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Determining Biology Teachers' Neuromyths and Knowledge About Brain Functions

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Abstract

Due to the advances in the field of medicine and neurology, neuroscience has taken its place as an important research field in the literature with an enormous reflection upon various interdisciplinary studies, including education. As an emerging field of study, educational neuroscience has attracted researchers' attention in recent years. Nowadays, common misunderstanding about brain mechanisms is called a neuromyth. The aim of this research is, thus, to determine what Biology teachers know as correct and incorrect (neuromyths) about brain functions. This study, carried out with Biology teachers, is important in bridging neuroscience and education (namely Educational neuroscience). For the purpose of the study, general survey model was utilized. The sample of the study constituted 146biology teachers. A survey tool titled 'Data Collection for Educational Neuroscience' was used as a data collection tool. The analysis explored the relationship between some demographic data and the neuromyths teachers possess. Obtained data were analyzed and reported by frequency and Spearman correlation coefficient According to the results of the study, it is seen that most of the Biology teachers know one out of three correct items whereas they did not have neuromyths for three of seven neuromyths.

Keywords

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Introduction

It is very important to design research with different dimensions in order to carry out effective studies in terms of Biology education together with emerging technologies. In order to address such novel problems, it is necessary to cooperate with different diciplines. Therefore, interdisciplinary studies are needed. This research is an interdisciplinary study covering the fields of Biology education and educational neuroscience.

Researchers use many fields of studies to explain the relationship between neuroscience and education. Examples include 'Cognitive neuroscience', 'Educational neuroscience', 'Neuroscience and education', 'Neuroscience', 'Neuroeducation', 'Mind, brain and education', and 'Brain-based education' (Gardner, 2020; OECD, 2002).

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Although the structure of the brain and the system of study are quite complex, researchers reveal various data due to neuroscience which is the sub-branch of biology. From this point of view, Wolfe (2004) stated in his research that the brain attaches a special importance to educators because the brain is a learning-related organ. Learning creates some changes in the central nervous system and cognitive neuroscience studies revealing this changes provide important contributions to education (Demirel, 2003; Kaas, 1991; Keleş & Çepni, 2006).

Although there are many theories explaining how learning takes place, there are many studies that try to understand the role of brain in this process. In the data obtained from the research carried out especially in neuroscience, it is becoming more evident how the brain works during learning. Thus, we happen to become more conscious of, and develop new acquisitions about learning (Duman, 2007).

Cognitive neuroscience investigates the relationship between mind and the brain, that is, it explores which neural processes are associated with which mental functions (Banich & Compton, 2011). The need to apply the theoretical knowledge obtained from research in the field of neuroscience to education has been mentioned by many researchers (Goswami, 2006). Based on aforementioned arguments, this research is designed to explore biology teachers' neuromyths with a measurement tool titled 'Data Collection tool for Educational Neuroscience '.

Trainers will learn how well the human brain works, making learning more effective and efficient for their students. However, some common myths associated with neuroscience lead to false beliefs (OECD, 2002). For example, there is a false belief that only ten percent of our brains are used. Since these misunderstandings are related to knowledge of the mind and the brain, and they are widely held as a belief in the society, they are called neuromyths in the field of education (Geake, 2008; Goswami, 2008; Howard-Jones, 2014; OECD, 2002; Waterhouse, 2006).

These common misunderderstandings about accepted brain mechanisms in today's society usually begin with false readings and misinterpretations. In some cases, it starts with a deliberate distortion of scientifically established cases to create a domain, related to education. Myths (also known as misunderstandings) spread rapidly due to the extensive brain-based research in education. The presence of neuromyths in the field of education has been emphasized in a number of studies (Ansari & Coch, 2006; Geake, 2008; Goswami, 2006; Pasquinelli, 2012; Tardif & Doudin, 2011, Grospietsch & Mayer, 2020). Howard-Jones Franey, Mashmoushi, and Liao (2009), 'The Neuroscience Literacy of Trainee Teachers' how they think about brain development and function of teachers from doing their work in order to better understand. He collected his data by semi-structured interviews As a result of the interviews, it has been shown that these pre-service teachers exhibit a high degree of neuromyth in beliefs about misconceptions, misreading or misinterpretation of the cases created by neuroscientists.

Pasquinelli (2012) examined the origin, continuity and potential side effects of neuromyths in education. The aim of his study was to explain the misunderstandings that negatively affect the scientific approach -Mozart effect - into the education. Pasquinelli (2012) also discussed the origin of neuromyths and provided a theoretical framework to explain their insistence on opposing knowledge. He furthermore proposed some possible actions to have been taken to counter these negative effects related to science education. Dekker, Lee, Howard-Jones, and Jolles (2012) and van Dijk and Lane (2020), in their study, investigated whether belief in neuromyths is common among teachers interested in learning neuroscience. They also investigated which myths were the most common and least common. They also focused on the determining the factors embedded in these beliefs. As a result, they found no significant difference between the general prevalence among countries, and half of the teachers were found to have believed in most of these myths. Similarly Karakuş (2013), in her master's thesis, - using the scale developed by Dekker et al. (2012) -has investigated the primary and secondary teachers' misunderstandings, the source of their misunderstandings and the perceptions about training and neuroscience in Turkey. She used mixed method by including surveys and interviews. It was found that teachers had limited knowledge about the brain and generally believed in neuromyths. With these

findings, she compared Dekker's research results. Comparison with the United Kingdom, the Netherlands and Turkey was determined to have almost the same neuromyths. Similar studies were conducted by Howard-Jones (2014). Howard-Jones (2014) examined the results of different surveys conducted among teachers in the United Kingdom, the Netherlands, Turkey, Greece and China. In these separate studies, the most common neuromyths of the teachers in these countries were a total of seven neuromyths.

Deligiannidi and Howard-Jones (2015) applied 'The Neuroscience Literacy of Teachers in Greece' questionnaire to 217 primary and secondary schools teachers in Greece. The analysis revealed that Greek school teachers were misunderstood about the concepts related to brain-based education programs observed elsewhere in Europe. These include believing that differences in hemispheric dominance (left brain, right brain) can help explain individual differences between students and the effect of teaching on learning styles. However, international comparisons with other studies have revealed some differences that reflect the impact of cultural forces on teachers' ideas about brain function. For example, it seems that teachers in Greece have a more complex structure than those observed in the United Kingdom and the Netherlands, because this relationship is thought to be guided by the soul. There has also been a relationship between genetically linking educational results and believing in student achievement at a biological boundary.

Dündar and Gündüz (2016) aimed to investigate teacher candidates' neuromyths. They used a 59-item questionnaire consisting of two categories as training and neuromyths. As a result of the analyzes, they concluded that prospective teachers had common neuromyths and had no idea about the items in the questionnaire. They interpreted emerging findings according to the effect of book reading, according to the effect of popular science journal reading, according to the effect of reading the newspaper and according to the effect of graduation status.

There are different studies on neuromyths. For example; Horvath Donoghue, Horton, Lodge, and Hattie (2018) in their study, 'On the Irrelevance of Neuromyths to Teacher Effectiveness: Comparing Neuro-Literacy Levels Amongst Award-Winning and Non-award Winning Teachers', investigated the assumption of previous studies by evaluating the neuromyth acceptance rate between an internationally recognized, award-winning group of teachers and comparing it with previously published data, trainee and non-award-winning teacher populations. Their results showed that neuromyths were accepted to be almost identical between these two groups. The findings suggest that one cannot make simple, unqualified arguments about the relationship between neuromyths belief and teacher effectiveness. At the end of their study, the researchers concluded 'the idea that neuromyths have a negative impact on the teacher may be a neuromyth'.

McMahon, Yeh, and Etchells (2019) addressed innovations included in an ITE (initial teacher education) program to help prospective teachers to recognize and challenge the persistence of neuromyths. The sample consisted of 130 people. The questionnaires included Likert-type scale questions for quantitative analysis and open-ended questions for qualitative analysis. They analyzed the data with SPSS and NVivo programs. As a result, researchers investigated changes in their beliefs during a modified ITE program, which included a new intervention designed to challenge the beliefs of primary school teachers on neuromyths, and a new intervention designed to develop their beliefs as future critical consumers of neuroscience in education. They further suggested that the ITE program in general had no effect on the general knowledge of the brain and that there was a slight decrease in belief in neuromyths.

The research synthesized above indicate clearly that in majority of both teachers and teacher candidates hold neuromyths regarding how brain works. Although there is not a specific study carried out with biology teachers in Turkey, there is a reseach with pre-service biology teachers in Germany. Grospietsch and Mayer (2018) in their study titled as 'Professionalizing Pre-Service Biology Teachers' Misconceptions about Learning and the Brain through Conceptual Change', investigated the effects of

conceptual change texts on the validation of neuromyths with 57 pre-service Biology teachers at the University of Kassel. The results of this study proved that a university course designed with a professional conceptual change model had positive effects on the professional knowledge of pre-service biology teachers, their knowledge of the brain, beliefs and dispelled their misunderstandings based on learning theory (neurromyths).

Researches emphasize the importance of teachers to have an interest in educational neuroscience and the brain. The purpose of recent research is to increase the research of neuroscience in order to provide professional development for teachers (Dubinsky, Roehrig, & Varma, 2013; Hook & Farah, 2012). In this context, it is assumed that if teachers knew where the neuromyths came from and what was happening, they would prevent the spread of neuromyths and provided more effective instruction.

Having considered all these factors and their contribution to education in general, there are two main objectives of this study. The first aim of this research is to find out what biology teachers have accurate knowledge about the structure and functions of the brain. If the existing knowledge of biology teachers is incomplete or incorrect, it may lead to the formation of new neuromyths. The second is to reveal whether biology teachers have neuromyths. If biology teachers become aware of the fact that they have neuromyths and are made aware of it, they will provide their students with more effective instruction in the nervous system and prevent the spread of neuromyths.

It is thought that especially biology teachers should be informed about neuromyths. 'Human Physiology' unit of secondary school biology lesson in the 11th grade explains the structure and functions of the brain as an organ within the framework of the Nervous System. In this context, determining the current knowledge levels of biology teachers about the structure and functions of the brain will be an important basis for future studies.

Studies conducted among teachers about neuroscience and education in Turkey is limited. This study, carried out with Biology teachers, which is significant in terms of being a study in the field of biology education in order to contribute to the studies between neuroscience and education

Research Problems

1. How accuarate biology teachers' knowledge are about the brain mechanisms?
2. What are the neuromyths that biology teachers have about the structure and functions of the brain?

Method

Research Model

This study is designed as a survey research The survey model is based on depicting the current state as it is (Karasar, 2005). Surveys help researchers observe the arrangements made in the universe consisting of a large number of elements in order to reach a general judgment about the universe, or through a group, sample or sample to be taken from the universe (Karasar, 2005). The study context of the research included biology teachers working at different schools affiliated with the MONE in the different provinces of Turkey between 2017-2019 years. The total number of biology teachers in the target population is 23.714, among which 764 biology teachers were reached from the target universe. These teachers were reached by sending a Google Survey Form from a social media site. The sample of the study who responded to the survey was 146 biology teachers, from 27 different provinces in Turkey. The aim of this study is not to generalize the sample to the target population, but to generalize the sample to the accessible population. So it has external validity, but it is limited and this is the limitation of the research sample. 25 of the 146 biology teachers were male and 121 were female. All participation was voluntary. All teachers in the sample have internal validity because they really respond to their own will.

Data Collection Process

Before collecting the data, a pilot study was conducted with four biology teachers in order to test the applicability of the instrument. As a result of the pilot application, it was found that the instrument took approximately 15 minutes to complete and no revisions were needed to transform. Since the research instrument is clear, no addition or subtraction was performed. Ethical permissions were sought and obtained prior to data collection. In addition, permission to use the measurement tool developed by Dekker et al. (2012) was also obtained. The survey instrument entitled 'Data Collection for Educational Neuroscience' was transformed into Google Survey Form with a demographic information section and sent to teachers.

Data Collection Tools

'Data Collection for Educational Neuroscience' was used as a data collection tool. First part consisted of seven demographic questions in order to obtain personal and educational background information of biology teachers. These questions were about their age, gender, graduation status, the province where they live, their occupational experience, reading habits of scientific journals and taking a course about educational neuroscience or participating in workshops. The relation of neuromyths with 5 variables selected from 7 problems was investigated. These variables; gender, graduation status, occupational experience, reading of scientific journals and taking a course in educational neuroscience or participating in workshops. The second part included 41 questions, including both correct and incorrect (neuromyths) information about brain functions. In additional of the measurement tool included both correct information and neuromides of brain function with 41 items. Of the 41 items in the measuring instrument, 19 were accurate, and 22 were neuromyths. The first 32 items in the measurement tool were developed by Dekker et al. (2012). First of all, these items were trained in English and translated into Turkish by a total of 4 people including 1 language and 3 education experts. The translated items were then compared and translated into the original language. Subsequently, the items in both languages were compared by the researchers and their translation was decided. The remaining nine items in the measurement tool were developed by researchers. Afterwards, it was tried to provide scope validity and reliability by taking expert opinions about the measurement tool and making necessary arrangements. Cronbach alpha value was examined to ensure the reliability of the items. According to Can (2019), the value between $0.60 < \alpha < 0.90$ shows that the scale is very reliable. Cronbach alpha value was found to be $\alpha = 0.7$ and the reliability of the measuring instrument was ensured.

Data Analysis

The data obtained from biology teachers were analyzed by descriptive statistics, mainly using the frequency and percentage scores. The data obtained at the end of the application were given frequency values with SPSS 20 program and Spearman correlation coefficients were examined. Since the variables are continuous but not normally distributed, Spearman correlation coefficient has been examined for the relationship between them (Büyüköztürk, 2005). According to Can (2019), there is a weak correlation or no correlation between 0.0 and 0, 4, moderate correlation between 0.4 and 0.6, and a high correlation between 0.6 and 1.

Results

The Findings of the First Problem of the Research

In order to reveal the items that biology teachers know correctly about the structure and functions of the brain, the findings of correct items in “Data Collection for Educational Neuroscience", which is the data collection tool of the research, are given in Table 1.

Table 1 presents the findings of the correct items in the ‘Data Collection for Educational Neuroscience’.

Table 1. Findings of the Correct Items in the 'Data Collection for Educational Neuroscience'as a Data Collection Tool

Correct Items in the 'Data Collection for Educational Neuroscience'	True	False	Unknown
	f	f	f
1. We use our brains 24 h a day.	124	17	5
3. Boys have bigger brains than girls.	56	71	19
6. When a brain region is damaged, other parts of the brain can take up its function.	25	105	16
8. The left and right hemispheres of the brain always work together.	44	93	9
13. Information is stored in the brain in a network of cells distributed throughout the brain.	103	19	24
14. Learning is not due to the addition of new cells to the brain.	89	28	29
16. Learning occurs through modification of the brains' neural connections.	83	25	38
17. Academic achievement can be affected by skipping breakfast.	141	3	2
18. Normal development of the human brain involves the birth and death of brain cells.	89	31	26
20. Vigorous exercise can improve mental function.	121	12	13
23. Circadian rhythms ("body-clock") shift during adolescence, causing pupils to be tired during the first lessons of the school day.	101	10	35
24. Regular drinking of caffeinated drinks reduces alertness.	93	30	23
26. Extended rehearsal of some mental processes can change the shape and structure of some parts of the brain.	76	32	38
27. Individual learners show preferences for the mode in which they receive information.	143	1	2
29. Production of new connections in the brain can continue into old age.	109	19	18
31. There are sensitive periods in childhood when it's easier to learn things.	100	-	-
35. Using technology while doing something we don't like reduces our threshold level against boredom.	66	32	48
37. As the technology in our environment changes, our brain adapts to the appropriate skills.	140	2	4
41. Frequent use of the computer contributes to the cognitive functions of older individuals.	25	73	47

Table 1 shows the frequency and percentage distributions of the responses of the teachers to the correct items. According to Table 1, item 31 ('There are sensitive periods in childhood when it's easier to learn things') of the correct items in the 'Data Collection for Educational Neuroscience', which is the data collection tool of the research, was answered correctly by all biology teachers. This finding shows that teachers have the right knowledge about this article. Item 27 ('Individual learners show preferences for the mode in which they receive information') was answered correctly by 143 teachers, item 37 ('As the technology in our environment changes, our brain adapts to the appropriate skills') was answered correctly by 140 teachers, Item 17 ('Academic achievement can be affected by skipping breakfast') was answered correctly by 141 teachers. 124 of biology teachers to ('We use our brains 24 h a day') item 1 answered correct, 17 of them answered wrong, 5 of them answered unknown. 121 teachers to ('Vigorous exercise can improve mental function') item 20 answered correct. Item 29 ('Production of new connections in the brain can continue into old age') was answered correctly by 109 teachers, item 13 ('Information is stored in the brain in a network of cells distributed throughout the brain') was answered correctly by 103 teachers, item 23 ('Circadian rhythms ("body-clock") shift during adolescence, causing pupils to be tired during the first lessons of the school day.') was answered correctly by 101 teachers, item 14 ('Learning is not due to the addition of new cells to the brain.') was answered correctly by 89

teachers, item 24 ('Regular drinking of caffeinated drinks reduces alertness.') was answered correctly by 93 teachers, item 16 ('Learning occurs through modification of the brains' neural connections.') was answered correctly by 83 teachers, item 18 ('Normal development of the human brain involves the birth and death of brain cells.') was answered correctly by 89 teachers. The rest of the items were answered correctly by 76 and fewer teachers.

13 of the 19 correct items in the 'Data Collection for Educational Neuroscience' were answered correctly by most teachers. This finding shows that most of the 100 teachers in the study group have accurate information about 13 items. The number of teachers who answered the remaining 6 items correctly was low. This finding shows that most of the teachers in the study group had misunderstandings about these six items.

The Findings of the Second Problem of the Research

The findings of the neuromyths in the 'Data Collection for Educational Neuroscience' are given in Table 2.

Table 2. Findings of the Neuromyths in the 'Data Collection for Educational Neuroscience'as a Data Collection Tool

Findings of the Neuromyths in the 'Data Collection for Educational Neuroscience'	**True**	**False**	**Unknown**
	f	**f**	**f**
2. Children must acquire their native language before a second language is learned. If they do not do so neither language will be fully acquired.	64	69	13
4. If pupils do not drink sufficient amounts of water (6–8 glasses a day) their brains shrink.	38	56	52
5. It has been scientifically proven that fatty acid supplements (omega-3 and omega-6) have a positive effect on academic achievement.	127	3	16
7. We only use 10% of our brain.	55	75	16
9. Differences in hemispheric dominance (left brain, right brain) can help to explain individual differences amongst learners.	140	2	4
10. The brains of boys and girls develop at the same rate.	46	74	26
11. Brain development has finished by the time children reach secondary school.	5	121	20
12. There are critical periods in childhood after which certain things can no longer be learned.	118	14	14
15. Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic).	100	-	-
19. Mental capacity is hereditary and cannot be changed by the environment or experience.	8	131	7
21. Environments that are rich in stimulus improve the brains of pre-school children.	128	6	12
22. Children are less attentive after consuming sugary drinks and/or snacks.	75	19	52
25. Exercises that rehearse co-ordination of motor-perception skills can improve literacy skills.	134	5	7
28. Learning problems associated with developmental differences in brain function cannot be remediated by education.	29	94	23
30. Short bouts of co-ordination exercises can improve integration of left and right hemispheric brain function.	135	2	9
32. When we sleep, the brain shuts down.	12	125	9
33. The use of a smartphone reduces our focus time.	127	1	18
34. Using technology while doing a job we love reduces our threshold level against boredom.	63	37	46

Table 2. Continued

Findings of the Neuromyths in the 'Data Collection for Educational Neuroscience'	True	False	Unknown
	f	f	f
36. Computer use negatively affects our intelligence.	33	88	25
38. The use of smartphones and social media reduces our face-to-face communication.	131	7	8
39. The use of technology prevents human creativity.	66	78	2
40. Playing intelligence on the computer improves our intelligence.	77	35	34

According to Table 2, item 15 ('Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic).') was answered by all biology teachers wrong, and they might carry a neuromyth about learning styles. This finding shows that 146 teachers in the study group considered the wrong information as accurate knowledge. In Table 2, neuromyth item 9 ('Differences in hemispheric dominance (left brain, right brain) can help to explain individual differences amongst learners.') was correctly stated by 140 teachers, neuromyth item 30 ('Short bouts of co-ordination exercises can improve integration of left and right hemispheric brain function.') was correctly stated by 135 teachers, neuromyth item 25 ('Exercises that rehearse co-ordination of motor-perception skills can improve literacy skills.') was correctly stated 134 teachers and neuromyth item 38 ('The use of smartphones and social media reduces our face-to-face communication.') was correctly stated by 131 teachers, neuromyth item 33 ('The use of a smartphone reduces our focus time.') was correctly stated by 127 teachers, neuromyth item 21 ('Environments that are rich in stimulus improve the brains of pre-school children.') was correctly stated by 128 teachers, neuromyth item 5 ('It has been scientifically proven that fatty acid supplements (omega-3 and omega-6) have a positive effect on academic achievement.') was correctly stated by 127 teachers, neuromyth item 12 'There are critical periods in childhood after which certain things can no longer be learned.' was correctly stated by 118 teachers. The remaining items were correctly stated by 100 or fewer teachers.

9 of the 22 neuromyth items in the 'Data Collection for Educational Neuroscience', is given in Table 2, were stated correctly by most teachers. This finding shows that most of the 146 teachers in the study group have accurate information about 9 neuromyths items. The number of teachers who answered the remaining 13 neuromyths items correctly was low. This finding shows that (1) most of the teachers in the study group misunderstood 13 neuromyths items, (2) considerably less numbers of teachers possess these neuromyths, and (3) they mostly responded accurately to the items.

Table 3. Spearman Correlation Relationship

			Toplam madde
Spearman's rho	Article 4	Correlation coefficient	0,45
		Sig. (2-tailed)	0,00
		N	146
	Article 6	Correlation coefficient	0,42
		Sig. (2-tailed)	0,00
		N	146
	Article 34	Correlation coefficient	0,55
		Sig. (2-tailed)	0,00
		N	146
	Article 35	Correlation coefficient	0,55
		Sig. (2-tailed)	0,00
		N	146
	Article 41	Correlation coefficient	0,46
		Sig. (2-tailed)	0,00
		N	146

In Table 3, the relationship between each item score and total item score is examined by Spearman Correlation coefficient. Item 4 'If pupils do not drink sufficient amounts of water (6–8 glasses a day) their brains shrink.' and a moderate correlation was found between r = 0.45 and total substance score. There is also a moderate relationship between the item 6 and the total item score (r = 0,42). Likewise, Article 34 'Using technology while doing a job we love reduces our threshold level against boredom' r = 0.55, Article 35 'Using technology while doing something we don't like reduces our threshold level against boredom'and article 41 'Frequent use of the computer contributes to the cognitive functions of older individuals', the correct item r = 0.46.

The 5 items given in Table 3 are indicative of a total of 41 items. Items with no relationship or a weak relationship were not included. In the scoring of the items, 2 points were given to the right, 1 point to the wrong and 0 points to the I do not know. The total score of a person who makes all the questions correctly is 60.

Conclusion, Discussion and Suggestions

The results of the study revealed that biology teachers' existing knowledge about the nervous system is incomplete or inaccurate. This could lead to new neuromyths by introducing false information around it. It is a real concern to observe teachers with such false information might lead to misinformation transfer to school children, as well. These results, similar to existing research findings, confirm the previously expressed concerns about the proliferation of neurons in the field of education (Goswami, 2006; OECD, 2002). Pasquinelli (2012) stated in his study that the formation of new neuromyths begins with widespread misunderstandings about brain mechanisms. In the same way, he stated that new neuromyths are formed and multiplied by people distorting scientific facts, making unnecessary simplifications of scientific results and misinterpreting them. Parallel to the results of the study, Karakuş (2013) found that teachers had limited knowledge about the brain and generally had neuromyths in their master thesis. Karakuş (2013) 's work also supports this research.

The findings of the second problem of the research revealed that the teachers have nine neuromyths, which can disseminate the neuromyths to their students. Similarly, many survey results (Dekker et al., 2012; Howard-Jones, 2014; Abdelkrim, Alami, Abdelaziz, & Souirti, 2020) indicated the prevalence of similar neuromyths among teachers in different countries such as United Kingdom, the Netherlands, Turkey, Greece and China. Dekker et al. (2012) in his study stated 'we use only 10% of our brain' neuromyth not only neuromyth but also affect the teaching process in schools.

When the findings of the study were examined, it was found that 5 items, 3 of which were the correct item and 2 of which were neuromyths, were the determinants of 41 items.

Item 15 ('Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic)') has been checked wrong by all of the 146 biology teachers in the study group. This demonstrates that this neuromyth has rapidly been disseminated and may have serious consequences.

Howard-Jones et al. (2009) determined the protective effect of knowledge on neuromyths in a sample of teacher candidates. Dekker et al. (2012) also showed that belief in neuromyths positively correlated with general information about the brain. The findings of this study support the results of existing literature.

The fact that educational neuroscience is an emerging field. The lack of research in the field of biology education is considered to be an important study since it will provide guidance to relevant researchers and educators. In this context, some key suggestions for researchers are presented below:

- Trainers should be trained on educational neuroscience practices. Thus, it is thought that it will benefit from a more scientific understanding of the processes related to the data to be obtained from the researches related to learning.

- The trainings given in this area may be given by relevant field experts and researches including larger teacher candidates may be suggested.
- In the field of educational neuroscience, quantitative research methods can be suggested to inquire more in-depth analysis supported by qualitative research methods.
- For future research, emphasis should be placed on examining the interventions to improve teacher competence in understanding the misconceptions of teachers (such as books, colleagues) and the functioning of the brain. It is thought that this could provide valuable information for the prevention of future neuromyths and the development of valid educational innovations.
- In teacher training programs, it will be useful to conduct studies to raise teacher awareness on these issues and to make them part of their education on the basis of the formation and prevalence of educational neuromyths.

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Appendix 1. First Part of Data Collection for Educational Neuroscience

First Part of Data Collection for Educational Neuroscience	Answer
Age	
Gender	Woman
	Man
Graduation Status	Other
	Education Institute
	Faculty of Education
	Faculty of Arts and Sciences
Occupational Experience	1 - 5 years
	5 - 10 years
	10 - 15 years
	15 - 20 years
	Over 20 years
Living City	
Do you read science journals?	Once a month
	Once a week
	Once every three months
	Once a year
	No
Have you taken any courses on educational neuroscience or did you attend a workshop?	No
	Yes

Appendix 2. Second Part of Data Collection for Educational Neuroscience

Second Part of Data Collection for Educational Neuroscience	Answer
We use our brains 24 h a day.	True
Children must acquire their native language before a second language is learned. If they do not do so neither language will be fully acquired.	False
Boys have bigger brains than girls.	True
If pupils do not drink sufficient amounts of water (6-8 glasses a day) their brains shrink.	False
It has been scientifically proven that fatty acid supplements (omega-3 and omega-6) have a positive effect on academic achievement.	False
When a brain region is damaged, other parts of the brain can take up its function.	True
We only use 10% of our brain.	False
The left and right hemispheres of the brain always work together.	True
Differences in hemispheric dominance (left brain, right brain) can help to explain individual differences amongst learners.	False
The brains of boys and girls develop at the same rate.	False
Brain development has finished by the time children reach secondary school.	False
There are critical periods in childhood after which certain things can no longer be learned.	False
Information is stored in the brain in a network of cells distributed throughout the brain.	True
Learning is not due to the addition of new cells to the brain.	True
Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic).	False
Learning occurs through modification of the brains' neural connections.	True
Academic achievement can be affected by skipping breakfast.	True
Normal development of the human brain involves the birth and death of brain cells.	True
Mental capacity is hereditary and cannot be changed by the environment or experience.	False
Vigorous exercise can improve mental function.	True
Environments that are rich in stimulus improve the brains of pre-school children.	False
Children are less attentive after consuming sugary drinks and/or snacks.	False
Circadian rhythms ("body-clock") shift during adolescence, causing pupils to be tired during the first lessons of the school day.	True
Regular drinking of caffeinated drinks reduces alertness.	True
Exercises that rehearse co-ordination of motor-perception skills can improve literacy skills.	False
Extended rehearsal of some mental processes can change the shape and structure of some parts of the brain.	True
Individual learners show preferences for the mode in which they receive information.	True
Learning problems associated with developmental differences in brain function cannot be remediated by education.	False
Production of new connections in the brain can continue into old age.	True
Short bouts of co-ordination exercises can improve integration of left and right hemispheric brain function.	False
There are sensitive periods in childhood when it's easier to learn things.	True
When we sleep, the brain shuts down.	False
The use of a smartphone reduces our focus time.	False
Using technology while doing a job we love reduces our threshold level against boredom.	False
Using technology while doing something we don't like reduces our threshold level against boredom.	True
Computer use negatively affects our intelligence.	False
As the technology in our environment changes, our brain adapts to the appropriate skills.	True
The use of smartphones and social media reduces our face-to-face communication.	False
The use of technology prevents human creativity.	False
Playing intelligence on the computer improves our intelligence.	False
Frequent use of the computer contributes to the cognitive functions of older individuals.	True