ORIGINAL

Prevalence of Neuromyths in the Mexican Academic Environment[1]

Prevalencia de Neuromitos en el Ámbito Académico Mexicano

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Abstract

Neuromyths are understood as false concepts and beliefs about the brain and that have an application or impact, generally negative, in the educational field and, specifically, in the teaching and learning processes. We start from previous studies in which it has been analyzed how neuromyths persist in society and in educational personnel, both at the level of basic education, upper secondary education, university education and even in postgraduate studies, and from there we arrive at our own results. In this work, a survey was conducted among 290 participants (N = 290) to determine to what extent neuromyths prevail among the university student community (M = 42.8%), the general public (M = 27.5%) and teachers in Mexico (M = 29.7%). It was possible to integrate students and teachers from 20 states of the Mexican Republic, between 18 and 70 years of age. We found that there is basically a group of four neuromyths that capture the attention and belief of the participants (M = 91.05%) and that are related to the so-called "learning styles" (visual, auditory and kinesthetic) (M = 96.6%), as per the speculative anatomy of the brain: "the rational hemisphere and the creative hemisphere" (M = 90.7%) or the "triune brain" (M = 89%). Other neuromyths analyzed in this work were, for example, the belief in the effect of certain elements on neural performance: "the Mozart effect" (M = 74.5%); "sugar and hyperactivity" (M = 80.7%); "video games and violence" (M = 63.8%). Neuromyths prevail in Mexico not only among students, but also among the teaching community, regardless

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of educational level. Some neuromyths, such as that of differentiated learning pathways, or three brains in one, have already been "naturalized", that is, "normal" is to consider them true by repetition, but without having been adequately analyzed.

Keywords: Neuromyths; Neuroeducation; Learning styles; Brain

Resumen

Los neuromitos se entienden como conceptos y creencias falsas sobre el cerebro que tienen una aplicación o impacto, generalmente negativo, en el ámbito educativo y, específicamente, en los procesos de enseñanza y aprendizaje. Partimos de estudios previos en los que se ha analizado cómo persisten los neuromitos en la sociedad y en el personal educativo, tanto a nivel de educación básica, educación media superior, educación universitaria e incluso en estudios de posgrado y a partir de ahí llegamos a nuestros propios resultados. En este trabajo, se realizó una encuesta entre 290 participantes (N = 290) para determinar en qué medida prevalecen los neuromitos entre la comunidad estudiantil universitaria (M = 42.8%), el público en general (M = 27.5%) y los docentes en México (M = 29.7%). Se logró integrar a estudiantes y docentes de 20 estados de la República Mexicana, entre 18 y 70 años de edad. Encontramos que básicamente hay un grupo de cuatro neuromitos que capturan la atención y la creencia de los participantes (M = 91.05%) y que están relacionados con los llamados "estilos de aprendizaje" (visual, auditivo y kinestésico) (M = 96.6%), así como con la anatomía especulativa del cerebro: "el hemisferio racional y el hemisferio creativo" (M = 90.7%) o el "cerebro trino" (M = 89%). Otros neuromitos analizados en este trabajo fueron, por ejemplo, la creencia en el impacto de ciertos elementos sobre el rendimiento neuronal: "el efecto Mozart" (M = 74.5%); "azúcar e hiperactividad" (M = 80.7%); "videojuegos y violencia" (M = 63.8%). Los neuromitos prevalecen en México no solo entre los estudiantes, sino también entre la comunidad docente, independientemente del nivel educativo. Algunos neuromitos, como el de las vías de aprendizaje diferenciadas o tres cerebros en uno, ya se han "naturalizado", es decir, "lo normal" es considerarlos verdaderos por repetición, pero sin haber sido adecuadamente analizados.

Palabras clave: Neuromitos; Neuroeducación; Estilos de aprendizaje; Cerebro

Neuromyths are misconceptions that originate from the misinterpretation or distortion of brain research findings in education and other sectors. Neuromyths are an element that can prevent the practice of neuroscience in the classroom in an adequate way because the conclusions obtained from the studies are distorted, and erroneous ideas are frequently adopted among teachers. With the growth of cognitive neuroscience, many findings have emerged from studies in laboratories around the world (Álvarez Hernández & De La Riva Lara, 2021; Thatcher & John, 2021; Uddin et al., 2011) and the understanding of human beings of their own brain structure and cognitive function has entered a new era, especially thanks to the definition of current live brain scanning and computational imaging tools (Cash et al., 2021). The applications of neuroscience to education can be multiple, and the study of the student's brain is essential for the adoption of innovative didactics in education. But putting basic brain research into classroom teaching isn't done yet because people still hold on to ideas, many of which are partially or completely wrong and slow down the process of adopting neuroscientific advances.

For 15 years, the Organization for Economic Cooperation and Development (OECD, 2007) has paid attention to the possibilities of the study and application of brain sciences to promote good educational practices, but they found that there were some ideas about the conceptualization and biology of the

brain itself that are not objectively defensible. Previously, works from the end of the 20th century had addressed specific issues of neuromyths, such as the essay by Radford (1999) on the belief that only 10% of the brain is used (Morandín-Ahuerma, 2022). Each published work shows that, although beliefs in neuromyths are widespread (Bruyckere et al., 2015), the evidence indicates that there is little evidence to support them.

The value of this work lies in the fact that, until now, no similar articles have been found in Mexico. Although some references are presented as those of Carrillo-Avalos & Laguna-Maldonado (2022), they did not have a representative sample of the population (N = 13); On the other hand, with a relatively broad base of participants (N = 290) in the present results report, it was possible to recover the opinion of both students, teachers, and the general public from 20 of the 32 states of the Mexican Republic.

A review of the literature is made, the method used in the study, the data collection instruments, analysis, and discussion of the same are described, and, finally, the authors share some conclusions that, although they do not constitute conclusive findings, coincide with most previous international studies. Likewise, it shows that in Mexico, despite the existence of a teaching pedagogical culture (Álvarez Hernández & De La Riva Lara, 2021), some erroneous beliefs about the brain persist.

Literature Review

The prevalence of neuromyths, especially in education, has been studied by many authors (Della Sala, 2007; Howard-Jones, 2014; Macdonald et al., 2017; Newton, 2015). They can be basically divided into two categories, those who make theories about neuromyths, that is, those who analyze the phenomenon of beliefs, most of them wrong, about the brain, its characteristics, and functions (Bruyckere et al., 2015; Mateos-Aparicio & Rodríguez-Moreno, 2019) and, on the other hand, who have carried out mixed and quantitative studies on the prevalence of neuromyths in society (Howard-Jones, 2014). In Mexico, no records of studies in this regard were found in the main databases such as Scopus and Web of Science.

In 2007, the Organization for Economic Cooperation and Development [OECD] published the book "Understanding the Brain: The Birth of a Learning Science" in which it released the results of the "Learning Sciences and Brain Research" project. carried out by the Center for Educational Research and Innovation [CERI] of the same OECD that began in 1999. The results of this work demonstrated the high potential that the study of the brain had in relation to education; however, it also emphasized in the most frequently repeated neuromyths, which, in some way, affect the teaching-learning processes. The neuromyths that we address in this work and that the OECD (2007) already referred to are: the popularized belief that "only 10% of the brain is used"; that "men use their left brain more and women the right"; and that, therefore, "men and women have different brains". Other neuromyths that were not addressed here, but that we can cite are: "What is not learned before the age of three", "there are critical periods in which children must learn"; other myths are that "infants can only learn one language at a time"; and, finally, beliefs such as "you have the ability to learn while you are asleep" (OECD, 2007). Here is the translation to English:

Neuromyths have been spread by two factors, the first of which may be reckless on the part of the media, which, having to synthesize scientific information, is prone to misinterpretations; on the other hand, and not so innocently, those who, in their eagerness to profit, invent possible ways to "enhance the brain" and offer courses, seminars, or publications that promise to "awaken the dormant area of the brain". Later, Dekker et al. (2012) took up some arguments and studied the prevalence of 32 neuromyths among 242 teachers in the United Kingdom and the Netherlands, and their results were that, despite the fact that most teachers are interested in brain sciences and have even studied some aspects related to education, they are not immune to believing in some of these neuromyths.

Among the erroneous statements mentioned in the publication by Dekker (2012) and his team, are,

for example: that "you must drink a lot of water otherwise the brain shrinks"; that "omega 3 and omega 6 help academic performance"; that "brain development ends upon entering high school"; that "cognitive abilities are hereditary"; that "environments that are full of stimuli help children learn"; and, that "the brain turns off while the person sleeps"; among other false claims, according to the study cited above.

Another relevant work is the book "Urban myths about learning and education" by De Bruyckere, Kirschner and Hulshof (2015) in which the authors review the most repeated neuromyths and devote a good part of the book to analyzing the general nature of myths. Likewise, they answer the question of why neuromyths persist and affirm that it is a necessity of society to believe in certain things as valid, especially when they have a halo of scientism. Thus, they find that myths persist in educational policies, educational technologies, the definitions of gender addressed here, and so-called learning approaches, among others.

For his part, Sergio Della Sala (2007) makes a compilation under the title: "Tall Tales About the Mind and Brain: Separating Fact from Fiction" in which he deals with multiple issues related to neuromyths. A publication in which he, of course, addresses "the 10% brain myth", the so-called "dual brain", "race-related intelligence", "the Mozart effect", among others. But he also addresses issues that are difficult to analyze in the academy, such as "extrasensory experiences outside the body", the "cloning of the human brain" and even "the possibility of speaking with the dead". Each of the topics, or myths, is analyzed from an objective point of view and, in most cases, with arguments from neuroscience. The result is, broadly speaking, that it is difficult to open the door to metaphysics. The neuromyths related to education must be analyzed with care and skepticism until certainties are obtained, that is, an empirical remnant solid enough to be able to rationally argue its implications in the classroom.

It is for the above reasons that we wanted to know to what extent neuromyths have permeated the beliefs of people in Mexico, especially among students around health sciences and university teachers.

Method

Participants

The total sample of the study was 290 participants, from 20 states of the Mexican Republic. The ages of the participants ranged from 18 to 70 years old. The mean age was 32 years old, of which 69.7% (n=202) were women, 30% (n=87) men, and .3% (n=1) responded non-binary. 49.7% (n=144) of the participants said they had their academic training around health sciences; 16.2% (n=47) in the economic-administrative area; 15.2% (n=44) in the area of arts and humanities; 7.2% (n=22) from the engineering area and 11.4% (n=33) said they came from other areas.

Regarding their last academic degree, 42% (n=124) said they were still a university student; 22.8% (n=66) answered having completed a bachelor's degree; 19.7% (n=57) have a master's degree; 12.1% (n=35) with a doctorate; and 2.8% (n=8) with some specialty. It should be noted that the respondents basically belong to five universities: Meritorious Autonomous University of Puebla (BUAP); Popular Autonomous University of Veracruz (UPAV); Veracruz University (UV); National Autonomous University of Mexico (UNAM); and Autonomous University of Nuevo León (UANL). It should be noted that 29.7% (n=86) of the participants said they were teachers, while 70.3% said they were not teachers (n=204).

Instruments

The instrument used for the study was a simple questionnaire of 21 questions. The first six questions were intended to identify participants by gender, age, geographical origin, highest level of education completed, field of knowledge, and whether or not they were teachers.

The next 15 bivalent items were statements to find out to what extent the participants believed or disbelieved in the same number of beliefs about the brain and neuromyths. The general title of the instrument was called «Test on neuroeducation» (Table 1) and consisted of the following sentences that the

participants had to answer stating whether or not they agreed with them.

Although the statements are not cataloged under a system, it was sought that by thematic affinity or ideological contiguity they follow a scheme: One statement (1) about learning; four statements (2, 6, 7, 8 and 10) about knowledge about the brain, its anatomy, and its abilities; five statements (3, 4, 5, 9 and 11) related to differences between women and men; and, Four statements (12, 13, 14 and 15) about exogenous agents and their influence on the brain.

The instrument initially warned participants that: "The BUAP-CA-354 research team invites you to participate in this survey, which is not an exam, we just want to know your opinion." The above is to make it clear that a survey such as the one applied has only epistemological aspirations at the *doxa* level, that is, opinion, and that it does not constitute a knowledge test, especially for those who are teachers of the same university of affiliation and who could interpret that it was a measurement of their knowledge with respect to neuroeducation.

It should be clarified that participants were not given the opportunity to develop open-ended responses, nor were neutral responses such as "I don't know" or "maybe" allowed, since it was considered that at the opinion level, all participants could offer one, so only the possibility of binary responses in which they could respond with "agree" or "disagree" was offered.

At the end of their participation, the system would send a confirmation message so that those who answered the questionnaire knew that their answers had been duly sent.

All the answers were mandatory, that is, they could not leave any of the questions unanswered because otherwise the instrument could not be sent.

We tried not to use images in the questionnaire or the visible progress bar frame as they responded so that, in case any participant did not have wi-fi or quality internet or was consuming their digital telephony data package, they would not use much data or have other technical problems if their internet failed. In this way, only questions and answers with two options were used, without other resources such as drop-down lists or checkboxes.

Table 1
Test statements about neuroeducation

1. People learn best when they receive information according to their dominant learning style, for example, auditory, visual, or kinesthetic.
2. Humans only use 10% of our brain.
3. On average, boys have larger brains than girls.
4. Girls are generally smarter than boys.
5. Single-sex education (separating boys and girls in separate classrooms) offers advantages in the teaching-learning process.
6. The right hemisphere is the emotional, creative, and artistic hemisphere; the left hemisphere is rational, calculating, and mathematical.
7. Some people develop more of the left hemisphere than the right.
8. We have a triune brain: instinctive-animal, limbic-emotional, and cognitive-rational.
9. Men are visual, and women are auditory.
10. We can focus our attention on several tasks at the same time.
11. Women can do several things at the same time, men can't.
12. Sugar consumption causes hyperactivity and reduces attention, especially in children.
13. Listening to classical music, for example, Mozart, increases cognitive abilities.
14. Violent video games generate violent children and adolescents.
15. Coffee improves concentration.

Regarding reliability, Cronbach's alpha coefficient was used to measure the internal consistency of the questionnaire. A Cronbach's alpha greater than 0.70 is considered acceptable, and in our study, the questionnaire obtained a coefficient of 0.78, indicating good internal consistency.

For content validity, a review was conducted by two educational research experts from BUAP and a neurologist from the Regional Hospital of Teziutlan, Puebla, to ensure that the statements included in the questionnaire were representative of the most common and relevant neuromyths in the context addressed.

For construct validity, an exploratory factor analysis (EFA) was performed to confirm that the statements were grouped coherently into factors related to different aspects of neuromyths (e.g., beliefs about the brain, gender differences, exogenous influences).

Finally, a pilot test was conducted with a small group of participants (N=30) to assess the clarity of the questions and ease of response. Feedback from this test was used to adjust the wording of some statements and improve the overall comprehension of the questionnaire.

Procedure

The instrument to collect the answers was made on the Google Drive platform and was built in Google Forms with a shortened hyperlink to be distributed through WhatsApp and Telegram groups of academics and students at the aforementioned universities (BUAP, UPAV, UV and UANL).

The questionnaire was available for 72 hours from October 8, 2022 at 08:00 hours and closed on October 10, 2022 at 23:59 hours. The highest participation of responses was received in the first 24 hours, 63% (n=183), the next day 23% (n=67) and the rest, 14% (n=40) on the last day. Each participant used an average of 10 minutes to answer the questionnaire.

The study was conducted under the ethical parameters of the Declaration of Helsinki (Assembly, 1964) and all participants did so voluntarily, informing them of the academic objectives of the work and the confidentiality of their responses. Since the survey did not collect personal information, nor did it use experimental techniques on people or animals, approval by an Ethics Committee was not necessary.

Results

The results obtained can be seen in Figure 1. The order in which the results are presented is descending, that is, the statements that had greater acceptance are presented first, that is, those that more people believe to be true, then successively those that have fewer followers, and so on until reaching those that have a lower degree of acceptance. The most deeply held belief is that of "learning styles": 96.6% of respondents considered that "people learn best when they receive information according to their dominant learning style, for example, auditory, visual, or kinesthetic". Only 3.4% disagreed with this statement (Table 2, Question 1). As you can see, this is the most deeply rooted neuromyth in the community. No matter what grade level you have or if it is students or teachers (29.7% = teachers and 70.3% = non-teachers), 9 out of 10 people argue that there are learning styles that determine if the person learns better or worse. The second most entrenched neuromyth is the idea that "there are those who develop more left hemisphere than the right" (Table 2, Question 7): 90.7% of the people surveyed believe so and only 9.3% believe that it is not so. This statement was presided over by the statement that "the right hemisphere is the emotional, creative, artistic hemisphere; and the left is rational, calculating and mathematical" (Table 2, Question 6), which obtained 87.9% acceptance, compared to 12.1% rejection. The 89% acceptance is the theory of the "triune brain: instinctive-animal, limbic-emotional and cognitive-rational" (Table 2, Question 8). Only 11% consider it a myth. The 80.7% consider that "sugar consumption produces hyperactivity and reduces attention, especially in children" (Table 2, Question 12). 19.3% consider that this is not the case. The 74.5% believe that "listening to classical music, for example, Mozart, increases cognitive abilities" (Table 2, Question 13). The 25.5% do not consider it so. The 71% believe that "we can fix our attention on several tasks at the same time" (Table 2, Question 10). The 29% do not believe so. The 63.8% believe that "violent video games generate violent children and adolescents" (Table 2, Question 14), while 36.2% do not consider it so. The 46.6% believe that "women can do several things at the same time, men cannot" (Table 2, Question 11). 53.4% do not believe so. The 44.8% believe that "humans only use 10% of our brain" (Table 2, Question 2). 55.2% do not consider it so. The 44.1% consider that "coffee improves concentration" (Table 2, Question 15), while 55.9% do not believe it. The 32.4% believe that "girls are generally smarter than boys" (Table 2, Question 4), while 67.6% do not consider it that way. The 31.7% consider that "men are visual and women are auditory" (Table 2, Question 9). 68.3% do not believe so. The 18.6% believe that "on average, boys

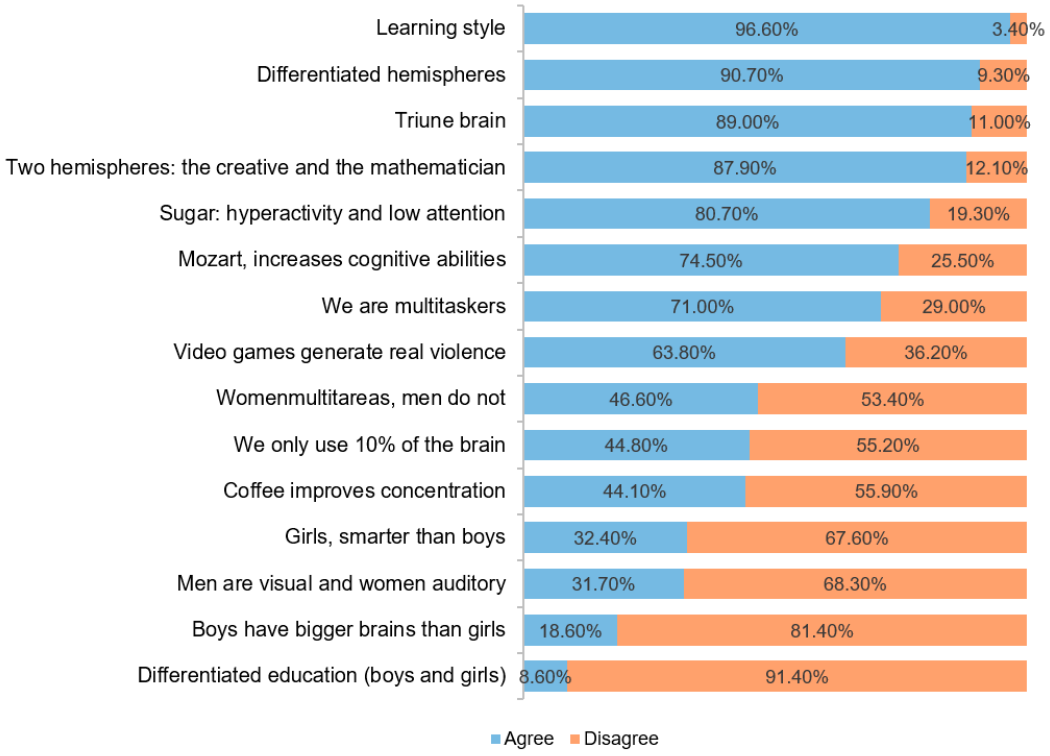

Figure 1. Neuromyths

have larger brains than girls" (Table 2, Question 3), while 81.4% do not consider it so. Finally, only 8.6% consider that "single-sex education, that is, separating girls and boys into different classrooms, offers advantages in the teaching-learning process" (Table 2, Question 5), while 91.4% do not believe so. The mean standard deviation (SD) was 0.39. In total, the average data of the 15 neuromyths analyzed show that 59% of Mexicans believe in neuromyths, while 41% are skeptical, according to the results (Table 3).

Discussion

Neuromyths, and myths in general, are ingrained among people (Enser, 2020) regardless of gender, age, or academic background. It is striking that not only among people without formal academic training (13.8%), but also among the university community (86.2%) (Sullivan et al., 2021), of course, the formed by teachers, who, in some cases, have information and pedagogical tools that could be related to some aspects of neuroscience concomitant to education (71%). Although there are quality teacher training programs with topics on neuroeducation (JHSE, 2022), not all teachers can take them (29%).

As it can be observed there is no obvious difference between those who have a high academic training (12.1% with a doctorate) and those who are teachers to believe or not in the neuromyths raised here. On the other hand, a marginal difference (42.8%) between the beliefs that the students have could be observed.

There are two statements, false, which have a greater place, the first refers to the so-called "learning styles" that, by repetition, has managed to position itself as a "fact" not properly questioned and even, for some, presented as a flag for construction "modern" of educational public policies (Newton, 2015).

However, as reported by Clark et al. (2015) there is little or no influence on student learning and

Table 2
Frequencies and percentages of held beliefs

		f	%
Q1. People learn best when they receive information according to their dominant learning style, e.g. auditory, visual or kinaesthetic	Agree	280	96.6
	Disagree	10	3.4
	Total	290	100
Q7. Some people develop more left hemisphere than right hemisphere	Agree	263	90.7
	Disagree	27	9.3
	Total	290	100
Q6. The right hemisphere is the emotional, creative, artistic hemisphere; the left hemisphere is rational, calculating and mathematical	Agree	255	87.9
	Disagree	35	12.1
	Total	290	100
Q8. We have a triune brain: instinctive-animal, limbic-emotional and cognitive-rational	Agree	258	89
	Disagree	32	11
	Total	290	100
Q12. Sugar consumption causes hyperactivity and reduces attention, especially in children	Agree	234	80.7
	Disagree	56	19.3
	Total	290	100
Q13. Listening to classical music, e.g. Mozart, increases cognitive abilities	Agree	216	74.5
	Disagree	74	25.5
	Total	290	100
Q10. We can focus our attention on several tasks at the same time	Agree	206	71
	Disagree	84	29
	Total	290	100
Q14. Violent video games breed violent kids and teens	Agree	185	63.8
	Disagree	105	36.2
	Total	290	100
Q11. Women can do several things at the same time, men cannot	Agree	135	46.6
	Disagree	155	53.4
	Total	290	100
Q2. Humans only use 10% of our brains	Agree	130	44.8
	Disagree	160	55.2
	Total	290	100
Q15. Coffee improves concentration	Agree	128	44.1
	Disagree	162	55.9
	Total	290	100
Q4. Boys have larger brains than girls on average	Agree	54	18.6
	Disagree	236	81.4
	Total	290	100
Q9. Men are visual and women are auditory	Agree	92	31.7
	Disagree	198	68.3
	Total	290	100
Q3. Boys have larger brains than girls on average	Agree	54	18.6
	Disagree	236	81.4
	Total	290	100
Q5. Differentiated education (separating girls and boys into separate classrooms) offers advantages in the teaching-learning process	Agree	25	8.6
	Disagree	265	91.4
	Total	290	100

Table 3
Inferential Analysis

		N	Mean	Typical deviation	Typical error	Confidence interval for the mean at 95%	
						Lower limit	Upper limit
Some people develop more left hemisphere than right hemisphere	Men	87	1.11	.321	.034	1.05	1.18
	Women	202	1.08	.278	.020	1.05	1.12
	Nonbinary	1	1.00				
	Total	290	1.09	.291	.017	1.06	1.13
Humans only use 10% of our brains	Men	87	1.67	.474	.051	1.57	1.77
	Women	202	1.50	.501	.035	1.43	1.57
	Nonbinary	1	2.00				
	Total	290	1.55	.498	.029	1.49	1.61
Boys have larger brains than girls on average	Men	87	1.72	.450	.048	1.63	1.82
	Women	202	1.65	.477	.034	1.59	1.72
	Nonbinary	1	2.00				
	Total	290	1.68	.469	.028	1.62	1.73

Table 4
One-way ANOVA

	df	F	Sig.
Some people develop more left hemisphere than right hemisphere*	2, 287	0.39	0.678
Humans only use 10% of our brains**	2, 287	3.885	0.022
Boys have larger brains than girls on average***	2, 287	0.93	0.396

Note: * *Some people develop the left hemisphere of their brain more than the right.* Null hypothesis: Some people think that the left hemisphere is developed more than the right. Alternative hypothesis: Some people think that the left hemisphere is not developed more than the right. 91.58% of women agreed, as did 88.5% of men and 100% of non-binary people, with 90.68% of respondents thinking that the left hemisphere is developed more than the right, so the null hypothesis is accepted. ** *Humans only use 10% of our brain.* Null hypothesis. Some people think that humans only use 10% of their brain. Alternative hypothesis: Some people think that humans do not only use 10% of their brain. 50% of women agreed, on the other hand, 66.66% of men disagreed and 100% non-binary disagreed, with 55.17% of respondents thinking that humans do not only use 10% of their brain. The null hypothesis is rejected. *** *Girls are generally smarter than boys.* Null hypothesis: Some people think that girls are smarter than boys. Alternative hypothesis: Some people do not think that girls are smarter than boys. 65.34% of women, 72.41% of men, and 100% non-binary disagreed with the question, with the majority of respondents at 67.58% disagreeing. The null hypothesis is rejected.

outcomes when "approaches to learning" tactics are used. That is, many people who profess to be in favour of one method of instruction benefited little from adopting it. When pedagogical practises have been based on a "learning style" it has been shown to be less successful for certain students than for others, which has a negative impact on the general performance of students (Terada, 2018).

There is also little evidence from empirical studies (Bruyckere et al., 2015; Kirschner, 2017) to support the idea that people naturally group into different social categories. At least three problems arise when it comes to classifying students into predetermined categories: first, most students don't fit neatly into any particular style, making it difficult to assign a specific focus to them; second, the information used to do so is often insufficient; for example, the data given by the students themselves are the most used to see these divisions; and third, there are so many different styles and combinations that it is extremely difficult and subjective to want to classify them all (Terada, 2018).

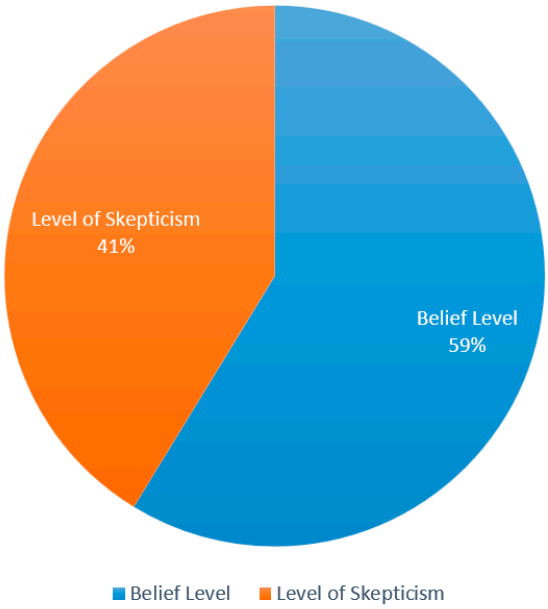

Figure 2. Credibility index in the neuromyths in Mexico

Subsequently, those neuromyths that have to do with differences between the sexes should be discussed, that is, for example, that "girls are more intelligent than boys", and that "they can do several things at the same time", all these affirmations They have turned out to be lies. Because despite people's beliefs, especially in macho cultures, studies show that both women and men have the same intellectual capacities (Skočajić et al., 2020; Van Mier et al., 2019).

Our study also revealed a lack of knowledge about the structure of the brain and its functions. Almost 90% of people believe in the idea that there are two or three brains in one. The first idea is that the left side is cold and calculating and the right side is artistic and sensitive (Arenas-Dolz, 2019). While it is true that specific functions such as speech have been in the left hemisphere, it is not appropriate to assume that one part of the brain works one way and the other differently. Much less the idea, also generalized, of the so-called triune, reptilian, emotional and rational brain (Dervenis & Tsialogiannis, 2017). All the dissociations that are made of the brain turn out to be insufficient and reductionist regarding the complexity and interdependence of the various areas of the brain, as our work demonstrates.

The triune brain theory was introduced by Paul MacLean (1952), inspired by Papez (1937), and revised by MacLean again in 1990 (MacLean, 1990) and to this day continues to have many adherents and has even been "naturalized" as show the results of the study. The author proposed that there is a so-called reptilian or primitive brain located in the basal ganglia; later on a more external level is the paleomammal or emotional brain, located in the limbic system and; finally, the neomammalian or rational brain that encompasses the neocortex. This idea, although widely extended, has also been criticized by Semenova et al. (2021) who explain that this evolutionary theory of the biological development of the brain is actually a restrictive and insufficient explanation, since there are no circuits or isolated systems such as the limbic on emotions or the purely rational neocortex. They suggest that the brain produces complex adaptive predictions according to the environment and carries out interactions and interconnections that balance homeostatic, allostatic and cognitive functions in sudden changes in which

various factors such as interaction with the environment and social interaction are involved.

While our study could suffer from the bias of having used the word "neuromyth" in the questionnaire, which, in some way, could have suggested that the statements were, strictly speaking, false, the truth is that the beliefs of the people surveyed were stronger than the bias that the introduction of the concept may have had.

Another neuromyth is that sugar causes hyperactivity, but there are documented studies (Johnson et al., 2021) that show the opposite: the glycemic peak is very brief and, on the other hand, the "fall" is even greater, that is, children and adults feel rather tired after consuming foods with excess refined sugars. The same has been found with coffee, contrary to what many believe, although it acts as a momentary stimulant, the drop curve causes people to feel nervous and unable to concentrate (Gökcen & Şanlier, 2019). Other neuromyths refer to gender differences that are adopted and have enormous social repercussions, usually against women since they do not have a smaller brain, because the size is proportional, nor are they more or less intelligent, but they are equal, and differentiated education does not bring benefits and, on the contrary, it inhibits equal treatment and the development of intergeneric social skills in both girls and boys, future youth, and adults.

There are many myths regarding whether one gender is better than the other. That "boys are better at arithmetic than girls" is a widespread false belief, and not only among educators, some even argue that there are biological or genetic reasons for it (Van Mier, Schleepen and Van den Berg, 2019). However, this belief must be carefully analyzed for its negative implications towards girls. There have been studies reporting country-by-country results that frequently indicate that women perform as well or better than boys in mathematics (Skočajić, Radosavljević, Okičić, Janković, & Žeželj, 2020). In addition, it has been found that the historical research on which the difference theory is based is not always scientifically valid, so previous results that purported to confirm these disparities have been rejected (Cox, Abramson, Devine, & Hollon, 2012).

McFarland (1969) and Voyer and Voyer (2014) for boys and girls in the same class determined that separate courses for women do not appear to be advantageous either. The existence of differentiated classes in some countries showed this (Fournier, Durand-Delvigne and De Bosscher, 2020). Another meta-analysis of gender inequalities in academic performance showed (Voyer and Voyer, 2014) that school grades do not always reflect learning in a social setting, beyond the classroom, and that students should be assessed over long periods of time to draw plausible long-range conclusions. While standardized tests test fundamental or specialized academic talents and aptitudes at a single point in time, they will not necessarily have social effects (Sjøberg, 2015). Therefore, there is really no basis for supposing that girls or boys are "smarter" than the opposite sex. There is also no evidence that classical music makes children smarter, although it may have a therapeutic effect in cases of stress (Steele et al., 1999) does not mean that music itself makes children smarter.

Conclusions

In 2007, the OECD affirmed that the bridges between education and neuroscience were scarce, but, after 15 years of research, since the publication of the aforementioned work (OECD/CERI, 2007), the truth is that they have not yet been able to take the necessary steps to achieve those goals set to introduce, in a defined way, the advances of neuroscience in the educational field. With the rise of cognitive neuroscience, a wealth of research results has been born in laboratories around the world, and human beings' understanding of their own brain structure and cognitive function has entered a new era. The implications of neuroscience for education are undoubtedly enormous, and the study of the brain of students is necessary for the use of new didactics in education. However, applying basic neural research to classroom teaching has not yet become widespread. Neuromyths are a negative factor that hinders the practice of neuroscience in the classroom, and they are, surprisingly, also common among teachers. As seen so far, neuromyths are

false beliefs that arise from the misinterpretation or misrepresentation of the results of brain research in education and other fields.

Some researchers have used neural myth questionnaires to investigate beliefs among teachers at different levels, in various countries and regions. A meta-analysis by Howard-Jones (2014) of teacher survey results from eleven countries found that the average number of typical neuromyths that teachers could not judge correctly reached 50% on average. For example, among teachers from different countries, the most widespread neuromyth is that, as already explained, "we only use part of the brain", as also reported by Macdonald et al. (2017).

When teachers teach with misunderstood cognitive neuroscience concepts, this has a negative impact on students and teaching, mainly in the form of misdirected educational resources, distorting classroom research, and reducing student confidence (Macdonald et al. al., 2017).

In addition to the waste of teaching resources, teaching methods based on neural myths can also affect the smooth implementation of basic research. Currently, research in educational neuroscience is dedicated to exploring the relationship between learning objectives, learning assessment, learning content, and the most convenient learning technology (Morandín-Ahuerma, 2022).

Although some steps have been taken, there are still problems that cannot be explained by the research results. For example, how teachers' attitudes, student motivations and expectations affect the classroom; the impact of emotions on learning motivation, decision-making, attention, memory, and other problems related, for example, to gender (Morandín-Ahuerma, 2021).

Certain neuromyths take root in the classroom, as was seen, that of multiple intelligences or that of different types of personalities (MBTI), which can lead to the distortion of the real teaching environment of the classroom, thus affecting research and teaching. objective didactics, and even drawing wrong conclusions #. There are other neuromyths that are not addressed here but can be cited, for example: that "there is a rational left brain and an emotional right brain" (Hageman, Waldstein, & Thayer, 2003).

There is no doubt that neuroscience can inspire and help education. A large part of neuroscience research is devoted to improving the efficiency of student learning. However, due to the gap between the laboratory and the classroom, some neuroscience results are distorted and misunderstood, leading to an erroneous understanding of neuroscience.

The media have an inescapable responsibility in the process of non-dissemination of neuromyths, since they can make them take root by adding biased content with sensational effects, as in cinematography, and ignoring key information in the process of acquiring information. and development of cognitive skills.

Designing specific training, strengthening communication between scientists and educators, and building a comprehensive discipline that can be discussed could help dispel neuromyths and build a real bridge between neuroscience and the classroom. Training teachers in cognitive psychology, designing courses aimed at improving neuroscience literacy to learn how to distinguish knowledge from speculation, and equipping teachers with the ability to apply scientific conclusions in the classroom will make them capable of applying the conclusions from laboratory to training development and will protect students from the influence of pseudoscience.

Perhaps the sample for this work had some limitations because more than 40% of the participants are still university students, but this does not mean that it is not representative of the generalized ideas about some more entrenched neuromyths, as that of the "learning styles" in students, teachers and the general public.

The work also opens the door to continue with similar studies in Mexico to determine, specifically, what would be the prevalence, in particular of some of the neuromyths that deserve to be analyzed, both from the point of view of opinion (*doxa*), and the empirical remnants on the results of research that have been made in Mexico on the effects of music, sugar, coffee and divided attention for multiple tasks.

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