The brain and the US education system: Perpetuation of neuromyths

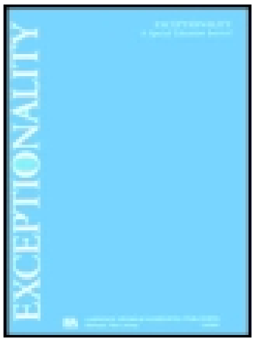
Article *in* Exceptionality · July 2018

DOI: 10.1080/09362835.2018.1480954

2 authors:

Wilhelmina van Dijk
University of Florida

Holly Lane
University of Florida



Exceptionality
A Special Education Journal

ISSN: 0936-2835 (Print) 1532-7035 (Online) Journal homepage: https://www.tandfonline.com/loi/hexc20

The brain and the US education system: Perpetuation of neuromyths

Wilhelmina van Dijk & Holly B. Lane

To cite this article: Wilhelmina van Dijk & Holly B. Lane (2018): The brain and the US education system: Perpetuation of neuromyths, Exceptionality, DOI: 10.1080/09362835.2018.1480954

To link to this article: https://doi.org/10.1080/09362835.2018.1480954

Published online: 19 Jul 2018.

EXCEPTIONALITY
https://doi.org/10.1080/09362835.2018.1480954

Routledge
Taylor & Francis Group

Check for updates

The brain and the US education system: Perpetuation of neuromyths

Wilhelmina van Dijk and Holly B. Lane

University of Florida

ABSTRACT
Misconceptions about the brain and its relation to education are widespread. This can lead to the implementation of ineffective methods and the waste of precious resources. To examine the extent of belief in neuromyths, a survey about the brain in education was conducted. Respondents (*n* = 169) came from special education (*n* = 83) and general education (*n* = 78), and included preservice teachers (*n* = 34), in-service teachers (*n* = 63), higher education faculty (*n* = 39), and educational leaders (*n* = 33). The survey contained 15 Myths and 18 Facts, and overall, participants were able to correctly identify approximately 66% of all the Facts. On the other hand, on average, respondents responded correctly for only one third of the Myths. The most commonly misidentified Myths were related to motor coordination exercises to improve literacy skills, the right brain-left brain myth, and learning styles. Higher education faculty were able to identify more Myths than any other group. Implications for teacher preparation and ongoing professional learning for teachers and educational leaders are discussed.

The human brain has long been a source of fascination and mystery. With many recent advances in neuroscience, that fascination has intensified, and findings from brain research have become a staple in popular media. “Brain-based learning,” “brain-based teaching,” and even “brain-based parenting” have become popular buzzwords, and public interest in brain training games and activities has skyrocketed. With each new discovery in neuroscience, a flood of news sound bites hits the airwaves and a plethora of new products hits the market.

This widespread interest in research related to the brain has likely been the impetus for positive changes in our education system. For example, in recent years, there has been an increased acknowledgement of the importance of early childhood education (Phillips & Shonkoff, 2000), and increased access to and public investment in early learning programs has occurred (U.S. Department of Education, 2014). Research on the effects of phonological awareness intervention on brain function has provided support for providing this instruction to struggling readers (Shaywitz et al., 2004). Increased understanding of the long-term neurological effects of bullying (Vaillancourt et al., 2008) has likely contributed to the development of bullying prevention policies and the increasing popularity of anti-bullying programs (Espelage, 2016). These and other findings from neuroscience have, for many educators, added validity and importance to the associated educational practice.

Unfortunately, misunderstandings about neuroscience research have also had widespread effect on educational practice. There are many myths about the brain—often called neuromyths—that permeate the media, advertisement, and the educational system. The Organisation for Economic Co-operation and Development (OECD) defined a neuromyth as “a misconception generated by a misunderstanding, a misreading, or a misquoting of facts scientifically established (by brain research) to make a case for use of brain research in education and other contexts” (OECD, 2002). These neuromyths have led to the adoption

CONTACT Wilhelmina van Dijk willavandijk@ufl.edu

of practices that are not actually supported by brain research (Geake, 2008). For example, one common neuromyth is that we only use around 10% of our brain, and that we can greatly increase our potential as individuals—and maybe even as a species—by activating the remaining 90% of our brain. This has led to the development of several training programs aimed to help increase the percentage of brain mass one uses. In fact, we do use each part of our brain, just not all parts simultaneously (Geake, 2008). A second neuromyth relates the influence of sugar on an individual's concentration and activity level. It is commonly believed that people, especially children, will display a surge in hyperactivity and decrease in attention after consuming snacks and drinks that contain high levels of sugar. In reality, there is no clear relation between sugar consumption and behavior and cognition of children (Wolraich, Wilson, & White, 1995). Some experiments have actually reported increased attention of children after consuming drinks high in sugar (Milich, Wolraich, & Lindgren, 1986). Most often, it seems that it is the perception of the observer that is influenced, and not the behavior of the child (Wolraich et al., 1995).

Besides these more general neuromyths about the brain, there are also neuromyths specifically related to education and child development. The perpetuation of some of these neuromyths has likely been responsible for inappropriate allocation of scarce educational resources, including time, effort, and money. Simply adding "brain-based" or "brain research" to marketing materials seems to have an effect on the likelihood of adoption of an educational product, even if the research being cited has little to do with the product (Bernard, 2010). For example, many teachers include body movements designed to increase literacy skills in their reading lessons, such as those advocated by Brain Gym®. While students may enjoy these movements, and physical activity in general is important for learning, there is no evidence that the specific movements like "lazy eights" (i.e., slowly drawing an eight on its side in the sky with an extended arm) contribute to improved reading outcomes (Hyatt, 2007; Spaulding, Mostert, & Beam, 2010). A second common neuromyth related to child development is the Mozart effect. According to this neuromyth, listening to classical music can increase intelligence, especially in young children. The original research, however, showed that listening to classical music right before a test, as opposed to waiting in silence or listening to a relaxation tape, temporarily increased college students' scores on that specific test (Rauscher, Shaw, & Ky, 1993). Unfortunately, other research teams have failed to replicate these findings (e.g., Steele, Bass, & Crook, 1999). Furthermore, despite a lack of evidence, many schools spend resources and time on the development and implementation of curricula based on the neuromyth that we should specifically tailor instruction to an individual child's learning style (i.e., either predominantly visual, auditory, kinesthetic, or tactile) or to a child's hemispheric dominance, (i.e., whether the child is "right-brained" or "left-brained"). These are only a few examples of widely believed neuromyths.

Pasquinelli (2012) suggested there are three common ways in which neuromyths can develop, either separately or in combination. First, a distortion of actual scientific facts or oversimplifying scientific results can result in the emergence of a neuromyth. This is most likely what happened with the proliferation of the Mozart myth. Second, a neuromyth may develop through the maintenance of outdated scientific hypotheses. For example, many people still believe the idea that dyslexia is a visual problem characterized by reversals of letters and words, when it has been confirmed that dyslexia actually represents a deficit in phonological processing with a neurological origin (Morris et al., 1998). And, finally, neuromyths can develop through misinterpretation of scientific results. An example of this is the idea that there is a limited period during which learning is optimal, particularly during the first three years of life. This has led to overemphasis of learning programs for young children, and the idea that not starting music, reading, and other skills early leads to missed opportunities and lesser accomplishments. These ideas are misinterpretations of scientific results from looking at anatomical factors only. The three-year myth credits learning only to the strengthening and pruning of synapses (i.e., the making and breaking of connections in the brain), which happens quite rapidly in the early years. The brain, however, has the ability to make these connections throughout life, although at a somewhat slower rate. In addition, the brain displays plasticity, that is, some areas of the brain can take over the functions of others, when the latter are compromised. These functional aspects of the brain are as important as the anatomical factors (Pasquinelli, 2012).

Neuromyths are not a new phenomenon. The myth that we only use 10% of our brain probably originated somewhere in the early 1900s and was made marketable even then through "popular science" and self-help books aimed at assisting people reach their full potential (Beyerstein, 1999). Within the last century, many researchers have debunked this myth, but this belief is still prevalent among educators (see, e.g., Dekker, Lee, Howard-Jones, & Jolles, 2012; Gleichgerrcht, Luttges, Salvarezza, & Campos, 2015). Such perpetuation of neuromyths despite overwhelming contradictory evidence is probably more problematic than their creation. According to Pasquinelli (2012), there are several reasons why neuromyths persist. A first set of reasons is related to the believer. That is, these myths can have a soothing function. It is comforting to think we can enhance a young child's intelligence merely by playing classical music during pregnancy and the early years of their childhood. Also, researchers have shown that humans are neurologically prone to confirmation bias. This means a piece of information is more likely to hold our attention if it is meaningful to us. In other words, we are more likely to notice and contemplate information if we already believe the ideas expressed therein. Moreover, confirmation bias relies much more on stories than on statistics or other kinds of scientific evidence (Grotzer, 2011), and this may lead to further spread of myths.

Possibly of greater influence on the perpetuation of neuromyths is how information circulates. One common factor is the sensationalism of the press when overestimations of scientific findings are made public without confirmation (Pasquinelli, 2012). Often, relevant information is left out of press releases but reporters will include empirically irrelevant information to give the piece a genuine appearance, for example by noting that specific mental processes take place in the brain (Pasquinelli, 2012). This is problematic because the addition of pseudo-neuroscience in information particularly affects the judgments of people with less background knowledge (Weisberg, Keil, Goodstein, Rawson, & Gray, 2008). For example, in one study, an added image of an fMRI scan and the words *brain* in the title increased consumers' interest and faith in the value of a fake educational product, when the descriptions were held constant (Lindell & Kidd, 2013). Many consumers of this type of information have limited access to the original research to verify the results, or they may not be as versed in the fluidity of research and, therefore, resist believing outcomes that disprove earlier findings (Grotzer, 2011).

Within the educational field, perpetuated belief in neuromyths is problematic because it could lead to waste of limited resources. For example, school leaders who believe in certain neuromyths may adopt commercial programs without scientific basis, or they may hire professional developers who perpetuate popular myths. On a smaller scale, individual teachers may spend time and resources on the development and implementation of activities that students may receive positively but have no real benefit for the intended purpose (Howard-Jones, 2014).

Within the past 10 years, researchers have examined the prevalence of neuromyths in the educational system internationally. The outcomes of several surveys indicate a common pattern in beliefs across different countries. For example, the belief in enhancing student outcomes by presenting information in a way that matches a preferred learning style is common among teachers in the United Kingdom and the Netherlands (Dekker et al., 2012), Argentina, Peru, and Chile (Gleichgerrcht et al., 2015), Turkey (Dündar & Gündüz, 2016; Karakus, Howard-Jones, & Jay, 2015), Greece (Deligiannidi & Howard-Jones, 2015; Papadatou-Pastou, Haliou, & Vlachos, 2017), Spain (Ferrero, Garaizar, & Vadillo, 2016), Portugal, (Rato, Abreu, & Castro-Caldas, 2013) and China (Pei, Howard-Jones, Zhang, Liu, & Jin, 2015). A similar global spread is seen for belief in the 10% myth, and the idea of hemisphericity.

Besides identifying the most widespread neuromyths, several of the studies also aimed to connect adherence to these beliefs with other factors. In one of the first studies, Howard-Jones, Franey, Mashmoushi, and Liao (2009) reported a significant correlation between general knowledge and myths. In other words, respondents who knew more facts about the brain, also believed in more myths. Both the Dekker and colleagues' (2012) and Gleichgerrcht and associates' (2015) surveys validated this finding. This is concerning, due to the overwhelming presence of neuro-related information in the media and the fact that media is one of the main catalysts of the development and perpetuation of neuromyths. Additionally, there is no evidence for a causal relationship between knowledge of facts and belief in myths. It may be that people who read a lot about neuromyths will also pick up several facts about the brain. While other factors (e.g., reading scientific literature, age, work situation) were also examined, none were found to correlate with the beliefs (Gleichgerrcht et al., 2015; Howard-Jones et al., 2009).

It is problematic to generalize the findings from these studies to the US educational system for several reasons. First, there seem to be subtle cultural differences in beliefs about the brain. For example, teachers in China believed more strongly in a fixed genetic influence on intelligence, and less in brain plasticity as teachers from other countries (Pei et al., 2015). Turkish teachers believed in the existence of critical periods for learning and the need to acquire a first language before learning a second more than teachers from other countries (Karakus et al., 2015). Second, it is unclear if the participants of the studies are representative for the general population. The study by Dekker and colleagues (2012) only included participants who already had an interest in the connection between the brain and education. This may have skewed the outcomes, and, as such, the findings may not be generalizable to other groups. This problem is also present in the large-scale study by Gleichgerrcht and colleagues (2015), who recruited most of their 3,451 respondents at an educational event focused on the connection between neuroscience and education. Additionally, only two of the studies were conducted within the United States. Alekno (2012) targeted in-service teachers in a Midwestern school district, but her questions did not follow the set-up that most other surveys used (i.e., Dekker et al.) limiting the possibility of comparing her results to the international trends. Lethaby and Harries (2015) recruited only ESOL teachers that graduated from a specific program, and all participants had a connection with the researchers, reducing the generalizability of the findings to a larger US population.

Finally, not all studies included participants from various segments of the educational system. The only study that included participants from several different groups in an educational system was conducted in Switzerland. Tardif, Doudin, and Meylan (2015) included in-service teachers, preservice teachers, and faculty involved in teacher preparation as respondents to their survey. However, their survey focused on three commonly believed myths: Brain Gym exercises, hemisphericity, and learning styles. The outcomes of the survey indicated no difference between the groups; this suggests beliefs in myths may be spread evenly within schools and teacher preparation programs. Even though only one study included multiple layers within an educational system, many researchers used the outcomes of their studies to recommend inclusion of basic neuroscience in teacher preparation programs and professional development for teachers (e.g., Deligiannidi & Howard-Jones, 2015; Howard-Jones et al., 2009; Karakus et al., 2015; Lethaby & Harries, 2015). These recommendations are part of a larger effort to establish a field of neuroeducation, yet if higher education faculty are just as prone to belief in meuromyths, it is unlikely such a recommendation could take hold. Similarly, only one study (i.e., Papadatou-Pastou et al., 2017) included participants associated with different types of education (i.e., preservice teachers of general education, special education, and speech therapy). The researchers, however, did not disaggregate their findings per group, but instead included additional statements related to students with disabilities.

A large-scale study of the prevalence of beliefs in neuromyths across multiple levels within the US educational system has not been conducted. Before making recommendations about how to address neuromyths in teacher preparation programs, it is important to know if stakeholders in these programs share this common belief. Additionally, a spread of these beliefs across other influential layers of the system, such as school and district level personnel in charge of design of curricula and professional development, could undo efforts of teacher preparation programs, since students only spend 2–3 years in a preparation program, but the rest of their careers at schools.

Method

The purpose of this study was to examine the pervasiveness of neuromyths in education in the United States. Specifically, we were interested in learning more about (a) the prevalence of belief in neuromyths in the US educational system, (b) which neuromyths are more commonly believed, (c) the relationship between the belief in neuromyths and knowledge of general facts about the brain, and (d) differences across subgroups of stakeholders within the system?

Survey design and development

To accomplish our research goals, we developed a survey and administered it to educators. The survey is a compilation of items from earlier surveys that assessed knowledge of myths versus facts among various populations (i.e., Dekker et al., 2012; Gleichgerrcht et al., 2015). Because the researchers in those studies did not report piloting the surveys, and because subsequent surveys using the same questionnaires in different languages found some interpretation difficulties, we decided to examine the validity of the survey items. The final version of the survey resulted from the following stages: (a) consideration of items from previously conducted questionnaires and separating them in themes; (b) in-depth conversations based on the themes with focus groups composed of several subgroups of interests to establish whether items are still relevant; (c) reviews of the items by both methodological and content experts; (d) cognitive interviews with representative members of several of the subgroups; and (e) pilot implementation. After each stage, we adjusted the wording of statements to improve readability and understanding. See Tables 1 and 2 for a complete list of the final version of the survey statements.

The survey was titled "the Brain in Education" to avoid influencing respondents by alerting them that some of the statements may be regarded as myths. Additionally, response options were presented as a 3-point scale: Agree, Neither Agree nor Disagree, and Disagree. In this way, the survey was presented as solicitation of opinions rather than an assessment of knowledge. We did this in hope that respondents would be less worried about being judged on their knowledge.

Several of the topics of the survey were addressed by two questions, one of which represented a myth, and a second the related fact. For example, the statements "*Children learn better when information is presented in their preferred learning style.*" and "*Children show preferences for the style in which they receive information.*" both addressed the topic of learning styles. The first statement is a myth (i.e., incorrect) and the second is a fact (i.e., correct). In the design of the survey, we paired the related questions and placed them into separate blocks of questions that were presented in random order to survey respondents. We did this to reduce the chance of one statement influencing the response to a related statement. Additionally, we adjusted the wording of statements to have an approximately equal number of true and false statements.

Table 1. Fact statements with percentage of responses to each answer option.

Fact	Correct	Incorrect	NAOD	DK
When we sleep, the brain shuts down.*	97	1	1	1
Cognitive abilities are inherited and cannot be modified by the environment or by life experience.*	91	2	5	1
We use our brains 24 hours a day in some capacity.	90	2	2	1
Learning occurs through the creation and modification of the brain's neural connections.	87	1	5	7
Students' brains continue to develop structurally during middle and high school.	86	5	2	7
Students have individual preferences for the style in which they receive information (e.g., visual, auditory, tactile, and kinesthetic).	83	10	7	0
Production of new neural connections in the brain can continue into old age.	81	4	5	10
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.	79	5	5	11
Vigorous physical exercise can improve your mental function.	76	7	9	8
Academic achievement can be affected by skipping breakfast.	75	9	11	5
When a part of the brain is damaged, other parts can take up its function.	57	12	14	16
The brain of boys and girls develop at the same rate in size and structures.*	56	10	11	24
Normal development of the human brain involves the birth and death of brain cells.	53	14	7	26
To learn to do something, it is necessary to pay conscious attention to it.	47	31	15	6
Learning occurs through the addition of new cells to the brain. *	41	26	13	18
Memories are stored in the brain much like a computer; that is, each memory goes into a tiny, identifiable piece of the brain.*	22	44	9	22
The left and right hemispheres of the brain always work together.	21	50	9	18
Boys have bigger brains (in size) than girls.	11	44	12	32

Note: NAOD = Neither agree or disagree, DK = do not know; *Incorrect statement

Table 2. Myth statements with percentage of responses to each answer option.

Myths	Correct	False	NAOD	DK
Environments that are rich in stimulus improve the development of brains of pre-school children.*	1	94	3	2
Short sessions of motor coordination exercises, such as crossovers, can improve the collaboration of the left and right hemisphere of the brain.*	4	78	5	14
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.*	11	65	2	17
Doing basic Brain Gym exercises help students to learn to read and use language better.*	11	59	11	19
Consuming drinks or snacks that contain a lot of (added) sugar can make students less attentive.*	12	68	15	5
Differences in hemispheric dominance (left brain, right brain) can help explain individual differences among learners.*	16	62	10	12
In general, students learn better when information is presented in their preferred learning style (e.g., auditory, visual, tactile, and kinesthetic).*	24	63	10	2
Following a specific diet can help overcome certain neurological disabilities, such as ADHD, Dyslexia, and Autism spectrum disorders.*	31	25	28	15
We only use 10% of our brain.*	42	29	9	18
Drinking less than 6–8 glasses of water a day can cause a developing brain to shrink in size.*	42	12	8	37
There are critical periods in childhood after which certain skills can no longer be learned.*	59	25	10	5
Regular drinking of caffeinated drinks (more than 5 cups of coffee, cans of soda, or energy drinks) increases alertness.*	64	8	15	12
Extended repetition of some mental processes can change the shape and structure of some parts of the brain.	65	4	8	22
Children must acquire their native language before a second language is learned. If they do not do so, neither language will be fully acquired.*	81	11	4	4
Education cannot remediate learning difficulties related to developmental differences in brain function.*	83	5	7	4

Note: NAOD = Neither agree or disagree, DK = do not know; *Incorrect statement.

Procedures

We used a snowball sampling technique to recruit participants. The survey was hosted on an online platform, and we posted invitations to complete the survey with an anonymous link on several Facebook pages and shared it via e-mail. The Facebook pages included the authors' personal pages and education-related group pages, with requests to share. The group pages targeted were ones that provided news and information for teachers and teacher educators. Posting on personal walls and group walls caused a snowball effect for the distribution of the link with respondents sharing the link within other groups, or on their own personal pages, making the link more widely available. Several respondents or otherwise interested individuals also shared the link to the survey with others through email. We shared the link in two waves, with a two-month gap in between waves.

Participant characteristics

In total, 213 individuals participated in the survey. Of these responses, 44 were discarded, 14 because the respondent was not currently employed in an educational position, and 30 because the respondent did not answer at least half of the survey questions. This resulted in 169 valid responses. The categories "Administrator at a Local Education Agency" and "Administrator at a State Education Agency or the Department of Education" had few respondents (n = 8 and n = 1, respectively). Therefore, we combined these categories with the category "School Administrator/School Leader" (24 respondents) under the umbrella of "Educational Leader" (for a total of 33 respondents). See Table 3 for participant characteristics.

Data analysis

After data collection stopped, all responses were imported into R (R Core Team, 2016), but only the responses with minimum of 50% of the questions answered were retained for further analysis. In order to gauge respondents' knowledge about facts and agreement with myths, we used a 2- option dummy code for all survey statements. For statements that were correct, we coded the "Agree" option as 1 and all other options as 0; for incorrect statements, we coded the "Disagree" option as 1, and all other options as 0. We

Table 3. Participant characteristics.

	n	%
Race		
African American	3	2
Asian	1	.5
Caucasian	144	85
Hispanic	10	6
Multiracial	6	4
Other	4	2
Rather not say	1	.5
Gender		
Female	150	89
Male	19	11
Position in Education		
Educational Leader	33	20
Higher Education Faculty	39	23
In-service Teacher	63	37
Preservice Teacher	34	20
Focus of Education		
General Education	78	46
Special Education	83	49
Other	8	5
	M (SD)	Range
Age	38.79 (13.48)	19–70
Experience	15.3 (11.39)	0–50
Experience in current position	6.34 (6.92)	0–42

separated the statements into Myths and Facts in accordance with Dekker and colleagues (2012) to be able to make comparisons with all studies based on their questionnaire. These authors made statements about educational neuromyths based on the definition and examples of the OECD (2002). To find out which of the myths are most prevalent in the US educational system, we calculated the percentage of correct responses per item, and per type of statement (i.e., Myths or Facts). We then calculated the total percentage of correct answers for each participant, as well as percent correct separated by Myths and Facts. Subsequently, we disaggregated data in two subgroups: by Focus of Education (i.e., General Education, Special Education, or other) and Position in Education (i.e., Educational Leader, Higher Education Faculty, In-service Teacher, or Preservice Teacher) and conducted four separate one-way, between-subjects ANOVAs to test for significant differences among subgroups. That is, a separate analysis for each subgroup in combination with the type of statement. We adjusted the degrees of freedom using the Welch method if variances among groups were unequal. For significant results, we followed up with post-hoc pairwise independent t-tests adjusted with Bonferroni. Finally, to examine if knowledge of facts and belief in myths are correlated, we calculated Pearson's correlation coefficient for sub scores of Myths and Facts for the total sample of respondents and for each of the categories within the two subgroups.

Results

To examine responses, we divided the items into Facts and Myths as indicated by Dekker and colleagues (2012) and considered each category separately. Tables 4 and 5 show these results for the total sample of respondents as well as disaggregated by subgroups. We also examined the relationships between responses related to facts and beliefs.

Facts

Results indicate the respondents identified 64% of the Facts correctly. This was an outcome similar for the various subgroups, with general educators and in-service teachers having the highest percentage of Facts correct (i.e., 66%) and preservice teachers and special educators the lowest

Table 4. Percentage of responses to fact statements per subgroup.

Group	Correct*	Incorrect	NAOD	DK
Total	64	15	8	12
Focus of Education				
General Education	66	16	6	11
Special Education	62	15	10	12
Position in Education				
Educational Leader	63	16	5	13
Higher Education Faculty	65	14	9	12
In-service Teacher	66	15	7	12
Preservice Teacher	61	16	12	11

Note: NAOD = Neither agree or disagree, DK = do not know; * = preferred response.

Table 5. Percentage of responses to myth statements per subgroup.

Group	Correct*	Incorrect	NAOD	DK
Total	36	41	10	13
Focus of Education				
General Education	36	43	10	12
Special Education	37	39	11	13
Position in Education				
Educational Leader	33	47	8	11
Higher Education Faculty	44	30	10	16
In-service Teacher	35	43	10	12
Preservice Teacher	33	43	12	12

Note: NAOD = Neither agree or disagree, DK = do not know; * = preferred response.

percentage of Facts correct (i.e., 61% and 62% respectively). The percentage of Facts identified correctly was not significantly different based on Focus of Education ($F_{2,\ 19.02} = 1.65$, $p = 0.219$) or Position in Education ($F_{3,78.25} = 0.96$, $p = 0.416$).

A majority of the Facts most known by the respondents were related to general functioning and structure of the brain. For example, almost all respondents (i.e., 97%) knew the brain does not shut down during sleep; only 90%, however, agreed that we use our brain 24 hours a day in some capacity. On the other hand, the Facts that dealt with more detailed functioning of the brain were mostly unknown to the respondents. For instance, most respondents knew learning occurs through modification and creation of neural connections (87%), but only 41% indicated the addition of new cells to the brain does not imply learning. Likewise, only a small percentage of the respondents knew that memories are not stored in small, identifiable pieces of the brain (22%), but 79% of the respondents knew that the memory system has different parts with different functions. Surprisingly, only 21% of respondents knew that the two hemispheres of the brain always work together, and 50% thought this was untrue. Additionally, only 11% knew that boys have bigger brains than girls. It is noteworthy that more than 20% of the respondents choose the answer option Do not Know for four of the Facts. Table 1 shows the percentage of all responses for each Fact.

Myths

The total sample of respondents identified only 36% of the Myths correctly. As with Facts, this percentage was similar for all subgroups with the exception of higher education faculty, who identified 44% of the Myths correctly. This difference in subgroups of Position in Education was statistically significant ($F_{3,\ 80.49} = 6.76$, $p < 0.001$). Post-hoc analysis indicated that Higher Education faculty scored statistically significantly different from all other groups (see Table 6). Additionally, it is noteworthy that this subgroup tended to choose the Do Not Know option more than the other subgroups (i.e., 16% versus 11%–12%), but this difference was not statistically significant ($F_{3,76.651} = 0.84$, $p = 0.474$). Finally, there were no statistical differences between the different subgroups in Focus of Education ($F_{2,166} = 0.29$, $p = 0.752$).

Table 6. Results of post-hoc pairwise comparisons for position in education.

	Educational Leader	Higher Education Faculty	In-service Teacher
Higher Education Faculty	< .001***		
In-service Teacher	1	.003**	
Preservice Teacher	1	< .001***	1

Note: Results are calculated with pooled SD and adjusted according to Bonferroni.
** $p < 0.01$; *** $p < 0.001$.

The most misidentified Myth was "Environments that are rich in stimulus improve the development of brains of pre-school children," which only 1% of the respondents identified correctly. The next six Myths were related to the most wide-spread neuromyths. For example, only 4% of the respondents disagreed that certain exercises can improve collaboration between the two hemispheres of the brain, and 16% thought hemispheric dominance does not explain individual differences in learners. Additionally, 12% of respondents did not think sugar affects children's attention, and 24% disagreed with the learning styles Myth. Finally, 11% of the total sample disagreed with the statements relating certain types of body exercises to improved literacy skills. Two Myths stood out because of the high percentage of the sample responding correctly. Eighty-three percent of the sample agreed that education is capable of remediating learning difficulties caused by neurological differences and 81% agreed children do not have to acquire their native language before starting to learn a second language. A striking pattern of responses occurred with the Myth that diets can help overcome neurological disabilities. This myth had the most equally distributed responses, with 31% choosing the preferred response, 25% the least preferred response, 28% the Neither Agree nor Disagree option, and 15% the Do Not Know option. Table 2 gives the percentages of responses for each Myth.

Relation between myths and facts

There was a significant moderate positive correlation between percentage of correctly identified facts and myths ($r = 0.31$, $t_{167} = 4.28$, $p < 0.001$) indicating that respondents who identified more Facts also identified more Myths correctly. Additionally, there were significant moderate correlations between certain sets of myths, indicating that respondents who agreed with one statement were more likely to agree with the second statement. For example, the statement "In general, students learn better when information is presented in their preferred learning style" had a moderate correlation with "Differences in hemispheric dominance (left brain, right brain) can help explain individual differences among learners" ($r = .54$, $p < 0.001$), and with "Doing basic Brain Gym exercises help students to learn to read and use language better" ($r = 0.43$, $p < 0.001$). The latter two statements also had a moderate correlation with each other ($r = 0.43$, $p < 0.001$). Additionally, "Doing basic Brain Gym exercises help students to learn to read and use language better" had a moderate correlation with "Certain exercises that practice the coordination of perceptual-motor skills can improve the literacy skills of children" ($r = .50$, $p < .001$). All these myths were in the top 7 most misidentified, ranging from 4% to 24% correct responses.

Discussion

We conducted this study to examine which neuromyths were most prevalent in the US educational system and how pervasive these myths are across different elements within the system. Overall, the results of this study are discouraging, but not surprising. The relatively low percentage of Myths respondents disagreed with (36%) indicates that these myths are either believed, or respondents were not sure about their truth-value. Additionally, even though knowledge about basic facts was higher, respondents were only able to correctly answer about two-thirds of the facts about the brain. The subgroup analysis showed these patterns to be similar across general and special education, and across most positions within the educational system. These results partly coincide with Tardif and colleagues (2015), whose sample also included in-service teachers, preservice teachers, and faculty involved in teacher training as respondents to their survey. They found a high prevalence of neuromyths in each group and their outcomes indicated no difference between the three groups. This is surprising since we found significantly less adherence to myths from higher education faculty involved in teacher preparation programs.

In general, our results validate the position of several myths being most prevalent in a global context. Learning styles, hemisphericity, and BrainGym have all been cited by earlier studies as being most widely believed and pervasive (e.g., Dekker et al., 2012; Gleichgerrcht et al., 2015; Tardif et al., 2015). This reiterates that belief in these myths is not an isolated problem for a particular district or country, but an international epidemic. This cluster of myths coincides with elements that are discussed frequently in educational spheres and on websites. Additionally, there are a myriad of commercially available products and teacher-made materials related to these myths. The popularity of such products provides further evidence that these neuromyths are widespread and intractable. Willingham (2017) suggested three reasons the learning styles myth has persisted among educators: resistance to questioning what they have been taught, the appeal of the myth as a quick fix, and the conflation of differences in preferences or abilities with difference in response to various modes of presentation. Similar reasons may explain the perpetuation of other myths.

Previous research showed an increase in general knowledge about the brain predicted belief in more neuromyths (e.g., Ferrero et al., 2016; Gleichgerrcht et al., 2015). One explanation for this might be that in a quest to find information about the brain, consumers are less able to distinguish what is real and what are myths, due to nature of how neuromyths emerge and perpetuate. Additionally, this inability to differentiate between fact and fiction may encourage additional skepticism when certain myths have been debunked. Similar behavior has been found in studies on correcting misconceptions about political facts. In fact, in several ideological groups, attempted redirection resulted in a "backfire effect." That is, the attempts to clarify led to an increase in a misconception instead of a correction (Nyhan & Reifler, 2010). Contrary to many earlier results, however, our results indicated a positive correlation between knowledge of facts and myths. Respondents in our sample who knew more general facts about the brain were also better able to debunk neuromyths. This result is similar to the outcomes in Papadatou-Pastou et al. (2017), but different from others (e.g., Dekker et al., 2012; Gleichgerrcht et al., 2015; Howard-Jones et al., 2009). Perhaps there is a "sweet spot" of knowledge about the brain at which one becomes better able to distinguish fact from myth, and perhaps there is truth to the maxim about "knowing just enough to be dangerous." That is, this could be an example the Dunning-Kruger effect (Kruger & Dunning, 1999), in which inadequate knowledge about a topic leads to overconfidence.

The results of this study partly support the hypothesis that belief in some myths is dependent on culture (Deligiannidi & Howard-Jones, 2015; Pei et al., 2015). Pei and colleagues (Pei et al., 2015) found that teachers in China believed more strongly in a fixed genetic influence on intelligence, and less in brain plasticity as teachers from other countries. Only 31% of their sample believed education can remediate learning difficulties due to developmental differences in brain function. In comparison, 83% of our respondents indicated agreement to the same statement. This percentage was higher than in any previous surveys, for example samples from Latin America 77% (Gleichgerrcht et al., 2015), the United Kingdom indicated 49% (Howard-Jones et al., 2009) and 69% (Dekker et al., 2012), the Netherlands 62% (Dekker et al., 2012), Turkey 65% (Karakus et al., 2015), Greece 57% (Deligiannidi & Howard-Jones, 2015). Moreover, this percentage was even higher than that of the sample of US and Canadian teachers in Lethaby and Harries (2015, 70%). This number could be influenced by the fact that almost 50% of our sample identified as being primarily involved in special education, where a belief in the ability to remediate is imperative to success (Allinder, 1994). Only one of the other surveys provided information about type of education (i.e., Papadatou-Pastou et al., 2017), but the authors did not disaggregate those data. Roughly one-fifth of their sample consisted of preservice teachers in special education. Fifty-five percent of the total participants believed in the possibility of remediation, which is lower than the earlier sample of Deligiannidi and Howard-Jones (2015), suggesting that the high number in our sample could still be culturally related. Additionally, many of our respondents had knowledge of the plasticity of the brain and its continuing development over time. For example, 91% believed cognitive abilities can be modified by the environment and life experience, and the fact that brain development continues into young adulthood was also known by the majority of respondents (86%).

A second belief that seems to be partly dependent on cultural values is if children need to acquire their native language first, before learning a second language. Turkish teachers believed in this need more than teachers from other countries (i.e., 32.4% Turkey, 40% in Latin America, 61% in the Netherlands, and 82% in the United Kingdom). With 81%, our sample is comparative to the UK. Karakus and colleagues (2015) attribute the difference in beliefs to a nation's ideology in allowing multilinguism or promoting monolinguism. The fact that more schools in the United States are promoting dual language immersion could be an indication of support for multilinguism and the belief that languages are easier to learn early on in life (Garcia & Jenson, 2006). In any case, the fact that such a large proportion of our sample did not believe in this myth is a positive fact for a country like the United States where such a large portion of students speak English as a second language. For example, data from the National Center for Education Statistics (NCES) for the 2014–1015 academic year show that 9.4% of all students participated in language assistance programs in school, with most children served in elementary grades (McFarland et al., 2017).

Beliefs about the effects of diet on neurological disabilities (e.g., ADHD, Dyslexia, and Autism spectrum disorders) were equally distributed across the four response options. Although some recent research (e.g., Ding, Taur, & Walkup, 2017; Foster & Neufeld, 2013) indicates possible links between gastrointestinal microbes and neurological function, evidence to support a causal connection is still limited. However, beliefs about the effects of diet have long been a part of education lore, and attempts to debunk them (e.g., Mattes, 1983) have met with skepticism. The current popularity of "all natural," "paleo," or "gluten-free" diets as panaceas for a wide range of health concerns may also contribute to the perpetuation of this myth.

Implications

An uncertain stance towards these neuromyths can have a detrimental effect on children's learning by including ineffective instructional techniques based on these beliefs and, by doing this, stifling scientifically proven techniques. For example, a belief in the myth that Brain Gym exercises can help develop literacy skills may take instructional time away from struggling readers, time better spent on phonological awareness or phonics-based instruction that has been proven to increase reading outcomes and sometimes even alter brain structures (Keller & Just, 2009; Krafnick, Flowers, Napoliello, & Eden, 2011).

The pervasiveness across the educational system is also discouraging when thinking about how to minimize these beliefs and advocate for evidence-based practices instead. For example, several authors in earlier studies suggested teacher preparation programs should include courses on brain functioning (e.g., Deligiannidi & Howard-Jones, 2015; Howard-Jones et al., 2009; Papadatou-Pastou et al., 2017; Tardif et al., 2015). Our results, however, suggest that this might ameliorate the pervasiveness only slightly, since the higher education faculty in our sample only knew two-thirds of the Facts about the brain and could identify less than 50% of the Myths. It could be that preparation programs do not have the qualified faculty needed to teach such courses. And even if such courses were taught successfully, and new teacher candidates had a good understanding about the brain and how it relates to education, a complete shift in culture is not guaranteed. Schools change slowly, and it is more likely that new hires will be drawn into the reigning culture in a school than that they are able to change this culture (Fullan, 2015). Moreover, the specific culture in a workplace is often a determinant for the content and type of continuing professional learning opportunities (Webster-Wright, 2009). Schools are embedded within larger structures of education agencies, and culture can be specific not just to a school, but also to a district. Besides including these proposed courses in teacher preparation programs, it may also be necessary to include them in leadership preparation programs and teacher professional development activities to generate a culture shift on a larger scale. Better informed school leaders, on the local, district, and even state and federal level, may be more critical when choosing and planning for profession development opportunities. Practicing teachers may need very carefully designed professional development to help them change long-held beliefs.

The framework for critically evaluating brain-based products proposed by Sylvan and Christodoulou (2010) could be a starting point for educators and other consumers to determine the appropriateness of some of their instructional methods. This framework, however, does not address common myths and instructional activities associated with them. There seems to be a genuine and substantial need for targeted efforts to debunk common neuromyths, to enhance knowledge related to the brain and education, and to develop critical evaluation skills among educators. Such myth-busting efforts should be sweeping and sustained to bolster our education system's capacity to reject poorly supported claims associated with these myths.

Limitations

The snowball sampling method using social media allowed for widespread distribution of the survey to a diverse audience, but it also posed some limitations. Although it is unlikely, the anonymous nature of the sample does allow the potential for participants to misrepresent themselves either in their role as educators or in their responses. Also, while our sample came from a wide variety of settings, it cannot be considered a random sample. Because we used social media to distribute the survey, the sample was limited to social media users, which may vary somewhat from the general population. It could be that our acquaintances, especially higher education faculty, are more versed in issues regarding the brain than others. Additionally, almost 50% of our sample indicated their primary focus was on special education, whereas only around 7% of in-service teachers are special educators (US Department of Education, 2013). Our statistical analysis, however, did not show any differences between these two groups. A larger survey using stratified random selection techniques will be needed for a better representation of the state of neuromyths within the US educational system.

Our survey focused mostly on the percentage of the respondents who answered the statements correctly (i.e., "Agree" when a statement was correct, and "Disagree" when a statement was false). It is possible respondents did not necessarily believe in the statements, but were unsure about the truth of a statement. Additionally, a correct response does not necessarily imply that a respondent uses instructional materials or techniques associated with the myth in daily educational activities. This is not represented in our results but could account for several surprising patterns in our results. For example, 21% of the respondents knew that both hemispheres of the brain always work together; however, only 4% of the respondents disregarded doing specific exercises as a way to improve collaboration between the hemispheres. In-depth interviews with educators, or more open-ended questions could help uncover the reasons behind certain discrepancies and the daily implications of believe in myths on educational instruction.

Finally, while we piloted the survey and used cognitive interviews and expert reviews to validate the statements, it may still be that the wording of some statements was unclear or led to respondents being less certain about their answers. For example, the low number of correct responses to the Myth that *Environments that are rich in stimulus improve the development of brains of pre-school* children was surprising. We hypothesize that respondents confused the presence of stimuli with the interaction of the child with the stimuli as a cause for brain development.

Conclusion

Neuromyths are a pervasive and persistent problem in the US education system. The outcomes of this survey indicate that the permeation of neuromyths within the system may be more widespread than previously thought. That is, this is not just an issue at the level of the classroom teacher. School leaders and university education faculty—those responsible for preparing teachers and fostering their professional development—are also vulnerable to belief in neuromyths. This contributes to the perpetuation of the problem and calls for a paradigm shift far larger than assumed in previous studies. This survey provides a glimpse into the extent of the problem, but more in-depth examination of this issue is warranted. It is clear, however, that eradicating the problem of neuromyths in education cannot be left to teacher preparation programs alone. A concerted, systemwide effort is needed.

References

Alekno, S. M. (2012). *Teachers' beliefs and practices regarding neuromyths* (Doctoral Dissertation). Retrieved from ProQuest Dissertations and Theses database (UMI No. 3505764).

Allinder, R. M. (1994). The relationship between efficacy and the instructional practices of special education teachers and consultants. *Teacher Education and Special Education*, *17*, 86–95. doi:10.1177/088840649401700203

Bernard, S. (2010, December 1). Neuro myths: Separating fact and fiction in brain-based learning [Blog post]. Retrieved from https://www.edutopia.org/neuroscience-brain-based-learning-myth-busting

Beyerstein, B. L. (1999). Whence cometh the myth that we only use ten percent of our brains? In S. Della Sala (ed.), *Mind myths: Exploring popular assumptions about the mind and brain* (pp. 4–24). New York, NY: J. Wiley & Sons.

Dekker, S., Lee, N. C., Howard-Jones, P., & Jolles, J. (2012). Neuromyths in education: Prevalence and predictors of misconceptions among teachers. *Frontiers in Psychology*, *3*(article 429), 1–8. doi:10.3389/fpsyg.2012.00429

Deligiannidi, K., & Howard-Jones, P. A. (2015). The neuroscience literacy of teachers in Greece. *Procedia-Social and Behavioral Sciences*, *174*, 3909–3915. doi:10.1016/j.sbspro.2015.01.1133

Ding, H. T., Taur, Y., & Walkup, J. T. (2017). Gut microbiota and autism: Key concepts and findings. *Journal of Autism and Developmental Disorders*, *47*(2), 480–489. doi:10.1007/s10803-016-2960-9

Dündar, S., & Gündüz, N. (2016). Misconceptions regarding the brain: The neuromyths of preservice teachers. *Mind, Brain, and Education*, *10*(4), 212–232. doi:10.1111/mbe.2016.10.issue-4

Espelage, D. L. (2016). Leveraging school-based research to inform bullying prevention and policy. *American Psychologist*, *71*(8), 768. doi:10.1037/amp0000095

Ferrero, M., Garaizar, P., & Vadillo, M. A. (2016). Neuromyths in education: Prevalence among Spanish teachers and an exploration of cross-cultural variation. *Frontiers in Human Neuroscience*, *10*. doi:10.3389/fnhum.2016.00496

Foster, J. A., & Neufeld, K. A. M. (2013). Gut–Brain axis: How the microbiome influences anxiety and depression. *Trends in Neurosciences*, *36*(5), 305–312. doi:10.1016/j.tins.2013.01.005

Fullan, M. (2015). *The new meaning of educational change* (5th ed.). New York, NY: Teachers College Press.

Garcia, E., & Jensen, B. (2006). Dual language programs in US schools. *Target*, *80*(60), 30–37.

Geake, J. (2008). Neuromythologies in education. *Educational Research*, *50*, 123–133. doi:10.1080/00131880802082518

Gleichgerrcht, E., Luttges, B. L., Salvarezza, F., & Campos, A. L. (2015). Educational neuromyths among teachers in Latin America. *Mind, Brain, and Education*, *9*, 170–178. doi:10.1111/mbe.2015.9.issue-3

Grotzer, T. A. (2011). Public understanding of cognitive neuroscience research findings: Trying to peer beyond enchanted glass. *Mind, Brain, and Education*, *5*, 108–114. doi:10.1111/mbe.2011.5.issue-3

Howard-Jones, P. A. (2014). Evolutionary perspectives on mind, brain, and education. *Mind, Brain, and Education*, *8*(1), 21–33. doi:10.1111/mbe.2014.8.issue-1

Howard-Jones, P. A., Franey, L., Mashmoushi, R., & Liao, Y. C. (2009, September). The neuroscience literacy of trainee teachers. In *British Educational Research Association Annual Conference* (pp. 1–39). University of Manchester.

Hyatt, K. J. (2007). Brain Gym® building stronger brains or wishful thinking? *Remedial and Special Education*, *28*, 117–124. doi:10.1177/07419325070280020201

Karakus, O., Howard-Jones, P. A., & Jay, T. (2015). Primary and secondary school teachers' knowledge and misconceptions about the brain in Turkey. *Procedia-Social and Behavioral Sciences*, *174*, 1933–1940. doi:10.1016/j.sbspro.2015.01.858

Keller, T. A., & Just, M. A. (2009). Altering cortical connectivity: Remediation-induced changes in the white matter of poor readers. *Neuron*, *64*(5), 624–631. doi:10.1016/j.neuron.2009.10.018

Krafnick, A. J., Flowers, D. L., Napoliello, E. M., & Eden, G. F. (2011). Gray matter volume changes following reading intervention in dyslexic children. *Neuroimage*, *57*(3), 733–741. doi:10.1016/j.neuroimage.2010.10.062

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, *77*(6), 1121–1134. doi:10.1037/0022-3514.77.6.1121

Lethaby, C., & Harries, P. (2015). Learning styles and teacher training: Are we perpetuating neuromyths? *ELT Journal*, ccv051. doi:10.1093/elt/ccv051

Lindell, A. K., & Kidd, E. (2013). Consumers favor "Right Brain" training: The dangerous lure of neuromarketing. *Mind, Brain, and Education*, *7*, 35–39. doi:10.1111/mbe.2013.7.issue-1

Mattes, J. A. (1983). The Feingold diet: A current reappraisal. *Journal of Learning Disabilities*, *16*(6), 319–323. doi:10.1177/002221948301600602
McFarland, J., Hussar, B., De Brey, C., Snyder, T., Wang, X., Wilkinson-Flicker, S., … Hinz, S. (2017). *The Condition of Education 2017* (NCES 2017-144). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved from https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2017144.
Milich, R., Wolraich, M., & Lindgren, S. (1986). Sugar and hyperactivity: A critical review of empirical findings. *Clinical Psychology Review*, *6*, 493–513. doi:10.1016/0272-7358(86)90034-6
Morris, R. D., Stuebing, K. K., Fletcher, J. M., Shaywitz, S. E., Lyon, G. R., Shankweiler, D. P., … Shaywitz, B. A. (1998). Subtypes of reading disability: Variability around a phonological core. *Journal of Educational Psychology*, *90*(3), 347. doi:10.1037/0022-0663.90.3.347
Nyhan, B., & Reifler, J. (2010). When corrections fail: The persistence of political misperceptions. *Political Behavior*, *32*(2), 303–330. doi:10.1007/s11109-010-9112-2
Organisation for Economic Co-operation and Development (OECD). (2002). *Understanding the brain: Towards a new learning science*. Paris, France: Author.
Papadatou-Pastou, M., Haliou, E., & Vlachos, F. (2017). Brain knowledge and the prevalence of neuromyths among prospective teachers in Greece. *Frontiers in Psychology*, *8*. doi:10.3389/fpsyg.2017.00804
Pasquinelli, E. (2012). Neuromyths: Why do they exist and persist? *Mind, Brain, and Education*, *6*, 89–96. doi:10.1111/mbe.2011.6.issue-2
Pei, X., Howard-Jones, P. A., Zhang, S., Liu, X., & Jin, Y. (2015). Teachers' understanding about the brain in east China. *Procedia-Social and Behavioral Sciences*, *174*, 3681–3688. doi:10.1016/j.sbspro.2015.01.1091
Phillips, D. A., & Shonkoff, J. P. (Eds.). (2000). *From neurons to neighborhoods: The science of early childhood development*. Washington, DC: National Academies Press.
R Core Team. (2016). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/
Rato, J. R., Abreu, A. M., & Castro-Caldas, A. (2013). Neuromyths in education: What is fact and what is fiction for Portuguese teachers? *Educational Research*, *55*(4), 441–453. doi:10.1080/00131881.2013.844947
Rauscher, F. H., Shaw, G. L., & Ky, K. N. (1993). Music and spatial task performance. *Nature*, *365*(6447), 611. doi:10.1038/365611a0
Shaywitz, B. A., Shaywitz, S. E., Blachman, B. A., Pugh, K. R., Fulbright, R. K., Skudlarski, P., … Fletcher, J. M. (2004). Development of left occipitotemporal systems for skilled reading in children after a phonologically-based intervention. *Biological Psychiatry*, *55*(9), 926–933. doi:10.1016/j.biopsych.2003.12.019
Spaulding, L. S., Mostert, M. P., & Beam, A. P. (2010). Is Brain Gym® an effective educational intervention? *Exceptionality*, *18*(1), 18–30. doi:10.1080/09362830903462508
Steele, K. M., Bass, K. E., & Crook, M. D. (1999). The mystery of the Mozart effect: Failure to replicate. *Psychological Science*, *10*(4), 366–369. doi:10.1111/1467-9280.00169
Sylvan, L. J., & Christodoulou, J. A. (2010). Understanding the role of neuroscience in brain based products: A guide for educators and consumers. *Mind, Brain, and Education*, *4*(1), 1–7. doi:10.1111/mbe.2010.4.issue-1
Tardif, E., Doudin, P. A., & Meylan, N. (2015). Neuromyths among teachers and student teachers. *Mind, Brain, and Education*, *9*, 50–59. doi:10.1111/mbe.12070
U.S. Department of Education. (2014). *A matter of equity: Preschool in America*. Washington, DC: Author. Retrieved from http://www2.ed.gov/documents/early-learning/matter-equity-preschool-america.pdf
U.S. Department of Education, National Center for Education Statistics (2013). *Schools and Staffing Survey (SASS), "Public School Teacher Data File," 1987-88 through 2011-12*. Retrieved from https://nces.ed.gov/programs/digest/d13/tables/dt13_209.10.asp
Vaillancourt, T., Duku, E., Decatanzaro, D., Macmillan, H., Muir, C., & Schmidt, L. A. (2008). Variation in hypothalamic–Pituitary–Adrenal axis activity among bullied and non-bullied children. *Aggressive Behavior*, *34*(3), 294–305. doi:10.1002/(ISSN)1098-2337
Webster-Wright, A. (2009). Reframing professional development through understanding authentic professional learning. *Review of Educational Research*, *79*(2), 702–739. doi:10.3102/0034654308330970
Weisberg, D. S., Keil, F. C., Goodstein, J., Rawson, E., & Gray, J. R. (2008). The seductive allure of neuroscience explanations. *Journal of Cognitive Neuroscience*, *20*(3), 470–477. doi:10.1162/jocn.2008.20040
Willingham, D. (2017). 3 reasons most teachers still believe the learning styles myth. *Advancing Educational Excellence*. Retrieved from: https://edexcellence.net/articles/3-reasons-most-teachers-still-believe-the-learning-styles-myth
Wolraich, M. L., Wilson, D. B., & White, J. W. (1995). The effect of sugar on behavior or cognition in children: A meta-analysis. *JAMA*, *274*(20), 1617–1621. doi:10.1001/jama.1995.0353020005