TRENDS AND PERSPECTIVES IN EDUCATIONAL NEUROSCIENCE STUDIES

Duygu Yayla
Necmettin Erbakan University, Türkiye
E-mail: dygyyl@gmail.com

Muhittin Çalışkan
Ankara Music and Fine Arts University, Türkiye
E-mail: muhittin.caliskan@mgu.edu.tr

Abstract

Recent advances in educational neuroscience research underscore the need for a comprehensive analysis of articles in this field; such scrutiny can elucidate the practical implications of neuroscience findings in education and illuminate future research directions. The purpose of this study was to conduct a descriptive content analysis of articles published in the field of educational neuroscience. The data collected through the Educational Neuroscience Articles Classification Form were analyzed via content analysis. The diversity of research in the field of educational neuroscience and the growth in the number of studies in recent years demonstrate that this discipline represents a comprehensive and potentially effective field. In addition, developing concrete suggestions for practice strengthens the integration of educational neuroscience into educational practices. Furthermore, future research needs to focus more on converting theoretical knowledge into practical applications and assessing the impact of these applications. Moreover, increasing interdisciplinary cooperations is crucial for educational neuroscience to realize its full potential. Finally, further studies conducted through mixed methods and qualitative research methods provide a more comprehensive and in-depth understanding of educational neuroscience. On the other hand, the following recommendations have been made based on these insights: applied research studies can be conducted to directly integrate neuroscientific findings into educational practices. In addition, cooperation among educational scientists, neuroscientists, and researchers in the field of psychology can make the integration of neuroscientific findings into educational practices more efficient. Last but not least, research conducted through qualitative and mixed methods provides a more comprehensive and in-depth understanding of educational neuroscience.
Keywords: *educational neuroscience, educational neuroscience studies, content analysis*

Introduction

Until Aristotle, knowledge could be used freely without sharp boundaries. With Aristotle's reductionism, interdisciplinary boundaries began to emerge (Flogie et al., 2015). Driven by reductionism, disciplines such as psychology, sociology, and philosophy, which contribute to learning and teaching practices, have historically been studied as distinct fields. However, humans are biological, psychological, and social beings. In order to address human learning, the human being must be evaluated in "all" its aspects. In this way, education can achieve a holistic perspective. One discipline that helps foster such a perspective in education is neuroscience.

Neuroscience has influenced several disciplines, with education being undoubtedly one of them. This is due to the fact that brain imaging studies enable us to observe the regions of the brain that are active during the learning process (Kaygısız, 2022). Imaging studies have provided new findings on how human beings learn. Ravet and Williams (2017) have believed that these findings hold importance as they have allowed for the development of new educational programs

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and learning approaches. By sharing neuroscience findings with educators, it becomes easier to view individuals as a whole, taking into account traits such as their motivation, emotional states, conceptual understanding, and problem-solving skills (Koyuncu, 2017). The bridge that conveys the findings of neuroscience to educators is educational neuroscience. Educational neuroscience seeks to translate findings from neuroscience research into educational practice. In doing so, it focuses on integrating theories from cognitive psychology, neuroscience, education, and even language theories (Kweldju, 2019). While neuroscience shows where to look in the brain, which neural functions have problems, and/or how they work, educational neuroscience serves as a bridge in transforming this information into interventions in the light of pedagogical principles (Howard-Jones et al., 2016).

Articles are one of the means of disseminating educational neuroscience studies to educators. Examining educational neuroscience articles is a critical step in understanding the impact of neuroscience on educational practice. This is because articles connect neuroscientific research with educators, contributing to the development of a deeper understanding of learning processes. There are numerous studies in the literature that focus on what educational neuroscience is (Bruer, 2016; De Corte, 2018; Dubinsky et al., 2022; Dündar-Coecke, 2021; Jamaludin et al., 2019; Pincham et al., 2014; Rueda, 2020; Tolmie, 2015; Vaninsky, 2017). There are also studies that comprehensively handle what neuromyths are, aiming to measure their prevalence in education and include suggestions/measures (Ferrero et al., 2016; Geake, 2008; Herwegen et al., 2022; Krammer et al., 2021; Pasquinelli, 2012; Sullivan et al., 2021). Studies also exist investigating how to use the neuroimaging techniques used to measure brain activity and cognitive processes in the context of education (Barreto & Soltanlou, 2022; Dan & Reiner, 2017; Plerou & Vlamos, 2016; Sohn et al., 2004). Research addressing and discussing the ethical issues regarding the use of neuroscience in education has also been published (Hardiman et al., 2012; Howard-Jones & Fenton, 2012; Lalancette & Campbell, 2012; Zocchi & Pollack, 2013).

An array of studies is present that address the question of "Can using neuroscience data in education contribute to educational programs?" (Abdillah, 2018; Kitchen, 2020; Watagodakumbura, 2017). Additionally, research exists that develops suggestions and methodologies for the field of educational neuroscience (Fathiazar et al., 2020; Leisman, 2022; Nowinski, 2021). In the field of educational neuroscience, topics such as the effect of music on learning and brain development, mathematics learning, language learning, and motivation have also been investigated (Berteletti et al., 2022; Düvel et al., 2017; Luria et al., 2021; Procopio et al., 2022; Ruiz-Mejias et al., 2021; Velez & Holguin, 2021; Ventura-Campos et al., 2022; Zhang, 2018). Furthermore, research has been conducted to develop educational programs, methods, techniques, and strategies for learning difficulties such as dyslexia and dyscalculia, and accurately redefine these difficulties using brain imaging data (Anderson et al., 2020; Bedard et al., 2016; Dresler et al., 2018).

Various articles have been published in the field of educational neuroscience and this field has especially been the focus of researchers' attention over the past decade. Therefore, examining educational neuroscience articles could hold additional merit. This endeavor can reveal the potential for using neuroscience findings in education. Moreover, it can help researchers understand current trends and explore future research topics in the field of educational neuroscience. For these reasons, this study sets out to conduct a content analysis of educational neuroscience articles. Content analysis reveals the similarities and differences between studies and the relationships between research dimensions, thereby providing a framework for the discipline in question (Çalık & Sözbilir, 2014).

This study represents an important step in understanding the applicability and impact of neuroscientific findings in education. Integrating neuroscientific findings into education allows for a deeper comprehension of learning processes and the shaping of educational practices based on this new knowledge. Neuroscientific research enables a more comprehensive assessment

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of individual attributes such as motivation, emotional states, conceptual understanding, and problem-solving skills, thereby fostering a holistic perspective in education. In this context, a content analysis of educational neuroscience articles provides significant insights into current trends in the field, explores future research topics, and reveals the potential applications of neuroscientific findings in education. Therefore, this study offers a valuable foundation for determining the impact of neuroscientific findings on education and understanding the direction of research in this domain.

The aim of the present study was to conduct a descriptive content analysis of articles published in the field of educational neuroscience. To address this aim, the following research questions were probed.

1. What is the distribution of the articles based on their publication years?
2. What is the distribution of the articles based on their topics?
3. What is the distribution of the articles based on their research methods?
4. What is the distribution of the articles based on their subject areas?
5. What suggestions are provided by the educational neuroscience articles?

Research Methodology

General Background

In the present study, descriptive content analysis was utilized. Descriptive content analysis involves classifying independently conducted studies, evaluating and synthesizing their trends and research findings, and systematically and holistically addressing the studies (Çalık & Sözbilir, 2014). This study adopted descriptive content analysis to reveal the general trends of articles published in the field of educational neuroscience up to December 31, 2022, and provide insights for future studies on this subject.

Sample

The population of the research consisted of all full-text accessible articles on educational neuroscience available in the Web of Science, Wiley Online Library, Taylor and Francis, Science Direct, SAGE Journal, Scopus, EBSCO, ERIC, PubMed, JSTOR, Directory of Open Access Journals (DOAJ), and Google Scholar databases. As a result of searches conducted with relevant keywords in these databases, all accessible full-text articles were analyzed individually and comprehensively, thus achieving a complete count. A complete count is considered to be achieved when all elements in the population are accessed, thoroughly examined, and analyzed to obtain the data (Arastaman, 2020, p. 177).

To access the articles, the keywords "educational neuroscience", "neuroeducation", and "mind, brain and education" were used. Filters were applied to search for the keywords in the "title", "abstract", and "keywords" sections, with the research type set to "articles" and the language to "English". This approach served to reduce the likelihood of accessing irrelevant studies by restricting the search to specific sections rather than the full text (Ültay et al., 2021). No start date was set for the search period, with the end date fixed on December 31, 2022. According to Çalık and Sözbilir (2014), when using descriptive content analysis, it is necessary to include studies from an extensive time frame to identify the overall trend on the topic in question. In this study, a complete count of all-time research was undertaken to ensure breadth rather than depth, thereby aiming to discern the general trend. To avoid potential losses and verify the obtained studies, the search process was repeated at regular intervals until December 31, 2023, resulting in the identification of 394 articles. During the preliminary reading, 78 articles were found to be unrelated to education and were thus excluded from the study. The remaining 316 articles were included in the analysis.

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Instrument and Procedures

Research data were collected through the "Educational Neuroscience Articles Classification Form". This form was developed by the researcher by taking into account the content analysis research in the literature (Çalışkan & Serçe, 2018; Durmuş & Çalışkan, 2022; Taşkıner-Şereflioğlu & Kılıç-Mocan, 2021) in order to ensure content validity. The draft form was sent to a faculty member experienced in content analysis to obtain expert feedback. Based on the feedback received, the form was revised and finalized. The final version of the Educational Neuroscience Articles Classification Form was made of six sections as; descriptive information about the identity of the article, publication year, topic, method, subject area and suggestions they presented.

Data Analysis

In this study, the data collected using the "Educational Neuroscience Articles Classification Form" were analyzed through content analysis. Categories for content analysis were generated at the beginning of the study in accordance with the research questions. The units of analysis were placed under the relevant category, and their frequencies were provided. A pilot study was conducted on a subset of ten randomly selected articles to ensure accuracy and consistency in coding the data. The selected studies were coded independently by the authors. The coding performed was compared, and efforts were made to reach a consensus. Thus, any potential errors in the coding process were addressed proactively. During the coding process, the first author's coding was periodically reviewed by the second author, identifying any deficiencies and necessary modifications. This process continued until a final decision was reached on the coding.

Research Results

Publication Years of the Articles

The distribution of the articles based on their publication years is presented in Table 1.

Table 1
The Distribution of the Articles Based on Year of Publication

Year	f	Year	f
1997	1	2014	11
1998	1	2015	21
2006	2	2016	19
2007	5	2017	21
2008	10	2018	22
2009	7	2019	29
2010	6	2020	24
2011	26	2021	31
2012	19	2022	40
2013	21		

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The inaugural publication in educational neuroscience was Bruer's article titled "Education and the Brain: A Bridge Too Far" in 1997. From 1997 to 2010, 2008 recorded the highest number of published articles. A notable increase in articles was observed in 2011 compared to previous years. However, the number of articles published in 2014 declined compared to the previous three years. After 2015, the publication count began to rise again, averaging 22 articles per year from 2015 to 2020. The substantial increase in articles in 2021 and 2022 is particularly noteworthy. This trend indicates that educational neuroscience has gained significant interest from researchers, and the number of articles published in this field has increased in recent years.

Topics of the Articles

The distribution of the articles based on their thematic focus is shown in Table 2.

Table 2
The Distribution of the Articles Based on Their Topics

Topic	f
Defining and introducing educational neuroscience	44
Neuroscience and interdisciplinary relations in education	35
Applying neuroscience findings to education	32
Investigating brain activity in the learning process using imaging methods	31
Effects of neuroscience on learning	30
Neuromyths	21
Teachers' level of neuroscience awareness and teacher education	18
Neuroscience and cognitive and affective development	17
Project, model proposal	13
Neuroscience findings and program development in education	13
Neuroscience-based technological innovations and education	12
The relationship between neuroscience, ethics, and philosophy	10
Designing educational games according to the principles of neuroscience	6
Neuroscience-based course design	4
Other	30

The topics covered in educational neuroscience articles are quite diverse. The most frequently addressed topic is defining and introducing educational neuroscience. Following this are topics such as interdisciplinary relationships between neuroscience and education, the application of neuroscience findings to education, studying brain activities during the learning process using imaging methods, and the effects of neuroscience on learning, respectively. Other thematic foci in the articles include neuromyths, the level of neuroscience awareness among teachers and teacher training, as well as neuroscience and cognitive and affective development. There are also studies on project and model proposals, neuroscience findings and educational program development, neuroscience-based technological innovations, the relationship between education, neuroscience, ethics, and philosophy, designing educational games based on neuroscience principles, and neuroscience-based lesson design. It can be concluded that educational neuroscience articles focus on defining and introducing the field, highlighting the importance of interdisciplinary relationships for a holistic perspective in education, translating

findings from brain imaging studies into learning and teaching practices, and assessing the prevalence of neuromyths in education while offering recommendations and measures.

Research Methods of the Articles

The distribution of the articles based on their research methods is displayed in Table 3.

Table 3
The Distribution of the Articles Based on Their Research Methods

Research Methods	f
Unspecified	141
Literature review	76
Quantitative	61
Mixed	21
Qualitative	17

Out of the 316 articles analyzed, 141 did not specify a research method. 76 of the articles were literature reviews. Among the remaining articles, quantitative methods were the most commonly used, followed by mixed methods and qualitative methods. Qualitative methods were the least preferred research paradigm in the articles.

Subject Areas of the Articles

The distribution of the articles based on their subject areas is demonstrated in Table 4.

Table 4
The Distribution of the Articles Based on Their Subject Areas

Subject Area	f
Educational Sciences (Education – Teaching – Learning)	229
Mathematics Education	28
Teacher Training	18
Special Education	10
Language Education	9
Education Programs	7
Instructional Technologies	6
Other (STEM/ Science Education/ Physical Education/Philosophy of Education)	4
Music Education	3
Assessment and Evaluation	1
Lifelong Learning	1

Educational neuroscience articles primarily focus on the areas of education, teaching, and learning. Additionally, specific subjects such as mathematics education, teacher training, and special education also hold a significant share. Other notable areas include language education, educational programs, and instructional technologies. This diversity highlights the broad scope and potential impact of educational neuroscience research.

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Suggestions of the Articles

The distribution of the suggestions presented in the articles is shown in Table 5.

Table 5
The Distribution of the Articles Based on the Suggestions They Presented

Suggestions	*f*
No suggestion	176
Recommendations on research methods and design	44
Neuroscience training for teachers	26
Examining learning-teaching methods and evaluating their effects	20
Conducting research that will contribute to the understanding of learning with imaging methods	20
Adopting a neuroscience-based interdisciplinary approach in education and strengthening interdisciplinary cooperation	16
Developing neuroscience-based and technology-supported educational games	16
Investigating the impact of neuroscience on learning	12
Increasing cooperation in the fields of education and neuroscience	12
Conducting in-depth research in educational neuroscience	8
Taking steps to debunk neuromyths	8
In-depth study of the brain and learning processes	7
Building a bridge between laboratory and classroom practices	7
Strengthening educational neuroscience through empirical research	6
Translating neuroscience data into a language that teachers can understand	5
Development and evaluation of neuroscience-based educational programs	4
Examining the ethical aspect of neuroscience interventions	3

The most striking finding in Table 5 is that no suggestions were presented in 176 out of the 316 articles analyzed. The most frequently presented suggestions in educational neuroscience articles pertain to the methods and designs of future research. Longitudinal studies with larger samples and control groups can be given as examples of this suggestion. These suggestions highlight the methodological and design aspects that should be considered to ensure that educational neuroscience research is based on a stronger and more robust foundation. Neuroscience education for teachers, including neuroscience literacy training for teachers and teacher candidates, and the addition of neuroscience courses in teacher education programs, is the second most common suggestion. These suggestions aim to enhance teachers' knowledge and skills in neuroscience, help them develop more effective teaching strategies in the classroom, and support students' learning processes. The third most frequently presented suggestion is the investigation of teaching and learning methods and the evaluation of their effects. Examples of this suggestion include researching the relationship between spatial factors in visual neuroscience and the learning process and exploring the link between brain-friendly teaching and language skills. These suggestions emphasize important practical applications. Another suggestion is to conduct research that will contribute to the understanding of learning with imaging methods. Examples of this suggestion include conducting research on the neural

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correlates of problem-solving and examining the brain's responses to mathematical activities. These suggestions are aimed at gaining a deeper understanding of how learning processes take place and how they can be improved using different brain imaging techniques and other neuroscientific tools. Adopting a neuroscience-based interdisciplinary approach to education and strengthening interdisciplinary collaboration was also recommended. Focusing on building a bridge between education and neuroscience and ensuring interdisciplinary content integration are examples of this suggestion. These suggestions focus on adopting a neuroscience-based interdisciplinary approach to education and strengthening interdisciplinary collaboration. The suggestions also include the development of neuroscience-based and technology-supported educational games. Research is recommended to ensure the effective integration of educational games, neuroscience-based learning principles, and technology.

Although other suggestions appear less frequently, each highlights important aspects of the various dimensions within the field of educational neuroscience. These suggestions draw attention to the need for a broader and more in-depth examination of educational neuroscience. As a result, the educational neuroscience articles provide suggestions for future research topics, while suggestions for practice are not adequate.

Discussion

The main purpose of this study was to conduct a descriptive content analysis of the articles published in the field of educational neuroscience. The data collected with the "Educational Neuroscience Articles Classification Form" were analyzed utilizing descriptive content analysis. To sum up, the following major findings were reached in the study. First, the field of educational neuroscience has been a field that attracts the attention of researchers. The number of articles on this subject has started to increase in recent years. The increase observed in 2021 and 2022 is particularly noteworthy. On top of this, educational neuroscience articles mostly focused on defining and introducing educational neuroscience. In addition, various topics, such as emphasizing the importance of interdisciplinary relations, translating the findings of brain imaging studies into learning and teaching practices, measuring the prevalence of neuromyths in education, and providing suggestions/measures, were also addressed. Quantitative methods were the most commonly used research paradigm in the articles, followed by mixed methods and qualitative methods. Qualitative methods were the least frequently employed. Educational neuroscience articles were primarily concentrated on topics related to education, teaching, and learning. Additionally, specific subject areas such as mathematics education, teacher training, and special education were also prominently featured. Other notable subject areas included language education, educational programs, and instructional technologies. Generally, educational neuroscience articles offered suggestions for future research topics but fell short on practical application suggestions.

The scrutiny into the distribution of articles by publication year revealed a significant increase in educational neuroscience articles, particularly in the last decade. This trend indicates that research at the intersection of neuroscience and education is gaining increasing interest and that academic contributions to this field are growing. The notable rise in the number of articles in 2021 and 2022 highlights that educational neuroscience is a current and dynamic field of research. This increase can be viewed as an indicator of the belief in the applicability of neuroscientific findings in education and the technological advancements in this field (Ravet & Williams, 2017).

The distribution of educational neuroscience articles by topic is quite diverse, and this diversity shows that the discipline represents a wide range of research areas. The greatest focus was on defining and introducing educational neuroscience. This emphasizes the importance of research aimed at understanding the basic principles and application areas of the discipline (Bruer,

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2016). Another significant theme was the interdisciplinary relationship between neuroscience and education. This is a critical area for understanding how neuroscience findings can be integrated into educational practices and how educational processes can be optimized (Howard-Jones et al., 2016). Moreover, the study of brain activity during the learning process using imaging methods is also of great importance. This kind of research provides us with important insights into the biological basis of the learning process and how we can apply this knowledge to educational practice (Kaygısız, 2022). The study of neuromyths helps us understand how misconceptions and myths in education can be addressed based on neuroscientific foundations. This is important for raising teachers' level of neuroscience awareness and developing more effective teaching strategies (Koyuncu, 2017). The focus of educational neuroscience articles on a variety of topics provides a broad coverage of the discipline. This contributes to making improvements in various areas of education and managing learning processes more effectively. However, further broadening and deepening this diversity is essential to fully unlock the discipline's potential.

The examination of the research methods in the articles revealed that, notably, many of them did not specify a research method. This is due to the theoretical or interpretative nature of some of the articles. Literature reviews and quantitative studies stood out among the articles conducted with a specific method. The prevalence of quantitative research may result from the importance of objective and measurable data in educational neuroscience. However, considering the scarcity of qualitative studies, it can be suggested that there is a need for more in-depth and contextual investigations in this field.

When the subject areas of the articles were examined, it was discovered that educational neuroscience articles mostly focused on education, teaching, and learning. This could be due to the importance attached to integrating neuroscientific findings into education and training processes. Education, teaching, and learning are the areas directly influenced by educational neuroscience and where its applications are most prevalent (Howard-Jones et al., 2016). In addition, specific subject areas such as mathematics education, teacher training, and special education also occupy a significant position in educational neuroscience research. Research in these areas aims to improve educational practices and increase student achievement by focusing on these issues (Bruer, 2016). Among other important subject areas were language education, educational programs, and instructional technologies. This diversity demonstrates the broad scope and potential impact of educational neuroscience research.

When the suggestions presented by the articles were analyzed, 176 of the 316 articles did not present any suggestions. This finding can be explained by the fact that the articles were mostly review articles that dealt with defining and introducing neuroscience. The most prevalent suggestion in the educational neuroscience articles concerned the methods and designs of future research. This finding can be interpreted as researchers' demand for methodological innovations to reach more robust and valid results in educational neuroscience studies. Neuroscience literacy training for teachers was the second most common suggestion. This finding can be interpreted as a strong emphasis in the articles on the need to train teachers to integrate neuroscientific knowledge into classroom practice. According to Bruer (2016), increasing teachers' knowledge and skills in neuroscience would help them develop more effective teaching strategies. The third most common suggestion was to research teaching-learning methods and evaluate their effects. This specific finding reveals that theoretical knowledge in educational neuroscience should be transformed into practical applications, and the effects of these applications should be analyzed. Conducting research that will contribute to the understanding of learning with imaging methods was another suggestion presented in the articles. This finding emphasizes the importance of research that will be conducted utilizing brain imaging techniques. This is because the use of brain imaging techniques in educational research will make neuroscientific data more directly applicable to learning processes. The suggestions to adopt

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a neuroscience-based interdisciplinary approach in education and to strengthen collaboration were also included in the articles. This finding draws attention to the importance of integrating educational neuroscience studies into different disciplines. Among the other suggestions was the development of neuroscience-based and technology-supported educational games. This finding can be interpreted as drawing attention to the need for using technology in education in creative and interactive ways. While the other suggestions occurred less frequently, each underscores significant aspects and dimensions within the field of educational neuroscience. For example, suggestions such as investigating the effect of neuroscience on learning, increasing cooperation in the fields of education and neuroscience, conducting in-depth research, and taking steps to debunk neuromyths emphasize the need for a broad and in-depth examination of the field. To summarize, it can be inferred that educational neuroscience articles suggest topics for future investigation, but suggestions for practice are lacking. This shortcoming reveals the necessity of developing practical suggestions. The lack of practical suggestions emerges as an aspect that needs to be emphasized more in future research. At this point, it can be said that it is important to evaluate the potential of educational neuroscience research to provide more suggestions and to integrate it more effectively into educational practice.

Conclusions and Implications

The present study has established several key conclusions regarding the field of educational neuroscience. It has been confirmed that the diversity and increasing number of research studies indicate that this discipline is both comprehensive and potentially influential. Furthermore, it has been found that developing concrete suggestions for practice will enhance the integration of educational neuroscience into educational practices. The study has also established that future research should focus more on converting theoretical knowledge into practical applications and evaluating the impact of these applications. Additionally, it has been verified that increasing interdisciplinary collaborations is crucial for educational neuroscience to realize its full potential. Finally, it has been demonstrated that conducting research with mixed methods and qualitative approaches will provide a more thorough and in-depth understanding of the field.

Future research should focus on conducting applied studies that directly integrate neuroscientific findings into educational practices. These studies should include concrete suggestions on how teachers can use neuroscientific knowledge in classroom settings. Additionally, to unlock the full potential of educational neuroscience, it is crucial to increase interdisciplinary collaboration. Future research involving collaboration between educational scientists, neuroscientists, and psychologists can enhance the efficiency of integrating neuroscientific findings into educational practices and increase the applicability of such research. Lastly, research utilizing qualitative and mixed methods should be conducted to provide a more thorough and profound understanding of educational neuroscience.

Note

Declaration of Interest

The authors declare no competing interest.

References

Abdillah, F. (2018). Demystify civic education through the educational neuroscience on Indonesia curriculum. *Advances in Social Science, Education and Humanities Research*, *251*, 76–78. https://doi.org/10.2991/acec-18.2018.18

Anderson, A., Sarlo, G. L., Pearlstein, H., & McGrath, L. M. (2020). A review of online dyslexia learning modules. *Frontiers in Education, 5*, 1–13. https://doi.org/10.3389/feduc.2020.00118

Arastaman, G. (2020). Evren ve örneklem [Population and sample]. In N. Cemaloğlu (Ed.), *Bilimsel Araştırma Teknikleri ve Etik* [*Scientific Research Techniques and Ethics*] (pp. 175–188). Pegem.

Barreto, C., & Soltanlou, M. (2022). Functional near-infrared spectroscopy as a tool to assess brain activity in educational settings: An introduction for educational researchers. *South African Journal of Childhood Education, 12*(1), 1–10. https://doi.org./10.4102/sajce.v12i1.1138

Bédard, M., Laplante, L., & Mercier, J. (2016). Development of reading remediation for dyslexic individuals: Added benefits of the joint consideration of neurophysiological and behavioral data. *Zeitschrift für Psychologie, 224*(4), 240–246. https://doi.org/10.1027/2151-2604/a000259

Berteletti, I., Kimbley, S. E., Sullivan, S. J., Quandt, L. C., & Miyakoshi, M. (2022). Different language modalities yet similar cognitive processes in arithmetic fact retrieval. *Brain Sciences, 12*(2), 1–18. https://doi.org/10.3390/brainsci12020145

Bruer, J. T. (2016). Where is educational neuroscience? *Educational Neuroscience, 1*, 1–12. https://doi.org/10.1177/2377616115618036

Çalık, M., & Sözbilir, M. (2014). Parameters of content analysis. *Education and Science, 39*(174), 33–38. https://doi.org/10.15390/EB.2014.3412

Çalışkan, M., & Serçe, H. (2018). Action research articles on Education in Turkey: A content analysis. *Ahi Evran University Journal of Kırşehir Education Faculty, 19*(1), 80–102.

Dan, A., & Reiner, M. (2017). Real time EEG based measurements of cognitive load indicate mental states during learning. *Journal of Educational Data Mining, 9*(2), 31–44. https://doi.org/10.5281/zenodo.3554719

De Corte, E. (2018). Educational sciences: A crossroad for dialogue among disciplines. *European Review*, *26*(2), 262–271. https://doi.org/10.1017/S1062798717000655

Dresler, T., Bugden, S., Gouet, C., Lallier, M., Oliveira, D. G., Pinheiro-Chagas, P., Pires, A. C., Wang, Y., Zugarramurdi, C., & Weissheimer, J. (2018). A translational framework of educational neuroscience in learning disorders. *Frontiers Integrative Neuroscience, 12*, 1–12. https://doi.org/10.3389/fnint.2018.00025

Dubinsky, J. M., Roehrig, G., & Varma, S. (2022). A place for neuroscience in teacher knowledge and education. *Mind, Brain, and Education, 16*(4), 267–276. https://doi.org/10.1111/mbe.12334

Durmuş, F. B., & Çalışkan, M. (2022). Çocuklarla felsefe konusunda Türkiye'de yapılmış akademik çalışmaların içerik analizi [A content analysis of academic studies on philosophy with children in Turkey]. *Felsefe Dünyası [The Philosophy World]*, *2*(76), 105–134. https://doi.org/10.58634/felsefedunyasi.1218929

Dündar-Coecke, S. (2021). Future avenues for education and neuroenhancement. *New Ideas in Psychology, 63,* 1–10. https://doi.org/10.1016/j.newideapsych.2021.100875

Düvel, N., Wolf, A., & Kopiez, R. (2017). Neuromyths in music education: Prevalence and predictors of misconceptions among teachers and students. *Frontiers in Psychology, 8*, 1–12. https://doi.org/10.3389/fpsyg.2017.00629

Fathiazar, E., Mani, A., Adib, Y. & Sharifi, Z., (2020). Effectiveness of an educational neuroscience-based curriculum to improve academic achievement of elementary students with mathematics learning disabilities. *Research and Development in Medical Education, 9*, 1–7. https://doi.org/10.34172/rdme.2020.018

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*, 1–11. https://doi.org/10.3389/fnhum.2016.00496

Flogie, A., Dolenc, K., & Aberšek, B. (2015). Transdisciplinarity in education is near. In Lamanauskas, V., Šlekienė, V., & Ragulienė, L. (Eds.), State of the art and future perspectives (1ˢᵗ International Baltic Symposium on Science and Technology Education 2015 (BalticSTE2015), 15–18 June, Siauliai). https://doi.org/10.33225/BalticSTE/2015.45

Geake, J. (2008). Neuromythologies in education. *Educational Research, 50*(2), 123–133. https://doi.org/10.1080/00131880802082518

Hardiman, M., Rinne, L., Gregory, E., & Yarmolinskaya, J. (2012). Neuroethics, neuroeducation, and classroom teaching: Where the brain sciences meet pedagogy. *Neuroethics*, *5*, 135–143. https://doi.org/10.1007/s12152-011-9116-6

Herwegen, J. V., Thomas, M., Marshall, C., & Gordon, R. (2022). Neuromyths about special educational needs: What should teachers know. *Impact, 16*, 1–9.

Howard-Jones, P. A., & Fenton, K. D. (2012). The need for interdisciplinary dialogue in developing ethical approaches to neuroeducational research. *Neuroethics, 5*, 119–134. https://doi.org/10.1007/s12152-011-9101-0

Howard-Jones, P. A., Varma, S., Ansari, D., Butterworth, B., De Smedt, B., Goswami, U., Laurillard, D., & Thomas, M. S. C. (2016). The principles and practices of educational neuroscience: Comment on bowers. *Psychological Review, 123*(5), 620–627. https://doi.org/10.1037/rev0000036

Jamaludin, A., Henik, A., & Hale, J. B. (2019). Educational neuroscience: Bridging theory and practice. *Learning: Research and Practice, 5*(2), 93–98. https://doi.org/10.1080/23735082.2019.1685027

Kaygısız, Ç. (2022). Educational neuroscience: Issues and challenges. *Erciyes Journal of Education*, *6*(1), 1–19. https://doi.org/10.32433/eje.990407

Kitchen, W. H. (2020). Neuroscience and the Northern Ireland curriculum: 2020, and the warning signs remain. *Journal of Curriculum Studies, 53*(4), 516–530. https://doi.org/10.1080/00220272.2020.1779350

Koyuncu, B. (2017). Eğitimsel sinirbilim (Neuroeducation): Eğitimciler neden sinirbilim verilerinden yararlanmalıdır [Neuroeducation: Why educators should employ neuroscience findings?]. *TAY Journal, 1*(1), 22–34.

Krammer, G., Vogel, S. E., & Grabner, R. H. (2021). Believing in neuromyths makes neither a bad nor good student-teacher: The relationship between neuromyths and academic achievement in teacher education. *Mind, Brain, and Education, 15*(1), 54–60. https://doi.org/10.1111/mbe.12266

Kweldju, S. (2019). Educational neuroscience for second language classrooms. *Journal of English Language, Literature, and Teaching, 3*(2)*,* 1–9.

Lalancette, H., & Chambell, S. R. (2012). Educational neuroscience: Neuroethical considerations. *International Journal of Environmental and Science Education, 7(*1), 37–52.

Leisman, G. (2022). Neuroscience in education: A bridge too far or one that has yet to be built: Introduction to the "brain goes to school". *Brain Sciences, 13*(1), 1–5. https://doi.org/10.3390/brainsci13010040

Luria, E., Shalom, M., & Levy, D. A. (2021). Cognitive neuroscience perspectives on motivation and learning: Revisiting self-determination theory. *Mind, Brain, and Education, 15*(1), 5–17. https://doi.org/10.1111/mbe.12275

Nowinski, W. L. (2021). Evolution of human brain atlases in terms of content, applications, functionality, and availability. *Neuroinformatics*, *19*, 1–22. https://doi.org/10.1007/s12021-020-09481-9

Pasquinelli, E. (2012). Neuromyths: Why do they exist and persist? *Mind, Brain, and Education, 6*(2), 89–96. https://doi.org/10.1111/j.1751-228X.2012.01141.x

Pincham, H. L., Matejko, A. A., Obersteiner, A., Killikelly, C., Abrahao, K. P., Benavides-Varela, S., Gabriel, F. C., Rato, J. R., & Vuillier, L. (2014). Forging a new path for educational neuroscience: An international young-researcher perspective on combining neuroscience and educational practices. *Trends in Neuroscience and Education, 3*(1), 28–31. https://doi.org/10.1016/j.tine.2014.02.002

Plerou, A., & Vlamos, P. (2016). Insights in EEG versus HEG and RT-FMRI neuro feedback training for cognition enhancement. *International Journal of Artificial Intelligence and Applications, 7*(6), 17–25. https://doi.org/10.5121/ijaia.2016.7602

Procopio, M., Procopio, L. F., Yáñez-Araque, B., & Fernández-Cézar, R. (2022). Cooperative work and neuroeducation in mathematics education of future teachers: A good combination? *Frontiers in Psychology*, *13*, 1–8. https://doi.org/10.3389/fpsyg.2022.1005609

Ravet, J., & Williams, J. H. G. (2017). What we know now: Education, neuroscience and transdisciplinary autism research. *Educational Research, 59*(1), 1–16. https://doi.org/10.1080/00131881.2016.1272429

Rueda C. (2020). Neuroeducation: Teaching with the brain. *Journal of Neuroeducation, 1*(1), 108–113. https://doi.org/10.1344/joned.v1i1.31657

Ruiz-Mejias, M., Pérez N., & Carrió, M. (2021). Knowledge of neuroscience boosts motivation and awareness of learning strategies in science vocational education students. *Journal of Neuroeducation, 1*(2), 30–44. https://doi.org/10.1344/joned.v1i2

Sohn, M. H., Goode, A., Koedinger, K. R., Stenger, V. A., Fissell, K., Carter, C. S., & Anderson, J. R. (2004). Behavioral equivalence, but not neural equivalence–neural evidence of alternative strategies in mathematical thinking. *Nature Neuroscience*, *7*, 1193–1194. https://doi.org/10.1038/nn1337

Sullivan, K. A., Hughes, B., & Gilmore, L. (2021). Measuring educational neuromyths: Lessons for future research. *Mind, Brain, and Education, 15*(3), 232–238. https://doi.org/10.1111/mbe.12294

Taşkıner Şereflioğlu, Y., & Kılıç Mocan, D. (2021). Türkiye'de eğitsel nörobilim (eğitimsel sinirbilim) konusunda yapılmış araştırmaların analizi [Analysis of researches on educational neuroscience in Turkey]. *Türkiye Bilimsel Araştırmalar Dergisi [Turkish Scientific Researches Journal], 6*(2), 468–480.

Tolmie, A. (2015). Neuroscience of education. In Wright JD (Ed.), International Encyclopedia of the Social & Behavioral Sciences (2nd ed., pp. 728–735). Elsevier. https://doi.org/10.1016/B978-0-08-097086-8.56033-4

Ültay, E., Akyurt, H., & Ültay, N. (2021). Sosyal bilimlerde betimsel içerik analizi [Descriptive content analysis in social sciences]. *IBAD Sosyal Bilimler Dergisi [IBAD Journal of Social Sciences], 10*, 188–201. https://doi.org/10.21733/ibad.871703

Vaninsky, A. (2017). Educational neuroscience, educational psychology, and classroom pedagogy as a system. *American Journal of Educational Research, 5*(4), 384–391. https://doi.org/10.12691/education-5-4-6

Vélez, J. C. L., & Holguin, J. S. V. (2021). Educational innovation into English as a foreign language practices for early children: Neuroeducation and the total physical response method. *Education Quarterly Reviews, 4*(3), 377–389. https://doi.org/10.31014/aior.1993.04.03.346

Ventura-Campos, N., Ferrando-Esteve, L., & Epifanio, I. (2022). The underlying neural bases of the reversal error while solving algebraic word problems. *Scientific Reports*, *12*, Article 21654. https://doi.org/10.1038/s41598-022-25442-5

Watagodakumbura, C. (2017). Principles of curriculum design and construction based on the concepts of educational neuroscience. *Journal of Education and Learning, 6*(3), 54–69. https://doi.org/10.5539/jel.v6n3p54

Zhang, Q. (2018). Application of music education in brain cognition. *Educational Sciences: Theory & Practice*, *18*(5), 1960–1967. https://doi.org/10.12738/estp.2018.5.095

Zocchi, M., & Pollack, C. (2013). Educational neuroethics: A contribution from empirical research. *Mind, Brain, and Education, 7*, 56–62. https://doi.org/10.1111/mbe.12008

Appendix 1. Educational Neuroscience Articles Classification Form

1. Descriptive information about the identity of the article:	
2. Publication year:	
3. Topic:	
4. Method	☐ Quantitative ☐ Qualitative ☐ Mixed ☐ Literature review ☐ Not specified

5. Subject area	☐ Educational Sciences ☐ Language Education ☐ Curriculum ☐ Lifelong Learning ☐ Mathematics Education ☐ Music Education ☐ Instructional Technologies ☐ Teacher Education ☐ Assessment and Evaluation ☐ Special Education ☐ Guidance and Counseling ☐ Other: ……
6. Suggestions:	

Duygu Yayla	Institute of Educational Sciences, Necmettin Erbakan University, 42090 Konya, Türkiye. E-mail: dygyyl@gmail.com ORCID: https://orcid.org/0000-0001-8553-3452
Muhittin Çalışkan *(Corresponding author)*	PhD, Professor, Department of Educational Sciences, Faculty of Music and Fine Arts Education, Ankara Music and Fine Arts University, Türkiye. E-mail: muhittin.caliskan@mgu.edu.tr ORCID: https://orcid.org/0000-0002-2341-0710