


THE CONTRIBUTION OF NEURO-SCIENTIFIC RESEARCH IN RELATION TO METACOGNITIVE TEACHING

IL CONTRIBUTO DELLE RICERCHE NEURO-SCIENTIFICHE IN RELAZIONE ALLA DIDATTICA METACOGNITIVA

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ABSTRACT

Recent neuroscientific research (Rivoltella, 2012) could make an important contribution with reference to metacognitive teaching. The Neuro Teaching approach (Gola, 2022; Gola *et al* 2023) could favor a significant impact with reference to inclusive practices (Booth & Ainscow, 2014) and teacher agency (Calvert, 2016). The intent is to explore the relationships between recent neuroscientific studies and the cognitive processes that substantiate metacognitive teaching.

Recent neuroscientific research (Rivoltella, 2012) could make an important contribution in reference to metacognitive teaching. The Neuro Teaching approach (Gola, 2022; Gola *et al*, 2023) could have a significant impact on inclusive practices (Booth & Ainscow, 2014) and teacher agency (Calvert, 2016). The intent is to explore the relationships between neuroscientific studies and the cognitive processes that substantiate metacognitive teaching.

KEYWORDS

neurosciences, neuro teaching, metacognitive didactics, teaching learning process.

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Introduction¹

New discoveries in the field of cognitive neuroscience allow us to better understand some of the mechanisms by which the mind learns. Although much remains to be discovered, the information available today allows us to structure paths aimed at better stimulating brain circuits related to learning and improving the quality of training. Neuroscience and cognitive science have demonstrated the interconnections between perception, action, emotion and cognition in knowledge/interaction in relation to the school context and in particular to school difficulties. It is therefore believed that the enhancement of body and emotional dimensions in teaching can improve teaching-learning processes.

In particular, the Neuro Teaching approach (Gola, 2022; Gola *et al.* 2023) could represent the field of study to be analyzed and interpreted in relation to inclusive practices, the dimension (Booth & Ainscow, 2014) within which educational-didactic activities are carried out through methodological strategies and educational-didactic tools, and the teacher agency (Calvert, 2016), the ability to act of teachers who intentionally promote their own development of professional learning (Ibidem) professional as well as that of colleagues. Metacognitive teaching is configured as a significant approach in order to investigate elements of interrelation between the Neuro Teaching approach and studies related to education and teaching and the response in order to outline methodological strategies that could foster new awareness and understanding of this process (teaching-learning) in an inclusive perspective and the enhancement of differences (Sibilio, Aiello, 2018).

1 Neuroscience and Didactic

There are numerous objections that neuroscience and studies anchored in these paradigms are not able to influence the practices of education, to attribute appropriate meanings to *how* individuals know and construct knowledge, to align pedagogical references, justifying that even in the presence of solid evidence they are still and only photographs of the mind. Meirieu (2018), in fact, argues that neuroscience cannot enter into subjective experiences, into class situations, they do not detect thought. New techniques and approaches to the study of the mind can describe the brain activity of individuals during learning activities, for example, but not affect the contents taught in the classrooms, the relationships evoked.

^{1 1} Milena Pomponi is the author of Par. 2. The abstract, the Introduction, the Conclusions are reworked by Milena Pomponi through the sharing of reflections of both authors.

¹ Mariangela Di Gneo is the author of Par 1.

The philosopher's provocation French similarly to others (Bowers, 2016; Krammer, Vogel, Grabner, 2021) finds its antithesis in several recent studies that converge on the meaning of the interaction between neuroscience and education. Neuroscience helps to understand the complexity of the brain, growth and changes also in relation to learning, generating new attention for those involved in education and teaching, at the research level and at the application level (Ansari, Coch, 2006; Hinton & Fischer, 2008; Thomas, Ansari, Knowland 2019).

Through the contribution of meta-analyses (Hattie, 2012; Marzano *et al.* 2007) and evidence-based education of international organizations, the correlation between teaching-learning processes and cognitive and social neuroscience appears clearer. Areas complement each other: classroom tests indicate *what* works, social neuroscience and cognitive science indicate *why* it works.

Brain mapping involves an area of neuroscience that tries to understand *how* this organ works and shows areas that are active for different tasks, thoughts, and emotions at a precise time. It would be important to understand *what happens* when we learn, or *how* teachers can best design-organize certain processes for their students.

Gaining knowledge about neuroscience would enable teachers to provide better classroom education (Lawrence *et al.* 2020). An important way in which the sciences of mind can enrich - through information from different studies - the educational processes is to promote and teach the ability to reflect critically and to develop an understanding of the processes and procedures that substantiate the planned and implemented educational-didactic activity.

If another critical objection to neuro-scientific models is that they are distant from the real world because they are mainly studied in the laboratory, recent research shows that experimental models are approaching realistic or as real as possible contexts.

An interesting study is proposed by the Brain-Brain hypothesis that finds in today's context numerous scientific anchors, especially through the synchronicity of the information collected - synchrony (Jenssen *et al.*, 2021). Using mobile neuroimaging techniques, some scholars (Dijkers *et al.*, 2017; Holper *et al.* , 2013) conducted a study trying to detect the synchronic relationship between teachers and students by simultaneously recording the brain activity of a group of students and the teacher over several days during a semester, while they were in class. The results suggest that brain-to-brain synchrony is a sensitive marker that can predict dynamic interactions in the classroom, and that this relationship can be driven by shared attention within the group. Still few studies have shown that interpersonal neural synchronization can be a marker capable of detecting various interactions,

including the teacher's activity during the teaching action. Other authors (Davidesco *et al.* 2020) simultaneously recorded students and their teacher during the usual lessons in some high schools, ascertaining neural activity with social and behavioral factors in the classroom. Brockington (2018) has started a study directly that evidence can be recovered on brain activity and physiological phenomena of students and teachers in a realistic situation such as that experienced in the classroom.

The Teaching Brain approach (Battro, 2010; Rodriguez, 2013) supposes the presence of neural markers that give different evidence when the teacher or student performs certain actions, uses different teaching strategies, interacts with each other etc. Neuro-scientific correlations trace a synergy with the dynamic interaction patterns of the teacher's and learner's mind. It is a field of research still little explored that could favor new instances on teaching and interaction between teacher and student, not forgetting precautionary attitudes. The central theme is the possibility of tracing new instances to the processes of information processing, coming out of polar logic, antagonisms and prejudices.

Neuroscience and education, biology and cognitive science, while maintaining a rigorous epistemological link within their own boundaries, can be interacting in understanding the role of the mind and brain in teaching-learning processes, or making new contributions, even challenging for the future. Indeed, the challenge for those involved in educational neuroscience is how neuroscientific research could help educational sciences and education shed light on cognitive processes. Neuroscience seems to constitute an invisible matrix of other sciences and practices, so it is easy to fall into a neuro-centric logic capable of understanding aspects substantiated by evidence considered more authoritative than others.

The Neuro Teaching approach aims to "take stock" of the ongoing scientific debates and the prospective impact of the field of educational neuroscience with respect to the science of teaching. The encounter between neuro-sciences and the sciences of education has its place in the middle of the last century, thanks to the epistemic delineation of cognitive neurosciences (Hagner, Borck, 2001) which has produced a flourishing scientific literature, both national and international. Neuro-scientific research has clarified how terms individuals differ in their response to education in two ways both in terms of their genes and the environment in which they are immersed. According to Rueda (2020) one of the emerging aspects of neuro-education concerns precisely the combination of information on brain processes related to cognitive abilities involved in learning with the efforts of the educational community to optimize the transmission and assimilation of knowledge. The brain learns through bodily experiences, from time to time transcoded thanks to the

cerebral device in which the action is characterized by the traits of contemporaneity and identity of the motor experience of those who act and those who observe. The new "era of reflection" of which we are spectators and builders involves teachers, researchers, pedagogues and doctors in a continuous dialogue in order to create an educational process capable of producing significant changes in the brain, new techniques and approaches for the learning / teaching process and capable of designing better designs and settings (Mora, 2022, pp. 17-19). Indeed, as stated above, acquiring information and experimenting with *what* neuroscience claims, could allow teachers and educators a better relational and methodological approach within the classroom context.

The Teaching Brain model (Gola, 2022) proposes a neuro-didactic research orientation and, at the same time, an applicative and operational way, which also finds correlations in the Neuro Teach model. This approach aims to identify specific neural areas involved during the educational-didactic actions carried out in the classroom and to study the neural relationships involving teachers and students in these actions, on the basis of which to design specific educational-didactic interventions. The basic assumption is to configure a facilitator model on the one hand aimed at the analysis of the teacher's postures and on the other hand aimed at the identification of neural markers that would allow the teacher a path of identification and improvement of the professional self. The results of neuroscientific evidence would allow us to decipher *how* neural architectures infer behaviors and actions also directly related to teaching in real contexts (Matusz *et al.* 2019; Throat, 2022).

The Neuro Teach model by Withman, Kelleher (2016), whose theoretical assumptions fall within MBE studies, addresses some challenges on teaching and learning through new scientific knowledge on the human brain in order to improve quality of teaching. Through the Neuro Teach studies applied directly in school contexts (Gola, 2022) it is intended to recognize *how* to improve students' attention and concentration, also trying to modify some teaching practices and strategies. Some possible neuro-didactic "ways" would be represented by educational-didactic proposals aimed at calming, involving, focusing, energizing the brain, through, for example, different ways of managing teaching times (chunked lesson, spaced learning, wait-time learning), with the precaution of not considering them as exemplary and dogmatic ways of accessing knowledge and processes of teaching-learning.

2 Interrelated elements: neuro teaching and metacognitive teaching

The Neuro Teaching approach (Gola, 2022; Gola *et al.* 2023) would represent an interesting study lens in relation to inclusive teaching and specifically to metacognitive teaching.

In consideration of the reflections advanced in the previous paragraph, this approach could in fact favor a significant impact in two directions: with reference to inclusive practices (Booth & Ainscow, 2014), the dimension of the Index for Inclusion within which the educational-didactic activities are expressed, and to the *teacher agency* (Calvert, 2016), the approach that reaches its meaningful explication through the development of professional learning (*Ibidem*).

The first element, therefore, is embodied in the attempt to explore the relationships between recent neuroscientific studies and the cognitive processes that substantiate the teaching-learning process in the field of metacognitive teaching.

Inclusive practices refer to the content and ways in which teaching and learning are taught within the classroom context and would represent the dimension within which the methodological strategies and the educational-didactic tools functional to the realization of the educational-didactic project activities are substantiated.

These are actions steeped in inclusive values - among the main ones are equality, respect for diversity, participation, community, sustainability - aimed at pursuing the development of communicative-relational, personal, social and learning and entrepreneurial skills (Council Recommendations.) and promoting the principle of equity (Agenda, 2030).

This dimension aims to establish a relationship between the learning of students and teachers themselves and the experience arising from the interaction of the teaching-learning process in which daily action in the classroom and at school comes to life, with a view to planning and implementing educational activities sensitive to the enhancement of differences.

In the perspective outlined in reference to learning and education processes, metacognitive teaching plays a significant role, fundamental for the development and consolidation of transversal skills, such as attention, memory, study method, and curricular skills, such as reading and comprehension of the text, mathematics, writing (Cottini).

Specifically, in the context of the teacher-pupil interaction that characterizes the teaching and learning process, the metacognitive approach would have a double value for the actors involved in this process. The metacognitive approach, in fact, would favor a greater awareness and enhancement of the mechanisms and methods of development of one's cognitive processes, therefore, of a greater ability to analyze and interpret situations, to plan and organize one's work as well

as to monitor and self-evaluate the procedural and procedural choices implemented.

A similar awareness would contribute to making the actors involved co-construct the teaching-learning process through an active role within a reflective process oriented to a continuous change with a view to improvement.

Metacognitive teaching in the light of the stated considerations would allow teachers the opportunity to acquire awareness about the knowledge to be transmitted, the ways in which to interact, the cognitive processes that underlie the simple primary processes (for example reading, writing and remembering) and therefore favor the development of superordinate mental abilities (Ibidem). This would entail a greater ability to manage the specific difficulties in relation to the individual pupil and in relation to the class.

At the same time, it would allow pupils the opportunity to become aware of the methods of their work, the procedural choices implemented in relation to the conditions and the context in which they would operate. What has been said underlies the consolidation and / or involves the development of attention skills in terms of selection and processing of information with a view to the quality of functional and optimal choices to achieve the purpose.

An educational-didactic intervention oriented towards the metacognitive approach would also be effective towards pupils with special educational needs (BES) - in particular with attention deficit hyperactivity, with mental retardation, with autism - in memory performance and in learning difficulties such as reading, reading comprehension, writing (Cottini, Morganti, 2015; Trincherò, 2015). For these students "the strengthening of the areas of operation and the development or compensation of the deficit areas are indispensable in order to guarantee the opportunity to achieve educational success, as required by recent legislation (Law 170/2010) and by the ministerial provisions on BES (D. M. of 27 December 2012; C. M. n. 8 of 06 March 2103)' (Damiani *et al.*, 2013).

The focus, therefore, of the interrelationship between recent studies related to neuroscience and metacognitive teaching (Willoughby *et al.* 2012) would be represented by executive functions (Isidori & Traversetti, 2018) which would represent "the cognitive skills necessary to plan, implement and successfully carry out behaviors aimed at a goal through a set of coordinated and strategic actions" (Ibidem).

These considerations take on significance in relation to the educational-didactic intervention by the teacher on four interconnected levels (Cottini) «the knowledge on general cognitive functioning; self-awareness of one's cognitive functioning; cognitive self-regulation strategies; the psychological variables of mediation'.

The intervention by the teacher would consist in the attention to knowledge and information on the functioning of the human mind - perception, attention (in the functions of selection and concentration), memory, emotions, logical skills, types of

learning - contextualized and in relation to the anamnesis of the student / s. Specifically, it would be essential to help the student to understand the functioning, "the capacities and limits of one's own mind when cognitive processes of different kinds are put into action" (Ibidem). A fundamental role would be represented by the feedback that the teacher provides to the student in relation to his performance with the aim of self-analyzing the correlations between the way in which the tasks are conducted and the personal processes that are activated (Ibidem).

In relation to what has been outlined, we report what Ianes (2001) said about three aspects to consider "the typical ("normal") general functioning, the limits of the process, its entity, the characteristics and interindividual variability and the possibility of actively influencing the development of the cognitive process with self-regulation strategies". The latter are important because they concern the processes of self-monitoring and self-regulation that would allow the monitoring and control of thoughts and actions, such as inhibition, planning, attentional flexibility, detection and correction of errors (Rivoltella, 2012; Rossi, Rivoltella, 2012) would therefore allow the student to conduct and direct the control of their cognitive processes aimed at solving tasks.

What has been said leads to the correlation with respect to the second element, of the initial reflection, which is substantiated in the attempt to outline new approaches and research perspectives that could favor new awareness and understanding of the teaching-learning process in an inclusive perspective and enhancement of differences (Sibilio, Aiello 2018).

The focus is on action and, therefore, on the ability to act on the part of the teacher - *teacher agency* (Calvert, 2016) - made explicit within an experiential learning based on inclusive values and on the enhancement of the various forms of diversity. The educational-didactic intervention would be aimed at promoting an active role as well as at the development of a reflective and critical thought of teachers and also of students, each respecting their own role and the person (as a subjectivity bearer of rights and duties), favoring peer learning and co-responsibility in the pursuit of the same learning process.

This consideration leads to reflect on the training of the development of professional learning (Ibidem) of school directors and curricular teachers in the perspective of re-thinking educational-didactic training paths oriented towards *focuses* such as innovative contents, such as the characteristics of functioning of the mind (Damiani *et al.*, 2013), and laboratory modalities that contextualize the theoretical aspects. The educational-didactic training proposal for managers and teachers in training should be more structured and organized by enhancing experiential learning and activities that contribute to the development of relational, emotional and empathic dimensions (play, sports activity, dramatization), as well as psychological variables (the *locus of control*, self-efficacy, self-esteem,

motivation) that support the student to develop a correct and effective perception of himself and to activate metacognitive processes.

Conclusions

The interrelated study of synaptic mechanisms and at the same time of educational-didactic practices and strategies allows the teacher to increase his knowledge and his skills, through new and innovative elements, in relation to the common awareness of the *way* of acting.

Neuroscience and education specifically represent an emerging area that brings together researchers in cognitive and developmental sciences, in educational psychologists, in educational theory and in other related disciplines in order to explore the interactions between biological and educational-didactic processes.

It is therefore essential to reflect on the *ways* in which studies related to neuroscience and teaching could be "contaminated" in an innovative and ameliorative perspective that involves students, teachers and school leaders.

Important contributions could come from studies on visuo-perceptual and visuo-spatial skills, as well as on the relationship between information and empathic capacity in relation to educational-didactic activities.

With respect to empathy, it could be interesting to analyze *how* the emotional and empathic dimension influence (in a positive or negative sense) the educational success of students and in general the development of transversal social and citizenship key skills, in order to achieve individual and collective well-being. In fact, it is recalled how fundamental emotional processes are in the correlation between cognition, decision-making processes and the development of skills, in fact they guide judgment and action (Immordino-Yang, Damasio, 2007).

The approach of metacognitive teaching could represent a sort of *trait d'union* between recent research in reference to neuroscience and studies related to teaching through the use of inclusive strategies and tools and the delineation of new research perspectives oriented to investigate correlations and possible new and innovative contributions.

Finally, these reflections focus on the theme of the development of vocational learning of school leaders and curricular teachers, strongly debated at intra/inter-institutional level, which requires the need for an active involvement of the actors involved (pupils, teachers and school managers) and for new policies with a view to innovation and improvement for various aspects such as planning and organization, the contents and methods of development, the structure and institutional partnership.

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