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Educational Neuroscience and Teachers' Perspectives on Pedagogy: A Critical Review of Pro, Con, and Neutral Perspectives

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ABSTRACT
With the growing interest in neuroscience application to education, neuroscience is now considered as an interdisciplinary approach to understanding the learning processes from the brain science perspective. However, its use in education has been contested because of the dangers of reductionism and neuromyths, and the lack of relevance of neuroscientific findings to classroom practice. The study seeks to critically examine the pro, counter and neutral positions on the integration of neuroscience in education and to identify a more balanced framework for its implementation. This study used a critical literature review method. The research data were obtained from 18 articles selected from 2018 to 2026 obtained from Scopus, Web of Science, and Google Scholar databases. The data were thematically analyzed to categorize arguments into three major perspectives: pro, counter, and neutral. The results suggest that the pro perspective highlights neuroscience as a scientific basis for evidence-based pedagogy whereas the counter perspective highlights risks of biological reductionism, neuromyths and loss of teacher autonomy. Meanwhile, the neutral perspective sees neuroscience as a contextual tool that should be critically integrated with educational theory and sociocultural realities. The scientific contribution of this article is the construction of a critical realist framework that reconciles competing perspectives, and repositions teachers as reflective practitioners mediating between scientific knowledge and pedagogical practice. The study concludes that the inclusion of neuroscience in education requires interdisciplinary, contextual and ethically grounded approaches to avoid simplification and strengthen meaningful learning practices.

1. INTRODUCTION

In the last two decades, the language and practice of education has incorporated a lot more neuroscience. Recent advances in cognitive neuroscience and technologies such as functional Magnetic Resonance Imaging (fMRI) have contributed to a better understanding of the biological mechanisms underlying learning processes. These developments have contributed to the emergence of educational neuroscience, an interdisciplinary field that seeks to bridge neuroscience, cognitive psychology, and pedagogy (Immordino-Yang & Damasio, 2007; Suryadi, 2020). The influence of neuroscience is increasingly felt not only in developed countries but also in educational contexts such as in Indonesia. Concepts like neuroplasticity, executive function, and the role of emotions in learning are increasingly brought into teacher training and instructional practices. Neuroscience is popular in education, and the popularity is closely related to the promise that the quality of learning can be improved by science-based approaches. Programs of brain-based learning have been advertised as new ways to improve student engagement and achievement. Surveys show that many teachers try to use their knowledge of the brain in the instruction process in the classroom (Ansya et al., 2025). The interconnectivity of emotion and cognition and the plasticity of the brain have led educators to view learning from a more holistic perspective. These perspectives indicate that learning capacities are dynamic and can be cultivated through meaningful experiences, interaction and supportive environments. Yet, even with this optimism, the integration of neuroscience into education has been a source of significant controversy. One big concern is the gap between findings

generated in laboratory settings and realities of classroom practice. Neuroscience research is generally performed in controlled environments, while the learning process in the classroom is a complex social, emotional and cultural interaction that cannot be easily reduced to biological explanations (Wijaya, 2018). Thus, there is a risk of oversimplification of the multidimensional nature of educational processes with the direct use of neuroscientific results in pedagogy. Another major concern is the proliferation of "neuromyths" — misinterpretations of neuroscience findings that are widely held among educators. Examples include the idea that people learn best through a certain learning style or that humans only use a small fraction of their brains. Such claims continue to be made though they are scientifically disproved because they are typically simplified and convincing, along with scientific terms (Judijanto et al., 2025). The prevalence of neuromyths suggests that the diffusion of neuroscience in education does not always come with sufficient scientific literacy in practitioners. Other challenges for the implementation of neuroscience-based educational approaches in developing countries such as Indonesia are associated with limited resources and professional capacity. Teachers are often told to use innovative methods even though they have unequal access to training opportunities and professional development support (Prihatin & Sutangsa, 2025). Consequently, the use of neuroscience terminology can be adopted superficially as part of educational trends that do not substantially change classroom practices. This condition increases the chances for educators to apply secondary interpretations that are not always scientifically credible.

Critics also warn of the danger of biological reductionism in educational neuroscience. This perspective can lead to a simplification of learning as a simple function of brain activity, ignoring the broader social, cultural, and ethical aspects of education. Similar critiques suggest that the dominance of neuroscience discourse can undermine teachers' professional autonomy by positioning educators as technical implementers of 'scientific prescriptions' rather than reflective practitioners who can interpret these ideas in context (Leyto & Stentiford, 2025). Furthermore, the commercialization of educational neuroscience has resulted in a proliferation of labels such as "brain-based learning" and "brain-friendly classrooms" as indicators of scientific legitimacy in educational markets, despite the fact that the scientific foundations of these claims are not always subjected to rigorous scrutiny (Ana et al., 2024). But not all views of neuroscience and education are dichotomous. Some researchers promote a more integrative approach in which neuroscience is one of many sources of knowledge that can be used to supplement developmental psychology, learning theory, and sociocultural perspectives in education (Williamson et al., 2026). In this sense, neuroscience is regarded as a complement to existing educational theories and in some cases a challenge to the current assumptions of teaching and learning (Zuanny et al., 2026). Simultaneously, this view highlights the significance of teachers' capacity to critically interpret scientific findings and contextualize them in classroom practice, rather than uncritically adopting neuroscience-based innovations (Muliati et al., 2025). Whereas earlier studies have mainly concentrated on the advantages of neuroscience for learning or the criticism of neuromyths, this article provides a holistic critical overview that brings supportive, critical, and neutral perspectives together in a single analytical framework. This work does not set neuroscience and education against each other, but rather investigates the tensions, opportunities and limitations that emerge from their interaction. This article contributes a more nuanced understanding of how neuroscience can be critically interpreted and contextually applied in education by situating these debates within the realities of educational practice in developing countries such as Indonesia. The article seeks to offer a reflective framework for educators and policy-makers to assess neuroscience-based educational approaches without succumbing to simplistic or reductionist assumptions.

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2. METHODS

The current study uses a critical literature review approach to examine and evaluate different perspectives on the integration of neuroscience in education. The choice is made because the study aims to go beyond the mere summary of previous studies, and to do a conceptual critique of the arguments, assumptions and pedagogical implications found in the literature. The sources were retrieved from journal articles and academic books indexed in Scopus, Web of Science, and Google Scholar, with the publication range restricted to 2018–2026 to ensure relevance to the rapidly developing nature of the topic. The search terms used were: educational neuroscience, neuromyths and brain-based learning. The first search returned 47 articles that were screened for the following inclusion criteria: (1) peer-reviewed publications, (2) direct relevance to neuroscience and education, and (3) explicit discussion of pedagogical implications. Following screening and assessment for eligibility, 18 articles were selected to form the main analytical corpus. The selection process is shown in a simplified flow diagram to explain the identification, screening, eligibility and inclusion stages. The selected studies were analyzed through a thematic critical analysis, grouping the arguments into three perspectives: pro, con and neutral. The articles were examined for their thematic content, but also for strength of claims, conceptual consistency and relevance to educational practice. This interpretive process allowed for cross perspective comparison and the identification of convergences, tensions and potential syntheses. To improve the critical dimension of the review, the analysis also involved an evaluation of the strength of the conceptual argument in each article and its relevance to educational contexts. The study therefore aimed to generate a more reflective and evaluative synthesis rather than a mere descriptive summary of the literature.

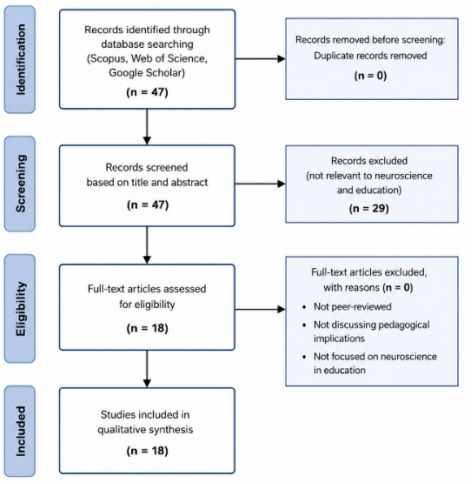

Figure 1. Diagram PRISMA

3. RESULTS AND DISCUSSION

3.1 The Pro Perspective: Neuroscience as a Tool for Teacher Empowerment

The pro side argues that the integration of neuroscience in education has a significant effect on re-conceptualization of teachers' knowledge about learning processes and student characteristics. One of the most influential contributions is in the concept of neuroplasticity, which underscores the fact that students' cognitive abilities are not fixed but can be augmented by the right learning experiences and stimulation of the environment (Chang et al., 2021). This perspective encourages a shift from deterministic assumptions about intelligence to a more developmental and optimistic understanding of learning potential. As such, teachers are increasingly being asked to create learning environments that promote ongoing cognitive development rather than simply monitoring static academic achievement. From a pedagogical point of view, neuroscience also provides insight into cognitive mechanisms such as executive function, attentional regulation, and inhibitory control.

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These results emphasize the importance of structured learning approaches such as scaffolding, incremental repetition, and experiential learning that align with the way the brain processes and organizes information (Brookman, 2016). In this sense, neuroscience informs not only theoretical understanding but also evidence-informed instructional approaches. Teachers who are aware of these mechanisms are often better able to detect individual differences in learning processes, and to adapt instructional strategies accordingly. Another important contribution of the pro perspective relates to teacher professionalism and inclusiveness. Understanding the biological basis of learning, could help to reduce the tendency to negatively label students, when they are struggling academically. Teachers are encouraged to view learning challenges, rather than failure, as part of a developmental process that is affected by multiple cognitive and environmental factors (Immordino & Damasio, 2007). This perspective supports a more inclusive pedagogical orientation whereby teachers are facilitators of growth rather than gatekeepers of achievement. Neuroscience-based approaches are increasingly being adapted in the context of Islamic education and madrasahs to improve both cognitive and spiritual aspects of learning. The intersection of neuroscience and religious education suggests that religious experiences are not only normative or doctrinal but also involve cognitive and emotional processes that can be developed through appropriate pedagogical approaches (Muliati et al., 2025). Such developments suggest that neuroscience has the potential to enrich not only secular educational discourse, but also faith-based educational contexts.

But the optimism of the pro perspective also must be critically examined. Much of the supportive literature is based on the assumption that neuroscientific findings can be translated into classroom practice in a relatively straightforward and universal manner. This assumption is problematic because educational settings are shaped not only by cognitive mechanisms but also by social interaction, institutional culture, economic inequality and contextual factors. Thus, methods that work well in the controlled environment of neuroscientific research may not necessarily translate into similar benefits in other educational settings. Sometimes neuroscience is promoted as a "scientific solution" to educational problems without sufficient regard for methodological limitations or contextual adaptation. In addition, the rise of the authority of scientific discourse in modern society contributes to the popularity of neuroscience in education. Neuroscience based approaches are often perceived as more credible due to the association with brain imaging technologies and biological explanations. As a consequence, teachers and institutions might use neuroscience language as a marker of innovation, even if the pedagogical benefits are not clear. This suggests that the appeal of neuroscience in education is not only scientific but also cultural and institutional.

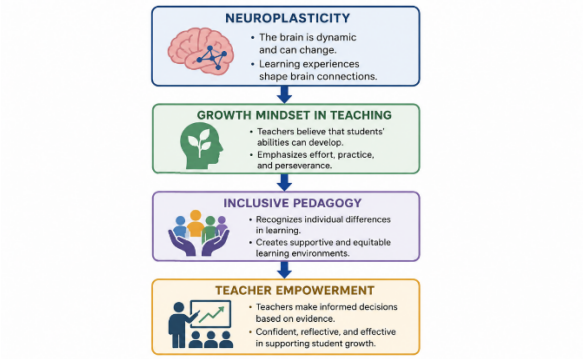

Figure 2. Neuroscience Contribution to Teacher Empowermen

3.2 Counterperspective: Reductionism, Neuromyths, and Epistemological Criticism

The counter perspective, in contrast to the pro perspective, refers to the risks of the integration of neuroscience into education . One of the main criticisms relates to biological reductionism, i.e. the tendency to explain learning processes only through brain activity. However, critics have argued that education cannot be reduced to neurological mechanisms alone, as learning

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has social, cultural, emotional, and relational dimensions (Bruer, 1997). Thus, neuroscience alone is viewed as insufficient to explain the complexity of learning in the classroom. Another major problem is the spread of neuromyths among educators. The learning styles myth (VAK) and the notion that people only use a small fraction of their brain are still widely accepted despite a lack of strong scientific evidence. The persistence of the myths suggests that neuroscience findings are often simplified during their transfer to educational practice. Neuroscience appears to be scientific and measurable, and thus gains authority in many cases, although some claims are not empirically well supported. The counter perspective also critiques the impact of neuroscience discourse on teacher professionalism. Sometimes teachers are situated as technical implementers of scientific findings constructed by experts rather than as reflective professionals who understand the contextual realities of learning (Leyton & Stentiford, 2025). This condition runs the risk of reducing teachers' autonomy and of overlooking the importance of pedagogical experience, intuition and interaction between teachers and students. Critics have raised ethical concerns that neuroscience-based approaches may result in the creation of normative standards for "ideal" cognitive performance. Consequently, students who do not meet these standards may be viewed as less capable or less optimal. This suggests that the critique of neuroscience is not only methodological but also touches upon the larger values and purposes of education. Thus, the counter perspective highlights the need for critical reflection so that neuroscience remains unchallenged in its predominance in educational discourse. These criticisms show that the debate surrounding neuroscience is not just about scientific validity but about how educational knowledge should be interpreted and applied in practice. This tension has led to more integrative approaches that attempt to put neuroscience in context in educational theory and practice.

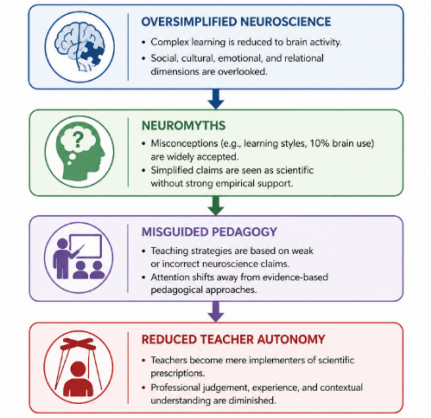

Figure 3. Risk of Neuroscience Integration in Education

3.3 A Neutral Perspective: Neuroscience as a Situated Tool

In response to the tension between the pro and counter views, a more integrative approach that positions neuroscience as a contextual and situated tool in education has emerged. Such a view rejects the simplistic dichotomy of wholesale acceptance or rejection of neuroscience and instead points to the need for critical and reflective integration. In this sense, neuroscience is not seen as a substitute for educational theory, but rather as a complementary source of knowledge that can enrich understanding of learning processes. Neuroscience, from this vantage point, is instrumental in offering insights about the cognitive and emotional mechanisms involved in learning, especially the mechanisms of attention, memory, and emotional regulation. However, these results cannot be directly generalized to classroom practice without interpretation. Educational realities and thus the way learning takes place are influenced by cultural contexts, institutional conditions and interpersonal interactions. Thus, neuroscience knowledge has to be translated in a contextual way and not adopted in a mechanical way (Immordino & Damasio, 2011). Beyond practical

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considerations, this perspective also points out important epistemological differences between neuroscience and education. Neuroscience is mainly concerned with the biological mechanisms of cognition, while education is concerned with meaning, values, social interaction and human development. Effective integration therefore requires an interdisciplinary dialogue rather than dominance of one discipline over another. In this context teachers are central actors, mediators of scientific findings interpreted according to students' needs and classroom realities. Consistent with this argument, the neutral perspective sees teachers not only as consumers of neuroscience knowledge, but reflective practitioners who can critically evaluate neuroscience-based claims. "It's the job of teachers to separate the scientifically supported from the educationally trendy and oversimplified." This approach promotes teacher professionalism, as teachers are active decision makers on how the scientific knowledge should be modified in pedagogical practice. Therefore, the neutral view does not see neuroscience as a panacea to all educational problems. Instead it advocates a balanced integration of scientific findings, educational theory and contextual experience. Such an approach minimises the risk of reductionism but still recognises the possible contribution of neuroscience to educational development. Hence neuroscience is one of many analytical lenses in understanding learning processes, not the only authority in educational practice. To further clarify the relationships among these perspectives, the findings of this study are summarized in Table 1.

Table 1. Comparative Perspectives on the Integration of Neuroscience in Education

Perspective	Changes in Teachers' Perspectives	Key Risks
Pros	Teachers as evidence-based cognitive designers	Over-optimism about quick fixes
Cons	Teachers as holistic educators (rejecting reductionism)	Rejecting all findings in neuroscience out of hand
Neutral	Teachers as reflective practitioners who use neuroscience as one of their lenses	Difficult to implement because it requires interdisciplinary training

As presented in the table, the integration of neuroscience impacts not only instructional strategies but also the construction of teachers' professional identities. From the pro perspective, teachers are instructional designers that leverage scientific findings to enhance learning effectiveness. Research shows the importance of understanding neuroscience ideas that can change the way teachers see students and learning processes in a more active and developmental way (Nurjaman et al., 2025). On the other hand, the opposing view holds that learning is not just biological activity but also has social, cultural and ethical aspects (Widyasari, 2025). This critique is important so that the hegemony of technocratic approaches that may neglect the humanistic aims of education is avoided. In contrast, the neutral view presents teachers as reflective practitioners, who selectively and critically integrate different types of knowledge, including neuroscience, depending on the educational needs of the context. This view is a reflection of the increasing focus on interdisciplinarity in modern educational studies, where educational problems are perceived as complex phenomena that cannot be explained by one discipline alone (Damayanti, 2026).

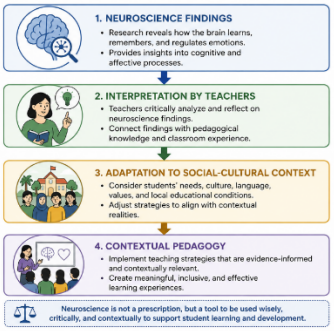

Figure 4. Contextual Integration of Neuroscience in Education

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3.4 Critical Realism as an Integrative Framework

The analysis of the pro, counter and neutral perspectives demonstrates that the relation between neuroscience and education cannot be understood in a simple dichotomy. The pro perspective is about the role of neuroscience in enhancing pedagogical understanding, whereas the counter perspective is about the dangers of reductionism, neuromyths and technocratic approaches. Meanwhile, the neutral perspective seeks to situate neuroscience within a wider discussion of education. Such differences suggest that neuroscience for education should not be taken as a final answer nor fully rejected, but rather critically interpreted, in the light of educational realities. Critical realism provides a useful framework for synthesising these different perspectives. Critical realism recognizes that there are real biological dimensions of learning processes, including cognitive and neurological mechanisms. Simultaneously, it recognizes that educational experiences are influenced by social structures, cultural contexts, emotional conditions, and human interaction. So learning is not reducible to brain activity and the biological aspects cannot be ignored. This is important because this approach avoids the two extremes. In one sense, critical realism is antithetical to biological determinism that reduces education to neural processes. It is, however, also against extreme relativism which flatly rejects scientific results altogether. Instead, critical realism fosters a dialogue between neuroscience and educational theory so that scientific findings can be critically interpreted and contextually applied. This means that neuroscience is just one of many explanatory frameworks for learning processes. The practical implication of this framework is the need to balance scientific literacy with pedagogic wisdom. Teachers need to know about neuroscience on a basic level to avoid neuromyths and to be able to critically evaluate claims based on neuroscience. But, effective teaching also depends on teachers' ability to comprehend students' social backgrounds, emotional conditions and cultural contexts. Thus, the professionalism of education is based not only on scientific knowledge, but also on reflective judgment and contextual sensitivity. Furthermore, critical realism sees teachers as active interpreters of scientific knowledge, rather than passive recipients of it. Findings in neuroscience cannot be applied mechanically but need to be adapted according to classroom realities and educational objectives. This neuroscience integration deepens interdisciplinary understanding without sacrificing the humanistic dimensions of education. Thus, a balanced integration between neuroscience and pedagogy can add more meaning to the development of education.

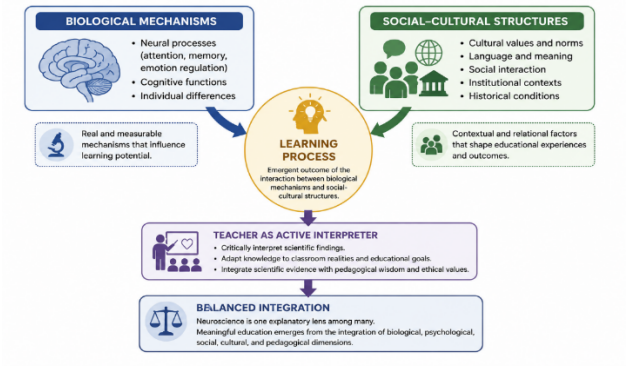

Figure 5. Critical Realism Framework

3.5 Pedagogical and Professional Implications

Pedagogical Implications: Integrating Neuroscience into the Local Context

Neuroscience into education should not be seen as a process of direct adoption, but adaptation to local contexts. On the bright side, learning strategies like cognitive load management and learning by experience are considered effective since they are grounded on the ways the brain processes information (Rustiyana et al., 2025). However, recent studies show that the effectiveness

of such strategies is highly context-dependent including social and cultural background of the students. For example, in the context of Indonesia, learning approaches must pay attention not only to the cognitive aspects but also the values of religion and social values contained in the education system. Therefore, the integration of neuroscience must be performed in a contextually manner taking into account the local characteristics. This approach enables a dialogue between neuroscience and existing teaching traditions, thus leading to more relevant and meaningful learning practices (Kusmanto, 2025).

Implications for Teacher Professional Development

The application of neuroscience to education also has important consequences for the professional development of teachers. One of the primary challenges is the low level of neuroscience literacy among teachers, which often results in the spread of neuromyths (Nurjadid et al., 2025). Recent research suggests that these misconceptions are still quite common even among trained educators . In this context, teacher professional development should focus not only on knowledge but also on reflective skills. Teachers should be trained to critically evaluate scientific claims and adapt them to learning needs. In Indonesia, efforts to strengthen the competencies of teachers in facing the digital age and globalization also require the integration of various disciplines including neuroscience. This means that teacher professional development should be holistic and sustainable, rather than short-term technical training. The analysis suggests that the incorporation of neuroscience into education should be taken with a balanced perspective. Neuroscience offers valuable insights into the learning process, but it cannot be the only factor in instructional design (Ray et al., 2025). An overly optimistic approach risks oversimplification, an overly skeptical approach stifles innovation. Thus, there is a need for an integrative approach which draws on the findings of neuroscience, educational theory, and social context. In this context, teachers play a strategic role as intermediaries between science and practice. By developing scientific literacy and at the same time maintaining pedagogical sensitivity, teachers can ensure that the integration of neuroscience does have a positive impact on the quality of learning.

4. CONCLUSION

The findings of this study suggest that the integration of neuroscience in education has great potential for improving the quality of learning but also presents conceptual and practical challenges. The pro perspective is the scientific basis of neuroscience for evidence-based learning, and the counter perspective emphasizes the importance of keeping the humanistic dimension of education and avoiding biological reductionism. The neutral view of neuroscience, however, depicts neuroscience as a contextual approach that should be integrated critically within educational practice. Moreover, the results indicate that low neuroscience literacy of teachers contributes to the spread of neuromyths. Thus, there is a need for a balanced interdisciplinary integration of neuroscience, educational theory, and pedagogy. The study has several limitations. First, the research is based on a critical literature review approach with secondary data that makes the findings conceptual and not empirical. Second, the study does not directly examine the use of neuroscience in schools or classrooms. Third, the number of reviewed articles is still limited in view of the rapid development of educational neuroscience research. Thus, future studies are suggested to conduct empirical investigations on the implementation of neuroscience-based learning, especially in developing countries like Indonesia. More research should also be conducted into teachers' neuroscience literacy, the persistence of neuromyths, and the effectiveness of professional development programs to improve the critical understanding of neuroscience concepts in education.

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