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DESIGN DIDACTICS WITH THE CONTRIBUTION OF NEUROSCIENCE TO FOSTER LEARNING OF STUDENTS WITH A SPECIFIC LEARNING DISORDER

PROGETTARE LA DIDATTICA CON IL CONTRIBUTO DELLE NEUROSCIENZE PER SOSTENERE L'APPRENDIMENTO DEGLI STUDENTI CON DISTURBO SPECIFICO DELL'APPRENDIMENTO

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Abstract

Education is a fundamental human right for guaranteeing the realization of other rights. In this overview the Neuroscience are able to provide teachers with advantageous information in order to design appropriate didactics for the development of functional skills for learning and active citizenship (Della Sala, 2016; Frauenfelder, Rivoltella, Rossi, Sibilio, 2013; Unesco, 2015). The contribution presents a case study concerning 30 students' with a Specific Learning Disorder who have followed a didactic rehabilitation program supported by the hypothesis that in these students' local perception takes place before the global one (Franceschini, Bertoni, Gianesini, Gori e Facoetti, 2017). The scientific contribution which has also been achieved from the studies, recognizes the importance of movement which is at the basis of mental representation and metacognition incited by active teaching (Peluso Cassese, 2017; Tino, Fedeli, Mapelli, 2019; Cornoldi, Friso, Palladino, 2006). The results of the students who attendes the program have been encouraging.

Educazione e formazione sono un diritto fondamentale per garantire la realizzazione di altri diritti. In questa prospettiva le Neuroscienze possono provvedere ai docenti vantaggiose informazioni per progettare adeguatamente la didattica per lo sviluppo di competenze funzionali all'apprendimento e alla cittadinanza attiva (Della Sala, 2016; Frauenfelder, Rivoltella, Rossi, Sibilio, 2013; Unesco, 2015). Il contributo presenta uno studio di caso riguardante 30 studenti con Disturbo Specifico dell'Apprendimento (DSA) che hanno seguito un programma di riabilitazione didattica supportati dall'ipotesi che la percezione locale avviene prima di quella globale (Franceschini, Bertoni, Gianesini, Gori e Facoetti, 2017). Il contributo scientifico riconosce anche l'importanza del movimento che è alla base della rappresentazione mentale e della metacognizione stimolata dalla didattica attiva (Peluso Cassese, 2017; Tino, Fedeli, Mapelli, 2019; Cornoldi, Friso, Palladino, 2006). I risultati finali sono stati incoraggianti.

Keywords

Neuroscience, Active Teaching, Specific Learning Disorder, Inclusion
Neuroscienze, Didattica Attiva, Disturbo Specifico dell'Apprendimento, Inclusione

Introduction

This historical period is characterized by the emergence of an increasingly complex reality that has long been questioning the duality between general and the particular.

The thoughts of Morin (2001) who has highlighted the multidimensionality of knowledge since the 1980s and Gardner (2013) whose studies have identified how a person is endowed with multiple intelligence layers, is still current. Each worldview (biological, sociological, anthropological, psychological, pedagogical, medical) is decisive as it is the expression of a specific instance but each is insufficient to explain the totality because it is the result of a limited panorama compared to its complexity (Santoianni, 2018).

In light of these changes, the Science of Education also had to review its disciplinary statute and was forced to make a radical change (Arboix-Calas, 2019). In fact, in recent decades, research carried out on the functioning of the human brain and on the learning processe are influencing the didactic choices of teachers and trainers (Edelman, 1987; Contini, Fabbri, Manuzzi, 2006).

In this perspective, Neuroscience is able to provide teachers with advantageous information with which to appropriately design didactic (Frauenfelder, Rivoltella, Rossi & Sibilio, 2013; Tino, Fedeli & Mapelli, 2019) from an inclusive perspective (Gomez Paloma, Damiani & Ianes, 2014). In fact, it is essential to support the educational success of all learners, from kindergarten to university, without neglecting the students with Specific Learning Disorders (SLD).

This work, which focuses on the contribution of studies, that investigate the neural and functional basis of the cognitive processes and the approach to active teaching, proposes an experiment to implement the learning of students with SLD.

1. Theoretical framework

The theoretical framework that supported the experiment, on the one hand, reflected on neuroscientific studies in the context of Specific Learning Disorders, which layout the processes and dynamics that are the basis of reading, writing and calculus; on the other hand, active didactic was discussed to debate on the perspectives that could help teachers to design the most effective educational path for SLD students.

It is a question of reasoning on the plural and complex character of teaching in respect to the multiple levels of the training proposals that include the intellectual, bodily, affective and relational dimensions of the person (Damiani, Santaniello & Gomez Paloma 2015).

In this perspective, the problem of Specific Learning Disorders inserts itself, in its complexity, into the paradigm of formal training. In fact, according to epidemiological surveys, it is estimated that the average incidence of students, who it concerns, is around 4.9% of the school population but is destined to rise (ISTAT 2020).

In this regard, By-Law 170 (Gazzetta Ufficiale, 2010) and its subsequent Guidelines (MIUR, 2011) allow the formal education system to recognize dyslexia, dysorthography, dysgraphia and dyscalculia as SLD because they refer to a specific domain of ability in a significant way but circumscribed in the presence of normal intelligence (p. 4). To this end, the national education system has been assigned the task of identifying the most appropriate teaching strategy and assessment methods so that students with SLD are able to achieve educational success.

As far as the etiological hypotheses of SLD are concerned, they can be grouped according to two distinct historical periods. The first period include the first half of the twentieth century and prefer the hypotheses with a psycho-dynamic, visual and phonological background (Arcolini, Zardini, 2002) while the second, dating from the 1990s onwards, is characterized by genetic, neurological, neurolinguistic and neuro -biological hypotheses (Galaburda, LoTurco, Ramus, Fitch & Rosen, 2006; Stella, 2002).

Studies have identified Specific Disorder in co-morbidity with Attention Disorder (Barkley, 1990; Banaschewski, Coghill, Danckaerts, Dopfner, Rohde, Sergeant, Barke, Taylor & Zuddas, 2009) and with the Autism Spectrum Disorder (Gliga, Bedford, Charman & Johnson, 2015).

The empirical studies on active and participatory teaching have been added to this descrip-

tion. They represent models to be applied to favour the learning processes of students that predispose them to understand rather than memorize (Fabbri, Melacarne, 2015). With respect to this perspective, students are at the center of the teaching process, they learn responsibly while also learning from experience (Fedeli, Grion & Frison, 2016). The brain, in fact, acquires concepts, notions and relationships much faster if it is pressed to put them into practice; because if it experiences them directly through physical and emotional involvement, they facilitate attention and memory, therefore there is an important relationship between corporeality and learning (Peluso Cassese, 2017).

Active teaching, favours the development of metacognition an excellent indicator of the success of the teaching-learning process, which makes one reflect on ones own individual way of learning, recognizing its strengths and weaknesses (Cornoldi, Friso & Palladino, 2006; Vygotski, 1931/2014).

2. The problem investigated

In the light of the theoretical framework illustrated, the problematic situation was examined in relation to the difficulties that students with SLD encounter. These were discussed regarding the neuroscientific hypotheses which would be useful for the teachers to design their own didactic in order to obtain the outcome desired.

In particular, a general slowness with reading and frequent stumbling over words are recognized as indicators of the Disorder; in writing disturbances in the execution of graphisms or the unsuccessful application of doubling of consonants, substitution of symmetrical graphemes, lack of accentuation in words, lack of apostrophes, the replacement of symmetrical graphemes, difficulties in understanding the text and in memorizing it (Zoccolotti, De Luca, Di Pace, Judica, Orlandi & Spinelli, 1999).

As far as mathematics are concerned, we find specular inversions of numbers, problems in counting and in the movement in the line of numbers (Lucangeli, Poli & Molin, 2003); difficulty in using the multiplication table (Profumo, 2002, p.154).

In this regard the research by Franceschini, Bertoni, Gianesini, Gori and Facoetti (2017) was useful. They afferm that in normal readers, the global visual scene is processed by the right hemisphere of the brain first, and after which, the local features are perceived by the left hemisphere. The researchers have found that individuals with dyslexia reverse the order, giving priority to details, struggling to recreate the global scene; they believe that an improvement of global perception would provide stronger reading abilities (p. 2). The same research highlights that a training of visual attention, involving silent reading of sentences with the masking of the letters and with set time limits, favors fluidity yet at the same time implements the global perception of it, in fact children with dyslexia have shown a reduction of local interference in the global task (Fig. 1d, p.3), with the use of better words and pseudoword reading performance (p. 6).

Detailed scientific studies of the method were considered. In this perspective, students who learn with a process that favors meaning, through active involvement, are better able to understand the text and study it in general (Calvani, 2012).

These assumptions call into question teachers and trainers as experts, who are willing to use didactic in a more competent way (Lo Presti, Tafuri, 2020).

3. Experimentation

3.1 Method

The experimentation was developed as a Research-Action aid, borrowing the empirical research model of Coggi and Ricchiardi (2005), which posed the question:

Would the discovery of neuroscience, which envisages local perception before the global one in DSA, have an effect on learning outcomes, if transferred to didatic, accompanied by the active involement of students?

In this perspective, a experimental group of 30 students was prepared, 15 attending primary

school and 15 attending secondary school.

The choice of the sample group was made on the basis of a functional analysis using the diagnosis by experts which highlighted the Specific Disorder in all of them and by taking into account the judgment of the teachers whose students were unsatisfactory in reading, comprehension of the text and in self-study (Tab. 1).

School Level	Primary School		Secondary School
No. of Students	8	7	15
Age of students	6-7	8—9 -10	11- 12-13
Clinical diagnosis: evidence of a Specific Learning Disorder	Reading Difficulty: 1) Incorrect predictive reading 2) sillabicate reading 3) Lack of rhythm in reading 4) Not respecting punctuation Difficulty in understanding Space-time difficulties Language difficulties Difficulty in attention Relational and communication difficulties	Reading Difficulty: 1) Incorrect predictive reading 2) sillabicate reading 3) Lack of rhythm in reading 4) Not respecting punctuation Difficulty in understanding Space-time difficulties and in calculating Language difficulties Difficulty in attention	Reading Difficulty: 1) Incorrect predictive reading 2) sillabicate reading 3) Lack of rhythm in reading 4) Not respecting punctuation Difficulty in understanding Difficulty in attention Difficulty in calculating
Judgment of the teachers	Difficulty in reading and writing Difficulty in understanding the text Difficulty in oral study Difficulty in mathematics Difficulty in attention Relational and communication difficulties	Difficulty in reading and writing Difficulty in understanding the text Difficulty in oral study Difficulty in mathematics Relational and communication difficulties	Difficulty in reading and writing Difficulty in understanding the text Difficulty in oral study among these, 10 also had difficulties in mathematics

Table 1: Ex -ante functional analysis

With the aim of attributing meaning to the question, the problematic situation was acted upon, through an experimental didactic project to bring about a change and document it without the presumption of generalizing the results obtained.

The experiment was conducted outside of the school context for about two months and following the tests, which were done to explore the results in reading, reading comprehension and self-study. the researcher shared them with the students, their families and the teachers of the classes' who attended the experiment.

The reading test evaluated the 4 descriptors that emerged from the functional analysis; the argumentative text comprehension, composed of 10 questions, allowed them to evaluate the objectives built on the basis of the adapted taxonomy of Anderson and Krathwohl (2001) in terms of knowledge (5 questions), ability (3 questions) and competence (2 questions)

Students were also offered a further test on the study of an historical piece, a discipline not normally dealt with in experimental didactic, which represented the litmus paper, showing and therefore, making it possible to evaluate the transfer of competence and verify the autonomous study and the metacognition.

The tests were considered passed, based on their compliance with the two qualitative indicators called 'Yes' and 'In part' however those identified by 'No' did not pass, these indicators were represented respectively by the marks 8, 7 and 5 and corresponding to the criteria defined for the descriptors of the tests (Domenici, 2009, pp. 90-95) (Tab. 2).

READING TEST			
Descriptors			
1) Correct predictive reading			
2) Unsyllable reading			
3)Respect for the rhythm in reading			
4)Respect for punctuation			
Indicators for qualitative assessment	Yes = mark 8	No= mark 5	Partially= mark 7
Criterions	All descriptors are satisfied	No descriptor	At least two descriptors are satisfied (Unsyllable reading and Correct predictive reading)
TEXT FOR COMPREHENSION TEST AND SELF-STUDY AUTONOMOUS (10 questions)			
Objective Taxonomy by Anderson and Krathwohl (2001)			
Remembering and Understanding (5 questions)	Applying and Analyzing (3 questions)	Competences (Evaluating and Creating and Metacognition) (2 questions)	
It represents the basic elements that the student needs to know in order to be familiar with a discipline (for example identify the specific terminology of the discipline and recognizing the links between the facts, recognizing the temporal sequence). Useful verbs: list, recite, outline, define, name, match, quote, recall, identify, label, recognize.	Knowledge of methods of operation, investigation methods and / or criteria for deciding when to use the appropriate procedures. For example, recognize the explicit and implicit message of the text. Useful verbs: calculate, predict, apply, solve, illustrate, use, demonstrate, determine, model, perform, present.	Knowing how to transfer a specific knowledge to other contexts, know how to make applications, know how to evaluate in a critical and/or appropriate test Useful verbs: choose, support, relate, determine, defend, judge, grade, compare, contrast, argue, justify, support, convince, select, evaluate.	
Indicators for qualitative assessment	Yes = Mark= 8	No= Mark= 5	Partially Mark= 7
Criterions	All descriptors are satisfied	Only the knowledge descriptor is satisfied	At least two descriptors are satisfied (knowledge and Applying and Analyzing)

Table 2: Indicators, criterion and descriptors of tests ex post

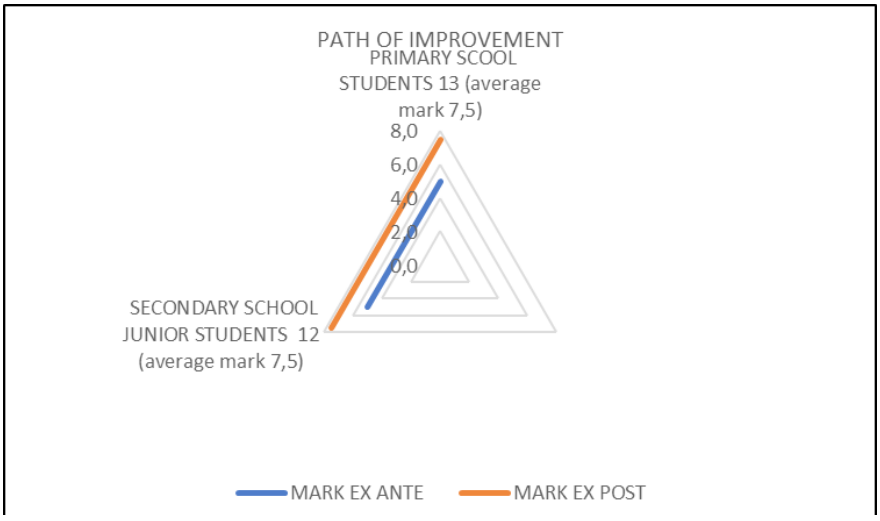
3.2 Results

The ex-post evaluation made it possible to document the effects of the experiment, highlighting the students' change in reading abilities, reading comprehension and self-study activities. Improvements were observed in the three tests for 83% of the total students. We'd like to add that the students who produced a more fluid reading ability also showed progress in reading comprehension and self-study; 56.6% of the students satisfied all the descriptors, 26.8% at least two and 16.6% did not improve their situation (Tab. 3).

READING TEST								
PRIMARY SCHOOL (8 students)			PRIMARY SCHOOL (7 students)			SECONDARY SCHOOL (15 students)		
Range 6-7 years old			Range 8-9-10 years old			Range 11-12-13 years old		
Mark 8	Mark 5	Mark 7	Mark 8	Mark 5	Mark 7	Mark 8	Mark 5	Mark 7
5 (16,6%)	1 (3,3%)	2 (6,6%)	4 (13,3%)	1(3,3%)	2 (6,6%)	8 (26,6)	3 (10%)	4 (13,3%)
TEXT COMPREHENSION TEST								
Mark 8	Mark 5	Mark 7	Mark 8	Mark 5	Mark 7	Mark 8	Mark 5	Mark 7
5 (16,6%)	1 (3,3%)	2 (6,6%)	4 (13,3%)	1(3,3%)	2 (6,6%)	8 (26,6)	3 (10%)	4 (13,3%)
SELF-STUDY AUTONOMOUS								
5 (16,6%)	1 (3,3%)	2 (6,6%)	4 (13,3%)	1 (3,3%)	2 (6,6%)	8 (26,6)	3 (10%)	4 (13,3%)

Table 3: ex-post evaluation

It can be said, that for 25 students, 13 attending primary school and 12 secondary school, the improvement path produced showed learning outcomes with an average grade of 7.5 (Graph. 1).



Graphe 1: Improvement path (qualitative)

3.3 Discussions

The results made it possible to explore the driving question of the research by bringing out three categories that made it possible to attribute meaning to it, through the characterizations of the didactic intervention that documented the change (Tab. 4).

Category 1	Implementation of the read-write
Category 2	Implementation of text comprehension and active didactic
Category 3	Self-study implementation

Table 4: Categories of change

3.3.1 Category 1: Implementation of the read-write.

The category linked the discovery of neuroscience, which foresees local perception before the global one in SLD students, to the experimental didactic activity prepared for the field of reading and writing. An exercise was proposed, to be carried out for 10 minutes a day, through which, the students spent this time reading spelling lists and rhythmic reading lists of single words identifying direct, inverse and complex syllables in order.

The logic of the activity lies in the stimulus sent to the local perception of the syllable, in order to implement the global perception. In fact, the students have learnt to segment words, pausing with the help of the rhythmic hand beat on each syllable, which is considered as a central unit of local representation. The reading was performed on the words twice in a syllabicate and rhythmic way, while the third time the students, observing the entirety of the word, repeated it all together, increasingly quickly (Franceschini et al., p.7).

To implement the global perception of the word, we also worked on writing, by proposing dictation of words with direct, inverse and complex syllables then continuing on to sentences and texts. The exercise is proposed for about 10-15 minutes a day requiring the student to repeat aloud the words spelt in syllables, matching the repetition of the syllable with the writing of the same. Also in this case the global perception was stimulated through the local one. After the exercice, it was possible to observe the change, in fact the students did not show any difficulties in the grapheme-phoneme correspondence, they did not omit syllables and/ or phonemes and graphemes and the reading was fluid with very few stumbles (Franceschini et. al., p. 8).

3.3.2 Category 2: Implementation of text comprehension and active teaching.

The second category was favored by the same exercise proposed for the reading of category 1, but not only. The students had the task of dividing the piece into several parts and finding for each of them, the most significant keywords that represented the links between the concepts expressed in the text.

This activity was accompanied by a discussion on the Taxonomy of the learning objectives to be achieved, which the students then used as a didactic guide for the overall understanding of the text. The proposed task allowed them to argue from different points of view and to make the knowledge explicit by defining its specific details. Furthermore, by reporting the relationships between the concepts described, the students highlighted the procedural knowledge that allowed them to choose the appropriate criterion for evaluating the piece, showing their ability to understand the text.

These activities were accompanied by a problem solving task, through in depth questions, such as: What do I need this information for? What do I know about this part of the text or topic? What strategies do I use to learn it? Did I understand what I did? How can I correct any mistakes? Have I achieved the goals I set myself?

This category has shown them how to be active students, at the center of the learning process, making them aware of the explanations on the characteristics of their way of learning and on the importance of experimental teaching strategies, preparing them to share the tools for the analysis of reading, study of the text and its evaluation, favouring it as a formative, constructive and transformative moment for learning (Tore, 2019).

3.3.3 Category 3: Implementation of the self-study

The category documented the change in studying abilities with respect to acting independently. It emerged that the same methods, experienced in category 2, were also applied to the study of the historical piece not dealt with experimentally. The students clarified in this way the transfer of competent action, favoring reasoning, reflection, critical and metacognitive skills.

This allows us to say that learning a method, understanding why and how to use it by experiencing it, also allows it to be reproduced in other fields of knowledge.

The categories allowed the researcher to analyze the learning process more profoundly by breaking it 0into three phases, called respectively phase 1, 2 and 3.

The first has strengthened the global perception into building a solid foundation on which to work on for the selection of information. The second allowed the selection of information linking it to the learning objectives in the context of active didactic. The last phase made it possible to verify the accuracy of understanding through the transfer of skills during the study of the historical text, helping students to fix concepts in their memory, to reason on the difficulties encountered and to evaluate the strategies used by developing metacognitive skills (Fig. 1).

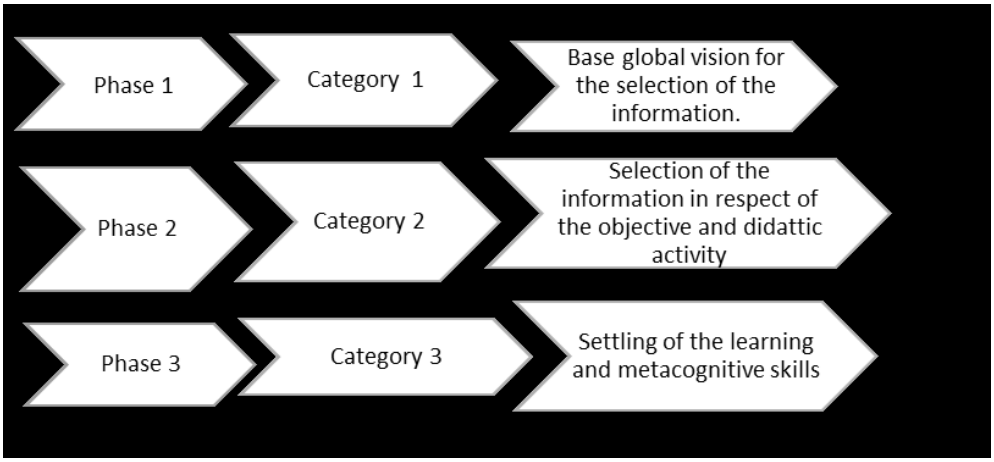


Figure 1: Fundamental phase of the learning process

4. Conclusions

Although the study can be improved, it presents results that are confirmed in literature (Cornoldi, Tressoldi, 2014) and that can be a significant starting point for teachers, determining practical implications. In fact, in response to the main question of the experiment and in accordance with the theoretical framework presented, some important aspects emerged: i) Having had the opportunity to learn about research, in the neuroscientific field, based on the discovery that local perception is predominant compared to the global one in students with SLD, it allowed the researcher to structure a didactic path for improvement that suggests repercussions in the learning of students with positive implementations on other skills as well.

ii) The active didactic approach has strengthened basic knowledge (decoding, memory, attention, intelligence, reasoning, problem solving, emotional-relational and metacognitive aspects) favoring reasoning on the meaning of the text, the recruitment of knowledge already possessed, integrating it with new information, selecting the most important information, omitting the irrelevant and associating concepts to produce new ideas.

iii) The proposed didactic activities have supported the competent actions of the students as evidenced by the learning outcome of independent study of the historical text with the transfer of knowledge learnt in a context not treated experimentally. The resulting implications could contribute to the improvement of teachers' practices, which can therefore be used in education and training, allowing students to be not only users, but active authors and producers of learning.

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