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LEARNING, AUTONOMY AND EMANCIPATION: DIALOGUES BETWEEN FREIREAN PEDAGOGY AND DEHAENIAN NEUROSCIENCE?

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ABSTRACT

In this article, we aimed to discuss the possibilities for the contributions of Dehaene (2022) and Freire (2006) to complement each other in the construction of pedagogical practices that are both effective, from a neuroscientific point of view, and emancipating, from a social point of view, promoting active, meaningful, and transformative learning. To this end, we carried out this study based on a qualitative approach and guided by the comparative method. As a result, taking into account the complementarities, convergences and distances, we consider that Freire's and Dehaenian theories can complement each other in the construction of pedagogical practices that are simultaneously effective from a neuroscientific point of view and emancipatory from a social point of view by integrating approaches that value both cognitive processes and the sociocultural and political aspects of learning. This enables the development of methodologies that promote both the development of critical awareness and the neuroscientific effectiveness of learning, such as interdisciplinary projects, active methodologies and formative evaluations that value error as part of the process of knowledge construction.

Keywords: Neuroscience. Critical pedagogy. Autonomy. Apprenticeship.

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INTRODUCTION

In this article, we carry out a movement of dialogue between Paulo Freire and Stanislas Dehaene based on the works "Pedagogy of Autonomy: necessary knowledge for educational practice", by the first author, and "This is how we learn: why the brain works better than any machine (yet...)", by the second author.

The understanding of what we call "learning" has been the object of study in both the cognitive sciences and Critical Pedagogy, and, although they start from different perspectives, these fields present points of convergence that can be significant for the advancement of Education. Therefore, it becomes necessary and important to know how neuroscientific approaches converge with historical, sociological, political, and pedagogical aspects of Education, in this case, how the theoretical conceptions of Freire (2006) and Dehaene (2022) talk to each other.

Regarding the fields of study of the authors that we brought to establish a dialogue, Stanislas Dehaene is a French cognitive neuroscientist, who investigates how the brain learns, highlighting the importance of attention, engagement, error and interaction in the process of acquiring knowledge. And, as far as Paulo Freire is concerned, he was an important Brazilian pedagogue and philosopher, who proposes a critical and liberating approach, through which learning takes place through dialogue, problematization and collective construction of knowledge.

In this context, the attempt to establish a dialogue between Paulo Freire (2006) and Stanislas Dehaene (2022) is justified by the need to investigate possible complementarities of their approaches to education and learning, given the importance of the studies of both authors. Freire (2006), with his critical and humanist perspective, emphasizes the importance of dialogue, awareness and the construction of knowledge in a collaborative way, aiming to empower students and promoting an education that liberates and transforms. On the other hand, Dehaene (2022) brings a neuroscience-based perspective, offering *insights* into the cognitive mechanisms that underpin learning, exploring how the brain processes information and what pedagogical practices can optimize this process.

Thus, when dealing with the ideas of these two authors, we can reflect on an educational approach that not only considers the social, historical, political, and ethical dimensions of education, but also the neuroscientific bases that support them, and vice versa. In this way, such dialogue enables the enrichment of pedagogical practices, in addition to enabling educators to adopt methods that respect both the emotional, political

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and social aspects of learning and the neurobiological foundations. With this, with the combination of Freire's (2006) and Dehaene's (2022) views, we seek to encourage the search for a more integrated education, which seeks to develop the potential of students, respecting their individualities and contexts.

In this scenario, we emphasize that the search for dialogue between the theories of these two thinkers can allow us a more comprehensive view of Education, uniting neuroscientific discoveries about brain mechanisms with an ethical and political perspective of the construction of knowledge. And it was based on this understanding that, in this article, we aimed to discuss the possibilities for the contributions of Dehaene (2022) and Freire (2006) to complement each other in the construction of pedagogical practices that are both effective, from a neuroscientific point of view, and emancipatory, from a social point of view, promoting active, meaningful, and transformative learning.

Regarding the organization of this study, it was as follows: in the following section we discuss the theoretical assumptions of the qualitative approach research and the comparative method, as well as describe the operationalization of the study; in section three, we present the main propositions and, consequently, the main ideas discussed by Freire (2006) and Dehaene (2022) in their respective works; In section four, we carry out the discussions resulting from the analysis of the two works. And, finally, we end with some considerations and reflections.

METHODOLOGY

As already highlighted, in this research we seek to establish a dialogue between Paulo Freire and Stanislas Dehaene based on the works "Pedagogy of Autonomy: necessary knowledge for educational practice", by the first author, and "This is how we learn: why the brain works better than any machine (yet...)", by the second author. In this sense, we carried out this study based on a qualitative approach, as we are concerned with the understanding of a level of reality that cannot be reduced to quantifications, so that we stick to a universe of meanings, values, ideas, habits and other phenomena that constitute social reality (Minayo, 2007).

Still on qualitative research, Ghedin and Franco (2011) emphasize that, in it, the researcher gradually passes, in the evolution of the investigation, from object to subject, because qualitative research will focus on the discovery of this subject, on its understanding, it will seek its collaboration, become its partner. Thus, the authors maintain

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that through qualitative research, the serious, committed, constant look of the researchers on everyday life certainly allows them to free their thinking from many supposed reasonings and to face realities that are never suspected, although always present.

As far as the method is concerned, we have taken the comparative method as a basis. In this sense, Schneider and Schmitt (1998) highlight that comparison is an essential cognitive process for the construction of knowledge, as it allows establishing connections and understanding the relationships between different phenomena or objects. Thus, far from being just an instrument to identify similarities and differences, comparison makes it possible to discover patterns, general principles and even ideological conceptions that influence the object of study.

In addition, the authors emphasize that this practice allows the researcher to abstract and expand his understanding, achieving a more comprehensive view of the dynamics and processes that involve a certain phenomenon, enabling the observation of displacements and transformations, the comparison is not limited to capturing fixed aspects of reality, but also evidences changes and continuities over time.

In any case, the essence of the comparative method lies in the explanatory analysis of phenomena based on their convergences and divergences, involving the comparison of events of a similar nature, inserted in different social contexts or areas of knowledge, with the purpose of identifying patterns and particularities. In this way, the comparative method not only enriches scientific investigation, but also favors more critical and in-depth interpretations of the phenomena studied (Fachin, 2006).

Regarding the operationalization of the comparative method, we read in full the two works, that is, "Pedagogy of Autonomy: necessary knowledge for educational practice", by Paulo Freire, and "This is how we learn: why the brain works better than any machine (yet...)", by Stanislas Dehaene. In this way, we sought to carry out a careful discussion of the two works, which allowed us to identify complementarities, convergences and distances in Freire's and Dehaenian theories.

PAULO FREIRE AND THE PEDAGOGY OF AUTONOMY & STANISLAS DEHAENE AND THE FUNDAMENTAL PILLARS OF EFFECTIVE LEARNING

Before continuing our reflections, it is important that we present the main propositions and, consequently, the main ideas discussed by Freire (2006) and Dehaene (2022). Respectively, the authors approach: a) education in a critical and reflective way,

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emphasizing the need for a constant dialogue between educator and student, arguing that this education should be an act of freedom and awareness, allowing individuals to become protagonists of their own learning; and b) the importance of understanding the cognitive processes involved in education, offering valuable *insights* to improve pedagogical practices (Chart 1).

Chart 1 – Main propositions in the works of Paulo Freire (2006) and Stanislas Dehaene (2022)

FREIRE **Pedagogy of Autonomy: knowledge necessary for educational practice**	**DEHAENE** **This is how we learn: why the brain works better than any machine (yet...)**
Teaching, learning and researching deal with these two moments of the gnosiological cycle: the one in which the already existing knowledge is taught and learned and the one in which the production of knowledge that does not yet exist is worked on.	When we learn, the raw data that shocks our senses turns into refined ideas, abstract enough to be reused in a new context.
I research to verify, verifying, I intervene, intervening I educate and I educate myself. I research to know what I don't know yet and communicate or announce the news.	It is the projections of the brain that ultimately make sense of the flow of data that comes to us from the senses. [...] The brain internalizes a new aspect of reality: it adjusts its circuits to appropriate something that was out of its control until then.
[...]to the school [...] to respect the knowledge with which the students, especially those from the popular classes, reach it socially constructed knowledge in community practice [...]	In fact, it is astonishing that simply by correcting mistakes, it is possible to discover a whole set of appropriate tips for the problem at hand.
There would be no creativity without the curiosity that moves us and makes us patiently impatient in front of the world we have not made, adding to it something we do.	One of the foundations of active engagement is curiosity – the desire to learn or the thirst for knowledge.
It is not possible to think of human beings even far from ethics, let alone outside of it. Being far away, or worse, out of ethics, between us, women and men, is a transgression. That is why to transform the educational experience into pure technical training is to belittle what is fundamentally human in the educational exercise: its formative character.	[...]Meta-knowledge – the ability to know ourselves, to self-evaluate, to mentally simulate what would happen if we acted in this or that way – plays a fundamental role in human learning. The opinions we form about ourselves help us to progress or, in some cases, close us in a vicious circle of failures.
To think right is to do right. [...] Part of right thinking is the taste of generosity which, while not denying those who have the right to anger, distinguishes it from unbridled anger.	Our species is the only one that shares information on its own initiative [...] in our brains, the highest-level information, the one that reaches our conscious knowledge, can be explicitly declared to others.
The prejudiced practice of race, class, gender offends the substantivity of the human being and radically denies democracy. [...] There is no intelligibility that is not communication and intercommunication and that does not merge into dialogicity.	[...] Even a nine-month-old baby can distinguish someone who intentionally commits mischief from someone who does it unintentionally, or someone who purposely refuses to help someone else from someone who has no way to help. [...] This social skill plays a key role in learning.
Critical teaching practice, which implies right thinking, involves the dynamic, dialectical movement between doing and thinking about doing.	Efficient learning does not combine with passivity; it means involvement, exploration and an activity that generates hypotheses, which will be tested in the outside world.
When I enter a classroom I must be being open to questions, curiosity, students' questions, their inhibitions; a critical and inquisitive being, restless in the face of the task I have – that of teaching and not	Motivation is essential: we only learn well if we have a clear goal and if we are completely committed to achieving it

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that of transferring knowledge.	
In fact, the incompleteness of the being or its incompletion is characteristic of the vital experience. Where there is life, there is incompleteness. But only among women and men did the incompleteness become conscious. [...] At the moment when human beings, intervening in the *medium*, were creating the *world*, [...] it was no longer possible *to exist* without *assuming* the right and the duty to choose, to decide, to fight, to do politics.	Some (brain) areas learn to criticize others: they constantly evaluate our capabilities and predict the rewards or punishments we are subject to receive.
To be in the world without making history, without being made by it, without making culture, without "treating" its presence in the world, [...] without points of view about the world, without doing science, or theology, without astonishment in the face of mystery, without learning, without teaching, without ideas of formation, without politicizing is not possible.	[...] Each region of the brain imposes its own set of demands on learning. [...] We can, of course, learn new facts, but they need to find their neuronal niche, a space of representation appropriate to their natural organization.
[...] The incompleteness of which we have become aware has made us ethical beings.	Good teachers are already fully aware of these ideas. They prove daily that the Roman saying *errare humanum est*, to err is human. With a comprehensive look they face the mistakes of the students, because they recognize that no one learns without making mistakes.
The qualities or virtues are built by us in the effort we impose on ourselves to reduce the distance between what we say and what we do.	Numerous studies, in humans and animals, confirm that stress and anxiety can drastically impair the ability to learn.
My response to the offense to education is the conscious, critical and organized political struggle against offenders.	In the face of such poor results (recent decline in the comparison of the development of children in certain parts of the world), we are sometimes quick to point the finger at teachers. [...] Whatever the cause, I am convinced that advances in the science of learning can help reverse this bad trend.
Women and men are the only beings that, socially and historically, we have become capable of apprehending.	Adopting a developmentally oriented mindset does not mean telling every child that they are the best, under the simple pretext of nurturing their self-esteem. It means, rather, drawing attention to the progress they make on a daily basis, encouraging their participation, rewarding their efforts...
My anger, my righteous anger, is based on my revolt in the face of the denial of the right to "be more" inscribed in the nature of human beings.	Only by getting to know ourselves better will we be able to make the most of powerful algorithms that rig our brains.
[...]that we have in the resistance that keeps us alive, in the *understanding* of the future as *a problem* and in the vocation to *be more* as an expression of human nature in the process of being, foundations for our *rebellion* and not for our *resignation* in the face of offenses that destroy our being.	Experts in the classroom, teachers are responsible for the precious task of educating our children, who will soon have the future of this world in their hands. Still, in general, we leave teachers with very scarce resources to accomplish this purpose. They deserve greater respect and greater investments.
The exercise of curiosity summons imagination, intuition, emotions, the ability to conjecture, to compare, in the search for the profiling of the object or the finding of its reason for being.	A few simple ideas about play, curiosity, socialization, and sleep can amplify what is already our brain's greatest talent: learning.
As a teacher, it is not possible for me to help the student to overcome his ignorance if I do not permanently overcome mine. I can't teach what I don't know.	I am deeply convinced that one cannot teach correctly without possessing, implicitly or explicitly, a balanced mental model of what goes on in the minds of learners.

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[...]The pedagogical space, neutral par excellence, is the one in which students are *trained* for apolitical practices, as if the human way of being in the world was or could be a neutral way.	While cognitive science doesn't have all the answers, we're beginning to understand that all children begin life with a similar brain architecture—a *Homo sapiens* brain, radically different from that of any other ape.
[...]As a specifically human experience, education is a form of intervention in the world.	All learners benefit from focused attention, active engagement, error *feedback*, and a cycle of daily repetitions and nightly consolidation—factors that I call the "four pillars" of learning, because, as we shall see, they underlie the universal human algorithm present in our brains, in both children and adults.
There is no decision that is not followed by expected, unexpected or unexpected effects. That is why the decision is a responsible process.	Brain plasticity decreases, but it never disappears. [...] Higher education areas retain their potential for adaptation throughout life [...] and that is why educational interventions sometimes work miracles, especially when they are rapid and intense.
It is in the directivity of education, this vocation that it has, as a specifically human action, of "addressing" itself to dreams, ideals, utopias and objectives, that what I have been calling the politicity of education is found. The quality of being a politician, inherent to his nature.	[...] we are not aware of our mental limits (in fact, it would be paradoxical if we could, who knows how, become aware of our lack of awareness!). [...]The allure of the screen and the myth of multitasking are among the most dangerous inventions of our digital society.
The question that arises for us is to fight in favor of the understanding and practice of evaluation as an instrument for appreciating the what-to do of critical subjects at the service, for this very reason, of liberation and not of domestication. Evaluation in which speaking is stimulated *as the way of speaking* with.	When we hear a sentence, the first region of the cortex that activates is the primary auditory area – this is the entry point into the brain for all auditory information. This area also lit up in the child's brain as soon as the sentence began.
The discourse of globalization that speaks of ethics, however, hides that theirs is the ethics of the market and not the universal ethics of the human being, for which we must fight bravely if we really opt for a world of people. [...] It is not, let us add, a question of inhibiting research and slowing down advances, but of putting them at the service of human beings.	[...] Their pedagogical freedom will in no way be curtailed by the growth of the science of how the brain learns. On the contrary, one of the objectives is to allow teachers to better exercise this freedom.
[...] If my inconclusion, of which I am conscious, attests, on the one hand, to my ignorance, it opens for me, on the other, the way to know.	Learning is a vital principle, and the human brain is capable of enormous plasticity – of modifying itself, of adapting.
Affectivity is not excluded from knowability.	Today, the question is no longer just to deepen introspection, but to understand the neural mechanisms that generate our thoughts, in an attempt to use them in the best conformity with our needs, goals and desires.

Source: Freire (2006) and Dehaene (2022).

Dealing primarily with Freire's (2006) conceptions, for the author teaching is not limited to the mechanical transmission of ready-made contents, but is an act of creation and discovery, in which educator and student share a continuous learning process, so that education is conceived as a political, ethical and formative act, which cannot be reduced to a simple technical training devoid of reflection and criticality.

In addition, Freire (2006) emphasizes the importance of research in educational

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practice, showing that research is an act of intervention and transformation of reality. Thus, curiosity is a fundamental element of this process, as it drives both the educator and the student to question, investigate and build knowledge in an active way. In this way, the author understands that teaching must respect the previous knowledge of the students, especially those from the popular classes, recognizing them as historical subjects who bring with them socially constructed prior knowledge.

Another relevant issue discussed by the author is the relationship between ethics and education, as he argues that there is no neutral education and that the act of teaching implies choices and positions that reflect values and conceptions of the world. Therefore, the denial of ethics in educational practice results in the very reproduction of social inequalities, as well as in the maintenance of structures of oppression. In this way, Freire (2006) defends an education committed to social transformation, which combats prejudiced practices and fosters democracy through dialogue and the active participation of students.

In addition to this, for Freire (2006), teaching should be guided by a critical and reflective attitude, in which the educator not only teaches, but also learns from his students in a dialogical and dynamic process that, in turn, enables this educator to question his own practice and constantly seek to improve his pedagogical action. In addition, the author warns us of the danger of an education that intends to be neutral and apolitical, as human existence itself is marked by the need to make choices, intervene in the world and build its history.

Another point highlighted by Freire (2006) is his understanding of the incompleteness of the human being as an essential characteristic of and for his existence, so that the awareness of this incompletion allows the subject to recognize himself as a being in a constant process of transformation and learning. Therefore, considering this perspective of incompletion of the human being, we observe that there is a need for an education that values autonomy, creativity and critical thinking, which enables individuals to question reality, as well as to fight for their humanization.

In this scenario, Freire (2006) criticizes the market logic that permeates education in contemporary society, as globalization imposes an ethics focused on the interests of the market to the detriment of a humanizing ethic. In this continuum, he proposes an evaluation that is not an instrument of domestication, alienation, castration, but rather of liberation, encouraging dialogue and the active participation of students in the evaluation process. And, in this process, the author considers that affectivity is not dissociated from

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knowledge, because learning involves emotions, intuitions and interpersonal relationships that must be considered in educational practice.

In any case, Freire (2006) reaffirms the need for conscious and organized political struggle as a response to the denial of the right to "be more", and education should be a space of resistance and rebellion against the oppressions that dehumanize individuals. Therefore, a liberating educational practice, therefore, must be committed to the construction of a fairer world, in which everyone has the opportunity to learn, teach and transform their realities.

Regarding Dehaene's (2022) conceptions, the author elaborates them from the search for understanding the neuroscientific mechanisms that underlie human learning and its superiority over machines. The author points out that learning occurs through four essential pillars, namely: attention, active engagement, corrective feedback, and consolidation. For Dehaene (2022), these four elements are crucial for the acquisition of knowledge, and should be considered in the development of effective pedagogical methods.

Regarding the first pillar, attention, the author understands it as a limited cognitive resource, but essential for learning, since it directs the brain's efforts to relevant information and, without attention, the brain cannot properly encode stimuli, which compromises knowledge retention. In this way, this aspect, or this pillar, reinforces the importance of educational strategies that encourage students' curiosity and interest, making learning more meaningful (Dehaene, 2022).

Regarding the second pillar, that is, active engagement, Dehaene (2022) places it as a determining factor for the consolidation of learning, as students learn better when they are challenged to solve problems, formulate hypotheses, and test their ideas. In this context, in the author's conception, simple passive exposure to content does not promote lasting learning, since the brain needs to interact with knowledge to assimilate it efficiently. With this, Dehaene (2022) draws attention to the need for educational methods based on the active participation of students, such as investigative and experimental approaches, so that these students are not spectators, but active participants in the educational process.

The third pillar proposed by Dehaene (2022) is corrective feedback, as it plays a key role in adapting and refining knowledge, considering that the human brain learns through error detection and continuous adjustment of responses. In this context, those educational environments that provide quick and accurate feedback allow students to

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correct mistakes and improve their cognitive skills, so it is important to have formative and error-valuing assessments as part of the learning process.

Finally, the fourth pillar addressed by Dehaene (2022) is consolidation, which, in turn, is responsible for the fixation of knowledge in the long term and, as defended by the author, the brain performs this task during sleep, reorganizing information and strengthening neural connections. In this way, Dehaene (2022) draws attention to the need for regular breaks between study sessions and the appreciation of rest as part of effective learning, which contrasts with the practice of excessively concentrated studies in a short period of time, demonstrating that spaced repetition contributes to deep memorization.

In any case, these issues discussed by Dehaene (2022) are relevant to the educational field, because they provide us with knowledge about how the brain learns, providing guidelines to optimize pedagogical practices. In addition, the author proposes that educators rely on these neuroscientific principles to create more efficient and motivating teaching environments, so that understanding the brain mechanisms that underpin learning allows the formulation of more effective strategies to stimulate students' cognitive potential and improve teaching processes (Dehaene, 2022).

Having presented the main propositions and ideas discussed by Freire (2006) and Dehaene (2022), let us move on to our discussions of how the theories of the two authors can complement each other in the construction of pedagogical practices that are both effective, from a neuroscientific point of view, and emancipatory, from a social point of view, promoting active, meaningful, and transformative learning.

RESULTS AND DISCUSSIONS

Although in 1996[6] neuroscience research did not travel through the "pedagogical corridors", it is possible to deal with some relationships between the works of Freire (2006) and Dehaene (2022). In this sense, first, we need to consider three issues.

The first issue to be seen is in relation to autonomy. For neuroscience, as we can see in Dehaene (2022), autonomy can be seen as the brain's ability to act independently, making decisions and performing actions without depending exclusively on external stimuli, which involves complex cognitive processes, such as the ability to plan, make decisions based on personal goals and values, and control impulses.

In the autonomy addressed by Freire (2006), mental processes are evoked that,

[6] Original publication date of *Pedagogy of Autonomy: necessary knowledge for educational practice*, by Paulo Freire.

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together with the cerebral tool and the historical-cultural processes, provide the opportunity to think about practice through the demands that teaching demands. And this claim, not dissociated from empirical research, arises in the daily doing, in the praxis and in the pedagogical processes of those who are in education to do education.

In this continuum, in relation to autonomy, it is possible to observe that Dehaene (2022) explores the brain mechanisms of learning, highlighting how the human brain adapts, generalizes, and builds knowledge in an active way, emphasizing the importance of error, attention, engagement, and *feedback* in the learning process. Freire (2006) discusses learning as an act of freedom and construction of knowledge based on the reality of the learner, proposing a dialogical and problematizing education, which builds and respects the autonomy and critical consciousness of students. In any case, both authors defend the importance of active learning, however, the first explains this from the cognitive sciences and the second does so from a social and philosophical perspective.

The second question to be asked is the importance given by the authors to interaction and the environment in learning. For Dehaene (2022), effective learning depends on the interaction of the brain with stimuli from the environment, reinforcing that teaching must be structured to stimulate brain plasticity. And, for Freire (2006), learning takes place in the interaction between educator and student, where knowledge is collectively constructed in a social and cultural context. With this, both value the role of the environment and interaction, but Dehaene (2022) approaches it from a neuroscientific point of view, while Freire (2006) emphasizes the political and social dimension of education.

Finally, a third issue to be considered is the way in which the authors conceive the development of consciousness and critical thinking. In this sense, Dehaene (2006) suggests that learning involves the active construction of knowledge by the brain, which is in line with the idea that the student needs to be engaged and motivated to learn. And for Freire (2006), education is seen as a means of liberation, in which the student develops critical awareness to transform his reality. In this context, both authors converge in agreeing that learning is not passive and that the subject needs to be active in the process.

In general, we can see that the approaches of Dehaene (2022) and Freire (2006) complement each other, when they bring different perspectives, and, at the same time, they converge in some aspects of learning. This understanding is based on the fact that Dehaene (2022) presents the neuroscientific basis of learning, demonstrating how the human brain has a remarkable capacity for adaptation, error and correction, memorization,

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and generalization of knowledge, emphasizing the importance of attention, engagement, and interaction with the environment for effective learning. And Freire (2006), when approaching education from a philosophical and social point of view, argues that learning should be a dialogical, critical and liberating process, where the learner is not a mere receiver of content, but an active subject in the construction of knowledge.

In this sense, we can reconcile the conceptions of the two authors when we observe that cognitive science reinforces principles that were already present in Freire's pedagogy, so that, when Dehaene (20022) states that the brain learns better when it is motivated, challenged, and in constant interaction with the environment, he supports Freire's (2006) understanding that learning should start from the reality of the learner and be meaningful to him. Similarly, when Freire (2006) advocates a problematizing and emancipatory education that stimulates critical thinking, he hints at a model that is aligned with neuroscience findings on how the brain best adapts to active, exploratory, and collaborative learning.

In any case, we can consider that the authors are close when both: I) consider that learning is dynamic and transformative; II) highlight the importance of the teacher in the mediation of knowledge; III) consider the student as an active participant in learning; IV) they defend that learning is interactive and depends on the active engagement of the student; V) recognize curiosity and creativity as essential for learning; VI) recognize the importance of educational inclusion; and VII) consider evaluation as a development tool.

However, it is also necessary to consider that there are important distances between Dehaene (20022) and Freire (2006), because, if Freire (2006) emphasizes the social and political dimension, Dehaene (2022) focuses on brain processes. If Freire (2006) sees the teacher as a political agent, Dehaene (2022) sees him as a structurer of the cognitive environment. If Freire (2006) focuses on critical consciousness, Dehaene (2022) focuses on brain plasticity. If Freire (2006) prioritizes dialogue and social experience, Dehaene (2022) prioritizes the neurocognitive structure. If Freire (2006) sees creativity as a form of emancipation, Dehaene (2022) sees it as a factor that enhances learning. If Freire (2006) places politics at the center of education, Dehaene (2022) treats it neutrally. And, finally, if Freire (2006) prioritizes critical reflection, Dehaene (2022) prioritizes the correction of errors through *feedback*.

In practice, taking into account the complementarities, convergences and distances between Freirean and Dehaenian thought, we consider that a transformative education must consider both the brain processes and the social context of students, it must start

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from methods that reconcile pedagogical approaches based on neuroscientific evidence (use of *feedback* effective, error-based learning and attention enhancement etc.) with a critical and humanizing pedagogical posture, which will enable a more efficient and emancipatory teaching. And this requires the teacher to be attentive not only to the cognitive needs of the student, but also to their social context, encouraging autonomy and the construction of knowledge in a dialogical way.

FINAL CONSIDERATIONS

In this article, we aimed to discuss the possibilities for the contributions of Dehaene (2022) and Freire (2006) to complement each other in the construction of pedagogical practices that are both effective, from a neuroscientific point of view, and emancipating, from a social point of view, promoting active, meaningful, and transformative learning.

Throughout our discussions, we observed that the contributions of Dehaene (2022) and Freire (2006) can complement each other in the construction of pedagogical practices that are simultaneously effective from a neuroscientific point of view and emancipatory from a social point of view by integrating approaches that value both cognitive processes and the sociocultural aspects of learning.

Dehaene (2022) offers a meaningful understanding of how the brain learns, highlighting the importance of engagement, motivation, error, and feedback for knowledge consolidation. Freire (2006), on the other hand, proposes a critical and liberating education, which starts from the reality of the student and seeks to develop his consciousness to transform the world. In this scenario, by articulating these perspectives, it is possible to develop pedagogical practices that respect the way the brain processes information and, at the same time, promote meaningful and contextualized learning.

In addition, the complementarity between the two authors is also manifested in the understanding of the role of the teacher, because, while Freire (2006) understands him as a political agent who mediates learning in a critical way, Dehaene (2022) sees him as a structurer of the cognitive environment, responsible for organizing effective strategies to enhance learning. Thus, an educator who combines these perspectives can use methodologies that promote both the development of critical awareness and the neuroscientific effectiveness of learning, such as interdisciplinary projects, active methodologies and formative evaluations that value error as part of the process of knowledge construction.

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In any case, we consider that the dialogue between Freire's and Dehaen's conceptions enables and enhances a transformative education, which not only respects the cognitive processes of the human brain, but also recognizes the importance of social interaction, creativity and critical reflection for truly meaningful learning.

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