of Illes *et al.* (2010) and Cho & Yeh (2024) stand out, in which the internet is pointed out as the most important source of information on neuroscience and the prevalence of informants who are not very specialized and spread, mainly through social networks and considered influencers.

Given society's interest in neuroscientific advances, specialists face the challenge of communicating their findings in a media context. This challenge is compounded by the proliferation of digital and interactive media ready to disseminate content that attracts views and reactions and opens the gap that disconnects education from knowledge about the brain and its functioning.

To facilitate the dialogue between specialists and the general public, several proposals have been made from and for the scientific community with an emphasis on *i*) favoring cultural change in which scientific dissemination is explicitly recognized and rewarded, *ii*) identifying and developing experts in neuroscience communication and, *iii*) strengthening research on the public communication of neuroscience (Illes *et al.*, 2010).

For the school environment, it has been proposed: *i*) to seek the dissemination of the main concepts of neuroscience, mainly cognitive neuroscience, *ii*) to promote media literacy and the critical evaluation of massively available content, and *iii*) to promote the dissemination of neuroscientific knowledge in the classroom, mainly when it is a question of clarifying incomplete, reductionist or sensationalist information, to take advantage of the credibility invested by the teacher and the ability of educational centers to focus students (Cho & Yeh, 2024).

Rousseau (2024) proposes specifically for teachers, training and education programs focused on updating -and accuracy- of their knowledge, specifically on neuroscience, and oriented to understand the prevalence of *neuromyths* and their impact on behavior with the ultimate goal of designing didactic strategies that are feasible to be applied, effective to overcome neuromyths and that strengthen the critical evaluation of available information sources.

Since current research on educational strategies to reduce *neuromyths* is limited, it is highly recommended that the public's media literacy be strengthened, particularly. Addressing the generation of *neuromyths* and correcting existing neuromyths should be high on the

educational science agenda, along with promoting positive attitudes toward neuroscience. Such activities also fall to educational policymakers responsible for assessing and improving society's *neuroscientific literacy* through formal education.

Conclusions

The field of educational neuroscience is still in its incipient phase. This fact represents an opportunity that the scientific community should seize to generate the appropriate dissemination channels to replicate laboratory findings in the teaching-learning process, implement *neuroeducation*, and face the challenges imposed by traditional education.

Neuromyths are in themselves a challenge for education. They evolve, perpetuate, take root, and diversify according to the context that hosts them, communication gaps, and access to information or lack of it. *Neuroeducation* misconceptions are more likely to lead to behavioral and decision-making changes than other disciplines. These behavioral changes, the factors that contribute to their occurrence, and the underlying causes of *neuromyths* are topics that require further attention and deepening by the scientific community to provide a complete understanding of how to address and prevent these misconceptions and mitigate their impacts.

Considering that *neuromyths* have important social implications, it would be valuable to explore strategies to dispel them, mainly those focusing on rational thinking and anecdotal evidence, *i.e.*, case studies, devaluing intuitive thinking. In addition, it is beneficial to establish standardized tests for studying *neuromyths* in each of the contexts in which they occur, particularly on the intervention of mass media such as the Internet.

Given the urgent and undeniable need to improve the media literacy of teachers, students, and society in general, effective mechanisms for verifying disseminated facts and filtering false information must be managed. This management requires the participation of educational researchers in the elaboration of professional development and teacher updating programs, as well as formal education curricula supported by neuroscience and scientific communication initiatives to the public.

Interdisciplinary intervention in designing educational interventions that address *neuromyths* from theoretical and practical perspectives is essential to mitigate their proliferation and effects. However, due to the lack of experimental measurements on the influence of traditional media and internet advertising on the acquisition of neuroscientific knowledge or *neuromyths*, we suggest promoting studies with rigorous hypotheses and

collecting and analyzing comprehensive data on the factors involved in the generation, entrenchment, and proliferation of *neuromyths.*

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