Education in Medicine Journal

ORIGINAL ARTICLE

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Submitted Date: 27-01-2025

Accepted Date: 28-04-2025

Please cite this article as: Pye RE, Rushaidhi M, Lim JJ, Soo YL, Hubbard PS. The Understanding, use, and prevalence of neuromyths among medical students, health sciences students, and educators in Malaysia. Education in Medicine Journal. 2025 (early view).

The Understanding, Use, and Prevalence of Neuromyths among Medical Students, Health Sciences Students, and Educators in Malaysia

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ABSTRACT

Neuromyths are ideas about the brain that, whilst based on a kernel of truth, are applied inaccurately. This is especially relevant in the field of education, where such myths are prevalent and potentially undermine progress by distracting educators from using evidence-based approaches. In this study, we explored the prevalence of neuromyth belief in a sample of secondary school teachers, university lecturers, and university students from medical and health sciences background in Malaysia. Participants were recruited via opportunity sampling through e-mail and asked to complete a questionnaire containing 'neuromyth' and 'neurofact' statements. Results show that all groups demonstrated a high level of belief in these myths, similar to rates found internationally. Group-level differences were found, with university lecturers believing fewer myths than the teachers and students. We found a significant relationship between the number of myths believed and the number of facts known about the brain, indicating that science knowledge could be a protective factor.

***Keywords**:* Neuromyths, Neuroeducation, Universities, Students, Brain,

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INTRODUCTION

Neuromyths were first described in the 1980s by Crocker, referring to misunderstandings of how the brain works in the medical field (1). The increasing use of neuroscience evidence in education has led to a concomitant increase in the number of research studies looking at educators and their beliefs and misunderstandings of how the brain works, and how this information can be used to serve students of all ages better. This research has generally shown, through questionnaire-based methods, that there is a wide range of misunderstandings from trainee teachers to experienced educators, and that these misunderstandings are common across different levels of education and different countries. Waterhouse (2) stated that such misconceptions are harmful to education in three ways: damaging developing educators' epistemologies of the learning process; focusing resources and attention on aspects of education with little or no empirical evidence that effective strategies are overlooked; belief in neuromyths damages the field of education in its acceptance of poorly-evidenced theories. Despite this, there is a deep-seated adherence to beliefs in neuromyths, even when educators are informed of the lack of evidence. For example, Foliano et al. (3) found that primary-school teachers in the UK intended to continue to teach children about growth mindsets, despite being part of a large randomised-controlled trial demonstrating a null effect of this intervention on academic and personal outcomes, and Newton and Miah (4) found that teachers who know that learning styles 'VAK – Visual, Auditory, Kinesthetic' is a myth continue to use it in their practice. When looking at what predicts belief in neuromyths, the evidence is contradictory. Several papers have found that interest in and experience of scientific literature in neuroscience predicted firmer belief in neuromyths (5-7). In contrast, other papers have found the opposite (8-10). Some studies have demonstrated that education plays a protective role, with educators holding more advanced degrees showing less susceptibility to neuromyth belief (9, 11), whilst other studies have found that education level plays no significant role in neuromyth belief (10, 12). Macdonald et al. (9) showed that those trained in neuroscience believed fewer neuromyths, though these were not completely eliminated, and Im et al's (13) intervention study demonstrated some effectiveness of training in neuroscience concepts in reducing neuromyth beliefs. It is clear therefore, that belief in neuromyths, and implementing interventions and approaches based on faulty understanding, is of concern to the field of education, and identification of the factors that lead to the development and promulgation of such beliefs should be identified to improve understanding and develop appropriate training for educators.

Whilst prevalence estimates of neuromyth belief are useful, especially in a global context, researchers are calling for methodological improvements in this area, in order to identify more convincingly whether the belief in neuromyths does negatively impact teaching outcomes (14). This is in addition to a more basic consideration of how neuromyths are conceptualised, as knowledge of the brain develops (15). The most commonly used set of questions used in this literature comes from Dekker et al's (5) key paper, based on Howard-Jones et al.'s (8) focus group work with pre-service teachers. Using a three-point scale (Correct, Don't Know, Incorrect), twelve neuromyth statements were intermingled with 'general statements' about the brain, in order to measure general knowledge of the brain as well as provide a form of balance to responses. Whilst researchers have amended the wording, dropped or added items, these remain the core neuromyth ideas and items in the research field. Sullivan et al. (15) recently highlighted how methodological issues around response scales, the wording of both neuromyth and neurofact statements, and the changing nature of myths into fact and vice versa, impede development of understanding in this research area. They therefore recommended that negative-coded items are removed from questionnaire items as they can easily confuse, and that wording of statements should be carefully considered, highlighting Grospietsch and Mayer's (12) definition that neuromyths are based on a kernel of truth: if a neuromyth is an oversimplification of a legitimate neurofact, it becomes incredibly important that statements do not themselves oversimplify complex ideas. This is compounded by insensitive response options, such as agree / disagree. Additionally, Sullivan et al. (15) suggested that a pool of experts, including neuroscientists, psychologists and educators, are used to create and update neuromyth research statements to ensure items reflect current knowledge accurately, and ensure researchers can share and pool data across studies. In this study therefore, particular attention was paid to the items used, looking at the wording of statements and identifying oversimplifications and changing neuroscientific understanding.

Much of the early work on neuromyths in education focused on Western, educated, industrialized, rich and democratic (WEIRD) (16) countries (e.g. UK and Netherlands (5); Australia: (17); Germany: (12). Ferrero et al. (6) conducted a meta-analysis of studies using the Howard-Jones (8) and Dekker (5) questions to identify cross-cultural differences. They found that despite similar levels of prevalence across the ten countries / regions analysed, there were cultural differences across items. Recently, studies have looked at prevalence and type of neuromyth belief in developing / Global South countries such as Morocco (18) and Trinidad & Tobago (19). In Asia thus far, research has mainly occurred in China (11, 20) including Hong Kong (21), and South Korea (13), which whilst not WEIRD are also not Global South, and perhaps unrepresentative of developing Asian nations as a result of their advanced scientific and educational achievements. As Bissessar & Youssef (19) highlight, there is a need to identify if educators in developing nations display similar levels of misunderstanding, as a way to determine how these myths develop, and therefore how interventions can be implemented. On one hand, the lack of advanced scientific education in developing nations may protect educators from these beliefs, although they may also demonstrate a lower level of understanding of neurofacts too. Alternatively a lack of rigorous scientific education may well mean staff who are interested in neuroscience have not been taught to distinguish between fact and myth in a systematic manner. Finally, it is possible that developing scientific education has learned from the mistakes of more developed nations, and attention and focus has been given to the dangers of neuromyth belief and related impact on education. The 24 papers included in Torrijos-Muelas et al.'s (22) systematic review indicate similar prevalence levels of Neuromyth belief across countries eligible for Overseas Development Aid; Organisation for Economic Co-operation and Development (ODA; OECD; m=51.1%, SD=11) compared to those ineligible for ODA (m=55.7%, SD=13.7), indicating that developing countries have not benefited from a raised awareness of neuromyths, but have similar levels of misunderstanding.

In this study, we invited teachers working in Malaysia across a variety of institutions and roles, to complete a questionnaire study looking at the prevalence of support for 'neuromyth' and 'neurofact' statements. Malaysia is currently considered an upper middle income country on the OECD's list of nations eligible for overseas development aid (ODA) in SE Asia (23), with compulsory education from 6 to 17 years and high rates of literacy (95% in 2019; (24)). Whilst 99% of primary school teachers are reported as 'trained' (24), there are multiple routes to qualification, which for primary school teachers may not involve university-level education. We also invited university students from medical and health sciences backgrounds as well as the higher education staff to participate in the studies. To date, the focus of evaluating the presence of neuromyths has been on teachers, with the only other study done in Malaysia surveying registered school teachers (25). The questionnaire comprised of previously used items, as well as additional items which reflected general beliefs about the brain observed locally. The authors are two neuroscientists (PH and MR) and one psychologist (RP), at the time working in private higher educational institutions in Malaysia. We aimed to identify whether the prevalence of neuromyths is similar to those in other countries, and to identify whether there are differences in the type of beliefs, in order to create effective interventions (if required). We also aimed to explore possible predictors of neuromyth belief, such as education and training experience, as per the studies listed above.

METHODS

Ethics

Ethical approval for this research was provided by the Newcastle University Faculty of Medical Sciences Ethical Approval Committee - Application No: 2203/14082/2020. An information page at the start of the questionnaire explained the study and participants were asked to confirm informed consent for information to be used for research.

Participants

Participants were recruited via opportunity sampling, with adverts distributed via social media, and direct contact with schools. Advertisements gained 107 student responses University of Reading Malaysia (UoRM) and Newcastle University Medicine Malaysia (NUMed), with 8 responses from students across Malaysia. All staff responses were gained from social media adverts or through direct contact with an international school in Johor. Demographic information can be found in Table 1.

Table 1: Demographic information of participants

	Students	**HE Staff**	**Secondary School Staff**
Number of Participants	115	22	31
Average Age	21.2	39.7	34.8
Gender			
Male	29	4	9
Female	85	17	21
Prefer not to say	1	1	1
Level of Study/Teaching			
Pre-university	2	0	31
University	113	22	0
Nationality			
Malaysian	87	15	20
International	28	7	11

Materials

Neuromyths questionnaire

In order to construct the questionnaire, we used previously validated and published questions from Dekker et al. (5), van Dijk and Lane (26), Grospietsch and Mayer (12), Papadatou-Pastou et al. (10) and Pei et al. (20). Our questionnaire followed Macdonald et al.'s (9) methodological recommendation and replaced the three-option answer format Correct/Incorrect/I don't know used by Dekker (5) and others with a 4-point Likert scale using the responses Strongly Agree, Somewhat Agree, Somewhat Disagree and Strongly

Disagree. A neutral middle response was not included to ensure participants clearly agreed or disagreed with the statements, as appropriate in situations where participants may not have a fully formed opinion on the topic (27), with the addition of a 'Don't Know' option.

Eighty-nine question items were identified from the papers above; twenty-four additional items were added based on the authors' experience of common neuromyths which were not captured previously, totaling 113 items. Three authors then blind-rated each item using the four-point Likert scale. Scores were collated and discussed in detail. Disagreements were noted and ambivalent or unclear wording was changed. The reworded items were then re-rated. Twenty-four neuromyths were chosen (see Table 2 for items and original source), with 12 items having zero disagreement between raters, and 12 items having minor disagreement. NeuroFacts were chosen to balance the responses of participants as per Dekker et al. (5); 24 items were chosen, 13 with a correct response as agreement, and 11 with a correct response of disagreement. Twelve items had no disagreement between raters and 12 items had some disagreement. Presentation order was determined using a random number generator in Excel.

Auxilliary Questions

A further twenty questions asked participants for their opinions on and experience of neuroscience in their day-to-day and professional lives. These questions were based on those used in previous research, to explore if the same experiences of neuroscience training were available in Malaysia, and to explore if similar patterns of relationships between general interest in science had a protective / enhancing effect on neuromyth beliefs. A 4-point Likert scale plus 'Don't Know' option was used.

Procedure

Questionnaires were distributed via social media, e-mail, and direct contact with schools. After reading the Information Sheet and providing consent, participants completed the questionnaire online hosted by Bristol Online Surveys. A series of demographic questions were asked, followed by the 24 neuromyth and 24 neurofact questions in random order, and 20 auxiliary questions on attitudes and experience. Participants were thanked for their time, and invited to leave their email address if they wished to be entered into a prize draw.

RESULTS

To assess the internal reliability of the question items a Cronbach's alpha score was calculated separately for the neuromyth, neurofact and auxiliary items from the 168 respondents. For the 24 neurofact items alpha = 0.74, for the 24 neuromyth items alpha = 0.82, for the 20 auxiliary questions alpha = 0.82. This suggests that the internal reliability of the neurofact items were acceptable (□ >0.7) and the neuromyth and auxiliary items were good (□>0.8).

To enable exploration of broad agreement in line with previous studies, the 'somewhat agree' and 'strongly agree' responses were initially combined to provide an overall 'agree' percentage, and 'somewhat disagree' and 'strongly disagree' combined to give an overall 'disagree' percentage. These 'agree', 'disagree' and 'don't know' scores are presented in Tables 3,4 and 5. The correct answer for each item in the table is shaded in grey, with the highest percentage score for each item highlighted in bold.

For the neuromyth items (Table 3), of 24 items the majority of the students correctly rejected 50%, University staff correctly rejected 70.8% and Secondary school teachers correctly rejected 41.6%. The majority of the neuromyths believed by the cohort were in the neurobiological and neurolearning category, with the learning style myth (item 28, 88.1%), the 'right brain, left brain' myths (items 11, 69% and 38, 56%) and the brain gym myth (items 19, 67.3%, 37, 61.3% and 39 69.6%) most prominent.

For the neurofact items (Table 4) the majority of students correctly accepted 83.3% of items, University staff accepted 87.5%, and secondary school teachers accepted 53.8%. That is, for most of the items, the majority of participants in each cohort were able to correctly recognize if a neurofact was correct or not, with the secondary teachers getting more facts incorrect as a group than the other cohorts.

The pre-university staff had a majority of participants choosing the incorrect score in 2 items that the other groups were correct in the majority. These were items 1 (45.2%) - 'Any brain region can perform any function', and 22 (51.6%) – 'Mental capacity cannot be changed by environment or experience because it is hereditary'. For items 45 – 'Our brain has maps of the surface of the body and of the visual field', and 20 – 'In the majority of right-handed people, speech is a specialty of the left-brain hemisphere', the majority of the pre-university staff chose the 'don't know' option when the other cohort groups mostly got these items correct.

Neuromyth Belief Index

To assess if there is any correlation between understanding of neurofacts and belief in neuromyths across the whole cohort, a 'neuromyth score' was calculated. To calculate a neuromyth score each item response was coded on a 4-pt scale such that a high score for neurofact items relates to a better understanding of neurofacts, whereas a high score for neuromyth items relates to a strong belief in neuromyths. 'Don't know' responses were excluded. Scores for each participant were summed and averaged for both the neurofact and neuromyth items to gain a neurofact and neuromyth index. Averaging negated any effect of participants choosing 'don't know' for some items. Since the neurofact and neuromyth index are arbitrary, Z-scores were calculated so that individual scores compared to the mean for each index could be plotted and compared.

Figure 1 shows a significant negative correlation (Spearman's Rho, -0.471, $p<0.001$, one tailed, $n=168$) where a higher neuromyth index (greater belief in neuromyths) is associated with a lower score in the neurofact index. Direct comparison (independent samples Kruskal-Wallis test) of neuromyth index scores between groups showed an overall significant difference ($p=0.14$). Pairwise comparison of groups showed there was no significant difference in scores between staff and students, but there was between university staff and secondary school staff ($p=0.01$, Bonferroni correction for multiple tests; Figure 2).

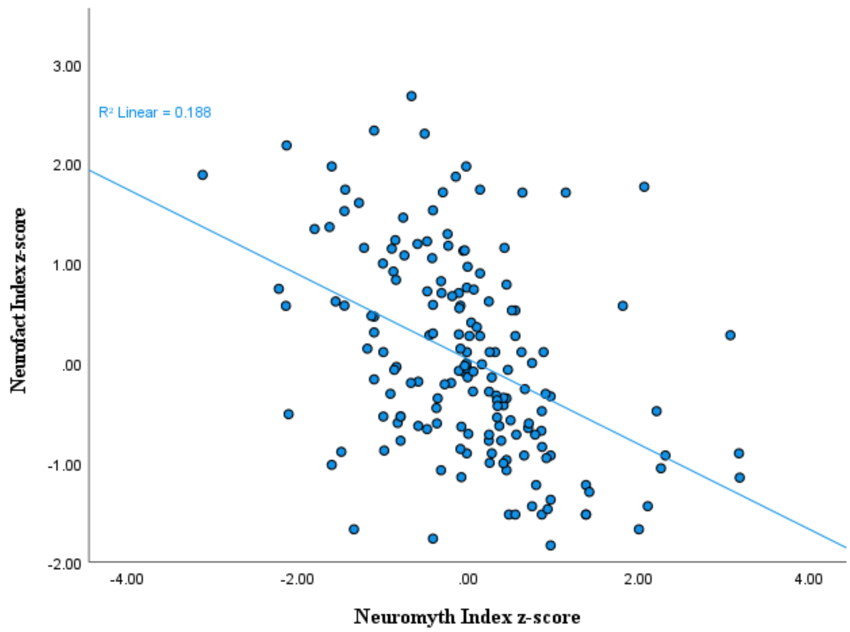

Figure 1. Correlation of Participant's Neuromyth Index with Neurofact Index.

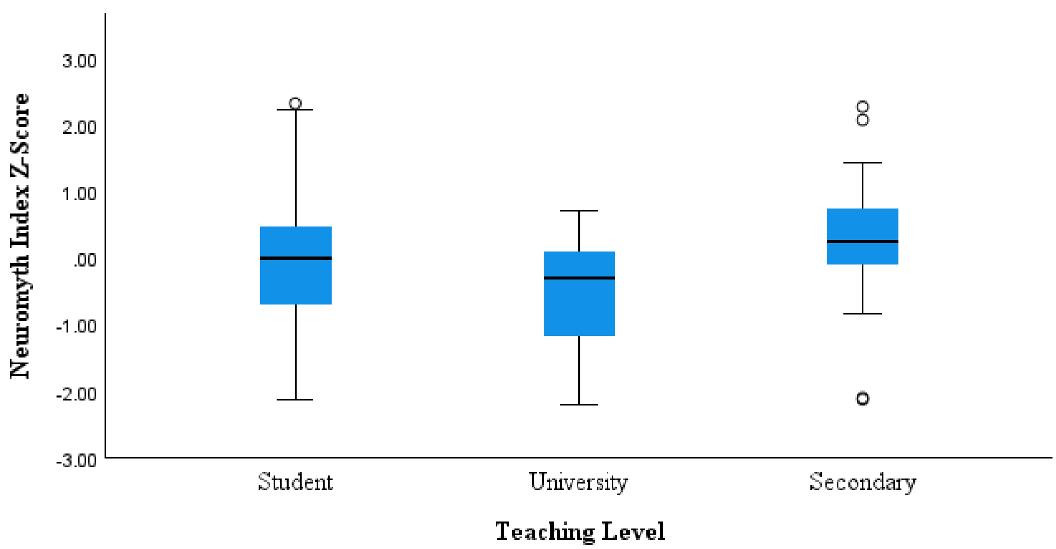

Figure 2. Box and whisker plot showing the range of neuromyth index z-scores for each participant group with outliers (z score ≥ ±3) removed. Differences in score between university and secondary school staff was significant (p=0.01), but comparison between Students and university staff (p=0.13) and secondary school staff (p=0.26) was not significant.

Auxiliary Questions

Auxiliary questions were coded into four themes; Neuroscience: items 1, 6, 11; Neuroeducation: items 3,5,12,13,14,17,18,20, General Education: items 7,8,1519; and General Science; items 4,9,10,16 (item 2 could not be assigned to a theme; see Table 5). An index was created in a similar way to the neuromyth index; there was no correlation between the neuromyth index and science literacy (data not shown).

DISCUSSION

The results showed that, similarly to other countries, belief in neuromyths were high amongst all groups of participants: Malaysian students in higher education, staff in secondary schools and staff in higher education institutions. Myths that were most common were learning styles (88% across all groups), co-ordination exercises improving hemispheric integration (70%) and 'right brain left brain' differences (69%), with the highest myth beliefs falling in the neurolearning category. This indicates that, similarly to data published by Amran and Sommer (25), Malaysia has not been protected against the belief in the neuromyth items assessed in this paper, and the fact that the most believed myths are largely educationally-relevant should be a cause of concern. The strong negative relationship between neuromyth belief and neurofact belief indicates that, perhaps similarly to Macdonald et al.'s (9) and Gleichgerrcht et al.'s (7) studies, knowledge of the brain and science could be a protective factor against neuromyths. The study did find some group-level differences in the number of accepted neuromyths, with secondary school teachers believing significantly more myth statements than those teaching in higher education. At the moment, it is difficult to determine whether this is due to the education levels (higher education staff typically being qualified to doctoral level), or due to the type of institutions and staff recruited for this initial study (the majority of staff and students in the higher education institutions coming from a medical and health sciences or science background, compared to a broader sample of teaching staff at secondary school level). This can also be seen when looking at the neurofact item scores. The majority of participants correctly answered the neurofact statements in 22 of out 24 items, supporting the suggestion that this cohort of participants had a high neuroscientific understanding. Of the two items where this was not the case; item 8 ('When a brain region is damaged other parts of the brain can take up its function') and item 27 ('An epileptic crisis results from the temporary silencing of a brain area; this is why epileptics lose consciousness during a crisis.'), it could be argued that these are items requiring specialist neuroscientific knowledge so might be expected to score lower. That the highest percentage for item 27 was 'don't know' supports the notion that participants opted out of items when they felt the statement was pitched above their level of neuroscientific understanding, providing a degree of confidence in the results obtained.

Further exploration of background/education factors was included in the 20 auxiliary questions, which looked at self-reported science and education literacy, attitudes to neuroscience and its relationship to education. However, there were no significant relationships between the four factors explored in the auxiliary questions and neuromyth belief. It is possible that this is a power issue, with only 168 participants in this study, compared with more than 3000 in Macdonald et al. (9), who found a significant effect of neuroscience learning on neuromyth agreement. Based on the evidence the results of this study and of Amran and Sommer (25), do suggest that previous neuromyth belief patterns seen in the literature are mirrored in Malaysia. However, a wider study, looking at a broader range of students and staff across Malaysia, would be useful to confirm.

In this study, we sought to utilise the methodological improvements suggested by Sullivan et al. (15) by using a panel of three neuroscientists and psychologists to independently rate and then discuss each item before inclusion. We noted disagreements to capture some of the ambiguity of the items. It is notable that the three most-believed myths were taken from Dekker et al.'s (5) seminal work on this topic, indicating that these myths are firmly entrenched. However, one of these items had a small level of disagreement from the panelists about whether this was a myth or not, supporting Sullivan et al.'s (15) suggestion that such discussions can identify a shifting understanding of the 'kernel of truth' underpinning these myths. Interestingly, some of Dekker et al.'s (5) myth items are no longer believed; including items on critical periods of neural development (items 14 and 16), the necessity of drinking water (item 48) and language development (item 31). Given that these are more neurobiological items, except for language, it could indicate that increasing knowledge of neuroscience could become a protective factor. It is also interesting that in multilingual Malaysia, participants overwhelmingly disagreed that languages need to be acquired in serial order, suggesting that personal experience might also play a role in the beliefs of such myths. Exploring such factors through qualitative research would be useful.

It should be noted that there were some clear limitations in this first exploration of neuromyth belief in Malaysia. Firstly, our sample came from private educational institutions in one area of Malaysia, with a relatively high number of non-Malaysian participants, thus limiting the generalisability of the study to the wider Malaysian education sector. Additionally, the questionnaire was delivered in English, which is not an official language of Malaysia, although a language which is a compulsory school subject and one in which every child is expected to be proficient in by graduation from secondary education (28), and the language of education delivery in the participating institutions. Finally, it is pertinent that one of the two included higher education institutions was specifically science focused, as a medical school providing allied biomedical programmes, with a high proportion of science experts; though we note that this did not lead to a complete lack of myth belief in this particular group of participants. Whilst the results of this study suggest knowledge of the brain and science could be a partial protective factor against neuromyths, the relatively small sample size meant that we could not complete an exploratory factor analysis to look at other potential predictors of belief in neuromyths. It is therefore imperative that future studies on this topic use a broader range of participants from different educational backgrounds, providing questionnaires in the national language, Bahasa Melayu, as well as English.

This study has therefore provided evidence that in Malaysia, educators at secondary and higher education levels, and students in higher education albeit coming from medical and health sciences background, believe particular neuromyths, many of which pertain particularly to educationally relevant topics. Whilst there are some group differences between staff in the different levels, clear myth belief was seen in all groups. We cannot determine whether educational levels *per se*, or the area of specialisation of our participants, could hold a protective factor. It is unknown at this stage where these beliefs have come from, and how they are maintained. Several studies (3, 4) have indicated that simply knowing that a belief is incorrect doesn't lead to educators changing their beliefs or practice. Indeed, Rogers and Cheung (21) concluded that teacher training itself may embed these beliefs more firmly, indicating a generational transmission of myth as fact through formal training. Waterhouse (2) discussed Shermer's three possible reasons why educators may believe in ideas that lack supporting evidence: *credo consolans* (the idea offers comfort through predicting a good outcome, makes a person feel powerful or in control); immediate gratification (instant solutions for difficult problems) and easy explanations (a simple story to explain a difficult concept). Further, qualitative, exploration of the seeds for these beliefs would help identify which, if any, of the three possible reasons for these beliefs and provide additional information on how best such beliefs can be countered. It is noted that some have questioned whether a belief in neuromyths is a problem: Horvath et al. (29) found no difference in beliefs in neuromyths between international award-winning teachers and teachers who had not been recognised for outstanding performance. However, as a team of neuroscientists and psychologists, we would argue that inaccurate understanding of the brain and behaviour, especially when applied educationally as a rationale for a particular teaching approach, should not be accepted.

CONCLUSION AND INTERVENTIONS

This study has shown that, similar to studies in other countries, educators in both secondary and higher education maintain beliefs in educational neuromyths. Furthermore, students are entering university education with similar neuromyth beliefs. The study also suggests that, whilst belief in neuromyths are more prevalent in secondary educators, they persisted in educators and students in higher education even in science and medically related subjects. In medical education teaching should have a foundation in evidence based science, and the prevalence of neuromyths in medical education risks reputational damage if it is the foundation of teaching methodology. We therefore suggest the following possible interventions to reduce the risks of beliefs in neuromyths:

1) Initial teacher training courses such as Professional Teacher Certificate, Postgraduate Certificate in Education (PGCE), Masters in Education, or other teaching qualifications should include the neurobiology of learning as a topic, alongside training to critically evaluate and dispel common neuromyths.
2) Workshops should be developed to support and train existing teachers about neuromyths and how to avoid using them in teaching.
3) Study skills courses in schools should include neuroscience based study techniques that explain common neuromyths and instead encourage active and deep learning techniques in students.

ACKNOWLEDGEMENTS

This project was funded by Newcastle University's Faculty of Medical Sciences Educational Research, Development and Practice Network. We thank Sin On Hui, Sam Bosely and Caitlin Cooper for their support with literature searching and questionnaire compilation, as part of their placement activities at Universiti Malaysia Sarawak (SOH) and University of Reading UK (SB and CC) respectively. Findings from this research have been presented in poster form at the Newcastle University internal Teaching and Learning Conference.

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Table 2: List and categorisation of neuromyth items into themes, and neurofact items into correct and incorrect statements.

Item	Statement	Theme/Category	Source
1	Any brain region can perform any function.	Neurofact incorrect statement	Papadatou-Pastou et al. (2017)
2	Brain activity depends entirely on the external environment: with no senses stimulated, we don't see, hear or feel anything	Neurofact incorrect statement	Pei et al. (2015)
3	The enhancement of the sense of touch in the blind is due to an increase in the number of receptors in the fingertips and not to changes in the brain.	Neurofact incorrect statement	Papadatou-Pastou et al. (2017)
4	Children are less attentive after consuming sugary drinks and/or snacks.	Neuro-Environmental myth	Dekker et al. (2012)
5	Our handwriting reveals our personality.	Social/Cultural myth	Papadatou-Pastou et al. (2017)
6	The development of the brain's areas of specialism can be accurately identified by the shape of the skull	Neurofact incorrect statement	Papadatou-Pastou et al. (2017)
7	Communication between different parts of the brain happens through electrical impulses and chemical substances.	Neurofact correct statement	Papadatou-Pastou et al. (2017)
8	When a brain region is damaged other parts of the brain can take up its function.	Neurofact correct statement	Dekker et al. (2012)
9	Raising children similarly leads to similarities in their adult personalities.	Neuro-Developmental myth	Papadatou-Pastou et al. (2017)
10	Eating a wide variety of vegetables makes us more intelligent	Neuro-Environmental myth	
11	Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.	Neurobiological/Neurolearning myth	Dekker et al. (2012)
12	Learners perform better when they are able to study different topics systematically one-by-one rather than intermingled with one another.		Grospietsch & Mayer (2019)
13	Boys' brains are hardwired to be better at spatial tasks than girls' brains	Neurofact incorrect statement	
14	There are critical periods in childhood after which certain things can no longer be learned.	Neuro-Developmental myth	Dekker et al. (2012)
15	Learning occurs through modification of brains' neural connections.	Neurofact correct statement	Dekker et al. (2012)
16	Brain development has finished by the time children reach secondary school.	Neuro-Developmental myth	Dekker et al. (2012)

17	Following a specific diet can help overcome certain neurological disabilities, such as ADHD, Dyslexia, and autism spectrum disorders.	Neuro-Environmental myth	van Dijk & Lane (2020)
18	Performance in activities such as playing the piano improves as a direct function of the number of hours spent practicing.	Neurofact correct statement	Papadatou-Pastou et al. (2017)
19	Doing basic Brain Gym exercises help students to learn to read and use language better.	Neurobiological/Neurolearning myth	van Dijk & Lane (2020)
20	In the majority of right-handed people, speech is a specialty of the left-brain hemisphere.	Neurofact correct statement	Papadatou-Pastou et al. (2017)
21	Almost all autistic children are savants (A savant is someone who exhibits exceptional skills / knowledge in a specific area).	Neurofact incorrect statement	Papadatou-Pastou et al. (2017)
22	Mental capacity cannot be changed by environment or experience because it is hereditary	Neurofact correct statement	Dekker et al. (2012)
23	IQ scores almost never change over time.	Social/Cultural myth	Papadatou-Pastou et al. (2017)
24	Normal development of the human brain involves the birth and death of brain cells.	Neurofact correct statement	Dekker et al. (2012)
25	Speaking more than one language protects against dementia	Neurofact correct statement	
26	Our genetically determined number of brain cells determines the maximum level at which we can learn.	Neuro-Environmental myth	Grospietsch & Mayer (2019)
27	An epileptic crisis results from the temporary silencing of a brain area; this is why epileptics lose consciousness during a crisis.	Neurofact incorrect statement	Papadatou-Pastou et al. (2017)
28	Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic).	Neurobiological/Neurolearning myth	Dekker et al. (2012)
29	We perceive the world visually with tiny emissions from our eyes	Social/Cultural myth	
30	If a child does not learn a language before a critical window closes, they will never become fluent	Neuro-developmental myth	
31	Children must acquire their native language before a second language is learned. If they do not do so neither language will be fully acquired.	Neuro-developmental myth	Dekker et al. (2012)
32	Dyslexia is associated with intelligence.	Neurofact incorrect statement	Papadatou-Pastou et al. (2017)
33	Male brains mature later than female brains	Neurofact correct statement	
34	Individuals can learn new information, like new languages, when asleep.	Neurobiological/Neurolearning myth	Papadatou-Pastou et al. (2017)

35	Listening to classical music improves one's reasoning ability	Neuro-environmental myth	
36	Processes to consolidate what we have learned occur during sleep.	Neurofact correct statement	Grospietsch & Mayer (2019)
37	Certain exercises that practice the coordination of perceptual-motor skills (e.g., body awareness and lateralized body movements) can improve the literacy skills of children.	Neurobiological/Neurolearning myth	van Dijk & Lane (2020)
38	The right brain hemisphere is more involved in creative thought processes, and the left in logical thought processes.	Neurobiological/Neurolearning myth	Grospietsch & Mayer (2019)
39	Short bouts of co-ordination exercises can improve integration of left and right hemispheric brain function.	Neurobiological/Neurolearning myth	Dekker et al. (2012)
40	Human memory works like a tape recorder or video camera and accurately records the events we've experienced.	Neurobiological/Neurolearning myth	Papadatou-Pastou et al. (2017)
42	Brain activity can be studied through the oxygen consumption of specific brain areas.	Neurofact correct statement	Papadatou-Pastou et al. (2017)
43	Locomotion consists of a series of reflexes; this is why we can do other things and walk at the same time.	Neurofact correct statement	Papadatou-Pastou et al. (2017)
44	We only use 10% of our brain.	Neurobiological/Neurolearning myth	Dekker et al. (2012)
45	Our brain has maps of the surface of the body and of the visual field.	Neurofact correct statement	Papadatou-Pastoue t al. (2017)
46	Keeping a phone number in memory until dialing, recalling a recent event, and remembering distant experiences all use a different part of the memory system.	Neurofact correct statement	van Dijk & Lane (2020)
41	When we sleep, the brain shuts down.	Neurofact incorrect statement	Dekker et al. (2012)
47	The bigger the brain, the more intelligent the animal.	Neurofact incorrect statement	Papadatou-Pastou et al. (2017)
48	If pupils do not drink sufficient amounts of water (=6-8 glasses a day) their brains shrink.	Neuro-environmental myth	Dekker et al. (2012)

Table 3: Percentages scores for each neuromyth statement by participant group organised by percentage highest to lowest overall agreement

			Student			**HE Staff**			**Pre-Uni Staff**			**All**		
Item Number	***Fact or Myth**	**† Correct Response**	**Don’ t know now**	**Disagree**	**Agree**	**Don’ t k now**	**Disagree**	**Agree**	**Don’ t k now**	**Disagree**	**Agree**	**Don’ t k now**	**Disagree**	**Agree**
28	M	D	3.5	7.0	**89.6**	4.5	22.7	**72.7**	3.2	3.2	**93.5**	3.6	8.3	**88.1**
39	M	D	24.3	7.8	**67.8**	22.7	0.0	**77.3**	25.8	3.2	**71.0**	24.4	6.0	**69.6**
11	M	D	15.7	17.4	**67.0**	4.5	22.7	**72.7**	12.9	12.9	**74.2**	13.7	17.3	**69.0**
19	M	D	20.0	13.9	**66.1**	22.7	18.2	**59.1**	12.9	9.7	**77.4**	19.0	13.7	**67.3**
37	M	D	31.3	11.3	**57.4**	13.6	13.6	**72.7**	25.8	6.5	**67.7**	28.0	10.7	**61.3**
38	M	D	22.6	20.0	**57.4**	22.7	31.8	**45.5**	19.4	22.6	**58.1**	22.0	22.0	**56.0**
9	M	D	8.7	33.0	**58.3**	18.2	**50.0**	31.8	6.5	35.5	**58.1**	9.5	35.7	**54.8**
5	M	D	7.8	37.4	**54.8**	9.1	**54.5**	36.4	12.9	29.0	**58.1**	8.9	38.1	**53.0**
29	M	D	13.9	32.2	**53.9**	**36.4**	**31.8**	**31.8**	19.4	35.5	**45.2**	17.9	32.7	**49.4**
4	M	D	15.7	40.9	**43.5**	9.1	**50.0**	40.9	6.5	35.5	**58.1**	13.1	41.1	**45.8**
12	M	D	15.7	33.0	**51.3**	4.5	**72.7**	22.7	9.7	**51.6**	38.7	13.1	41.7	**45.2**
35	M	D	27.0	33.0	**40.0**	22.7	36.4	**40.9**	29.0	16.1	**54.8**	26.8	30.4	**42.9**
40	M	D	5.2	**57.4**	37.4	0.0	**54.5**	45.5	3.2	**51.6**	45.2	4.2	**56.0**	39.9
10	M	D	14.8	**49.6**	35.7	9.1	**59.1**	31.8	12.9	35.5	**51.6**	13.7	**48.2**	38.1
34	M	D	23.5	**40.0**	36.5	22.7	**50.0**	27.3	38.7	16.1	**45.2**	26.2	**36.9**	**36.9**
44	M	D	15.7	**49.6**	34.8	9.1	**50.0**	40.9	19.4	**45.2**	35.5	15.5	**48.8**	35.7
14	M	D	11.3	**55.7**	33.0	4.5	**54.5**	40.9	3.2	**61.3**	35.5	8.9	**56.5**	34.5
17	M	D	22.6	**46.1**	31.3	18.2	**45.5**	36.4	22.6	**51.6**	25.8	22.0	**47.0**	31.0
31	M	D	12.2	**60.0**	27.8	9.1	**72.7**	18.2	9.7	**58.1**	32.3	11.3	**61.3**	27.4
30	M	D	11.3	**64.3**	24.3	9.1	**77.3**	13.6	9.7	**64.5**	25.8	10.7	**66.1**	23.2
26	M	D	20.0	**56.5**	23.5	18.2	**68.2**	13.6	35.5	**38.7**	25.8	22.6	**54.8**	22.6
48	M	D	23.5	**56.5**	20.0	0.0	**95.5**	4.5	25.8	**45.2**	29.0	20.8	**59.5**	19.6
16	M	D	13.0	**68.7**	18.3	4.5	**86.4**	9.1	6.5	**77.4**	16.1	10.7	**72.6**	16.7
23	M	D	7.8	**81.7**	10.4	4.5	**86.4**	9.1	22.6	**67.7**	9.7	10.1	**79.8**	10.1

*M=Neuromyth, †D=correct response is to disagree with statement

Table 4: Percentages scores for each neurofact statement by participant group organised by percentage highest to lowest overall agreement

			Student			**HE Staff**			**Pre-Uni Staff**			**All**		
Item Number	***Fact or Myth**	**† Correct Response**	**Don’t know**	**Disagree**	**Agree**	**Don’t know**	**Disagree**	**Agree**	**Don’t know**	**Disagree**	**Agree**	**Don’t know**	**Disagree**	**Agree**
7	F	A	6.1	3.5	**90.4**	0.0	0.0	**100.0**	6.5	0.0	**93.5**	5.4	2.4	**92.3**
15	F	A	11.3	10.4	**78.3**	4.5	4.5	**90.9**	16.1	3.2	**80.6**	11.3	8.3	**80.4**
18	F	A	7.0	18.3	**74.8**	9.1	27.3	**63.6**	6.5	6.5	**87.1**	7.1	17.3	**75.6**
36	F	A	16.5	13.0	**70.4**	13.6	13.6	**72.7**	22.6	6.5	**71.0**	17.3	11.9	**70.8**
46	F	A	18.3	12.2	**69.6**	13.6	13.6	**72.7**	32.3	3.2	**64.5**	20.2	10.7	**69.0**
43	F	A	13.0	16.5	**70.4**	22.7	9.1	**68.2**	25.8	16.1	**58.1**	16.7	15.5	**67.9**
45	F	A	16.5	10.4	**73.0**	13.6	13.6	**72.7**	**48.4**	6.5	45.2	22.0	10.1	**67.9**
42	F	A	20.0	20.9	**59.1**	22.7	9.1	**68.2**	25.8	9.7	**64.5**	21.4	17.3	**61.3**
25	F	A	22.6	26.1	**51.3**	13.6	27.3	**59.1**	16.1	16.1	**67.7**	20.2	24.4	**55.4**
24	F	A	17.4	24.3	**58.3**	9.1	**45.5**	**45.5**	29.0	22.6	**48.4**	18.5	26.8	**54.8**
20	F	A	34.8	19.1	**46.1**	22.7	13.6	**63.6**	**38.7**	25.8	35.5	33.9	19.6	**46.4**
33	F	A	27.0	26.1	**47.0**	22.7	**54.5**	22.7	9.7	**48.4**	41.9	23.2	33.9	**42.9**
21	F	D	13.9	**46.1**	40.0	18.2	**59.1**	22.7	22.6	**41.9**	35.5	16.1	**47.0**	36.9
27	F	D	**35.7**	34.8	29.6	**36.4**	27.3	**36.4**	**51.6**	9.7	38.7	**38.7**	29.2	32.1
8	F	A	15.7	**56.5**	27.8	9.1	**50.0**	40.9	16.1	**51.6**	32.3	14.9	**54.8**	30.4
1	F	D	4.3	**69.6**	26.1	0.0	**72.7**	27.3	0.0	12.9	**45.2**	3.0	**67.3**	29.8
2	F	D	6.1	**63.5**	30.4	0.0	**63.6**	36.4	9.7	**67.7**	22.6	6.0	**64.3**	29.8
13	F	D	15.1	**58.5**	26.4	22.7	**59.1**	18.2	9.7	**58.1**	32.3	17.9	**54.2**	28.0
6	F	D	23.5	**53.0**	23.5	31.8	**40.9**	27.3	35.5	**41.9**	22.6	26.8	**49.4**	23.8
3	F	D	14.8	**61.7**	23.5	4.5	**86.4**	9.1	19.4	**48.4**	32.3	14.3	**62.5**	23.2
32	F	D	28.7	**47.0**	24.3	13.6	**77.3**	9.1	22.6	**64.5**	12.9	25.6	**54.2**	20.2
47	F	D	13.9	**64.3**	21.7	13.6	**72.7**	13.6	9.7	**71.0**	19.4	13.1	**66.7**	20.2
41	F	D	2.6	**83.5**	13.9	0.0	**95.5**	4.5	6.5	**87.1**	6.5	3.0	**85.7**	11.3
22	F	D	7.0	**81.7**	11.3	4.5	**86.4**	9.1	12.9	35.5	**51.6**	8.3	**82.7**	8.9

*F=fact, †A=correct response is to agree to statement, D = correct response is to disagree with statement

Table 5: Percentages scores for each auxiliary statement by participant group

		Percentage Scores											
		Student			**HE Staff**			**Pre HE Staff**			**All**		
Item No.	**Statement**	**Don' t Know**	**Disagree**	**Agree**	**Don' t Know**	**Disagree**	**Agree**	**Don' t Know**	**Disagree**	**Agree**	**Don' t Know**	**Disagree**	**Agree**
1	There is a lot still to learn about how the brain works	0.9	0.9	**98.3**	0.0	0.0	**100.0**	0	0	**100**	0.6	0.6	**98.8**
2	Religion and science are equally important in education	6.1	22.6	**71.3**	9.1	31.8	**59.1**	3.2	25.8	**71.0**	6.0	24.4	**69.6**
3	Specialist subject teachers (such as in biology) need to understand neuroscience and the brain, but not others	7.0	**68.7**	24.3	0.0	**77.3**	22.7	6.5	**74.2**	19.4	6.0	**70.8**	23.2
4	I often read science-related news items	4.3	40.0	**55.7**	0.0	31.8	**68.2**	0.0	38.7	**61.3**	3.0	38.7	**58.3**
5	Neuroscience has no place in teacher education in my country	13.9	**60.0**	26.1	9.1	**81.8**	9.1	12.9	**67.7**	19.4	13.1	**64.3**	22.6
6	Students in my country should be taught the basic principles of how the brain works	2.6	3.5	**93.9**	4.5	4.5	**90.9**	0.0	3.2	**96.8**	2.4	3.6	**94.0**
7	I regularly buy education-related magazines	4.3	**73.0**	22.6	0.0	**77.3**	22.7	3.2	**58.1**	38.7	3.6	**70.8**	25.6
8	Teaching is more about intuition than learning specific approaches	13.9	**47.0**	39.1	9.1	**54.5**	36.4	3.2	**61.3**	35.5	11.3	**50.6**	38.1
9	I regularly read scientific literature in peer-reviewed journals	4.3	**59.1**	36.5	4.5	31.8	**63.6**	0.0	**51.6**	48.4	3.6	**54.2**	42.3
10	I regularly buy science-related magazines	4.3	**75.7**	20.0	0.0	**72.7**	27.3	3.2	**77.4**	19.4	3.6	**75.6**	20.8
11	I am not interested in how the brain influences behaviour	3.5	**85.2**	11.3	4.5	**81.8**	13.6	6.5	**77.4**	16.1	4.2	**83.3**	12.5
12	It is essential that teachers should have regular training in basic neuroscience	4.3	20.9	**74.8**	18.2	9.1	**72.7**	6.5	6.5	**87.1**	6.5	16.7	**76.8**
13	There are more important things for teachers to consider than brain development	5.2	47.0	**47.8**	13.6	40.9	**45.5**	12.9	41.9	**45.2**	7.7	45.2	**47.0**
14	Teachers in my country should understand how children's brains develop	5.2	8.7	**86.1**	0.0	0.0	**100.0**	0.0	3.2	**96.8**	3.6	6.5	**89.9**
15	I regularly read education-related news items	2.6	45.2	**52.2**	0.0	36.4	**63.6**	0.0	25.8	**74.2**	1.8	40.5	**57.7**
16	Scientific understanding changes so quickly that it is impossible for non-experts to keep up to date	11.3	35.7	**53.0**	9.1	**45.5**	**45.5**	6.5	**48.4**	45.2	10.1	39.3	**50.6**
17	Neuroscience research is relevant to modern teaching practice	7.8	7.0	**85.2**	9.1	13.6	**77.3**	6.5	6.5	**87.1**	7.7	7.7	**84.5**

18	Teachers of younger children need neuroscience information more that those teaching older children	10.4	34.8	**54.8**	13.6	**59.1**	27.3	3.2	**51.6**	45.2	9.5	41.1	**49.4**
19	I regularly read education-related literature in peer reviewed journal articles	6.1	**60.9**	33.0	0.0	40.9	**59.1**	6.5	**51.6**	41.9	5.4	**56.5**	38.1
20	Most brain-based teaching / training programmes are a waste of money	13.0	**74.8**	12.2	9.1	**72.7**	18.2	25.8	**54.8**	19.4	14.9	**70.8**	14.3