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# INTEGRATION OF NEURODEVELOPMENTAL PRINCIPLES IN THE PRACTICAL APPLICATION OF THE BNCC: CHALLENGES AND PERSPECTIVES FOR BRAZILIAN EDUCATION

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## ABSTRACT

This article presents a literature review on the interface between the principles of neurodevelopment and the practical application of the National Common Curricular Base (BNCC) in the Brazilian educational context. The review shows that, although there is a growing recognition of the importance of neuroscience for education, the translation of this knowledge into pedagogical practices faces significant challenges, particularly related to insufficient teacher training and socioeconomic inequalities in the country. The findings suggest that the continuous training of teachers in educational neuroscience, combined with the adaptation of pedagogical practices to the different phases of students' brain development, is essential for the effective implementation of the BNCC guidelines. In addition, the study highlights the need for public policies that consider regional disparities and offer adequate support to schools in vulnerable contexts. It is concluded that an interdisciplinary approach, which seeks to integrate Neuroscience and Education in a more robust way, could promote a more inclusive and effective education, aligned with the neurodevelopmental needs of students.

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## INTRODUCTION

In recent decades, advances in neuroscience have provided a deeper understanding of neurodevelopmental processes and their implications for child learning and development. According to Goswami (2006), the field of educational neuroscience has demonstrated that children's cognitive and emotional development is closely linked to brain development, which suggests that pedagogical practices should be adapted to the different stages of neurodevelopment.

In the Brazilian context, the National Common Curriculum Base (BNCC) emerges as a public policy aimed at guiding the formation of school curricula that meet national quality standards. The BNCC, according to Bittencourt (2020), establishes guidelines that aim not only at standardization, but also at the inclusion of pedagogical practices that promote the integral development of students. However, the practical application of these guidelines still faces significant challenges, especially when it comes to aligning such practices with the neurodevelopmental needs of students.

Several studies indicate that understanding the stages of development of the children's brain is crucial for the development of effective pedagogical practices. According to Johnson and Haan (2015, p. 78), "brain development at different stages of childhood suggests that pedagogical approaches should be flexible and responsive to the cognitive and emotional changes that occur in these stages". This view is shared by Damásio (2014, p. 92), who emphasizes that "the neuroplasticity of the developing brain requires an educational approach that adjusts to the evolving cognitive capacities of children".

In Brazil, this discussion gains even more relevance with the implementation of the BNCC, which, as argued by Duque *et al.* (2024), has the potential to incorporate neuroscientific principles into pedagogical practice, but still lacks a more systematic approach that considers individual differences in neurocognitive development. This gap in the practical application of the BNCC, in line with the principles of neurodevelopment, represents a fertile field for academic research and for the improvement of educational policies.

Therefore, the objective of this article is to conduct a literature review in order to evaluate how the principles of neurodevelopment have been applied in the practical implementation of the BNCC guidelines. It is hoped that this analysis will contribute to a better understanding of how pedagogical practices can be adjusted to meet the neurodevelopmental needs of children at different stages of their education, promoting more inclusive and effective teaching.

## LITERATURE REVIEW

Neurodevelopment refers to the structural and functional changes in the brain during child and youth development. Neuroscience has shown that the brain is highly plastic during the early stages of life, implying that the educational environment can significantly influence children's cognitive and emotional development (Goswami, 2006). Immordino-Yang (2016) notes that:

> understanding neurocognitive processes is key to creating learning environments that are not only stimulating but also appropriate to children's developmental needs (Immordino-Yang, 2016, p. 75).

The integration of neuroscientific principles in education can improve the effectiveness of pedagogical strategies. Johnson and Haan (2015, p. 89) point out that "educational approaches that consider brain development and neural plasticity tend to be more successful in promoting learning and emotional development". These principles are particularly relevant to the BNCC, which aims to ensure that the school curriculum is inclusive and responsive to the varied needs of students.

### THE BNCC AND ITS RELEVANCE IN THE BRAZILIAN EDUCATIONAL CONTEXT

The BNCC establishes curricular guidelines for basic education in Brazil, seeking to ensure that all students have access to a curriculum that promotes essential skills for integral development (Brasil, 2017). Vantroba *et al.* (2023) state that the BNCC represents a significant effort to standardize the curriculum and ensure quality education, but its implementation must be aligned with the latest findings in neuroscience to be truly effective.

The review points out that the BNCC, by establishing curricular goals and content, can benefit from a more informed approach to neurodevelopment. Blakemore and Frith (2005, p. 22) emphasize that "education must be adapted to the capacities and limitations of the developing brain, which implies that the curriculum must consider the critical phases of cognitive and emotional development". However, there is a challenge in ensuring that the BNCC guidelines are flexible enough to incorporate these neuroscientific nuances.

### CHALLENGES IN THE IMPLEMENTATION OF NEUROSCIENTIFIC PRINCIPLES IN THE BNCC

The application of neuroscientific principles in the BNCC curriculum faces several challenges. Teacher training often does not include a deepening of the neuroscientific concepts necessary to apply these principles in the school environment.

In addition, Brazil's socioeconomic and regional diversity complicates the uniform implementation of the BNCC. Some authors discuss how the variation in available resources and teaching conditions in different regions of the country affects the ability of schools to implement pedagogical practices based on neurodevelopment. Otero (*apud* ONU, 2019), Unesco's Education Coordinator in Brazil, points out that the quality of education depends on several factors, including the infrastructure of the school environment. It also highlights that schools in urban areas generally have better conditions than those in rural areas, which greatly affects student performance.

Several authors discuss how variation in teaching resources and conditions affects the implementation of pedagogical practices based on neurodevelopment.

Brandão, Caliatto, and Antoniuk (2019) discuss the contributions of neuroeducation to pedagogical practice and emphasize the need for adequate infrastructure and continuous teacher training for the effective implementation of these practices. In this same perspective, Riechi and Valiati (2020) address the importance of adequate conditions for child neurodevelopment and how the lack of resources impacts education and the implementation of pedagogical practices based on neurodevelopment.

Costa (2023), in his article "Neuroscience and learning", addresses how neuroscience concepts, such as neuroplasticity and higher nervous functions (attention, memory, motivation, emotions, and executive functions), are related to learning. The author seeks to articulate the contributions of neuroscience to pedagogical practices, promoting reflections that aim to make learning more meaningful for students.

Guimarães Jr. *et al.* (2024) carried out a study on the application of neuropsychopedagogy in teaching. The authors mapped the main neuroscience-based techniques and strategies used to improve teaching and support students with learning difficulties. In addition, they highlighted innovative methodologies and strategies to promote student engagement and development, providing theoretical and practical support for educators, managers, and researchers.

Crespi, Noro, and Nóbile (2020) explore brain development during the first years of life, highlighting the structure and maturation of the nervous system. They emphasize the crucial role of early experiences in child development and the importance of pedagogical practices in early childhood education to promote neurodevelopment.

Carvalho (2011) discusses the importance of integrating neuroscience advances into teacher training courses. The author argues that knowledge about the functioning of the brain can improve the understanding of learning and, consequently, pedagogical practice. It also highlights the need to review the curricular structures of teaching degree and teacher

training courses, suggesting the inclusion or restructuring of disciplines to facilitate the dialogue between neuroscience, teaching and learning.

Therefore, the variation in available resources and teaching conditions in different regions of the country affects the ability of schools to implement neurodevelopment-based pedagogical practices. This highlights the need for public policies that support teacher training and the adaptation of the curriculum to local needs.

### EFFECTIVE INTEGRATION OF NEUROSCIENTIFIC PRINCIPLES

To overcome these challenges, the literature suggests several strategies. Ongoing teacher training in neuroscience is crucial. As emphasized by Howard-Jones (2014, p. 102), "teacher training must include a significant component of educational neuroscience so that they can implement pedagogical practices based on neuroscientific evidence".

In addition, the adaptation of the curriculum must take into account the different stages of brain development. Damásio (2014, p. 97) states that "flexibility in curriculum and teaching methodologies is necessary to meet the needs of children at different stages of development".

Public policies that offer additional support are essential for pedagogical practices based on neuroscience to be effectively implemented in all schools. This includes investments in continuing education for teachers, adequate didactic resources, school infrastructure, and psychopedagogical support programs. These measures help to create a more inclusive and effective learning environment, ensuring that all students, regardless of their region or socioeconomic status, can benefit from advances in neuroscience in education.

## RESULTS

The analysis of the selected literature reveals that the interface between neurodevelopment and the practical application of the National Common Curricular Base (BNCC) has been increasingly explored, although there are still significant gaps in the understanding and application of neuroscientific principles in the Brazilian educational context. As pointed out by Howard-Jones (2014, p. 96), "the field of educational neuroscience has the potential to transform education, but the translation of this knowledge into pedagogical practice still faces considerable challenges".

## PEDAGOGICAL PRACTICES BASED ON NEURODEVELOPMENT

The first category of results identifies pedagogical practices that incorporate neurodevelopmental principles as recommended by the BNCC. Studies such as that of Immordino-Yang (2016, p. 82) indicate that "education that takes into account children's brain development can not only improve learning, but also promote emotional well-being". In the Brazilian context, the BNCC has the potential to transform Brazilian education, especially when integrated with neurodevelopment-based approaches. In early childhood education and the early years of elementary school, these practices can promote a more inclusive and effective learning environment. In this way, the BNCC provides clear guidelines that, when combined with knowledge from neuroscience, help develop cognitive, emotional, and social skills from an early age, better preparing students for future challenges.

Thus, the practices that are most successful include individualized teaching strategies, which respect the differences in cognitive and emotional development between children.

## GAPS IN THE LITERATURE AND CHALLENGES IN IMPLEMENTATION

While there have been advances, the review also reveals significant gaps in the literature. A limited number of studies address the direct application of neuroscientific principles in the BNCC curriculum, especially in the final years of elementary and high school. According to Thomas, Ansari, and Knowland (2019, p. 114), "one of the biggest barriers to the effective implementation of neuroscience in education is the lack of adequate teacher training in relation to neuroscientific concepts and how to apply them in practice". In Brazil, Bihringer *et al.* (2024) highlight how the inclusion of neuroscience knowledge in teacher training can lead educators to critically reflect on their pedagogical practices and to develop more effective strategies, based on the principles of Science of Mind, Brain and Education (MCE).

Therefore, teacher education still lacks a solid foundation in neuroscience, which limits teachers' ability to effectively integrate neurodevelopmental principles into their pedagogical practices.

## PRACTICAL CHALLENGES AND PROPOSALS FOR OVERCOMING

The results also indicate significant practical challenges in adapting the BNCC guidelines to the neurodevelopmental needs of students. For Goswami (2006, p. 213), "neuroscience has shown that the critical phases of brain development require specific

pedagogical approaches, but the implementation of these practices on a national scale faces considerable logistical and pedagogical challenges". In Brazil, socioeconomic and cultural diversity also complicates the uniform application of these principles in different regions and school contexts. Koide and Tortella (2023) explore how neuroscience-based pedagogical practices can improve learning performance in contexts of high social vulnerability. Using a descriptive and exploratory case study, the authors analyze teacher training, executive functioning skills, and pedagogical practices. The authors suggest that challenging children's learning skills can improve their ability to cope with adverse situations, potentially altering their life trajectories.

Despite the challenges, some examples of good practice emerge from the literature. Damásio (2014, p. 92) argues that "schools that adopt a pedagogical approach based on neuroscience, such as the use of active methodologies that involve social and emotional cognition, have demonstrated success in the application of the BNCC". Case studies in public and private schools show that the use of educational technologies that incorporate neurodevelopmental principles, such as adaptive learning programs, can increase engagement and improve academic outcomes.

The literature review points to the need for more research that integrates neuroscience with education, particularly in contexts involving the BNCC. According to Reis and Negrão (2022), there is still much to be explored at the interface between neurodevelopment and school curriculum, especially with regard to the continuing education of teachers and the development of didactic materials based on neuroscientific principles.

In addition, it is crucial that future studies adopt rigorous methodological approaches to assess the impact of neurodevelopment-based practices on children's learning and development.

## DISCUSSION

The findings of this review reveal a complex dialogue between the principles of neurodevelopment and the practical application of the BNCC guidelines in Brazil. Although the literature indicates promising advances, there are still significant challenges in the effective integration of neuroscience with the pedagogical practices established by the BNCC.

The discussion about the importance of neuroscience in education has gained prominence in recent decades. As pointed out by Blakemore and Frith (2005, p. 15), "understanding the brain processes underlying learning can provide valuable insights for

the development of more effective pedagogical practices". In the context of the BNCC, this perspective is essential to ensure that educational practices not only meet established standards, but are also aligned with the neurodevelopmental needs of students.

However, as discussed by Goswami (2006), the translation of neuroscientific findings into pedagogical practice is not a direct process. According to the author, "although neuroscience offers a powerful framework for understanding child development, there is a great challenge in applying these principles in a practical way in classrooms" (Goswami, 2006, p. 216). This challenge is even more pronounced when considering the diversity of educational contexts in Brazil, where socioeconomic inequalities can influence the effective implementation of the BNCC.

The results of this review highlight the existence of significant gaps in the practical application of neurodevelopmental principles within the BNCC guidelines. In particular, the lack of adequate teacher training in educational neuroscience emerges as a crucial obstacle. Thomas, Ansari, and Knowland (2019, p. 120) argue that "without a solid understanding of neuroscience, teachers may find it difficult to incorporate these principles meaningfully into their daily practices." This scenario is confirmed in the Brazilian context by Lomba and Schuchter (2023), who observe that current teacher training does not provide the necessary basis for teachers to effectively integrate neuroscientific principles with BNCC guidelines. The authors highlight the need for public policies that address regional inequalities and offer continuous support to educators.

In addition, the review suggests that the practical implementation of the BNCC, when aligned with neurodevelopmental principles, requires careful adaptation to the different stages of child development. According to Johnson and Haan (2015, p. 83), "pedagogical practices must be sensitive to the critical phases of brain development, as these phases are essential for learning and emotional development". However, the application of these principles in Brazilian basic education still faces difficulties, especially in schools with limited resources.

To overcome the challenges identified, the literature suggests several promising approaches. First, it is essential that there is continuous investment in teacher training in educational neuroscience. As Howard-Jones (2014, p. 100) emphasizes, "the training of teachers in neuroscience is crucial so that they can apply this knowledge effectively in their pedagogical practices". In Brazil, Crespi (2020) investigates how the continuing education of teachers can be enriched with knowledge of neuroscience. Focused on educators of daycare centers and preschools in Farroupilha/RS, the study analyzed teachers' previous knowledge about neurodevelopment and learning, and evaluated the impact of continuous

training meetings. The author indicates that neuroscience-based training can promote more effective pedagogical practices, valuing the integral development of children in early childhood.

In addition, the adoption of flexible pedagogical methodologies that adapt to the different stages of child development is essential. Damásio (2014, p. 95) suggests that "the neuroplasticity of the developing brain requires pedagogical approaches that are responsive and adaptive to the needs of children". In the context of the BNCC, this could mean personalizing teaching to accommodate variations in the pace of cognitive and emotional development of students.

Finally, it is important that Brazilian public policies consider regional and socioeconomic inequalities in the implementation of the BNCC. Santos (2013) argues that "adapting the BNCC guidelines to the principles of neurodevelopment requires a contextualized approach, which takes into account regional differences and offers adequate support to schools in less favored areas". This could include the provision of additional resources and the development of specific programs for schools located in vulnerable contexts.

The analysis of the results suggests that the field of educational neuroscience in Brazil is still in the development phase, but it has significant potential to improve the quality of education offered to children. The implementation of a BNCC that aligns with the principles of neurodevelopment can result in a more inclusive and effective education. However, as Blakemore and Frith (2005, p. 18) suggest, "the real challenge lies in translating neuroscience findings into pedagogical practices that are applicable in a variety of educational contexts."

Future research should continue to explore how neuroscience can inform and transform educational practice, with a particular focus on how these practices can be equitably implemented across the Brazilian territory. Assessing the impact of these practices on students' academic performance and emotional well-being is crucial to ensure that Brazilian education evolves in a way that meets the neurodevelopmental needs of all children.

## CONCLUSION

This article addressed the complex intersection between the principles of neurodevelopment and the practical application of the National Common Curriculum Base (BNCC) in the Brazilian educational context. The review revealed both the advances and

the gaps that exist in the integration of these concepts, highlighting the importance of neuroscience for a more inclusive and effective education.

The results indicate that, although there is a growing awareness of the relevance of neuroscientific principles in education, their practical application faces significant challenges, mainly due to insufficient teacher training and the socioeconomic diversity of Brazil. Teacher training emerges as a critical factor for the successful implementation of pedagogical practices that are informed by neuroscience. Howard-Jones (2014, p. 105) emphasizes that "without a deep understanding of neuroscience, it is unlikely that teachers will be able to translate these principles into effective pedagogical practices".

In addition, the review suggests that careful adaptation of the BNCC guidelines to the neurodevelopmental needs of students is essential to promote an education that respects the different stages of brain development. As Goswami (2006, p. 220) points out, "education must be adapted to the critical stages of development, which requires a methodological flexibility that is often lacking in traditional curricula".

The central conclusion of this review is that, for the BNCC to reach its full potential, a coordinated effort is needed that includes the continuing education of teachers, the adaptation of pedagogical practices to the neuroscientific needs of students, and the consideration of regional and socioeconomic inequalities in the implementation of these guidelines. Conte and Habowski (2021, p. 125) suggest "a contextualized and adaptive approach is essential for neurodevelopment-based practices to be effectively integrated into the BNCC".

The implications of this review indicate that future research should focus on assessing the impact of neuroscience-informed educational practices on children's academic and emotional development. Additionally, it is crucial for policymakers and educators to work together to create an educational environment that supports the neurocognitive development of all children, regardless of their socioeconomic background.

Finally, this review highlights the need for an interdisciplinary approach, where neuroscience and education talk in a more integrated way, allowing scientific findings to inform educational policies and pedagogical practices in a direct and practical way. This path, although challenging, promises an education more aligned with the real needs of children and the demands of the contemporary world.

Therefore, it is concluded that, although the BNCC represents a significant advance in the standardization and quality of teaching in Brazil, its practical application can be substantially improved with the incorporation of insights on neurodevelopment. It is

recommended that future research focus on pedagogical strategies that more deeply integrate neuroscientific principles, promoting more individualized and effective teaching.

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