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Research paper

Belief in neuromyths among primary school teachers: A cross-national study of 11 countries

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A R T I C L E I N F O

Keywords:
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Informal learning sources

A B S T R A C T

Background: This study compares primary school teachers' beliefs in neuromyths related to brain function and learning across different cultural and linguistic contexts. Two main research questions are explored and analyzed: "Which neuromyths are believed by primary school teachers?" And "What are the formal and informal sources of these neuromyths among primary school teachers?"
Methods: Data were collected from 1257 primary school teachers in 11 countries using the Multilingual Neuromyths Identification Questionnaire, available in eight languages. The descriptive survey design explored the prevalence of neuromyths and the sources that shape teachers' understanding of learning and intelligence.
Results: The findings indicate that 13 out of 21 neuromyths are prevalent in all of the countries that were surveyed. Notably, over 90 % of participants agreed with the theories of multiple intelligences and learning styles. These misconceptions are primarily acquired through formal sources, such as teacher training programmes and professional seminars, as well as through professional experience and personal intuition. In contrast, informal sources, such as the media and popular culture, appear to play a minor role in developing these beliefs.

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Conclusions: The persistence of neuromyths among teachers underscores a critical need for evidence-based neuroscience and cognitive psychology content in teacher education. This study underscores the urgent need to integrate evidence-based neuroscience and cognitive psychology into teacher education programs. The widespread belief in neuromyths highlights serious gaps in current educational policy and practice. To address this, coordinated national and international strategies are needed to inform ministries of education and policy makers about the prevalence and impact of these misconceptions.

1. Introduction

The intersection of cognitive neuroscience and education has garnered significant attention in recent years, driven by the potential for insights from brain research to inform educational practices [1]. As this interdisciplinary field evolves, researchers explore how insights into brain functions can enhance learning outcomes. However, this growing interest has also spawned the proliferation of neuromyths rooted in misinterpreting or oversimplifying scientific findings [2]. These incorrect preconceptions, also known as "neuromyths," are defined by the OECD [3] as misconceptions generated by a misunderstanding, misreading, or misquoting of scientifically established facts. Such myths frequently result in the erroneous application of brain research in formal educational and adjacent contexts [4,5]. Moreover, these beliefs can perpetuate erroneous notions about learning, impeding educational outcomes and leading to misguided pedagogical strategies [2,6]. In the absence of intervention to dispel these misconceptions, there is a risk that instructional approaches will become ineffective or counterproductive [7,8]. A contributing factor is the insufficient interdisciplinary collaboration between neuroscience and education, which often leads to fragmented and misinterpreted applications of scientific findings [9,10]. The brain's enigmatic nature has long captivated the public and been subject to commercial exploitation [7]. Various media sources, including films, documentaries, advertisements, social media, and popular literature, have disseminated misleading or oversimplified interpretations of neuroscience research [4,6,11]. The prevalence of neuromyths in formal and informal educational settings poses a significant challenge to educators and stakeholders, who must distinguish accurate scientific knowledge from pseudoscientific beliefs [3]. While educators were not previously expected to critically evaluate neuroscientific claims, today's information-rich landscape requires that teachers be equipped with the skills to critically assess such claims [2,12].

This study seeks to identify neuromyths and their origins through a comprehensive international comparison. An overall understanding could provide a comparative picture, enabling regional diagnostics to be made, local shortcomings to be identified, and better-targeted remedial initiatives to be launched. Although several studies have investigated the prevalence of common neuromyths, large-scale comparative research across diverse national populations is still limited [8,13]. Additionally, while some studies have examined the origins of neuromyths, few have investigated how these misconceptions spread through different sources. The role of formal dissemination sources, such as teacher training programs and academic courses, as well as informal sources, such as the media and peer communication, in spreading neuromyths is particularly under-explored [14,15]. These findings underscore a significant gap in the literature and highlight the need for further investigation into the mechanisms by which neuromyths are transmitted and reinforced in educational contexts. This study, the largest of its kind to date, examines the international prevalence of neuromyths among primary school teachers in 11 countries and eight languages: French, English, Turkish, Greek, Kazakh, Arabic, Malay and Chinese. Participating countries include Belgium, Cameroon, Canada (Quebec), Greece, Kazakhstan, Malaysia, Mali, Morocco, Senegal, Taiwan, and Turkey. Two main research questions are explored and analyzed:

Q1- Which neuromyths are believed by primary school teachers? This question seeks to identify and analyze the specific misconceptions that primary school teachers hold about some important brain functions and the learning process. It also provides cross-country comparisons to examine differences in neuromyth beliefs between countries.

Q2- What are the formal and informal sources of these neuromyths among primary school teachers? This question examines the various formal (e.g., undergraduate/graduate education, professional development programs, academic publications, professional experience) and informal (e.g., social media, websites, colleagues or friends, other publications, the movies, television programs, advertisements) sources that influence the dissemination of neuromyth beliefs

1.1. Theoretical framework

Neuromyths emerge through misinterpreted scientific data, incomplete information, reductionist thinking, limited scientific literacy, confirmation bias, and the simplification of complex research findings [2]. A recurring theme in several studies is teachers' widespread belief in neuromyths. For example, Rousseau [16] and Sazaka et al. [15] reported a relatively high and worrying prevalence of neuromyths among teachers, students, and stakeholders. Neuromyths greatly impact teachers' instructional practices and persist as beliefs about learning styles, multiple intelligences, hemispheric dominance and the belief that highly stimulus-rich environments enhance learning, and these misconceptions frequently influence curriculum design and pedagogical approaches despite a lack of empirical support [7,9,17,18]. Bissessar and Youssef [19] reported that over 35 % of teachers confess to incorporating such scientifically unfounded beliefs into their classroom instruction. Despite contradictory scientific evidence, Newton and Miah [20] found that these neuromyths persist among teachers.

Furthermore, research by Hughes et al. [7] and Im et al. [21] suggests that even teacher education programs are largely ineffective in dispelling neuromyths, underscoring the challenge of correcting these pervasive misbeliefs. Commercial interests also play a significant role in perpetuating neuromyths [6,7]. Companies frequently exploit these misconceptions by promoting "brain-based" products and educational programs that lack empirical support, capitalizing on the appeal of neuroscience to educators and the public alike [5,14]. Popular media further amplify the issue by distorting scientific findings to craft sensationalized narratives, contributing to the public misunderstanding of neuroscience [4,6]. A prominent example is the enduring belief in "learning styles," which remains widely accepted in educational practice despite lacking empirical support [22,23]. Research has also revealed the widespread acceptance of other neuromyths, such as the effectiveness of Brain Gym or the notion that individuals use only 10 % of their brains [7,17]. These misconceptions often stem from the misinterpretation or oversimplification of legitimate scientific research [4,8]. A frequently cited neuromyth in the literature is the belief that short-term motor coordination exercises can enhance brain function by improving communication between the brain's hemispheres. Despite a lack of empirical support for this claim, this misconception persists among teachers and is often incorporated into classroom practices [5,7,17]. n a large-scale study of 1359 Australian pre-service teachers, Carter et al. [17] found that 56.6 % of participants incorrectly agreed with the statement that 'short-term motor coordination exercises can improve the integration of left and right hemispheric brain function. This finding reflects a broader trend whereby teachers accept scientifically unsupported claims about motor-coordination exercises and cognitive enhancement, potentially leading to ineffective or misguided instructional strategies being implemented.

Similarly, Zhang et al. [24] and Hughes et al. [7] report that many teachers believe that short-term motor coordination exercises can improve thinking and brain development. Zhang et al. [24] conducted a study of 253 head teachers in Gansu Province, China, and found that a large proportion of participants agreed with statements about the cognitive effects of short-term motor coordination exercises. Hughes et al. [7] surveyed 228 in-service teachers in Australia and found that 91 % of participants endorsed the statement that exercises rehearsing coordination skills can improve literacy outcomes. Additionally, 94 % believed that short-term motor coordination exercises enhance integration between the brain's hemispheres.

Neuromyths detract from educational quality by imposing artificial barriers to learning [2]. One of the most prevalent neuromyths is the belief that students learn more effectively when instruction is tailored to their preferred "learning styles," despite a lack of empirical evidence supporting this belief [4,5,9]. Similarly, the notion that intelligence is fixed rather than flexible can negatively impact teachers' expectations and reduce their support for student growth and achievement [7,25]. Effectively addressing these neuromyths requires educators to develop the ability to critically evaluate and apply neuroscientific evidence [6,10]. Integrating accurate, research-based neuroscience content into teacher education programs is crucial for building resilience against pseudoscientific ideas and improving pedagogical practices [8,14].

2. Method

The study employed a survey model to examine primary school teachers' beliefs about the learning process and the informational resources informing their pedagogical practices. Data was collected using the *Multilingual Neuromyths Identification Questionnaire*, which was developed, adapted, and translated into eight languages: Arabic, Chinese, English, French, Greek, Kazakhstani, Malay, and Turkish [26].

2.1. 2.1. participants

This study surveyed 1257 primary school teachers from 11 countries. Among the participants, 73 % were female, 26 % were male, and 1 % did not specify their gender. Convenience sampling leveraged existing research connections to include representatives from four continents: Europe, Asia, North America, and Africa. The distribution of research participants by country and gender is shown in Table 1.

As shown in Table 1, the highest participation rates in the study were from Belgium, Kazakhstan, Taiwan, and Turkey. Of the 1257 participants, 88 % work in public schools (1102 participants), while 12 % are employed in private schools (155 participants). Nearly 50 % of participants are from large cities. In terms of teaching experience, 36 % (454 participants) have 21 years or more of experience, 16 % (207) have 16–20 years, 18 % (223) have 11–15 years, 15 % (186) have 6–10 years, and 15 % (187) have 5 years or less. A similar distribution is seen in age groups: 36 % are 41–50, 28 % are 31–40, 21 % are 51 or older, 11 % are 26–30, and 3 % are under 25. These distributions indicate that the sample predominantly comprises experienced teachers with significant seniority.

Table 1
Participant's country and gender.

Country	Participants	Gender		
		Female	Male	Ns
Belgium	271	228	42	1
Kazakhstan	257	250	6	1
Taiwan	138	82	56	0
Turkey	116	82	33	1
Morocco	97	49	47	1
Greece	82	56	26	0
Senegal	79	39	40	0
Canada (Quebec)	63	59	4	0
Mali	62	8	54	0
Malaysia	50	38	10	2
Cameroon	42	26	15	1
Total	1257	917	333	7

2.2. Data collection instrument

The "*Multilingual Neuromyth Identification Questionnaire*" (MNIQ) comprises a total of 30 statements and tests for 12 possible learning sources (Author1 et al., in press). The validity and reliability in identifying these sources have been established through a comprehensive investigation of the available relevant literature. Twenty-one of the used statements consisted of incorrect statements corresponding to neuromyths (S1-S2-S4-S6-S7-S9-S10-S11-S13-S14-S15-S16-S17-S19-S20-S21-S23-S25-S26-S28-S30; see Table 5 for the statements) and nine of them consisted of correct statements (S3-S5-S8-S12-S18-S22-S24-S27-S29) that did not refer to neuromyths and were used to reduce of the most knowledgeable participants' possible distrust in the instrument. The development of the MNIQ process unfolded in four main stages: (1) a thorough literature review to identify the most "common" neuromyths and relevant survey instruments, (2) the design of the initial questionnaire, (3) pilot testing to evaluate and refine the instrument, and (4) language adaptation to ensure cultural and linguistic appropriateness in the target languages. During the first phase, a literature review and thematic analysis were conducted to create the item pool and ensure content validity. Examples of these references are provided in Table 2.

In the design phase, the questionnaire items were crafted in terms of content and format, preparing them for pilot testing. During the implementation phase, item characteristics were examined through pilot testing. Upon finalizing the 30-item questionnaire's structural properties, the Cronbach Alpha internal consistency coefficient was 0.90, and the Spearman-Brown Coefficient value was 0.86. Finally, in the adaptation phase, the questionnaire was translated (and back-translated to ensure validity) into the eight target languages, and its structural properties were analyzed.

2.3. Research data collection process

The MNIQ was integrated into the multilingual survey platform "Interceptum®" and disseminated to international contacts for recruitment purposes. Project coordinators in each country recruited participants through networks and provided the survey link. Participants completed the survey via smartphone or computer, with minimal disruptions apart from occasional internet connectivity issues. After providing the platform with sociocultural information, each participant

Table 2
Scientific references of neuromyths statements.

Statements	References
S1	Dekker et al. [9]
S4	Tokuhama-Espinosa [2]
S9	Schmitt et al. [27]
S10	Bruyckere et al. [28]
S11	Bruyckere et al. [28]
S13	Papadatou-Pastou et al. [29]
S14	Tokuhama-Espinosa [2]
S15	Howard-Jones [30]
S16	Dekker et al. [9]
S17	Schmitt et al. [27]
S19	van Dijk et al. [5]
S20	Dekker et al. [9]
S21	Bruyckere et al. [28]
S23	Bruyckere et al. [28]
S25	Dekker et al. [9]
S26	Betts et al. [31]
S28	Dekker et al. [9]

had to declare the first statement as either correct or incorrect, after which they had to select one or more possible sources (list of 12) for the answer they provided. Participants then responded to the remaining 29 items in the same manner. The term "neuromyth" was intentionally excluded from all communications about -and within- the questionnaire to prevent negative bias in responses.

To prevent participants from consulting external sources, a 30-second delay was implemented between questions. Additionally, a small incentive - a "smiley" stamp - was offered (in a draw) to encourage participation. The data collection occurred from March 10th to May 10th, 2024.

2.4. Data analysis

The research data were analyzed using descriptive and inferential statistical methods. First, the responses to the questionnaire items were examined without distinguishing between countries. Descriptive statistics, including arithmetic means, frequencies, and percentages, were used to summarize the data for this exploratory analysis. Invalid or incomplete responses were excluded, and the dataset was cleaned and prepared for analysis in SPSS version 26.0. Descriptive analyses were then conducted in SPSS to determine the overall distribution of responses across all items.

After the general analysis, country-level analyses were performed. The prevalence of neuromyths was examined for each participating country using descriptive statistics, which provided a comparative overview of neuromyth endorsement rates across national contexts. A three-cluster solution was then employed to identify patterns and groupings among countries based on similarities and differences in neuromyth prevalence. This cluster analysis revealed how countries aligned or diverged in terms of neuromyth belief profiles.

In order to assess the degree of difference in neuromyth beliefs between countries, the distribution characteristics of the data were examined prior to analysis. Because there were a lot of countries in the study and their sample sizes were different, the data did not follow the normal distribution. Therefore, nonparametric tests were used to analyze group differences. Specifically, the Mann-Whitney U test was used to identify statistically significant differences in neuromyth beliefs between pairs of countries. In these comparisons, the independent variable was the country, while the dependent variable was the level of belief in each specific neuromyth. Separate analyses were conducted for each neuromyth item to assess whether statistically significant differences existed between country pairs. Significant differences detected in the comparisons were interpreted by calculating the effect sizes using Cohen's d. All analyses were conducted with careful attention to statistical significance and practical relevance. The research data was analyzed using descriptive statistics. In addition to analyzing the existence of neuromyths, a descriptive analysis was conducted to determine the sources from which teachers acquired these misconceptions. Initially, a general review of learning sources revealed largely consistent patterns across countries. Consequently, a combined analysis was conducted to identify the frequency and percentage distribution of formal and informal learning sources associated with neuromyth endorsement.

3. Results

3.1. Which neuromyths are believed by primary school teachers?

Table 3 presents the results, which reveal the number of teachers who endorsed or rejected each of the 21 statements about neuromyths.

Table 3 highlights in bold characters the predominating answer for all statements. Totally the 21 potential statements, 13 were predominantly identified (incorrectly) as "accurate". Although a significant proportion of participants endorse numerous false statements, we will selectively identify "confirmed neuromyths" as those statements that demonstrate a clear majority of incorrect assessments within a particular

Table 3
Distribution of teachers' answers to the 21 incorrect statements, for all countries.

Statements	N	"Correct" (Neuromyth believers) N (%)	"Incorrect" N (%)	"I can't answer"
About the learning process				
S1-Individuals learn better when they receive information in alignment within their dominant learning styles (ex: visual, auditory, kinesthetic etc.)	1201	1108 **(92 %)**	62 (5 %)	31 (3 %)
S2-The dominant intelligence profile of learners (ex: mathematical, verbal, spatial) must be considered in teaching	1035	965 **(93 %)**	36 (4 %)	34 (3 %)
S4-Different parts of the brain operate independently during the learning process	1155	507 **(44 %)**	446 (39 %)	202 (17 %)
S6-Learning is a purely cognitive skill, not emotional	1195	440 (37 %)	676 **(57 %)**	79 (6 %)
S7-Learning takes place independent from individuals' learning backgrounds	1165	477 (41 %)	596 **(51 %)**	92 (8 %)
S9-Individuals can learn new information even while in a state of sleep	1221	562 **(46 %)**	353 (29 %)	306 (25 %)
S10-Humans are good multitaskers	1209	816 **(68 %)**	246 (20 %)	147 (12 %)
S11-The fact that some people are more "right-brained" and others are more "left-brained", helps explain the differences in how we learn	1175	874 **(75 %)**	132 (11 %)	169 (14 %)
S13-There are specific periods in childhood after which certain things can no longer be learned	1183	513 (43 %)	526 **(45 %)**	144 (12 %)
S14-Memorization has no impact on the learning process	1216	279 (23 %)	864 **(71 %)**	73 (6 %)
S15-Environments that provide a larger amount of stimuli improve the brains of pre-school children	1190	998 **(84 %)**	102 (9 %)	90 (7 %)
About brain and intelligence characteristics				
S16-Mental capacity is hereditary and cannot be changed by the environment or experience	1211	298 (25 %)	827 **(68 %)**	86 (7 %)
S17-Listening to classical music improves mental capacity	1238	724 **(59 %)**	123 (10 %)	391 (31 %)
S19-Short periods of coordination exercises can improve brain function (for example, touching your right ankle with your left hand and vice versa)	1188	917 **(77 %)**	52 (4 %)	219 (19 %)
S20-We use only 10 % of our brain	1236	599 **(49 %)**	278 (22 %)	359 (29 %)

(continued on next page)

Table 3 (*continued*)

Statements	N	"Correct" (Neuromyth believers) N (%)	"Incorrect" N (%)	"I can't answer"
S21-Individuals with larger brains are smarter	1239	243 (20 %)	684 **(55 %)**	312 (25 %)
S23-Male and female brains are designed for different types of skills	1226	553 **(45 %)**	370 (30 %)	303 (25 %)
S25-Supplements such as Omega-3 and Omega-6 have a positive effect on academic achievement	1225	759 **(62 %)**	55 (4 %)	411 (34 %)
S26-Brain development is complete by the time children reach the end of puberty	1210	279 (23 %)	621 **(51 %)**	310 (26 %)
S28-The brain shuts down during sleep	1228	233 (19 %)	890 **(73 %)**	105 (8 %)
S30-Humans are born with all the neurons they will have in their lifetime	1214	506 **(42 %)**	350 (29 %)	358 (29 %)

population. Considering all our participants taken together, they are S1; S2; S4; S9; S10; S11; S15; S17; S19; S20; S23; S25; and S30. Among those, we will specify as "common neuromyths" those who reach 60 to 80 % (S10; S11; S19; and S25), and "strong neuromyths" (S1; S2; and S15) those who reach 80 % and more. They are:

- Strong neuromyths
  - Individuals learn better when they receive information in alignment with their dominant learning style (92 %);
  - The dominant intelligence profile of learners (examples: mathematical, verbal, spatial) must be considered in teaching (93 %); and
  - Environments that provide a larger amount of stimuli improve the brains of preschool children (84 %).
- Common neuromyths
  - Humans are good multitaskers (68 %);
  - The fact that some people are more "right-brained" and others are more "left-brained" helps explain the differences in how we learn (75 %);
  - Short periods of coordination exercises can improve brain function (for example, touching your right ankle with your left hand and vice versa) (77 %); and
  - Supplements such as Omega-3 and Omega-6 have a positive effect on academic achievement (62 %).

Notably, 58 % of participants agreed with the statement, S17, "Listening to classical music improves mental performance". As research findings indicate, this neuromyths are still widespread among teachers in different countries. Other studies examining their prevalence highlight how deeply entrenched these misconceptions are in educational practices and underscore the urgent need for systematic assessments of teachers' neuroscience literacy, alongside the implementation of targeted educational interventions to correct them [4–9]. Teachers commonly agreed with correct statements. However, there was noticeable hesitation about certain statements. For example, although the statement S18, "When one part of the brain is damaged, other parts can take over its function," is scientifically accurate, only 39 % of teachers agreed with it. In contrast, 28 % disagreed with the statement, and 33 % could not provide an answer. This suggests that teachers may lack knowledge of certain technical concepts, reflecting gaps in their neuroscience literacy. Similarly, many teachers answered incorrectly to the statement S29, "On average, males have larger brains than females". Participants had difficulty in acknowledging the biological fact that males tend to have larger brain volumes than females. A substantial proportion (41 %) chose not to respond, highlighting their hesitation. These findings underscore the broader issue of teacher's limited neuroscience knowledge and literacy, which may influence their pedagogical practices and decision-making.

3.1.1. International comparison of provided answers

A comparative analysis was conducted to investigate cross-cultural variations in neuromyth beliefs. Table 4 presents the responses to false statements by country. Table 4 facilitates a cross-country comparison, highlighting similarities in neuromyth adherence among teachers globally and differences in responses.

As shown in Table 4, the strong neuromyths S1 and S2 were found at comparable rates in all countries. Neuromyth S1, which states that "individuals learn better when they receive information in accordance with their dominant learning styles (e.g., visual, auditory, kinesthetic)," had an overall prevalence of 92 %. In Taiwan, the entire set (100 % [$N = 138$]) of teachers believed this neuromyth, followed by 99 % in Greece, 98 % in Malaysia, and 97 % in Turkey. Similarly, the strong neuromyth S2, "The dominant intelligence profile of learners [...]" was endorsed by 100 % of teachers in Malaysia, 99 % in Taiwan, and 98 % in Turkey, Kazakhstan, and Mali. The remarkably high endorsement rates (up to 92 %) indicate widespread belief in the neuromyths of learning styles and multiple intelligences among teachers across participating countries. Canada reported the lowest rates of belief in both these two strong neuromyths, but even there, 79 % of teachers held these myths, suggesting that although below the overall average, a significant proportion of teachers in Canada-Quebec still subscribe to these myths.

A similar pattern was observed for other items with high levels of agreement in the learning process category, particularly statements S15 (strong), S11, and S10 (both common neuromyths). The neuromyth, S15, which states, "Environments with more stimuli enhance preschool children's brain development," revealed exceptionally high endorsement rates, surpassing 90 % in countries such as Mali, Turkey, Kazakhstan, Morocco, Senegal, and Taiwan. In contrast, the lowest agreement rates were observed in Greece (16 %) and Canada (57 %), indicating a significant deviation from the global trend. Similarly, the common neuromyth S11 according to which "some people are more "right-brained" while others are more "left-brained [...]"—was less prevalent in Canada and Belgium compared to the overall average. Conversely, it was more prevalent in Turkey (86 %), Kazakhstan (85 %), Malaysia (86 %), and Taiwan (89 %), all reporting rates well above the global average of 74 %.

Neuromyth S10 (common), stating that "humans are good multitaskers", with a general acceptance rate of 67 %, was particularly widespread in African countries such as Cameroon (95 %), Mali (90 %), Morocco (92 %), Senegal (85 %), as well as in Taiwan (81 %). Belgium exhibited the lowest level of belief in this neuromyth (45 %).

When examining teachers' beliefs in neuromyths related to brain function and intelligence, it is rather obvious that neuromyth S19, (common) "short-term motor coordination exercises can improve brain function [...]" is prevalent across all countries at comparable percentages, with an overall acceptance rate of 77 %. The highest levels of belief in this neuromyth were found in Turkey (86 %), Cameroon (94 %), Kazakhstan (89 %), Malaysia (82 %), and Mali (87 %). So, in many places, this myth can be considered a strong one.

Similarly, neuromyth S25 (common), "Supplements such as Omega-3 and Omega-6 have a positive effect on academic achievement," recorded particularly high in Turkey (79 %), Kazakhstan (85 %), Mali (75 %), and Morocco (74 %). Notably, 34 % of participants chose not to respond to this item, indicating a significant level of uncertainty about this statement.

It is noteworthy that neuromyth S17, "Listening to classical music improves mental capacity", with an overall acceptance tendency of 58 %, is particularly high in countries such as Turkey (67 %), Cameroon (71

Table 4
Distribution of teachers' answers to the 21 false statements, by country.

Country	Statements	Canada (Quebec)	Turkey	Belgium	Cameroon	Greece	Kazakhstan	Malaysia	Mali	Morocco	Senegal	Taiwan
S1	Correct	79 %	97 %	85 %	95 %	99 %	90 %	98 %	96 %	96 %	97 %	**100 %**
	Incorrect	***19 %***	3 %	14 %	0 %	0 %	2 %	0 %	2 %	4 %	0 %	0 %
S2	Correct	79 %	98 %	83 %	96 %	**100 %**	98 %	100 %	98 %	93 %	96 %	99 %
	Incorrect	***17 %***	1 %	10 %	0 %	0 %	0 %	0 %	2 %	1 %	0 %	0 %
S4	Correct	32 %	55 %	24 %	70 %	65 %	53 %	58 %	**78 %**	33 %	55 %	27 %
	Incorrect	49 %	31 %	49 %	19 %	17 %	29 %	31 %	18 %	***52 %***	28 %	60 %
S6	Correct	2 %	41 %	5 %	64 %	7 %	72 %	29 %	**78 %**	47 %	70 %	22 %
	Incorrect	***95 %***	52 %	93 %	33 %	89 %	13 %	67 %	19 %	47 %	26 %	70 %
S7	Correct	35 %	26 %	21 %	78 %	13 %	**81 %**	51 %	74 %	30 %	63 %	7 %
	Incorrect	60 %	73 %	62 %	20 %	83 %	15 %	41 %	25 %	53 %	25 %	***90 %***
S9	Correct	42 %	58 %	45 %	44 %	**61 %**	35 %	49 %	58 %	51 %	48 %	42 %
	Incorrect	19 %	18 %	16 %	44 %	13 %	***49 %***	35 %	33 %	32 %	38 %	24 %
S10	Correct	55 %	55 %	45 %	95 %	64 %	65 %	86 %	90 %	**92 %**	85 %	81 %
	Incorrect	25 %	27 %	28 %	0 %	21 %	***30 %***	14 %	10 %	6 %	6 %	12 %
S11	Correct	58 %	86 %	60 %	70 %	71 %	85 %	86 %	79 %	66 %	68 %	**89 %**
	Incorrect	***22 %***	3 %	18 %	19 %	14 %	5 %	6 %	15 %	15 %	9 %	5 %
S13	Correct	21 %	17 %	28 %	54 %	28 %	**81 %**	53 %	77 %	36 %	70 %	20 %
	Incorrect	66 %	76 %	45 %	41 %	54 %	13 %	45 %	21 %	59 %	25 %	***69 %***
S14	Correct	13 %	20 %	9 %	29 %	11 %	43 %	22 %	**56 %**	16 %	45 %	7 %
	Incorrect	83 %	70 %	80 %	66 %	81 %	52 %	78 %	43 %	83 %	53 %	***92 %***
S15	Correct	57 %	94 %	83 %	86 %	16 %	94 %	79 %	95 %	**99 %**	94 %	93 %
	Incorrect	21 %	2 %	4 %	8 %	***74 %***	2 %	4 %	5 %	0 %	0 %	4 %
S16	Correct	0 %	19 %	6 %	32 %	6 %	61 %	25 %	**63 %**	21 %	27 %	7 %
	Incorrect	***93 %***	73 %	86 %	63 %	85 %	31 %	69 %	34 %	76 %	66 %	87 %
S17	Correct	37 %	67 %	36 %	71 %	63 %	**87 %**	62 %	67 %	46 %	55 %	51 %
	Incorrect	16 %	3 %	7 %	14 %	4 %	5 %	12 %	21 %	24 %	22 %	8 %
S19	Correct	72 %	86 %	65 %	94 %	69 %	**89 %**	82 %	87 %	77 %	79 %	67 %
	Incorrect	3 %	3 %	7 %	0 %	1 %	2 %	4 %	13 %	3 %	3 %	6 %
S20	Correct	51 %	52 %	38 %	24 %	49 %	54 %	46 %	**77 %**	60 %	43 %	45 %
	Incorrect	21 %	18 %	17 %	45 %	27 %	30 %	32 %	16 %	20 %	25 %	14 %
S21	Correct	5 %	15 %	3 %	39 %	6 %	30 %	26 %	**56 %**	26 %	32 %	18 %
	Incorrect	***76 %***	49 %	65 %	37 %	54 %	52 %	49 %	41 %	59 %	53 %	50 %
S23	Correct	25 %	57 %	15 %	49 %	39 %	**70 %**	50 %	56 %	65 %	44 %	42 %
	Incorrect	38 %	19 %	***44 %***	32 %	38 %	15 %	28 %	38 %	24 %	39 %	28 %
S25	Correct	52 %	79 %	40 %	58 %	53 %	**85 %**	54 %	75 %	74 %	44 %	58 %
	Incorrect	3 %	3 %	2 %	5 %	7 %	3 %	14 %	5 %	5 %	10 %	4 %
S26	Correct	16 %	12 %	8 %	28 %	24 %	25 %	34 %	**62 %**	36 %	32 %	23 %
	Incorrect	***66 %***	***66 %***	56 %	53 %	43 %	52 %	44 %	33 %	29 %	55 %	51 %
S28	Correct	2 %	18 %	4 %	32 %	3 %	40 %	13 %	**54 %**	11 %	40 %	7 %
	Incorrect	***97 %***	74 %	93 %	61 %	73 %	47 %	77 %	44 %	81 %	51 %	85 %
S30	Correct	29 %	41 %	17 %	75 %	18 %	58 %	50 %	**85 %**	48 %	68 %	29 %
	Incorrect	34 %	20 %	42 %	10 %	***43 %***	18 %	23 %	11 %	31 %	12 %	***43 %***

%), and Kazakhstan (87 %). The country with the lowest level of this neuromyth is Canada (37 %). So even if it is not overall common, in certain countries, it is, while in others, it is not even confirmed.

Another result worthy of note is that neuromyth S23, "Male and female brains are designed for different types of skills", which has a general acceptance rate of 45 % (only confirmed), is highest in countries such as Turkey (57 %), Kazakhstan (70 %), Mali (56 %), and Morocco (65 %). The countries where this neuromyth was found very rarely were Belgium (15 %) and Canada (25 %).

In addition to all these neuromyths, there are also notable differences in some other of the statements in Table 4. For example, although "S6 Learning is a purely cognitive skill, not emotional" is an explicit neuromyth that excludes affective aspects from the learning process, it is noteworthy that it is accepted by teachers in countries such as Turkey (41 %), Cameroon (64 %), Kazakhstan (72 %), Mali (78 %), and Senegal (70 %). Despite these high rates of general acceptance, it is accepted by only 2 % in Canada, 5 % in Belgium, and only 7 % in Greece. Again, this shows a lot of variability since it is unconfirmed in some places, and goes up to being common in others.

3.1.2. Analysis of the effect size of countries that differ significantly in cross-country comparisons of neuromyths

A simple two-step cluster analysis based on Table 2 provided a three-cluster solution that is interesting to interpret, and with a good cohesion and separation (>0.5). The first cluster comprises *Canada* (Québec) and *Belgium*, distinguished by relatively low adherence to neuromyths across most statements, with notable exceptions being S4 and S30. The second cluster is the larger and is formed of *Turkey, Cameroon, Greece, Kazakhstan, Malaysia, Morocco, Senegal* and *Taiwan*. It is characterized by higher adherence to S1, S2, and by scattered adherences to all other statements. The third is formed of only *Mali*, with a distinction appearing through higher adherence to all neuromyths, except maybe S13, S16 and S11. Testing a four-cluster solution did not generate a lot of difference, except maybe revealing a difference of *Kazakhstan* with lower adherence to S4, and higher for S26 compared with *Mali*. Testing for more clusters did not clearly add to this interpretation.

The eventual presence of statistically significant differences in teachers' beliefs in neuromyths across countries was also examined, and effect sizes were calculated for countries where significant differences were found. Analysis of the research data revealed non-normal distribution patterns for each neuromyth. Therefore, differences in neuromyth beliefs between countries were analyzed using the nonparametric Mann-Whitney U test. For countries with significant differences, Cohen's d was used to calculate effect sizes, and differences were categorized as low ($r < 0.30$), medium ($0.30 \leq r \leq 0.49$), or high ($r \geq 0.50$). In this report, only differences with high effect sizes are summarized, as these represent the most substantial differences in neuromyth beliefs among the countries studied (See Appendix 2 for all effect sizes).

- For S1, "*Individuals learn better when they receive information in alignment with in their dominant learning styles (examples: visual, auditory, kinesthetic etc.)*" significant variation in teachers' beliefs was observed across countries. However, when effect sizes were analyzed, the general trend was found to be relatively similar across countries (92 %).

- For S2, "*The dominant intelligence profile of learners (e.g., mathematical, verbal, spatial) must be considered in teaching*" the general tendency across countries was similar (93 %). Statistically significant cross-country differences were detected, but further analysis revealed moderate effect sizes, indicating relatively small practical differences.
- For S4, "*Different parts of the brain operate independently during the learning process*" while cross-country comparisons revealed statistically significant differences, the effect sizes were moderate, indicating that the differences were not strongly pronounced.
- For S10, "*Humans are good multitaskers*" significant differences in neuromyth beliefs were observed across countries, but none showed a high effect size. This suggests that the belief is widespread and similarly prevalent in all countries surveyed.
- For S11, "*The fact that some people are more "right-brained" and others are more "left-brained", helps explain the differences in how we learn*", significant differences were also observed with medium effect sizes, indicating that this belief is widespread and similarly prevalent in all countries surveyed.
- For S13, "*There are specific periods in childhood after which certain things can no longer be learned*", significant high effect size differences were reported rather than moderate differences. Specifically, Kazakhstan showed higher support for the neuromyth than Canada (81 % vs. 17 %) ($U = 2935$, $Z = -9.05$, $p < .05$, $r = 0.52$). Similarly, Mali had stronger beliefs than Canada (77 % vs. 21 %), ($U = 767$, $Z = -6.04$, $p < .05$, $r = 0.56$). Large effect size differences were also found between Kazakhstan (81 %) and Turkey (17 %) ($U = 4749$, $Z = -11.36$, $p < .05$, $r = 0.61$), Mali (77 %) and Turkey ($U = 1253.50$, $Z = -7.51$, $p < .05$, $r = 0.58$), and Senegal (70 %) and Turkey ($U = 1662.50$, $Z = -7.02$, $p < .05$, $r = 0.53$). A significant difference was also found between Kazakhstan (81 %) and Belgium (23 %), ($U = 14{,}545$, $Z = -11.869$, $p < .05$, $r = 0.53$) and between Mali (77 %) and Taiwan (20 %), ($U = 1646$, $Z = -7.47$, $p < .05$, $r = 0.54$).
- For S15, "*Environments that provide a larger amount of stimuli improve the brains of pre-school children*", this neuromyth was found to have the most intense differences compared to other neuromyths. While this belief is highly prevalent in all countries surveyed, Greece showed significantly lower support, with only 16 % of teachers supporting it. Significant differences with high effect sizes were found between Greece and several other countries. In particular, Morocco showed a higher prevalence of this belief (99 %) compared to Canada (57 %) ($U = 1651$, $Z = -6.55$, $p < .05$, $r = 0.53$); indicating a marked difference in the acceptance of this neuromyth. The results show that significant differences were observed in the endorsement of the neuromyth between Greece and various countries. Specifically, Turkey (94 %) showed significantly higher belief than Greece (18 %) ($U = 1008$, $Z = -10.85$, $p < .05$, $r = 0.78$). Similarly, Cameroon (86 %) showed significantly higher support than Greece ($U = 440.50$, $Z = -7.23$, $p < .05$, $r = 0.67$), as did Belgium (83 %) ($U = 3456$, $Z = -11.15$, $p < .05$, $r = 0.60$) and Kazakhstan (94 %) ($U = 2133$, $Z = -13.91$, $p < .05$, $r = 0.78$). Malaysia (79 %) also reported significantly greater belief than Greece ($U = 712$, $Z = -7.01$, $p < .05$, $r = 0.62$), while Mali (95 %) showed a strong difference ($U = 3724$, $Z = -8.97$, $p < .05$, $r = 0.77$). Furthermore, Morocco (99 %) showed the highest agreement compared to Greece ($U = 625$, $Z = -10.95$, $p < .05$, $r = 0.84$). Significant differences were also found for Senegal (94 %) ($U = 569.50$, $Z = -9.16$, $p < .05$, $r = 0.77$) and Taiwan (93 %) ($U = 4537$, $Z = -11.36$, $p < .05$, $r = 0.77$), both of which showed much higher belief in this neuromyth than Greece.
- For S17, "*Listening to classical music improves mental capacity*", notable differences were observed among various countries, characterized primarily by moderate effect sizes. However, a significant high effect size was found in the comparison between Kazakhstan (87 %) and Belgium (36 %) ($U = 16{,}501$, $Z = -11.87$, $p < .05$, $r = 0.52$).
- For S20, "*We use only 10 % of our brain*", the neuromyth was found to be slightly more prevalent in some countries; however, significant differences between countries were lower overall. The findings revealed that a notable high effect size, ($r = 0.53$) was observed in the comparison between Mali (77 %) and Cameroon (24 %) ($U = 16{,}501$, $Z = -11.87$, $p < .05$).
- For S23, "*Male and female brains are designed for different types of skills*", significant differences were observed between countries; however, the effect sizes were generally small. Notably, a high difference in effect size was found between Kazakhstan (70 %) and Belgium (15 %) ($U = 14{,}915$, $Z = -12.54$, $p < .05$, $r = 0.55$).
- For S25, "*Supplements such as Omega-3 and Omega-6 have a positive effect on academic achievement*", significant differences were observed among many countries; however, no differences with high effect sizes were found.
- For S30, "*Humans are born with all the neurons they will have in their lifetime*", statistically significant differences emerged between almost all countries, with most differences generally categorized as having medium effect sizes. Notably, Mali exhibited a significantly higher belief compared to Canada (85 % vs. 29 %) ($U = 784$, $Z = -6.22$, $p < .05$, $r = 0.57$), as well as compared to Belgium (85 % vs. 17 %) ($U = 2521$, $Z = -10.51$, $p < .05$, $r = 0.59$). Furthermore, Cameroon was found to have a significantly higher belief than Greece (75 % vs. 18 %) ($U = 710$, $Z = -6.07$, $p < .05$, $r = 0.55$), and Mali compared to Taiwan (85 % vs. 29 %) ($U = 1836.50$, $Z = -7.28$, $p < .05$, $r = 0.52$).

3.2. What are the formal and informal sources of these neuromyths among primary school teachers?

After analyzing the teachers' general tendencies toward neuromyths, the learning sources that contribute to the dissemination of these neuromyths were also examined. The categorical responses provided by the teachers regarding the sources identified in the questionnaire, classified as formal or informal for each item are presented in Table 5. This table shows the percentages of participants who chose to identify the source of their neuromyths, taking into account only the cases in which they gave the inaccurate answer "correct" to false statements.

An analysis of Table 5 reveals that formal learning sources, including educational training, academic courses, and professional experience, play a substantial role in shaping teachers' neuromyth beliefs. The data reveal that over 90 % of the participants endorsed prevalent myths such as "multiple intelligences" and "learning styles." This finding suggests that these neuromyths are primarily embedded within the curricula of pre-service and in-service teacher training programs. Furthermore, professional experiences appear to catalyze the perpetuation of these beliefs, underscoring a nexus between the quality of education imparted in training programs and the prevalence of these myths.

These findings align with existing research indicating that formal sources, such as teacher education programs and academic publications, play a significant role in disseminating neuromyths [4,14,32]. This study notably highlights that formal education and professional experience may be the primary sources through which such misconceptions are reinforced. These insights emphasize the urgent need to critically evaluate and systematically update teacher training curricula and scholarly resources to address the ongoing acceptance of neuromyths among teachers. Our findings reveal no significant relationship between informal learning sources (e.g., social media, films, advertisements) and the spread of neuromyth beliefs among teachers, apart from the influence of professional experience. Teachers' classroom experiences, shaped by cognitive and affective factors such as past education, perceptions, and beliefs, appear strongly influenced by formal learning sources. These formal sources frame teachers' professional observations and may reinforce neuromyths by shaping how they interpret events.

This underscores the more significant influence of formal learning

Table 5
Learning sources for 21 incorrect statements, according to participant responses.

Sources Statements	Formal learning sources			Informal learning sources								NC*
	S1. Undergraduate/ graduate education	S2. Professional development programs	S7. Academic publications	*S3. Professional experience*	*S4. Social media*	*S5. Websites*	*S6. Colleagues or friends*	*S8. Other publications*	*S9 The movies*	*S10. Television programs*	*S11. Advertisements*	S12. Self-intuitions
Learning process												
S1 (1108)	**44 %**	38 %	23 %	**76 %**	17 %	18 %	22 %	27 %	7 %	8 %	3 %	30 %
S2 (965)	40 %	**41 %**	25 %	**71 %**	14 %	15 %	23 %	26 %	7 %	8 %	3 %	27 %
S4 (507)	**38 %**	37 %	28 %	**48 %**	18 %	19 %	19 %	32 %	6 %	13 %	3 %	23 %
S6 (440)	26 %	**36 %**	21 %	**51 %**	17 %	16 %	21 %	27 %	6 %	9 %	3 %	23 %
S7 (477)	25 %	**30 %**	16 %	**54 %**	19 %	12 %	21 %	23 %	7 %	10 %	4 %	24 %
S9 (562)	23 %	**26 %**	25 %	**34 %**	16 %	19 %	13 %	28 %	6 %	12 %	3 %	21 %
S10 (816)	**30 %**	**30 %**	22 %	**56 %**	15 %	18 %	18 %	24 %	6 %	10 %	3 %	**30 %**
S11 (874)	**37 %**	**37 %**	27 %	**46 %**	19 %	19 %	17 %	30 %	6 %	10 %	3 %	20 %
S13 (513)	**27 %**	26 %	17 %	**45 %**	14 %	11 %	16 %	20 %	7 %	9 %	3 %	25 %
S14 (279)	22 %	23 %	16 %	**47 %**	15 %	12 %	15 %	21 %	8 %	11 %	3 %	21 %
S15 (998)	32 %	**37 %**	22 %	**62 %**	15 %	16 %	20 %	24 %	6 %	9 %	3 %	26 %
Brain and intelligence characteristics												
S16 (298)	23 %	**28 %**	16 %	**49 %**	20 %	15 %	19 %	22 %	10 %	11 %	3 %	22 %
S17 (724)	22 %	24 %	21 %	**42 %**	21 %	18 %	14 %	26 %	9 %	15 %	4 %	24 %
S19 (917)	25 %	**31 %**	21 %	**44 %**	17 %	16 %	16 %	22 %	5 %	9 %	3 %	24 %
S20 (599)	**26 %**	23 %	**28 %**	25 %	20 %	20 %	10 %	27 %	9 %	13 %	3 %	17 %
S21 (243)	21 %	21 %	18 %	**32 %**	22 %	17 %	12 %	17 %	8 %	9 %	2 %	**24 %**
S23 (553)	22 %	21 %	23 %	**33 %**	19 %	17 %	15 %	**28 %**	6 %	11 %	4 %	**28 %**
S25 (759)	16 %	17 %	22 %	**25 %**	25 %	22 %	11 %	**27 %**	4 %	16 %	14 %	21 %
S26 (279)	22 %	22 %	23 %	**31 %**	11 %	16 %	9 %	17 %	5 %	9 %	2 %	**26 %**
S28 (890)	23 %	20 %	**28 %**	22 %	12 %	14 %	7 %	26 %	5 %	11 %	2 %	**35 %**
S30 (506)	25 %	20 %	21 %	**26 %**	16 %	18 %	10 %	24 %	5 %	11 %	2 %	**27 %**

* It is classified as a source that does not fall into formal or informal categories but has common characteristics.

processes, such as teacher training programs, textbooks, and scientific publications, over informal sources in the diffusion of neuromyths. Consequently, reforming the content and delivery of formal education is more urgent than addressing informal sources. Immediate analysis and updates to teacher training materials to align with current neuroscience research are essential to mitigate the spread of neuromyths and improve educational practices.

Other prevalent neuromyths among participants include beliefs like “Humans are good multitaskers” (S10, 67 %), “Some people are more right-brained and others more left-brained, which helps explain differences in learning” (S11, 74 %), “Environments that provide more stimuli improve the brains of preschool children” (S15, 84 %), and “Supplements such as Omega-3 and Omega-6 have a positive effect on academic achievement” (S25, 62 %). These neuromyths are prevalent and reinforced by formal education and professional experiences.

4. Discussion and conclusion

This study shows that most primary school teachers still believe in common neuromyths. These misconceptions can shape how they design instruction and teach. For instance, a teacher who believes in learning styles may base lesson plans on that false idea, potentially undermining effective practice. The extent to which these beliefs impact daily teaching practices is still uncertain. Still, the fact that over 90 % of teachers endorsed myths like learning styles and multiple intelligences suggests these ideas are deeply rooted and widespread across countries.

A notable finding of this research is the relative consistency of neuromyth prevalence across continents. While statistically significant differences were observed between countries, the majority of effect sizes were low to medium, with only a few neuromyths displaying high variation. This observation suggests the presence of shared beliefs among teachers globally. These findings offer valuable insights into the field, though we refrain from making audacious hypotheses about the observed differences. The observed variations may be attributed to structural, economic, political, cultural, ethnic, ideological, or religious factors. The complexity of these factors makes it difficult to determine their impact on beliefs with any precision.

The second aim of our study was the identification of the sources from which neuromyths are acquired, with a particular focus on the distinction of the relative influence of formal and informal learning sources. Table 5 provides a descriptive breakdown of the learning sources for 21 incorrectly endorsed statements. This data revealed that neuromyths were strongly influenced by formal educational sources, such as teacher education programs and professional training seminars, as well as professional experience and intuition. Informal sources, including the internet, social media, films, and advertisements, were reported to have considerably less impact. These results suggest that neuromyths are primarily perpetuated through institutional and experiential learning contexts rather than casual or entertainment-based media.

Our research indicates that teachers' intuition greatly influences the persistence and acquisition of all neuromyths. Among these neuromyths, Zrudlo [11] in his research on learning styles argues that the enduring appeal of the learning styles myth, is based on deeply held moral intuitions, which supports our findings. He identifies four moral intuitions that reinforce this belief: the desire for rational control, a modern sense of justice, the belief that each person is unique, and a reverence for nature. These intuitive moral frameworks help explain why educators often maintain their belief in learning styles despite substantial empirical evidence to the contrary. Addressing these intuitions directly, rather than merely presenting disconfirming evidence, may be a more effective strategy for countering neuromyths in teacher education programs [11].

While participants reported perceptions, these beliefs influence their teaching practices, suggesting that formal education may inadvertently contribute to spreading myths. This situation may be attributed to the recollection of brain-related knowledge acquired during teacher training, which is often distorted or oversimplified rather than inherently inaccurate in its original scientific context. Research has shown that even after formal education, teachers continue to endorse neuromyths, suggesting that misconceptions persist despite exposure to scientific content [4,7]. Therefore, a more systematic and critical evaluation of teacher training content and pedagogical methods is essential, especially in regions where neuromyths are prevalent [8,33]. Such an analysis could reveal structural weaknesses in professional development frameworks and inform the design of evidence-based educational initiatives. Reducing the influence of neuromyths and promoting scientifically grounded teaching practices that can enhance instructional effectiveness and learner outcomes are crucial efforts [6,10]. Some common neuromyths, while scientifically inaccurate, can inadvertently lead teachers to diversify their instructional practices. For instance, teachers who subscribe to the learning styles myth may use assessment tools to classify students' supposed preferences and adjust activities accordingly. Similarly, belief in multiple intelligences theory can often prompts teachers to design varied lesson plans aimed at engaging a broader spectrum of student abilities. Although these approaches are rooted in misconceptions [9,22], they often reflect teachers' well-intentioned efforts to create inclusive and supportive learning environments. However, such practices may misdirect valuable time and resources away from empirically supported strategies [6,7]. Therefore, improving neuroscience literacy among teachers is critical not only for advancing effective pedagogical practice but also for fostering students' cognitive and emotional development. Addressing this issue requires a comprehensive, policy-driven approach that incorporates multidimensional interventions, including reforms to both pre-service and in-service teacher education programs. Developing targeted intervention programs focused on neuromyths could help change these erroneous beliefs. However, existing programs have shown limited effectiveness [9]. Neuroscience literacy education, while beneficial, also has its limitations. For instance, Macdonald et al. [34] found that nearly half of participants retained classical neuromyths despite exposure to neuroscience education. This highlights the insufficiency of integrating neuroscience content alone in teacher training programs. Grospietsch and Mayer [4] stress the importance of training teachers to evaluate neuroscientific research findings critically. This approach could enhance their ability to discern evidence-based information and reduce the persistence of neuromyths in educational practices.

Boyle and Lyddy [35] found that neuroscience education alone cannot eliminate neuromyths, suggesting that incorporating cognitive neuroscience courses into teacher training may not fully address the problem. Comprehensive assessments across educational stakeholders and targeted, content-based strategies are needed to combat specific neuromyths effectively.

It is imperative to furnish educators with the essential skills to evaluate scientific research and counter distorted media portrayals. Preservice education programs must not only impart fundamental neuroscience knowledge but also cultivate an understanding of research methodologies to support evidence-based practices. Continuous professional development is indispensable to reinforce these competencies and enhance educational quality.

Artificial intelligence, particularly large language models (LLMs), offers significant potential in the context of educational neuromyths, but also poses notable risks. As more teachers integrate generative AI tools, such as ChatGPT, into tasks like lesson planning, student assessment, and content creation, concerns arise about the reliability and objectivity of these systems. LLMs may reflect or reinforce user biases and misconceptions by aligning their responses with the user's implied beliefs, a behavior known as "sycophancy" [36,37]. Furthermore, recent studies have highlighted the tendency of these systems to "hallucinate," or generate content that appears coherent and plausible yet is factually incorrect [38,39]. This issue is particularly problematic in domains requiring high levels of scientific accuracy because it can mislead teachers and students, perpetuating neuromyths in education. However, when designed, fine-tuned, and guided appropriately, AI systems can be powerful tools for debunking neuromyths. For example, research shows that LLMs can outperform human teachers at identifying false neuroscientific claims in structured formats [37]. Similarly, BrainGPT, a model trained specifically on neuroscience literature, has demonstrated superior predictive accuracy compared to human experts in anticipating experimental outcomes [40]. Innovative AI integrations, such as combining GPT-based models with humanoid robots like Pepper, have also shown promise. These systems engage users in interactive educational dialogues that effectively dispel common neuromyths [41]. Future research could examine the accuracy and consistency of AI-generated content addressing neuromyths on different platforms. Additionally, there is considerable potential to develop AI-based educational tools specifically trained to recognize and correct neuromyths. Leveraging AI's capabilities could enable the creation of targeted interventions to enhance neuroscience literacy among educators and the general public, helping to reduce the persistence of neuromyths in educational practice.

In conclusion, the findings of this study underscore the urgent need to re-evaluate educational policies and address neuromyths at both national and international levels. The high prevalence of these myths demands comprehensive, coordinated strategies to inform and raise awareness among ministries of education and policymakers about their impact. Strategic efforts are essential to secure support for initiatives combating these neuromyths. Furthermore, expanding research to include diverse educational stakeholders, such as university faculty, families, and special education professionals, can facilitate the development of targeted interventions, thereby fostering a more scientifically informed and effective educational system.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used ChatGPT for traduction and improvement. After using this tool, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the publication.

Ethical statement

We confirm that the work described in this manuscript:

- Has not been published previously, except as a preprint, abstract, academic thesis, published lecture, or registered report, in accordance with journal policy on redundant publication.
- Is not under consideration for publication elsewhere.
- Has been approved for submission by all authors and, where applicable, by the relevant institutional authorities.
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CRediT authorship contribution statement

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Declaration of competing interest

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Appendix

Appendix 1. Neuromyths items learning process and intelligence characteristics: english example

No	Items
M1	Individuals learn better when they receive information in alignment with in their dominant learning styles (examples: visual, auditory, kinesthetic etc.) ***(Incorrect)***
M2	The dominant intelligence profile of learners (examples: mathematical, verbal, spatial) must be considered in teaching ***(Incorrect)***
M3	In the learning process, the mind associates new information with previous knowledge
M4	Different parts of the brain operate independently during the learning process ***(Incorrect)***
M5	Learning occurs through changes in synaptic connections between neurons in the brain
M6	Learning is a purely cognitive skill, not emotional ***(Incorrect)***
M7	Learning takes place independent from individuals' learning backgrounds ***(Incorrect)***

(*continued on next page*)

(*continued*)

No	Items
M8	Some mental processes (experience, learning) repeated over a long period of time can change the structure and function of some areas of the brain
M9	Individuals can learn new information even while in a state of sleep ***(Incorrect)***
M10	Humans are good multitaskers ***(Incorrect)***
M11	The fact that some people are more “right-brained” and others are more “left-brained”, helps explain the differences in how we learn ***(Incorrect)***
M12	Individuals learn better when course content is presented in short sessions or modules
M13	There are specific periods in childhood after which certain things can no longer be learned ***(Incorrect)***
M14	Memorization has no impact on the learning process ***(Incorrect)***
M15	Environments that provide a larger amount of stimuli improve the brains of pre-school children ***(Incorrect)***
M16	Mental capacity is hereditary and cannot be changed by the environment or experience ***(Incorrect)***
M17	Listening to classical music improves mental capacity ***(Incorrect)***
M18	When a part of the brain is damaged, other parts can take over its function
M19	Short periods of coordination exercises can improve brain function (for example, touching your right ankle with your left hand and vice versa) ***(Incorrect)***
M20	We use only 10 % of our brain ***(Incorrect)***
M21	Individuals with larger brains are smarter ***(Incorrect)***
M22	The brain continues to generate new connections throughout an individual’s life
M23	Male and female brains are designed for different types of skills ***(Incorrect)***
M24	The brain remains active 24 h a day
M25	Supplements such as Omega-3 and Omega-6 have a positive effect on academic achievement ***(Incorrect)***
M26	Brain development is complete by the time children reach the end of puberty ***(Incorrect)***
M27	The normal development of the human brain involves the birth and death of brain cells
M28	The brain shuts down during sleep ***(Incorrect)***
M29	On average, males have bigger brains than females
M30	Humans are born with all the neurons they will have in their lifetime ***(Incorrect)***

Appendix 2. Source of learning: english example

For each item, please indicate which sources influenced your answers *(You can check more than one answer)*											
1. Undergraduate/ graduate education	2. Professional development programs	3. My professional experience	4. Social media (Twitter (X), Instagram, Linkedln, YouTube etc.)	5. Websites	6. My colleagues or friends	7. Academic publications	8. Other publications such as books, journals, popular magazines	9 The movies	10. Television programs	11. Advertisements	12. My intuitions

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