

Towards an Ecological Vision of NeurodidacticsÁlvaro Federico Muchiut^{1*}, Paola Vaccaro¹, Marcos Luis Pietto¹

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Abstract

Neuroeducation is a discipline that studies the teaching and learning processes from a neural perspective, in order to contribute to the educational field through interventions that seek to promote changes in the subjects of knowledge. On the other hand, neurodidactics is an emerging discipline with a recent theoretical development, whose implementation could contribute to the development of interventions, given its eminently practical nature in the field of teaching. That is why, in the present work, a journey through some of the conceptualizations of neurodidactics is exposed, trying to provide its differentiation of what is understood by neuroeducation; as well as an ecological vision of neurodidactics is proposed, as an approach that considers the classroom as a natural environment from which and for which pedagogical intervention strategies are developed in the light of neuroscientific findings, and positions the teacher as a mediator of this process, who plans their interventions to optimize the teaching and learning process.

Keywords: Neurodidactics, Neuroeducation, Ecological Intervention, Pedagogical Practices, Teaching

Introduction

Currently, neurosciences have gained prominence in different fields of knowledge, based on explanations about how neurons act to generate behaviors, and about how they are influenced by the environment and the behavior of other people [1]. Among the fields favored by the integration of the knowledge provided by the neurosciences is the educational one, in which the contributions make it possible to understand the learning process from a new perspective, considering the brain and its functions as the substrate of said process to strengthen the quality of formal education through specific interventions [2, 3].

At this point, it is important to understand the role of educators as mediators in the learning process; therefore, their own training should involve understanding how the brain learns and, at the same time, how it is possible to implement this knowledge in the design and application of pedagogical practices (hereinafter PP) that favor learning. In this sense, it is possible to understand that neurosciences are complementary and not exclusive of theoretical pedagogical approaches. In fact, the incorporation of knowledge about the functioning of the brain and how information can be used in educational institutions could be beneficial to take advantage of knowledge resources and how students assimilate learning [1, 4].

The multiple contributions that neurosciences make to the educational field are included under neuroeducation, a discipline that specifically investigates how the teaching-learning process

can be improved based on neuroscientific foundations [2].

From neuroeducation derives neurodidactics, and the object of this work is to explore its conceptualization, due to the fact that in the current bibliography it is common to observe an indistinct treatment of the terms neuroeducation and neurodidactics, being generally used as synonyms; when in fact they present specific characteristics that distinguish them from each other. For this reason, a tour of some of the conceptualizations of neurodidactics is presented, trying to provide its differentiation from what is understood by neuroeducation; as well as an ecological vision of neurodidactics is proposed as a strategy to think about practices in the classroom.

Neuroeducation/Neurodidactics

Neuroeducation is a science that unites pedagogy, cognitive psychology and neuroscience, and aims to establish improvements in the learning process taking into account brain mechanisms [1]. It so happens that this discipline is currently gaining increasing importance as a potentially innovative force in pedagogical thought from which neurodidactics emerges as a subfield; which involves, on the one hand, developing learning methods that consider brain neurobiology, and on the other hand, the subject's own disposition to learn [5, 6].

The concept of neurodidactics appears for the first time in 1988; when Friedrich and Preiss propose this new field as the one that seeks the most effective way to implement neuroscientific con-

tributions in the educational area, trying to "configure the learning that best fits in the development of the brain" [6, 7].

Years later, in 1990, the mathematics didactics expert Preiss proposed the concept of neurodidactics, emphasizing the learning potential of man, emphasizing the finding of situations for maximum progress [8].

In the words of Preiss "this discipline starts from the learning capacity of the human species and tries to find the conditions for its optimal development. The key idea is the conviction of the existence of an intimate relationship between brain plasticity and learning capacity. The results of neuroscientific studies allow us to investigate this relationship. The mission of neurodidactics would be to guide neurobiological knowledge towards didactics and apply them to the process of education and human formation" [9].

Neurodidactics as an emerging field of recent theoretical development presents some difficulty in its definition when it comes to distinguishing it from neuroeducation. Forés Miravalles and Ligoiz Vázquez base their definition by focusing on brain plasticity as a means of access to teaching and learning, which in turn are favored, since neurodidactics consists of the application of knowledge about how the brain works. brain and how neurobiological processes are involved in learning [10]. Consistently, Nieto Gil conceives neurodidactics as part of the psychodidactic sciences that results from the application of advances and discoveries in neuroscience to learning and teaching processes [11]. For his part Paniagua refers that neurodidactics is a branch of pedagogy based on neurosciences that gives a new orientation to education, defines it as the union of cognitive sciences and neurosciences with education, whose objective is to design more efficient teaching and methodological strategies that not only ensure a theoretical and philosophical framework, but also promote greater brain development (greater learning) in terms that educators can interpret [12]. For his part, Fernández Palacio states that this new subfield explains brain functioning, its needs and potentialities, providing theories that make it possible to speed up learning, making it more efficient [7].

Mendoza-Vargas et al. refers that the conceptualizations in general, are directed towards the central idea of neurodidactics as the discipline that seeks the optimization of learning, based on the development of the brain and the consideration of neuroscientific findings [13].

After reading these authors who have made a valuable contribution to this emerging field, the question immediately arises: What is it that distinguishes neurodidactics from neuroeducation? since they are not synonyms. In this regard, neuroeducation seeks to establish a connection between neuroscience and education, applying the knowledge provided by neuroscience to the educational field, while the originality of neurodidactics lies in its eminently practical nature in the field of teaching, of carrying out that neuroscientific knowledge into the classroom.

Based on the above, and taking up what was stated in Muchiut et al., we can say that neurodidactics is a discipline that draws on the contributions of neuroeducation and didactics, whose pur-

pose is to optimize methods, strategies and the tools involved in the teaching and learning processes, contributing to the determination of the most efficient way to make pedagogical knowledge accessible in light of advances in the neuroscientific field on how the brain learns [14]. Thus, neurodidactics is directly related to PP, in the sense that they highlight the possibilities offered by this new discipline.

The PP are actions that involve instruments and tactics carried out by teachers and aimed at class planning involving the adoption of new teaching measures. Specifically, they can be conceptualized as social practices that are carried out in the educational context, based on the link between a subject who teaches and another who seeks to learn, leading to the materialization of training purposes that are manifested in a pedagogical horizon. Therefore, it is necessary for PP to emphasize the collective construction of knowledge, orienting itself in favor of the maximum development of students, seeking to provide comprehensive training [15, 16].

Method

At first, in this work a bibliographic survey was carried out, in the first instance to investigate the conceptualizations of the central concepts, for which the Google Scholar search engine was used, using the following keywords as search engines: neuroeducation, neurodidactics, ecological vision/perspective, education, cognitive training. In the second instance, the same strategy was used to explore the existence of interventions or experiences in which neurodidactics were considered for the design and development of PP, for which the keywords were used: school interventions + neurodidactics, pedagogical practices + neurosciences / neurodidactics, teaching practices, neuroeducation, stimulation of executive functions.

Subsequently, the pertinent and concurrent investigations were selected for the purposes of the study.

In a second moment, three experiences carried out in a secondary school in the City of Resistencia (Chaco, Argentina) were exposed, in which PP framed from neurodidactics were carried out.

Results

Ecological Interventions in Neurodidactics: Beyond the Laboratory

Talking about ecological interventions in the field of neurodidactics is a novel proposal, since when the antecedents were considered, they were practically non-existent or evidenced practices associated with a clinical vision applied to the classroom that sought to promote changes in the subjects of knowledge. To this end, it was suggested that an ecological intervention would enable a new vision to think about PP in its specific context.

The bibliographic survey exposed the existence of different behavioral training programs that were intended to stimulate the development of cognitive abilities and the underlying brain mechanisms. Precisely, the paradigms involved in these intervention programs consist mainly of implementing laboratory tasks of the cognitive constructs of interest, such as training activities [17]. At the same time, programs based on neuroreha-

bilitation principles were found in the literature, in educational neuropsychology programs designed to provide action alternatives for neurodiverse students and in meditation practices such as mindfulness [7, 18, 19]. In most of the intervention studies, the activities consisted of training specific cognitive processes through practice with tasks that demand such processes (i.e., process-based approach) [17]. Another type of approach within this study framework consisted of teaching strategies for the development of metacognitive knowledge about the relevant procedures to carry out a task more efficiently [20]. In addition, multiple studies conducted during childhood and adolescence showed that cognitive skills training is associated with better performance on tasks that involve cognitive functions similar to those trained (near transfer effect); particularly in skills related to executive functions (e.g., working memory, inhibitory control, cognitive flexibility) and in contexts of typical and atypical development [21]. Likewise, other studies have shown impacts of cognitive intervention in untrained domains, such as academic learning, suggesting an effect of training in skills related to language and mathematics [22]. Although school success was associated with better efficiency in different cognitive processes, such as fluid intelligence, working memory, cognitive flexibility, visual attention and spatial thinking; the vast majority of cognitive interventions that resulted from the literature were not intended from the beginning to be applied in the educational field [22, 23]. These works, although very valuable, leave aside what is typical of the school, the teaching-learning and teacher-student relationships. Indeed, thinking about activities with specific cognitive demands based on how learning occurs in the academic setting could lead to the design of interventions that have greater ecological validity, which could improve academic skills efficiently and would have a functional impact in people's daily lives.

Talking about an ecological vision implies observing the variables of interest in the natural context in which they occur, that is, without introducing changes in the environment. Precisely, speaking of a natural context in academic learning refers to the classroom in precise institutional conditions [24]. At this point, it is important to refer to the concept of pedagogical ecology, which involves various variables that could influence student learning, emphasizing the importance of observing the student in the classroom, also considering their living environment and taking into account research from traditional cognitive psychology (focused on investigating the way in which people learn and studying the brain architecture involved). Positioning oneself from pedagogical ecology not only implies adding the individuality of students and their environments to each process, but also considering that this interaction as a whole could make significant differences between the different processes [25].

Then, neurodidactics could be thought of from an ecological perspective, as an approach that considers the classroom as a natural environment from which and for which pedagogical intervention strategies are developed in the light of neuroscientific findings, and positions the teacher as mediator of this process, who plans his interventions to optimize the teaching and learning process.

Our Experience from the Ecological Approach of Neurodidactics In accordance with the proposal that has been presented in previous sections, three studies have been carried out in which PPs were designed and implemented aimed at enhancing cognitive functioning in secondary school students, the starting point being the consideration of contributions from neuroeducation and neurodidactics for planning actions and strategies.

In the first place, under the framework of an institutional project, PPs were made specifically oriented to the promotion of self-regulation of learning, involving the stimulation of executive functions. The implementation took place in a private secondary level establishment, the PPs were carried out through the execution of activities that varied according to the different curricular spaces (Language, Geography, English, Mathematics and Music) and were addressed to 1st and 2nd year students. . The project was structured as an exploratory study, obtaining encouraging results in the executive functions of planning and decision making, as well as in the application of new strategies, from teacher appreciation. This experience presented as a limitation the absence of a control group and standardized evaluations, however it constituted a starting point for future interventions [26].

Along the same lines, in a subsequent study in which PPs were also directed at secondary school students, evaluation instances were incorporated with the aim of describing possible effects of the implementation of PPs specifically oriented towards the promotion of executive functions, through actions and strategies designed by teachers in congruence with training received on neuroeducation and neurodidactics; and the role of executive functions in the teaching and learning process. Although this study presented as limitations the absence of a control group and a limited sample; the results showed a better general performance in the evaluations carried out after the implementation of the PP, indicating evidence consistent with the assumption that ecological interventions that seek to enhance cognitive functioning (executive functions, in this case) from the contributions of the neurosciences could effectively favor student performance [27]. Consistently, continuing this line of research, Muchiut et al. presented neurodidactics applied to the classroom through the use of rubrics such as PP for the assessment of executive functioning in high school students [14]. This experience used the integration of the contributions of neurodidactics with the design of rubrics as a pedagogical strategy that was implemented in the classroom to know and estimate the level of the student in terms of executive performance. Prior to the assessment of executive functions, the teaching staff of the institution agreed and specified descriptions of five levels of achievement of the different actions that were proposed for the stimulation of working memory, planning, organization, decision making and cognitive flexibility [14].

These three experiences can be considered "samples" that the ecological educational interventions associated with the contributions of neurodidactics can favor and enrich the PP and, simultaneously, the student's personal performance, where teachers can think of another way of transmitting the academic contents and at the same time enhance the cognitive development of students.

Discussion

A conceptual differentiation was proposed, understanding neuroeducation as a science that combines neuroscientific contributions with cognitive psychology and pedagogy, and neurodidactics as the subfield that takes the contributions of neuroeducation and didactics for the optimization of methods, strategies and the practices that are implemented in the teaching and learning process.

The practical nature of the latter was highlighted, which, as a growing discipline, is gaining ground through the applicability demonstrated in pedagogical interventions that were designed taking the classroom as the starting and ending point. Being the classroom considered as one of the natural environments in which students not only learn but also form.

In addition, neurodidactics enables teachers to understand the diversity of cognitive functioning, and the skills that a student can develop and/or improve. In this regard, this discipline demonstrated its practicality with neurodiverse students, as it gave rise to the adaptation of teaching methods by providing pedagogical resources in accordance with the specific demands of the students, pursuing the optimization of the teaching-learning process [7].

The viability of neurodidactics as a paradigm to be considered in the classroom is evidenced in the experience documented by Muchiut et. al, where the use of a formative assessment pedagogical strategy such as rubrics was used to assess executive functioning in adolescents [14]. Other similar findings also make it possible to appreciate the practical nature of neurodidactics [26, 27].

On the other hand, it is essential to consider that the classroom is not a laboratory, much less an office, so thinking of PPs located in the natural context in which they occur was an encouraging proposal for intervention in the classroom. In this regard, Daniel and Poole pointed out that learning could be affected when teaching strategies and learning aids result from converting laboratory findings into classroom intervention suggestions while they are not generalized to the student's usual environments [25].

Considering PP from an ecological perspective of neurodidactics means the preparation of strategies and actions designed for a group of students who have individual characteristics, whose cognitive functioning is diverse. Therefore, PPs necessarily require consideration of the heterogeneity of the student body to achieve greater effectiveness when implemented, taking into account the probability that PPs may have an effect differently for each student, according to variables such as academic level, previous knowledge, interests, time, etc. [25]. In this sense, we consider, together with Forés Miravalles and Ligoiz Vázquez, that learning will be facilitated if teaching provides the stimuli that the brain requires for the maximum development of its potential [10].

In short, we are not talking about the transposition of a program for the stimulation and/or rehabilitation of cognitive functions

devised in a laboratory or made for the clinical/therapeutic field, but rather it is about devising, designing, planning and implementing PP from the classroom for the classroom.

Conclusion

We have tried to conceptualize what is understood by neurodidactics as a field that emerges from neuroeducation, at the same time that we propose an ecological vision of it, from which to position ourselves in the educational field to think about PP and promote the cognitive development of children. students at different levels.

Neurodidactics as an alternative for the development of institutional actions constitutes a tempting perspective that could be adopted in any educational establishment, since the implementation of PP based on this subfield of neurosciences can be made effective in educational settings in which there is a commitment to carry out innovations with a view to improving their educational quality. With this, we are not referring to the fact that this proposal is the best compared to other alternatives, but rather we seek to emphasize that it is possible to adopt neurodidactics as an additional contribution that comes to contribute directly to the teaching process of the teacher, on the one hand, and the student's learning process, on the other.

Likewise, we place special emphasis on the importance of teacher training under the paradigm of neuroeducation and neurodidactics, simultaneously with collaborative work, in which the shared experience can also generate efficient PP, understanding that thinking of an institutional project in key of neurodidactics, it is not a desire of a few, but of a group of teachers and institutional actors.

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