

NEUROSCIENCE AND TEACHER TRAINING: CONTRIBUTIONS TO TEACHING AND LEARNING

NEUROCIÊNCIA E FORMAÇÃO DOCENTE: CONTRIBUIÇÕES PARA O ENSINO E APRENDIZAGEM

NEUROCIENCIA Y FORMACIÓN DEL PROFESORADO: CONTRIBUCIONES A LA ENSEÑANZA Y EL APRENDIZAJE



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ABSTRACT

Given the contemporary challenges in education and the need for pedagogical practices based on scientific evidence, understanding how development and learning processes occur has been a major challenge. In this sense, Neuroscience presents its advances, contributing significantly to education. It is based on the premise that learning involves the integration of cognitive, emotional, and biological processes, with learning resulting from brain function articulated with attention, memory, emotion, and executive functions—central aspects for teaching and learning. Therefore, this study aims to analyze the contributions of neuroscience to the teaching and learning process, focusing on teacher training courses (initial training - Bachelor's Degree in Pedagogy). It is a qualitative research study, developed through an analytical-integrative approach, in which content analysis of articles, books, and legal documents, such as CNE/CP Resolution No. 4/2024 and the Pedagogical Projects of the Courses, was carried out. Thus, a sample of two public universities (University of Brasília – UnB, and Federal University of Piauí – UFPI) was presented. The analysis concludes that the systematic integration of Neuroscience and Education is indispensable for improving pedagogical practices and promoting reflective, inclusive, and evidence-based teacher training. However, the analyzed course plans revealed that these institutions do not offer a specific Neuroscience course as a curricular component. Nevertheless, the courses include some subjects that have relationships, similarities, or complementary content to the knowledge addressed by Neuroscience.

Keywords: Education. Neuroscience. Pedagogical Practices.

RESUMO

Diante dos desafios contemporâneos da educação, e da necessidade de práticas pedagógicas baseadas em evidências científicas, conhecer como ocorrem os processos de

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desenvolvimento e de aprendizagem, tem sido um grande desafio. Nesse sentido, a Neurociência apresenta seus avanços, contribuindo de forma expressiva para a educação. Parte-se do pressuposto de que aprender envolve a integração entre processos cognitivos, emocionais e biológicos, sendo a aprendizagem resultado do funcionamento cerebral articulado à atenção, memória, emoção e funções executivas, aspectos centrais para o ensinar e o aprender. Nesse sentido, este estudo objetiva analisar as contribuições da neurociência no processo de ensino e aprendizagem, com foco nos cursos de formação docente (formação inicial - Licenciatura em Pedagogia). Trata sobre uma pesquisa qualitativa, desenvolvida por meio de um estudo analítico-integrativo, em que foi realizada a análise de conteúdo de artigos, livros e documentos legais, como a Resolução CNE/CP nº 4/2024 e os Projetos Pedagógicos dos Cursos. Assim, tem-se uma amostra de duas Universidades Públicas (Universidade de Brasília – UnB, e Universidade Federal do Piauí – UFPI). A partir das análises conclui-se que a integração sistematizada entre Neurociência e Educação é indispensável para qualificar práticas pedagógicas e promover uma formação docente reflexiva, inclusiva e fundamentada em evidências. No entanto, constatou-se a partir dos planos de cursos analisados, que essas instituições investigadas não ofertam uma disciplina específica para a área de Neurociência, como um componente curricular. Todavia, os cursos possuem algumas disciplinas que têm relações, semelhanças ou conteúdos complementares aos conhecimentos trabalhados pela Neurociência.

Palavras-chave: Educação. Neurociências. Práticas Pedagógicas.

RESUMEN

Ante los desafíos contemporáneos en educación y la necesidad de prácticas pedagógicas basadas en evidencia científica, comprender cómo se producen los procesos de desarrollo y aprendizaje ha sido un reto fundamental. En este sentido, la neurociencia presenta sus avances, contribuyendo significativamente a la educación. Se basa en la premisa de que el aprendizaje implica la integración de procesos cognitivos, emocionales y biológicos, resultando de la función cerebral articulada con la atención, la memoria, la emoción y las funciones ejecutivas, aspectos centrales para la enseñanza y el aprendizaje. Por lo tanto, este estudio tiene como objetivo analizar las contribuciones de la neurociencia al proceso de enseñanza y aprendizaje, centrándose en los cursos de formación docente (formación inicial - Licenciatura en Pedagogía). Se trata de un estudio de investigación cualitativa, desarrollado mediante un enfoque analítico-integrador, en el que se realizó un análisis de contenido de artículos, libros y documentos legales, como la Resolución N° 4/2024 del CNE/CP y los Proyectos Pedagógicos de los Cursos. Así, se presentó una muestra de dos universidades públicas (Universidad de Brasília – UnB, y Universidad Federal de Piauí – UFPI). El análisis concluye que la integración sistemática de la neurociencia y la educación es indispensable para mejorar las prácticas pedagógicas y promover una formación docente reflexiva, inclusiva y basada en la evidencia. Sin embargo, los planes de estudio analizados revelaron que estas instituciones no ofrecen un curso específico de neurociencia como componente curricular. No obstante, los cursos incluyen algunas asignaturas que guardan relación, similitud o complementan el contenido de los conocimientos que abarca la neurociencia.

Palabras clave: Educación. Neurociencia. Práticas Pedagógicas.

1 INTRODUCTION

Contemporary education faces significant challenges with regard to the construction of pedagogical practices that recognize diversity as a constitutive element of the teaching and learning process. In this context, it is essential to understand that the act of educating goes beyond the simple transmission of content, requiring an approach that considers the multiple dimensions of human development (Mantoan, 2015; Sasaki, 2019; Relvas, 2016). For the understanding of this understanding by teachers, Neuroscience stands out, considering that its advances have contributed significantly to the learning processes, considering that learning involves brain functioning and the integration of cognitive functions such as attention, memory, perception, emotion and executive functions, all directly related to teaching and learning (Guerra, 2011).

In this context, this study recognizes the need for teachers to seek knowledge of Neuroscience in their initial and continuing education. It is known that this knowledge allows a more scientific approach to the teaching-learning process, as it is understood that the integration between Neuroscience and Education becomes fundamental for the development of these processes. However, as Guerra (2011, p. 2-3) points out, "neuroscience can inform education, but not explain or provide prescriptions, recipes that guarantee results; it can, however, make the work of the educator more meaningful and efficient".

Based on this understanding, it is considered that teachers need to seek knowledge in neuroscience, in view of the need to integrate neuroscientific knowledge with pedagogical practices, enabling greater reach in relation to the teaching and learning processes of students in all areas of knowledge, since "The act of learning is a modification of behavior that involves the mind (abstract concept that involves thinking, emotions/feelings) and the brain (physical organ responsible for biological functions)". It is noteworthy that the knowledge of Neuroscience is based on what is called "brain science and education as the science of teaching and learning" (Relvas, 2016, p. 199).

From this reflection emerges the question: How should teachers have access to Neuroscience knowledge? The answer to this question points to the need for such knowledge to be discussed and worked on during initial and continuing teacher training in teaching degree courses. Therefore, it is essential to rethink teacher training in Brazil, according to the contemporaneity of knowledge, so that the teacher is contemplated in meeting social demands among other knowledge such as that in the area of Neuroscience, considering it necessary to include this knowledge in the curricula of Teaching Degrees.

Thus, knowing how the development and learning processes occur has been a great challenge. In this sense, it is necessary to recognize the necessary integration of Neuroscience with Education, which will make it possible to advance in this knowledge, providing better understanding and quality to the teaching and learning processes in these areas. By knowing the relationship between learning and the brain, based on its cognitive functions, the teacher will be able to better develop his pedagogical work by basing his practice on scientific evidence. Thus, this study aims to analyze the contributions of Neuroscience in the teaching and learning process, focusing on teacher training. It is understood that the curricula of Pedagogy courses and teaching degrees in general need to include disciplines that prepare future teachers in relation to neuroscientific knowledge, enabling the understanding of how learning occurs in the students' brains and favoring better planning and development of pedagogical practices (Grossi; Borja, 2016).

To this end, a qualitative research was developed, of an analytical-integrative nature (Minayo, 2014; Souza; Silva; Carvalho, 2017), based on authors such as Damásio (2012), Cosenza and Guerra (2011) and Antunes (2011), who highlight the relationship between emotion, cognition and learning, highlighting the importance of pedagogical practices that respect people's singularities. In the research, content analysis was used, based on Bardin (2016) and Ferreira and Loguecio (2014), who consider this analysis as a

[...] an instrument for the interpretative exploration of documents of various natures, vectored by techniques that, in a coordinated manner, aim to organize and systematize units of their content in order to extract from them nuclei of meaning from which the main themes and concepts are harvested and meanings are captured. (Ferreira; Loguecio, 2014, p. 35)

When developing the study through the qualitative approach, the integrative review was used, which, according to Vosgerau and Romanowski (2014, p. 179), enabled the analysis of the results found in journal databases, providing conditions to form groupings and regroupings of the similarities found in the texts, in order to "[...] answer the central question of proposed research", that is, what are the contributions of neuroscience to teaching and learning in the context of teacher training? It is considered that the integrative review was presented as a methodological resource that enabled the systematization of the scientific knowledge theoretically developed in the analyzed texts, as well as the identification of new perspectives for future research, as stated by Botelho (et al., 2011). Thus, research of different methodologies and approaches was analyzed, prioritizing works with a qualitative approach.

Initially, inclusion and exclusion criteria were established, delimiting types of research,

languages and thematic relevance, which guided the selection of material. A systematic search of academic productions books, scientific articles, dissertations and theses was carried out in databases such as SciELO, Google Scholar and institutional repositories. As exclusion criteria, repeated materials, publications without scientific rigor, unreliable websites, Wikipedia, ongoing research, among others, were not used. The stages of identification, screening, eligibility and inclusion of the studies were followed: identification through the initial survey in the selected databases; screening with exclusion of duplicate texts from the reading of titles and abstracts; eligibility upon complete reading to verify alignment with the research problem; and, finally, the inclusion of texts that met all the defined criteria, composing the corpus of integrative analysis. The analysis of the institutional documents (Pedagogical Project of the Pedagogy Course) of the two investigated institutions – University of Brasília (UnB) and Federal University of Piauí (UFPI) – was also carried out, which enabled the development of this text in sections that deal with the foundations and contributions of neuroscience to teaching and learning, from the perspectives of different theorists, researchers in the area; the analysis of the Institutional Development Projects (PDI), based on the curriculum of the initial training courses of the Pedagogy course of the public institutions mentioned.

2 FUNDAMENTALS OF NEUROSCIENCE

Neuroscience, as an interdisciplinary field, is dedicated to the study of the nervous system and its relationships with human behavior, learning, and development (Lent, 2017). Its advances have enabled a deeper understanding of cognitive, emotional and social processes, contributing significantly to the educational field, by showing how the brain processes information, builds knowledge and responds to environmental stimuli. In this way, neuroscience expands the possibilities of reflection on contemporary pedagogical practices (Cosenza; Guerra, 2011). One of the central concepts of this field is brain plasticity, which refers to the brain's ability to reorganize its structures and functions in response to lived experiences (Relvas, 2016; Lent, 2017). This characteristic indicates that learning is not a static process, but dynamic and continuous, being strongly influenced by the interactions of the subject with the environment. Thus, knowledge is not simply transmitted, but built from experience, interaction and social mediation.

In this sense, environments rich in cognitive, social, and emotional stimuli favor the formation and strengthening of neural connections, contributing to the development of complex skills, such as critical thinking, problem-solving, and self-regulation (Cosenza; Guerra, 2011). On the other hand, contexts marked by prolonged stress, absence of stimuli or impoverished

relationships can negatively impact brain functioning, interfering in learning and development processes (Damásio, 2012).

The neuroscientific literature also highlights the close relationship between cognition and emotion. As Damásio (2012) argues, emotional processes are inseparable from cognitive processes, playing a fundamental role in decision-making, memory and learning. This perspective breaks with traditional conceptions that dissociated reason and emotion, reinforcing the need for pedagogical practices that consider the subject in its entirety.

Another relevant aspect refers to the importance of social interactions in the construction of knowledge. The human brain is essentially social, being shaped by the relationships established throughout life. In this context, language, pedagogical mediation and the bond between teacher and student play a central role in the learning process (Vygotsky, 2007). Learning, therefore, occurs in contexts of interaction, in which the subject culturally appropriates knowledge.

In addition, contemporary studies show the relevance of executive functions, such as working memory, inhibitory control, and cognitive flexibility, in the development of learning (Diamond, 2013). These skills are fundamental for planning, the organization of thought and the regulation of behavior, and are directly influenced by educational experiences. Thus, pedagogical practices that stimulate these functions contribute to the formation of more autonomous and critical subjects.

However, it is important to highlight that the approximation between neuroscience and education must occur in a critical and reasoned way. As Howard-Jones (2014) warns, the inadequate interpretation of neuroscientific concepts can lead to the dissemination of neuromyths⁶, which simplify or distort concepts about the functioning of the brain. Thus, understanding the foundations of neuroscience implies recognizing the complexity of learning and development processes, as well as the importance of experiences, emotions, and social interactions in the construction of knowledge. This understanding is essential for the elaboration of more effective, critical pedagogical practices aligned with the demands of contemporary education.

2.1 EMOTION, COGNITION AND LEARNING

Furthermore, if emotion, cognition and learning are dimensions that do not operate in a dissociated way, but rather constitute a system integrated in brain functioning, this perspective

⁶ Neuromyths - are mistaken information about neuroscientific discoveries, misinterpreted and that acquire a new meaning. They cause several educational losses, such as the use of pedagogical practices without scientific proof, in addition to the waste of resources in activities without a significant return in terms of learning.

breaks with traditional conceptions that separated reason and emotion, by demonstrating that emotional processes exert a direct influence on attention, memory, decision-making and, consequently, on learning.

According to Damásio (2012), emotions play a fundamental role in the regulation of behavior and in the construction of knowledge, acting as somatic markers that guide the individual's choices and responses to experiences. In this sense, emotionally significant experiences tend to be more easily stored and retrieved, which highlights the importance of affective involvement in the learning process.

Corroborating this perspective, Cosenza and Guerra (2011) highlight that learning is favored in contexts in which the individual feels safe, motivated and emotionally engaged. Positive emotions, such as interest, curiosity, and enthusiasm, contribute to increased attention and motivation, facilitating memory consolidation. On the other hand, negative emotions, such as fear, anxiety, and excessive stress, can compromise cognitive performance, making it difficult to assimilate new content.

In the context of academic learning, the educational environment plays a central role in the mediation of emotional experiences. Teachers who understand the relationship between emotion and learning are able to create pedagogical strategies that are more sensitive to the needs of students, promoting a classroom climate that favors student engagement, participation and the construction of knowledge. Thus, the bond established between teacher and student becomes a fundamental element for the educational process. Studies in the area of Neuroscience point out that brain structures, such as the amygdala and the hippocampus, perform complementary functions in learning. While the amygdala is related to the processing of emotions, the hippocampus is directly involved in memory formation and consolidation (Lent, 2017). The interaction between these structures shows that emotionally relevant experiences tend to be more easily memorized, reinforcing the idea that emotion and cognition are inseparable.

Another piece of data to consider refers to the performance of emotions in the self-regulation of learning. According to Diamond (2013), executive functions are working memory and cognitive flexibility that are directly related to the individual's ability to manage their emotions and behaviors based on cognitive demands. In this way, the development of these skills contributes to more autonomous and effective learning. From an educational point of view, this implies recognizing that teaching is not restricted to the transmission of content, but involves the creation of physical and psychological conditions, adaptation of environments and spaces that favor the emotional and cognitive development of students. In this sense, pedagogical

practices that value listening, dialogue, empathy and active participation tend to promote more meaningful learning (Vygotsky, 2007).

To this end, it is considered relevant to incorporate neuroscience knowledge into education, which is developed critically by teachers, so that they avoid neuromyths that may hinder the correct and effective application of this knowledge. Howard-Jones (2014) warns of the risk of oversimplification and misinterpretations, which can lead to the adoption of pedagogical practices based on these neuromyths. Thus, understanding the relationship between emotion, cognition and learning implies recognizing the educational process as complex, dynamic and deeply influenced by emotional experiences. This understanding, together with the teacher/mediator's understanding of the process of integral development of students, contributes to the construction of more effective, sensitive pedagogical practices aligned with the demands of contemporary education, enabling a better performance of the teacher.

2.1.1 Neurosciences: executive functions and learning

According to Diamond (2013), executive functions constitute a set of high-order cognitive skills, responsible for the control, regulation and organization of human behavior, and are fundamental for learning processes. These functions allow the educator to plan actions, maintain attentional focus, control impulses, solve problems and adapt to different situations, playing a central action in academic performance, contributing to the construction of complex competencies. These executive functions can be organized into three main components: working memory – the ability to hold and manipulate information for a short period. Essential for activities such as reading, problem-solving, and understanding instructions; inhibitory control – related to the ability to inhibit impulsive responses and stay focused on specific goals; and cognitive flexibility - the ability to switch between different tasks or perspectives, adapting to new demands.

In the field of Neuroscience, these functions are associated with the prefrontal cortex (a region of the brain responsible for planning, decision-making, and behavior regulation). These functions develop gradually, being highly influenced by experiences. In this sense, it is essential that students seek educational environments that stimulate complex competencies (Lent, 2017). Studies indicate, like Cosenza; Guerra (2011), that executive functions are closely related to learning processes, since they directly influence attention, the organization of thought and the ability to solve problems. Students with well-developed executive functions tend to have

greater autonomy, better academic performance, and a greater ability to deal with cognitive challenges.

Another relevant issue refers to the relationship between executive functions and emotional regulation. As Damásio (2012) and Diamond (2013) point out, the ability to control impulses and manage emotions is directly associated with the functioning of cognitive skills. From the educational point of view, it is relevant to understand the execution of executive functions, which implies recognizing that the teaching and learning process must go beyond the transmission of content, incorporating strategies that favor the development of these skills. Pedagogical practices that stimulate problem solving, critical thinking, task organization, and self-regulation contribute significantly to the strengthening of executive functions (Vygotsky, 2007).

In this context, the teacher needs to act as a mediator of the teaching and learning process, favoring the construction of knowledge and knowledge in a way that promotes meaningful learning⁷. In relation to knowledge, Tardif (2002) states that teaching knowledge is built in practice/in execution activities, which reinforces the need for training that includes updated scientific knowledge about cognitive functioning, made possible by the study and understanding of Neuroscience.

By planning pedagogical interventions that consider the development of executive functions, the teacher/mediator of the learning process favors the construction of knowledge in a more significant way. As Tardif (2002) points out, teaching knowledge is built in practice, which reinforces the need for training that includes up-to-date scientific knowledge about cognitive functioning. However, it is important to emphasize that the application of neuroscience knowledge in education must occur in a critical and reasoned way. The teacher's care in seeking specific knowledge in this area is emphasized, avoiding what authors such as Dekker (et al., 2012) highlight, who evidence the presence of neuromyths in the educational context, and the fact that these compromise the effectiveness of pedagogical practices, which reinforces the need for teachers to learn about neuroscience, and it is essential that teacher training policies be developed that contemplate this area.

Thus, understanding executive functions in the context of learning implies recognizing the complexity of cognitive development and the importance of teachers' knowledge of neuroscience so that they can develop intentional pedagogical practices, and become capable of promoting not only the acquisition of content, but the development of essential skills for the

⁷ Meaningful learning is a theory proposed by David Paul Ausubel, stating that it is not done through memorization, accumulation of information, but by incorporating new content, information to existing cognitive structures.

construction of autonomy and critical thinking. This understanding reinforces the need for teacher training based on scientific evidence, aligned with the demands of contemporary education, as well as the use of disciplines in training courses focused on neuroscience and the teaching and learning process.

3 CONTRIBUTIONS OF NEUROSCIENCE TO TEACHING AND LEARNING: THEORETICAL PERSPECTIVES ON TEACHER TRAINING IN PEDAGOGY

The Brazilian legislation that deals with the initial training of teachers (licentiates) is undergoing significant changes, with a strong emphasis on the inclusion of scientific evidence, which opens space for neuroscience applied to education. In this study, Resolution No. 4, of May 29, 2024, of the National Council of Education (CNE), which defines the National Curriculum Guidelines (DCNs) for the initial training of basic education teachers, stands out. However, it is observed that there is no precise orientation for the development of a curriculum focused on neuroscience, through specific disciplines:

Paragraph 2 - The exercise of teaching is understood as an educational action, based on the conduction of intentional and methodical pedagogical processes, which are based on knowledge and concepts specific to teaching and the specificities of different areas of knowledge, including the mastery and management of contents and methodologies, different languages, technologies, scientific evidence and innovations.

Neuroscience emerges as an interdisciplinary field, dedicated to the study of the nervous system integrated with man's behavioral relations (ontological⁸), involving learning and cognitive development. According to Lent (2017), the human brain has remarkable neural plasticity, which consists of the ability to modify its connections and restructure new experiences, enabling the development of cognitive, emotional, and social skills. It is observed that it is in early childhood (a period from birth to 6 (six) years of age) that maturation, adequate stimulation, affective bonding, meaningful experiences, and direct influence on the formation of the neurological bases of learning occur, which does not limit these capacities in other phases of human development (Relvas, 2022). In this way, this knowledge contributes to teachers being able, during their training, to understand and apply Neuroscience for the development and quality of interactions, in a specific way, family and school, which determines the strengthening of functions such as attention, memory, language and self-regulation. Scholars corroborate with

⁸ The term is related to ontology, from the Greek *ontos*, which means "to be" and *logos*, which means "study". The word designates the field of metaphysics that studies the nature of existence and reality itself. Ontology studies the nature of being and the relationship between mind and body (dic. Online).

information about the need to seek knowledge of Neuroscience, such as Damásio (2012), who states that studies on the understanding of brain functioning are knowledge that allows teachers to get closer, in a more concrete way, to educational needs. However, this knowledge can be misinterpreted if it is not in the context of a teacher training course, both initial and in continuing education.

This process of intermediation, in which the teacher recognizes himself as a mediator of the teaching and learning process, enables his performance in class and the expansion/adaptation of Neuroscience to the students' learning, respecting their maturation rhythms and expanding the possibilities of learning, regardless of the age of their student. Therefore, Neuroscience and Education are areas that, when integrated, will enable improvements in pedagogical practices, providing scientific subsidies that enable critical guidance on how the teacher can develop interventions in a more humanized and effective way. Thus, integrating neuroscientific knowledge into pedagogical practices represents a great advance, in view of the integral development of the human being in its affective, psychological, cognitive, social dimensions, among others, enabling school inclusion.

In this sense, it is necessary for the teacher to know the nature/differences and singularities of the student as a human being. Antunes (2011, p. 15) warns the teacher about the danger of standardizing "the billions of neurons and synapses" ignoring "the essence of the human being, his extraordinary uniqueness". Knowledge about Neuroscience enables teachers to develop in their classes the possibilities that this integration with education offers. It is considered that they will be able to develop new practices in a differentiated way, providing opportunities for better quality teaching and learning. Pedagogical practices need to be based on research, evidence, integrating cognitive and socio-emotional aspects.

Sá, Narciso and Fumiã (2020), state that through brain imaging and analysis of electrical signals, it is possible to study how brain injuries or changes affect cognition, allowing a better understanding of the mechanisms that support learning. Recognizing neuroscience enables the teacher's actions to be more inclusive, which seeks to involve the student in its entirety, in its psychological, cognitive, behavioral and learning dimensions.

Knowledge of neuroscience implies recognizing that "the learning of formal knowledge depends on the formation of new long-term memories and the expansion of existing memories" (Lima, 2017, p. 6), in this way effective, meaningful learning, which starts from the consolidation of knowledge, occurs from memory processes. In this sense, the education professional needs knowledge of Neuroscience, for the elaboration of their academic and professional activities, to contribute effectively to the teaching and learning process, considering that, according to

Cosenza and Guerra, (2011, p. 76),

[...] Neuroscience has shown that cognitive and emotional processes are deeply intertwined in the functioning of the brain and has made it evident that emotions are important for the most appropriate behavior for survival to be selected at important moments in the lives of individuals.

Likewise, it is from the understanding of the need to integrate teacher education/training with Neuroscience that the teaching process can be expanded, providing the teacher with the opportunity to develop more inclusive, innovative and diversified practices, favoring student learning in all its dimensions. Thus, there is a context of transformations that have occurred in the educational field, which are mainly caused by the globalization of the economy and the productive restructuring of capital, which imposes reflections on the role of the teacher in contemporary times, facing numerous difficulties in relation to their practices, educational innovation and especially in combining these factors with human formation, political, cultural and social.

It is relevant to highlight the initial and continuing education of the teachers who are present, related to the personal and professional development of these subjects, as well as to their knowledge and knowledge (Nóvoa, 1992; Tardif, 2002). These processes contribute to the theoretical-methodological discussions based on the construction of concepts related to initial and continuing education, making it necessary to understand the educational institution as a space for the construction and training of teachers, for the improvement of pedagogical practice. In terms of training and professional practice, what characterizes the mediator teacher is the recognition not as the owner of knowledge (the mastery of a discipline), but as a facilitator/mediator of a set of knowledge, which can be called teaching knowledge (Tardif, 2002). The author also considers that in terms of training and professional practice, knowledge integrated with the practices related to teaching is necessary. In this sense, the teacher's job will imply a "know-how" that can provide opportunities for learning the knowledge/contents that are present in the curricular guidelines, in addition to others. In this sense, it is considered essential that teachers acquire neuroscientific knowledge, and that these are considered "teaching knowledge" present in the curriculum of teacher training courses (Tardif, 2002).

For Giroux (1992), teacher training needs to be structured in such a way that students/future teachers can have learning built from autonomy in the formulation and resolution of problems about the current reality, the principles underlying different pedagogical methods, the themes and investigative procedures and the educational theories, in a way that is contextualized to the reality in which they are inserted, to the educational institution in which

he/she studies and/or works. In this direction, it is necessary to seek teacher training processes in which schools are conceived as essential institutions for the development of a truly critical, inclusive and creative democracy in the process of activities that seek the knowledge of Neuroscience, and also for the training of teachers who recognize themselves as intellectuals who integrate reflection and practice at the service of education in general and the teaching and learning of the specific knowledge of each discipline. Thus, initial and continuing education will enable the construction of professional identity in a reflective and critical way (Giroux, 1997).

3.1 TEACHER TRAINING BASED ON NEUROSCIENTIFIC EVIDENCE

The relationship between science and education should not be understood as a direct and linear application of neuroscientific knowledge to pedagogical practice. As Tokuhama-Espinosa (2011, p. 6) argues, "Mind, Brain, and Education Science is an interdisciplinary field that combines neuroscience, psychology, and education to better understand learning, recognizing that none of these areas, in isolation, is capable of explaining it."

In this sense, teacher training cannot be restricted to the transmission of traditional pedagogical content, but must contemplate the understanding of brain functioning, the biological bases of learning and the relationship between cognition, emotion and behavior. As highlighted by Cosenza and Guerra (2011), knowing how the brain learns enables the teacher to plan more effective pedagogical interventions, aligned with the needs of students and the natural learning processes. Understood as a continuous and reflective process, Imbernón (2011) highlights that continuing education is essential for teachers to be able to keep up with social and scientific changes, developing skills that allow them to act in a critical and innovative way.

The teacher is a professional who has diverse knowledge. For this reason, this knowledge is part of the multiplicity of his work, which as a professional who works in different situations needs to act in a differentiated way, mobilizing different theories, methodologies, skills. As stated by Tardif (2011, p. 118) "The knowledge of teachers is plural, heterogeneous, because it involves, in the very exercise of work, very diverse knowledge and know-how, coming from varied sources and, probably, of a different nature". For the author, teaching knowledge is built in practice, being the result of the articulation between theoretical and practical knowledge.

In view of this interrelation, this process leads to the concept of reflective teacher, proposed by Schön (2000), in which it is necessary that this theoretical-practical relationship be carried out from praxis (action-reflection-action, reflection on and in practice). The reflective teacher capable of analyzing his practice, questioning his actions and reconstructing his pedagogical strategies based on critical reflection, by incorporating knowledge from

neuroscience, this teacher expands his ability to understand the learning processes and to develop his reflections from this knowledge - enabling more effective interventions. This reflection based on neuroscience enables a guiding knowledge of the reflected practice. Therefore, training based on neuroscientific evidence implies recognizing the importance of emotional dimensions in the educational process.

As Damásio (2012) argues, emotion and cognition are inseparable, and it is essential that the teacher understands how emotional factors influence learning. In this sense, pedagogical practices that promote emotional safety, motivation, and engagement tend to favor academic performance. The sociocultural perspective of learning also contributes to the understanding of teacher training. Vygotsky (2007) highlights that knowledge is constructed through social interactions, and pedagogical mediation is a central element in this process.

3.2 INTEGRATION OF NEUROSCIENCE INTO TEACHING AND LEARNING: BUILDING PEDAGOGICAL PRAXIS

The integration between the areas of Neuroscience and Education is an expanding field, marked by significant possibilities, but also by theoretical and methodological challenges, which requires inserting in an institutionalized way the disciplines focused on the learning of neurosciences, their advances in relation to learning processes, their transposition to the educational context, among other issues that require a critical and reasoned approach, avoiding simplifications and misinterpretations (Howard-Jones, 2014). It is noteworthy that this integration requires the teacher to understand Imbernón's (2011) perspective on teaching being a dynamic practice in constant transformation, influenced by social, political and technological changes. In this context, critical reflection becomes essential for teachers to adapt to new demands and reorganize their performance in the face of contemporary challenges.

Zeichner (1993) emphasizes that critical reflection must go beyond individual experience, assuming a social and collective dimension. Thus, teachers need to analyze not only their practices in the classroom, but also the mission of educational institutions in maintaining or overcoming social inequalities, expanding the scope of reflection and linking it to the ethical commitment of the teaching profession. Alarcão (2018) states that reflecting on practice contributes to the consolidation of the teacher's professional identity.

In this study, we have the understanding of Nóvoa (1992) when he states that teacher training should be understood as a continuous process, in which critical reflection occupies a central position. For the author, professional development is directly related to the need for teachers to be able to analyze their practice, identify limitations and envision possibilities for

innovation, making reflection an essential element for teacher autonomy and emancipation, so that this practice is transformed into praxis. Perrenoud (2000) corroborates these statements when arguing about the teacher's professional competence, considering that it goes beyond the application of pedagogical techniques, involving the ability to make informed decisions in complex contexts. According to the author, this competence is developed through a constant reflective posture, which allows the teacher to interpret and respond critically to educational demands. Tardif (2011, 2022) reinforces that teaching knowledge is built in practice, and critical reflection is indispensable to make it conscious and organized.

In this sense, the reflective/critical practice enables the transformation of experience into pedagogical knowledge, contributing to the strengthening of professional identity and to the social recognition of teaching. In this sense, it is reinforced that Neuroscience needs to be present in this process of teacher learning about the understanding and influence of brain anatomical substrates and their mechanisms, such as the neurophysiological mechanisms of behavior, for a greater understanding of the causes of students' non-learning, being able to create the conditions that make it possible to overcome learning difficulties. Bearing in mind that one of the biggest concerns of the contemporary teacher is how to enable the student to learn effectively. Neuroscience offers contributions, enhancing the teacher's action, enabling from this knowledge to understand how to act in their praxis, based on evidence about the singularities of students, recognizing them as a unique and capable human being, developing a better understanding of the structure of the brain, considering that "The teacher's function is to enhance the brains in the classroom" (Relvas, 2017, p.1). From Neuroscience, it is understood that there are no people who do not learn, in the understanding that at a scientific level, the brain develops and changes throughout life (Carvalho, 2016). This understanding enables the teacher to seek ways to mediate this learning with teaching/mediation that effectively meets the student's capacity.

4 NEUROSCIENCE IN THE CONTEXT OF TEACHER TRAINING IN PEDAGOGY

Given the importance of Neuroscience and its contributions to the teaching and learning process of children, it is relevant to analyze the role of this knowledge in the context of the Pedagogical Project of the Pedagogy Course. From the point of view of scientific evidence, it can be said that the study of Neuroscience is essential for the training of Pedagogy teachers, as it provides the biological basis of how the brain learns and how knowledge is built. The evidence found in theoretical research has shown that neuroscience allows educators to deepen their knowledge, being able to create and adopt more effective pedagogical strategies.

In other words, knowledge about brain development allows the understanding of the functioning of emotions, creativity and memory, which helps to improve didactic transposition, focusing on attention, concentration, curiosity and interaction.

In this sense, with a view to offering better training to educators of children, shouldn't the curriculum of Pedagogy courses present Neuroscience as an indispensable component? And what about the main legislation and official documents that deal with the training of these educators, do such documentation contemplate the knowledge provided by neuroscience?

It is worth highlighting the emphasis made in this study, on the legislation and determinations regarding initial training in teaching degree courses, updated through Resolution CNE/CP No. 4 of May 29, 2024, which provides for the National Curriculum Guidelines for Initial Training at Higher Education for Teaching Professionals in Basic School Education. In its Article 1, paragraph 1, the Resolution presents its objectives by highlighting the importance of:

[...] promote the advancement of public education policies, in line with the goals of the National Education Plan - PNE, manifesting organicity between its Institutional Development Plan - PDI, its Institutional Pedagogical Project - PPI and its Course Pedagogical Project - PPC. (Brazil, CNE/CP Resolution No. 4, 2024).

Article 2, paragraph 1, of the Resolution determines that:

The initial training of teaching professionals referred to in the **caput** must ensure a broad and contextualized understanding of school education, aiming to ensure the production and dissemination of knowledge in a given area and participation in the elaboration and implementation of the pedagogical proposal of Basic Education institutions, with **the purpose of guaranteeing the rights and objectives of learning and development of students**, the democratic management of the school and education systems and the institutional evaluation processes aimed at the continuous improvement of the quality of the educational offer. (Brazil, CNE/CP Resolution No. 4, 2024 – emphasis added).

According to the article, when it emphasizes the rights and objectives of learning and development of students, tacitly, the legislation assumes the responsibility of offering teacher training based on neuroeducation. This training needs to promote the understanding of how the brain learns, reacts to stimuli and develops skills. To this end, it should present a proposal for theoretical and methodological training based on scientific evidence, deepening knowledge about the cognitive and emotional development of children, and studies on attention, memory and brain plasticity applied to teaching. This statement becomes even clearer in § 3 of the same Article 2, when it determines that the training of Basic Education teaching professionals shall:

[...] to consider the **integrality of the subject in formation** and of the educational phenomenon itself, articulating the scientific, aesthetic, technical and ethical-political dimensions inherent to the pedagogical processes. And this requires an education that, while assuming the responsibility of respecting the integrality of the student, teacher in training, offers subsidies so that this subject can understand, scientifically, not only the teaching process, but also how the child's brain works and learns.

Paragraph 2 of the same article warns again about:

the understanding of the exercise of teaching as an educational action, based on the conduction of intentional and methodical pedagogical processes, which **are based on knowledge and concepts specific to teaching and the specificities of different areas of knowledge**, including the mastery and management of contents and methodologies, different languages, technologies, scientific evidence and innovations. (Brazil, CNE/CP Resolution No. 4, 2024 – emphasis added).

From this understanding, the thought of Santos and Coutinho (2024, p. 26) stands out, "Neuroscience is a vast and interdisciplinary field that studies the nervous system, including the brain, spinal cord, and nerves". This interdisciplinary aspect deserves to be highlighted when thinking about neuroscience applied to education, since this study intends to demonstrate that the legislation itself requires that teacher training has access to knowledge and concepts from different areas of knowledge.

The need for this knowledge is understood when it is observed that the analysis of studies on neuroscience demonstrates that the teacher must understand how the nervous system works, which has repercussions on learning about: brain plasticity (the brain's ability to adapt and reorganize itself throughout life in response to experiences, injuries or environmental changes); functional modularity (the way the brain is organized into specialized modules that are responsible for specific functions, such as vision, hearing, movement, language, emotion, memory, among others); synaptic plasticity (that synapses can be strengthened or weakened based on neuronal activity, a fundamental process for learning and memory); and neural hierarchy (that the brain is organized into different levels of processing, from individual neurons to distributed neural networks, which work in an integrated way to produce behavior and cognition); among other knowledge.

In Article 4, Paragraph II, Resolution No. 4, highlights that Pedagogy and Teaching Degree Courses must present:

[...] solid training that provides knowledge of the epistemological, technical and ethical-political foundations of the sciences of education and learning and that allows the future professional of teaching to develop the skills of analysis and reflection on educational

practices and on the progression and processes of learning and the constant improvement of their work skills.

To know about the progression and learning processes, according to the cited article, the teacher in training needs to study about human development. Without knowledge in this area, there is no way to understand children's learning as a subjective and multifaceted process. Based on the above, the analysis of the Pedagogical Projects of the Pedagogy courses of the University of Brasília (UnB) and the Federal University of Piauí (UFPI) is presented, selected, having the following criteria: being federal public universities located in the cities of residence and work of the researchers (Brasília/DF and Teresina/PI). The following table is observed:

Table 1

Survey of Disciplines that Work on Neuroscience-Related Contents

UNIVERSITIES	MANDATORY CURRICULAR COMPONENTS THAT INCLUDE KNOWLEDGE OF NEUROSCIENCE/C.H
FEDERAL UNIVERSITY OF PIAUÍ – UFPI	Educational Psychology I – 60h Educational Psychology II – 60h Fundamentals of Early Childhood Education – 60h Fundamentals of Special Education – 60h Didactics of Early Childhood Education – 60h Body language and movement – 60h
FEDERAL UNIVERSITY OF BRASÍLIA - UNB	Educational Psychology - 60h Childhood, Children and Education - 60h Inclusive Education - 60h Early Childhood Education - 60h

Source: PPCs of UFPI and UnB, 2026.

In relation to the picture, it is observed that the discipline of Educational Psychology is present in the Project of the two institutions, and at UFPI there is a broader workload - 120 hours developed in two moments I and II. **Educational Psychology I** at UFPI, presents the following work proposal: "SUMMARY: Psychological science; Psychology and Education; constitution of subjectivity; subjectivity and transversal themes" (PPC Pedagogy/UFPI, 2018, p. 81); as for **Educational Psychology II** – "SUMMARY: Human development and school learning. Theories of development and learning. Cross-cutting themes in Educational Psychology" (PPC Pedagogy/UFPI, 20218, p. 85).

This discipline **Educational Psychology**, common to both courses, is presented in the Pedagogical Political Project of the Pedagogy Course – Daytime at UnB, with a workload of 60 hours and the following Proposal:

Summary: Studies that articulate Psychology with Education. Main theories of Psychology, their implications and foundation for the analysis of teaching/learning

processes. Conceptions of human development in its relationship with educational processes. Processes of subjectivation in contemporary societies and in the scenario of Brazilian education (PPC Pedagogia/UnB, 2018, p. 66-67).

In view of the above, in the table, it is observed that only the discipline Educational Psychology has the same name, and the others are correlated and that allow the teacher to work neuroscientific knowledge in a random way, without a proven systematization, even enabling the incidence of "neuromyths". It is noteworthy that when searching for knowledge related to Neuroscience in the Pedagogical Projects of the Pedagogy Courses of the two institutions, it was not found, in a specific way, the teaching on this theme in the disciplines present in the analysis framework, although the syllabuses allow the teacher to insert the knowledge of Neuroscience. A direct approach to the study of Neuroscience was also searched by means of keywords, as well as in the references in the syllabus of each discipline, but none of these references dealt specifically with the subject.

As for the disciplines related to Early Childhood Education, the UFPI curriculum brings the disciplines **Fundamentals of Early Childhood Education** (60 h) and **Didactics of Early Childhood Education** (60 h), while UnB brings the discipline **Early Childhood Education** (60 h) and **Childhood, Child and Education** (60 h).

At UFPI, the discipline **Fundamentals of Early Childhood Education** has the following syllabus: Early childhood education: historical, legal and pedagogical aspects. Child development: moral, cognitive, affective and motor aspects. Drawing, game and toy in Early Childhood Education. In the discipline **Didactics of Early Childhood Education**, the syllabus presents the following contents: Caring and Educating, Interactions and Play: the role of the teacher in early childhood education. Curriculum: Fields of Experience and areas of knowledge – Languages, Human Sciences, Mathematics and Natural Sciences. Organization of pedagogical work in Early Childhood Education: objectives, contents, methodologies, evaluation and practices. In these disciplines, it is observed that, only when dealing with child development in its cognitive, affective and motor aspects, in the discipline **Fundamentals of Early Childhood Education**, there is a concern with deepening the discussion about how the child develops.

At UnB, the **Early Childhood Education discipline** has the following syllabus: Public policies, history and foundations of early childhood education. The quality of early childhood education. The inseparability between caring and educating. Pedagogical proposal, Curriculum and the multiple languages of the child, monitoring and evaluation of the pedagogical process. Pedagogical Documentation. Management and inclusion. In other words, the discipline does

not deal with knowledge related to the study of the human brain and any other related to Neuroscience.

Also at UnB, the discipline Childhood, Child and Education has the following syllabus: Study on the historical, sociological and psychological conceptions of childhood and child. Culture and understanding of the uniqueness of the subjects of learning. The relationship between the processes of learning and human development in a cultural-historical perspective. The meaning of meaningful learning experiences in infants and children: between psychomotor and language aspects. Imagination and fantasies, the false dichotomy of caring-educating and the concept of fields of experience. Inclusion Processes in Early Childhood Education: challenges and perspectives. The experience of the Early Education Program. In this discipline, the presence of contents related to Neuroscience is observed, such as: the study of psychological conceptions of childhood and child, the uniqueness of the subjects of learning, the meaning of significant learning experiences in babies and children, among others.

UFPI also brings the discipline **Language body and movement**, whose menu explores the themes: the process of human development: body, gestures and movements. The relationship between culture, body and movement. Body culture: games, dances, fights and sports. Body activities at school. This discipline deals with psychomotor aspects that are also explored in neuroscience.

And, finally, with regard to Special and Inclusive Education, UFPI brings the discipline **Fundamentals of Special Education** (60 h) and UnB brings the discipline **Inclusive Education** (60 h). The UFPI discipline has the following syllabus: Principles of special and inclusive education. Historical foundations. Legislation and general structure. The special education student. Current perspectives of care. Disability/abilities/potentialities. Socio-educational inclusion. At UnB, the syllabus of the Inclusive Education discipline has as themes: Reflection on education, school and the other with disabilities, considering the historical, socio-political and cultural scope, aiming to understand and problematize the concept of inclusive education. Legal foundation on educational policies in this context, in order to foster educational premises, programs and support systems for people with disabilities, recognized from the sphere of human rights. Characterization of different alterities and teacher training of education professionals and their role in the face of diversity and difference. Study of the interdisciplinary aspects between the fields of health and education. In these two disciplines, in a diluted way, some knowledge inherent to Neuroscience is explored when dealing with the development of neurodivergent children, seeking to bring the discussion to the fields of health and education.

5 FINAL CONSIDERATIONS

This brief analysis demonstrates that, although contemporary studies recognize the relevance of Neuroscience in the curricula of teacher training courses, there is still no discipline that effectively works with this knowledge, integrating Neuroscience with teaching and learning. In view of the gap evidenced in the curricular matrices and in the syllabus of the disciplines of the Pedagogy courses analyzed, it is necessary to include a discipline directly focused on Neuroscience.

Knowledge of Neuroscience becomes fundamental, since it enables teachers to know the functioning of the brain and its influence on the teaching and learning process. As already highlighted, by unraveling how the brain learns, neuroscience allows educators to create more effective, personalized, and inclusive pedagogical strategies. It transforms teaching practice by basing teaching on neurological functioning (attention, memory, emotion), helping to overcome learning difficulties and optimize student engagement.

Understanding brain plasticity and that the brain is moldable enables the teacher to believe in the development potential of all students, reinforcing their role as a mediator. By highlighting the role of emotions (limbic system/amygdala) in motivation and knowledge retention, the educator begins to recognize that positive emotions facilitate learning, while excessive stress blocks it. In other words, the analysis developed in this study allowed us to understand that the articulation between Neuroscience and Education promotes the improvement of teaching and learning, enabling the mediation of the teacher in these processes, in a conscious way and based on scientific evidence. In this sense, it is considered that this study will promote reflections/discussions on the role of Neuroscience in the context of teacher training courses. The results of the analysis of the documents show that Neuroscience is not included as a curricular component. However, the courses have some disciplines that have relationships, similarities or complementary contents to the knowledge worked by Neuroscience.

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