Giornale Italiano di Educazione alla Salute, Sport e Didattica Inclusiva / Italian Journal of Health Education, Sports and Inclusive Didactics - Anno 5 n. 2 - ISSN 2532-3296 ISBN 978-88-6022-411-8 - aprile - giugno 2021 - CC BY-NC-ND 3.0 IT - https://doi.org/10.32043/gsd.v5i2.380

INNOVAZIONE DIDATTICA E NEUROEDUCAZIONE AI TEMPI DEL COVID-19: LA SPERIMENTAZIONE DELLO SPACED LEARNING (SL)

DIDACTIC INNOVATION AND NEUROEDUCATION AT THE TIME OF COVID-19: THE EXPERIMENTATION OF THE SPACED LEARNING (SL)

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Abstract

During the Covid 19 pandemic, distance education also called distance learning or DAD (in Italy) has become part of school and university daily life. From March 2020 until today, teachers have experimented with new ways of teaching, mixing traditional teaching strategies with new paradigms, often innovative or in some cases "never tried" by teachers. In this time of didactic experimentation imposed by the pandemic, the studies of neurodidactic (Rivoltella, 2012) broaden the knowledge on learning processes, focusing attention on the learner and on the implications for teaching. Especially the studies on *Spaced Learning* (SL), a didactic methodology that is functional to quickly store information in long-term memory through repetition, have proved useful for improving the structuring of the synchronous and asynchronous hours of lessons during DAD. Based on the neuroscientific study by Douglas Fields concerning the mnemonic potential of the brain, published in 2005, Paul Kelley (2008) proposed and tested Spaced Learning (in Italian Interval Learning) which experimented in the Liceo Musicale of Caserta, in the school year 2020/2021.

Durante la pandemia Covid 19, la *didattica a distanza* chiamata anche DAD (in Italia) è entrata a far parte della vita quotidiana della scuola e dell'università. Da marzo 2020 ad oggi, i docenti hanno sperimentato nuove modalità di insegnamento, mescolando strategie didattiche tradizionali con nuovi paradigmi, spesso innovativi o in alcuni casi "mai provati" dai docenti. In questo periodo di sperimentazione didattica imposta dalla pandemia, gli studi di neurodidattica (Rivoltella, 2012) ampliano le conoscenze sui processi di apprendimento, focalizzando l'attenzione sul discente e sulle implicazioni per la didattica. Soprattutto gli studi sullo *Spaced Learning* (SL), metodologia didattica funzionale all'archiviazione rapida di informazioni nella memoria a lungo termine attraverso la ripetizione, si sono rivelati utili per migliorare la strutturazione delle ore di lezione sincrone e asincrone durante la DaD. Basandosi sullo studio neuroscientifico di Douglas Fields riguardante il potenziale mnemonico del cervello, pubblicato nel 2005, Paul Kelley (2008) ha proposto e testato lo *Spaced Learning* (in italiano *Apprendimento Intervallato*) che è stato sperimentato nel Liceo Musicale di Caserta, nell'anno scolastico 2020/2021.

Keywords

Spaced Learning (SL), neuroeducation, distance learning (DaD), long-term memory, teaching.
Apprendimento intervallato, neuroeducazione, didattica a distanza (DaD), memoria a lungo termine, insegnamento

Introduction

Over the past two decades, the neurodidactics field of study has amplified knowledge about learning processes, focusing on the learner and the implications for teaching (Battro, 2007, 2010; Strauss, 2005; Fisher, 2009; Fisher, Daniel, 2009; Goswami, 2004; Geake, 2009; Hinton, Fisher, 2008; Busso, Pollack, 2014; Immordino-Yang, 2013; Tibke, 2019; Willingham & Llyod, 2007; Willingham, 2017).

Researchers have acquired a lot of information on how the brain learns, also favoring the development of new disciplines: educational neuroscience, mind, brain and education, neuro-education, brain-based learning, brain education cognition.

In Italy the studies of Rivoltella (2012) have made a contribution to the Italian debate on the subject by starting a fruitful field of research called neurodidactics. In this scenario it is recognized that knowledge on the mode of functioning and the anatomy of the brain fueled the understanding of teaching / learning processes and that a greater awareness of learning environments, aimed at promoting and sustaining that neuronal connections, are facilitators in learning processes. Several studies link brain plasticity with the ability to learn, explaining how this is dependent on changes in the architecture and chemistry of our brain (Caine & Caine, 2006).

During the Covid 19 pandemic, distance learning or DAD, which suddenly became part of school and university daily life from March 2020, pushed teachers to experiment with new forms of teaching / learning. New teaching methods mixed with traditional forms have activated the search for new paradigms.

In this period of experimentation imposed by the pandemic, neurodidactics studies (Rivoltella, 2012), which broaden the knowledge on learning processes, have provided valuable suggestions to teachers.

Interesting and current, in this regard, have been studies on memorization systems that have offered teaching new ideas and fruitful reflections, including the mechanism of long-term enhancement (LTP) and long-term memory construction (LTM) is certainly useful for the learning process (Fields, 2005).

Douglas Fields, in the article Making Memories Stick, published in 2005, in Scientific American, lays out his neuroscientific study on the mnemonic potential of the brain. Researchers from Fields' team, building on this research, have experienced how repeated stimuli separated by timed spaces without stimuli can initiate long-term enhancement (LTP) and long-term memory (LTM) encoding. The consolidation process uses a phenomenon called long-term potentiation (LTP), which occurs when the same group of neurons connect together, sending signals, so often that they become permanently sensitive to each other. When the same network of neurons is crossed over and over again by signals, the message is more likely to flow along the familiar path of "less resistance". (For example, if a piece of music is played multiple times, by repeatedly lighting the same cells in a certain order, the brain will repeat the same sequence of signals with less effort later, resulting in the musician becoming better and playing with fewer of errors). Scientists have tried to understand «long-term memory (LTM) processes through a variety of approaches including using repeated, spaced stimuli» (Kelley & Whatson, 2013, p.2).

In 2003, the memory enhancement model was studied in many different species and in different contexts (Morris, 2003) and it was concluded that repeated stimuli interspersed with periods with no stimulus make the links between the neurons.

These studies show that repeated stimuli interspersed with stimulus-free periods can lead to intracellular signaling mechanisms that activate genes, triggering protein production (Scharf et al., 2002; Hernandez and Abel, 2008). These proteins can then strengthen sensitized synapses, triggering LTP and LTP encoding (Frey and Morris, 1997; Barco et al., 2008; Moncada et al., 2011). The effectiveness of spaced repetition in creating long-term memories has been experimentally demonstrated in many species on minute time scales (Itoh et al., 1995; Scharf et al., 2002; Morris, 2003). LTP / LTM processes differentiate LTM from short-term memory (STM) since synaptic labeling and capture processes do not occur in STM. So while STM creates temporary memories more quickly, these memories quickly fade away in a day or two; on the

contrary, LTM can last a lifetime.

Over the past decade, advances in human neuroscience have highlighted the critical importance of time in creating long-term memories, as research in the neuroscience of long-term memory (LTM) has shown that time-spaced learning patterns during the three-day repetitions of information separated by two rest periods are effective in creating memories in mammals and humans.

Consequently, interval learning allows the construction of long-term memory, thanks to the fact that periods of stimulation of the neurons are followed by periods of absence of stimuli, which improve the effectiveness of long-term memory (Itoh et al., 1995; Scharf et al., 2002; Morris, 2003).

It was understood that the stimulations must be separated from empty moments in which the cell is not stimulated, it follows that the important factor in the memorization process is precisely time. This intuition is the basis of Spaced Learning (Kelley, 2008), a didactic methodology functional to the rapid storage of information in long-term memory through repetition (Caprino et al., 2016).

1. Neuroeducation and Spaced Learning

Based on Douglas Fields' neuroscientific study of the mnemonic potential of the brain, published in 2005 in Scientific American, Paul Kelley (2008) proposed and experimented with Spaced Learning, a learning method in which the learning content is repeated several times, with breaks from ten to fifteen minutes during which the students carry out other activities.

Starting from a "temporal code" used by Fields in his experiments, Paul Kelley has developed a learning method for the creation of long-term memories (Kelley, 2007), which is also inspired by the results of other neuroscientific research (Roediger & Karpicke , 2006; Poldrack, 2010; Roffman et al., 2016), from different epistemological pedagogical approaches, from cognitive theories and learning theories.

There are several cases of implementation of Spaced Learning, in fact in the e-learning method developed by Klemm short intervals are foreseen for the improvement of information conservation (Klemm, 2012). The experiments of Kelley and Whatson have shown that this type of spaced learning is optimal for encoding information and for activating the genes needed to form long-term memory (Kelley & Whatson, 2013). The development of this methodology through the integration of the pedagogical perspective of Spaced Learning with the different technological solutions in the e-learning environment offers the opportunity to add greater value to the educational process through two advantages: the reduction of time to favor the total learning and greater involvement of students as being their "digital natives" they see technology as an excellent tool for didactic mediation.

Spaced Learning is a powerful method for improving the acquisition and understanding of knowledge.

For those involved in pedagogy, a comparison with the scientific contributions coming from neuroscience is necessary. This is because today it is unthinkable to go into didactic-educational issues, doing without the results coming from the neuroscientific field. Many psychological theories, in fact, following the new acquisitions of neuroscience, must even be rewritten and this ends up having inevitable repercussions on the pedagogical concepts and on the didactic models used in the educational field. This confrontation, however, must take place without abandoning oneself to discounted reductionisms and without producing entrenchments on skeptical positions, which would only end up giving life to yet another dichotomy (cerebralism / mentalism, materialism / idealism).

The intent is to inaugurate a season of interdisciplinary and experimental dialogue, which can lead to new theoretical syntheses:

«Advances in research into the mind, brain and education require genuine collaboration between researchers and practitioners, with both groups working together to contribute to inquiry and knowledge. Research results can clarify educational practices and educational observations

can provide questions and insights for research» (Battro, Fischer & Lena, 2008, p.5)

The goal, therefore, is to build a bridge between what today remain two shores still very far from each other: pedagogy and neuroscience. There is a growing interest in the Western world for this area of research, but it is necessary to clarify some epistemological issues, which inevitably arise when trying to define a new area of study. It is necessary to highlight the increasingly close relationships that are being created between the world of neuroscientific research, and in particular of cognitive neuroscience, and the didactic-educational field. To do this, it becomes essential to start from the epistemological question, to clarify whether we are facing the birth of a new empirical science, a new research paradigm, or a "field of exchange" of empirical experiences of epistemologically distant disciplines.

If we add to all this the observation that we are talking about studies carried out largely in the Anglo-Saxon culture and that in any case the works published internationally are in English, with the related translation problems, we realize that how much it is necessary to dwell also on linguistic-terminological issues.

To make a correct analysis of the elements in the field it is therefore necessary to know how to move on a terrain that appears increasingly insidious, due to the uncontrolled proliferation of concepts, definitions and neologisms, which try to explain, not always successfully, the epistemological peculiarities of their own research fields.

The need to make neuroscience and the world of education dialogue has grown to the point of generating a jumble of experimental approaches, with subtle as well as impalpable epistemological and terminological distinctions, which have created a certain disorientation in those who approach it for the first time. To date, the international literature includes numerous denominations: Educational Neuroscience (Geake, 2009), Neuro-learning (Bruer, 2003), Neuroeducation (Fischer, 2004; Goswami, 2004; Petitto and Dunbar, 2004) Brain-based Education (Caine & Caine, 1995), Neuropedagogy (Danesi, 1988), Mind, Brain and Education (Battro, 2007), Neurodidattica (Preiss, 1998; Herrmann, 2006).

To avoid that this reflection also contributes to increasing lexical confusion, it was decided to adopt the term neuroeducation, because, with all its epistemological and philosophical limitations, better than others it highlights the peculiarity of this new pedagogical approach. Unlike Educational Neuroscience, which refers more to neuroscientific research useful for the solution of didactic-educational problems, or Mind, Brain, and Education, which while theorising a transdisciplinary space of investigation, keeps these three areas distinct, the term neuroeducation it already reveals on the terminological level the intention to characterize itself as a new paradigm of educational research or even as a new science.

Today neuroeducation is almost exclusively investigating the cognitive processes involved in school learning, which is why the attention paid to Spaced Learning and all those neuroscientific advances have had a very strong impact on the scientific world and beyond. These advances could not fail to have consequences on a discipline such as Pedagogy, which has the learning process as its epistemological and operational foundation. The neuroscientific discoveries, in fact, even if at times they have confirmed experimental intuitions and inferences made by previous works in the field of biopsychopedagogical sciences, in other cases they have overturned old scientific assumptions and forced to review the educational-didactic processes inspired by them.

The new frontiers of the study of the brain cannot fail to have an impact on the world of education, for the simple reason that the cognitive, emotional-affective and relational processes, which are the foundation of all learning and therefore of the entire life of the human being, they happen right in that organ. The problem is not to be convinced of this close relationship, but of the possibility that the effects of neuroscientific discoveries on the didactic-educational world are immediately "visible" and "expendable". A new need has arisen from this scientific horizon: to facilitate the dialogue between these two worlds. Thus, different approaches to the problem were born.

The area of neuroeducational research arises from the need to verify any implications of

neuroscientific discoveries for teaching and learning. It was in fact the spread of functional neuroimaging applied to research on cognitive processes, which opened up new scenarios and pushed the scientific community to undertake a serious discussion on these possible "contaminations".

The reflection is supported by the belief that today pedagogy can no longer ignore the acquisitions of neuroscience and in particular of cognitive neuroscience. The numerous discoveries that come from this scientific sector, especially those concerning brain plasticity and neural interconnectivity, are profoundly changing certain assumptions about learning and teaching processes. And to prevent teaching from continuing to be entangled and guided by "neuromites" or by a naive cognitive psychology, a continuous and more fruitful dialogue between the educational and training world and the neuroscientific one becomes indispensable. In this epistemological panorama, for Margiotta, pedagogy assumes the role of mediator between the scientific world and the humanistic world, which in fact recognizes its hermeneutic, regulatory and foundational specificity.

For Margiotta «The epistemological value of this theoretical position lies, in fact, in the pedagogical potential of the exercise of a "transversal" function that yields nothing to reductionism and takes nothing away from the radical vocation, the transcendental tension and the reflective and metatheorical nature of pedagogy. Because the proposing and explanatory role of pedagogy certainly places us at the junction of bioeducational and anthropoformative perspectives: pedagogy as a mediator between neuroscience and post-cognitivism, between the educational sciences and those of training; and propagator of a cultural result of great interest in the ongoing rethinking of training processes in the complex mind-brain-learning and nature-culture-training relationships» (Minello & Margiotta, 2011, p.227).

2. The experimentation of Spaced Learning in the Liceo Musicale

During the pandemic, Spaced Learning was experimented in the "Terra di Lavoro" Music High School of Caserta, during distance learning, (in fact from mid-October 2020 until mid-April, according to an ordinance of the Campania Region, high school students have followed all the remote lessons). The methodology was tested in a second class of the musical high school, for the disciplines of Letters and Geo-history.

The Spaced Learning activity experienced in the Music High School is organized in 6 steps:

1. First input (15/20 minutes): stimuli are provided through the presentation of many condensed contents (a short report, usually supported by a power point presentation).

2. Break (10 minutes): a short break with distracting activities (usually being musicians, playing their instrument or listening to music).

3. Second input (15/20 minutes): focuses on recall (reconsolidation), during which students are stimulated in various ways, eg. using the same presentation from which many keywords have been removed or viewing a video showing the topics presented in the first input.

4. Second Interval (10 minutes): Another short interval with distracting activity.

5. Final input: focuses on understanding, in this phase the students perform a task in which the knowledge or skills learned are applied, (a written work to be delivered by the end of the hour, via the G-suite for education platform).

6. Self-assessment: after completing the task useful for evaluating the knowledge and skills learned, each student fills out the cognitive autobiography (self-assessment tool).

Spaced Learning was used both for the explanation of new topics and for moments of recovery.

During the two 10-minute intervals the students (without ever turning off the webcam) could carry out a whole series of distraction activities, physical-manual activities ideal for minimizing possible interference in the synaptic coding and in the memorization processes that were occurring. but each time, almost everyone chose to play their study instrument or listen to music.

This interspersing lessons with a 10-minute break was completely new, in fact, during the DAD, students are used to having a synchronous hour and an asynchronous hour (most of the

time engaged in carrying out tasks assigned by the teachers). During Spaced Learning, the students gave up on the asynchronous time, happy to do these two 10-minute intervals and to be able to quickly learn the concepts explained.

The experimentation gave positive results, first of all a lesson hour in Spaced Learning had a greater impact than many traditional lesson hours, allowing a much faster learning and easily verifiable by the teacher.

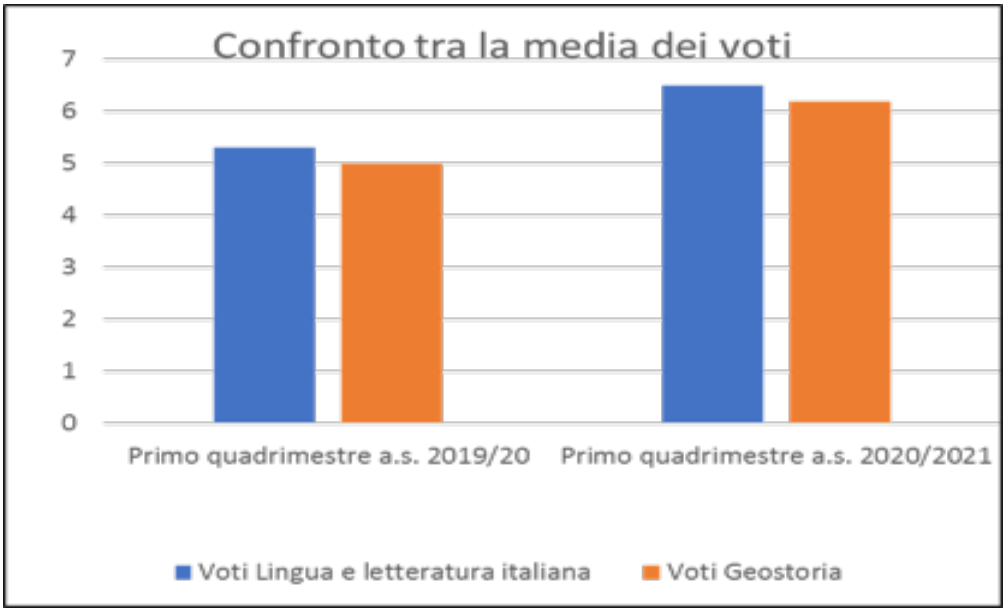

Figura 1. Confronto tra le valutazioni quadrimestrali.

The students learned the concepts much more quickly and the grades in the first quarter were significantly higher than in the first quarter of the previous year, despite the DAD. The grades reported by the students after the scrutiny of the first quarter (figure 1) indicated that Spaced Learning led the majority of the class towards educational success in Literature and Geo-history.

The intense moments of instruction were not an obstacle to understanding, indeed it was found that even weeks and months later in a Spaced Learning session, the information received was maintained, compared to days when the explanation was traditional.

The lessons were more participatory and dynamic, in fact the students were more responsible for their learning process, as well as the concentration of the students remained high. The cognitive autobiography, which is not only a self-assessment tool, but also a formative one, was also useful.

From the cognitive autobiographies very positive judgments emerged from the students who stated that Spaced Learning helped them to learn quickly and asked other teachers of the course to adopt the same method (especially those of scientific disciplines).

Conclusions

Spaced Learning made it possible to maximize the concentration of students, avoiding cognitive overload and favoring memorization by resorting to repetition. In close relation with the theories of neuroscience, this mnemonic technique allows to improve the learning abilities of students and can be applied in any school order and grade.

Neuroscientific research sheds new light on adolescent brains and the difficulties teachers

and educators face in their work. This means for the teacher that more than calling the student's responsibility towards the learning task, she will have to understand how to make it captivating. What can or should the school do in the face of these issues? The school cannot ignore how much cognitive neuroscience makes it possible to know in terms of learning: these are themes that must enter into the initial and in-service training of teachers. Starting from here, however, it will be the teacher's task to plan the teaching and manage the class because education - neuroscientists themselves indicate this - continues to be above all a relationship.

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