NEUROSCIENCE IN THE CLASSROOM: MAKING TEACHERS' LEARNING VISIBLE

NEUROSCIENZE IN CLASSE: RENDERE VISIBILE L'APPRENDIMENTO DEI DOCENTI

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ABSTRACT Understanding how the brain works can help improve teaching effectiveness. To this purpose, a research-training was set up with teachers from three schools serving students aged 3-13. Quantitative and qualitative tools were used in order to understand how neurosciences can improve educational practices. This paper presents the results of the use of the Thinking Routine "*Connect-Extend-Challenge*" with teachers. It describes how they could reflect on their teaching practice to implement new methodologies in the classroom. The themes that most scaffolded teachers' reflection is the functioning of cognitive processes and the importance of integrating emotions into teaching. Less attention is given to some concepts (i.e. feedback, curiosity, etc.) that are perhaps still taken for granted.

KEYWORDS Educational Neurosciences; Neurodidactics; Teacher's Training; Making Learning Visible; Visible Thinking.

SOMMARIO Comprendere come funziona il cervello può migliorare l'efficacia dell'insegnamento. A questo scopo, è stata impostata una ricerca-formazione con insegnanti di tre Istituti Comprensivi del centro Italia. Sono stati utilizzati strumenti quantitativi e qualitativi per capire come le neuroscienze possano migliorare le pratiche educative. Il presente contributo presenta i risultati dell'uso della Thinking Routine "*Connect-Extend-Challenge*"

con gli insegnanti. Descrive come hanno potuto riflettere sulla loro pratica di insegnamento per implementare nuove metodologie in classe. I temi che più hanno sostenuto la riflessione degli insegnanti sono il funzionamento dei processi cognitivi e l'importanza di integrare le emozioni nella pratica didattica. Minor attenzione è data ad alcuni concetti (es. feedback, curiosità, ecc.) che forse sono ancora dati per scontati.

PAROLE CHIAVE Neuroscienze Educative; Neurodidattica; Formazione degli Insegnanti; Rendere Visibile l'Apprendimento; Pensiero Visibile.

1. INTRODUCTION

Understanding how our brain works can help to improve teaching practices. Knowing how learning processes develop can help to create the best conditions for student success. "*Teachers try to change the human brain every day. The more they know about how it learns, the more successful they can be*" (Sousa, 2016, p.5) and the more they can promote well-being in the classroom (Harrinngton, Beale, Fancourt, & Luts, 2021; Steward, 2021).

Several scientific domains are considered in this contribution: cognitive neuroscience, since they focus on understanding how the brain enable us to think, reason and make decisions; educational neuroscience, focusing on issues related to education (Geake, 2009); affective neuroscience, which aims to explore how the mind is influenced by the interdependence between the body and the brain (Immordino-Yang & Damasio, 2007); and, finally, neurodidactic research (Rivoltella, 2012), focusing on the interaction of psychology, pedagogy and neuroscience.

Current studies focus both on processes and functions useful for developing domains of expertise, such as mathematical or reading literacies, by investigating how the neural networks involved in these specific learning domains function; and on "*domain-general processes, which include emotions, social processing and attention*" (Immordino-Yang, 2016, p. 87).

It is increasingly evident that the dichotomy between cognition and emotion does not make sense, both in terms of brain structures and in terms of students' skills development. Students learn within social and cultural contexts, which inevitably contribute to cognitive learning (Kress, Selander, Saljö, & Wulf, 2021). The student's engagement, the level of relevance that is given to the study and the emotions experienced in the learning process are strongly interconnected aspects; in fact, the mind, the body, the Self and the social context are not disconnected elements.

At present, studies on the impact of continuing professional development courses for teachers based on educational neuroscience are limited and it is therefore impossible to draw strong conclusions, although most of the results are promising (Privitera, 2021). However, the opportunity to learn about and reflect on false knowledge allows teachers to improve their ability to plan teaching (Betts et al., 2019). In this regard, involving experts from the disciplines of neuroscience and psychology to clarify neuromyths to educators and teachers was found to be one of the most important factors in improving the quality of training courses (Grospietsch & Mayer, 2020). It is also important to consider transversal dimensions in those kinds of courses, so that teachers can appreciate their application to lesson plans, since the brain functions and human behaviour include intertwined aspects (Damiani & Paloma, 2020).

This paper aims to present a teacher professional development course designed on neuroscience and brain-based research. The course took place in an online platform: technologies have allowed the delivery of the course to

teachers. The course was embedded in a wider action-research activity aimed to explore how neuroscience can promote innovative teaching and learning practices. This contribution reports on the first phase of the project and is intended to discuss preliminary results, or how teachers - trained on educational neuroscience - can reconsider their mindset and teaching practices and implement new scenarios in their classroom.

The course was designed to offer a professionalising opportunity, by relying on the potential of an online learning environment, and enhancing the autonomy and centrality of the participants (Ranieri & Giampaolo, 2018). The neurodidactic principals and the MBE (Mind, Brain and Education Science) studies represent the contents and activities' background proposed in this research training (Mori, Panzavolta, & Rosa, 2021).

2. KNOWING THE BRAIN TO IMPROVE TEACHING

The MBE studies that concerned the teaching-learning dynamic (Betts et al., 2019; Tokuhama-Espinosa, 2019) and neurodidactic research on teacher training (Rivoltella, 2012) offer several suggestions for improving teaching practices.

Dehaene (2019) lists four main pillars of learning:

1) attention, which amplifies the information our brains focus on;
2) curiosity, which is active engagement;
3) feedback on error and its importance; and
4) the consolidation of what has been learned.

"*The principle of active involvement states that it is essential that the student is motivated and engaged in learning*" (Dehaene, 2019, p. 225). Stimulating material, involvement, enjoyment and autonomy are for the author fundamental ingredients for effective learning. The author also points out that curiosity, as the ability to keep alive the desire to discover and learn, assumes a peculiar role in motivation: it has been seen that dopamine circuits are at the centre of curiosity, the more the nucleus accumbens and the tegmental area are activated, the more we are predisposed to learning. The desire to learn and the thought that we will be able to do so are already a reward for the body itself: curiosity directs us towards what is deemed useful to learn. This mechanism becomes important for us both as we train teachers and as content is conveyed to teachers in their teaching.

The process through which we learn encompasses the need for feedback and reflection on what we are doing: Dehaene (ibidem) gives the example of the hunter who learns to aim by trial and error, correcting the shot towards the target. Taking up Rescorla and Wagner's equation (1972), it describes how the brain learns when it detects a difference between what it expects and what it finds:

1) The brain makes predictions based on the input it acquires from outside and from its own experience.
2) It calculates a prediction error, i.e. the difference between what is expected and the stimulus received.
3) It corrects its internal representation, to make the next prediction more accurate.

At the cognitive level, the phases of this mechanism retrace the process of "assimilation and accommodation" already proposed by Piaget (1971) and highlight the central role of prediction in learning (Rivoltella, 2014).

Within this theoretical framework, learning means reducing unpredictability and surprise: this prediction is based on past knowledge and experience; it is useful for the brain because it avoids giving importance to predictable and already known signals, amplifying new and unpredictable stimuli.

All areas of the brain participate in these processes of prediction and error detection: this allows the mind to modify and correct its models of the world.

Some concepts, therefore, take on a central role in learning processes.

Memory has been reported as the cognitive construct most correlated with academic success (Geake, 2009), along with attention. Its function is much more about the future, rather than the past, as is often thought: it offers us in fact the ability to select and recollect information useful to face what will happen. The role of repetition and reiteration of stimuli is central to this process (Rivoltella, 2014).

As far as teaching is concerned, another central concept is that of motivation. As with other psychological constructs, motivation can also be described with a bell-shaped pattern: several models from the Yerkes-Dodson law (1908) to today tend to confirm that too low a level of activation does not allow the body to direct its energy and attention, while excessively high levels cause anxiety, mobility and a sense of helplessness. If the information that comes to us is too familiar, it does not arouse interest, but this is also the case if we consider it too distant or complex. "*Our curiosity directs us to what is new and accessible*" (Dehaene, 2019, p. 230).

However, there are many "*neuromyths*" (Betts et al, 2019), even among teachers, on how the brain functions and how this can influence the educational success of students.

Sousa (2016) suggests twenty-two key actions useful for guiding neuroscience-inspired instructional design. We summarise them as follows: always provide meaning to what the students are learning; foster a positive climate in class; fragment learning into mini-lessons of about 20 minutes each; use methods to increase motivation; promote rehearsal; pay attention to time management by giving space for questions; encourage memorization and chunking strategies; elicit connections to prior knowledge; use transfer to other contexts; employ multisensory activities; recommend imagining strategies; be conscious of the role emotions in learning; integrate technology to promote student engagement.

Dehaene (2019) points to thirteen strategies for optimising children's learning potential: never underestimate brain modules that are already present from infancy; take advantage of sensitive periods; make the learning environment rich in stimuli; keep in mind that brain structures are similar for everyone and therefore that teaching methods can effectively work with students to overcome difficulties; place great importance on attention; stimulate curiosity and active involvement; make the learning experience pleasant; deepen information to favour memory; give clear and precise objectives; consider mistakes as opportunities; favour the consolidation and automation of knowledge to reduce the overload on the prefrontal cortex; do not neglect the importance of sleep in learning processes.

All of these concepts and directions were the basis for both the design of the training course and the content of course.

3. VISIBLE THINKING AND THE CONNECTION WITH NEUROSCIENCES

Visible Thinking (VT) (Ritchhart, Church, & Morrison, 2011; Perkins, Tishman, Ritchhart, Donis, & Andrade, 2000; Tishman, Perkins, & Jay, 1995) is an approach to teaching thinking to learners that develop thinking dispositions, such as the inclination to be curious, open-minded, or planful, while also deepening their understanding of the topics they study. Such efforts typically focus on thinking skills like reasoning, problem-solving, and providing evidence to support a claim. However, if learners are to apply these skills with flexibility

in a variety of contexts, teaching thinking skills alone is not sufficient. Decades of research at Project Zero (PZ)[1] - a research centre at the Harvard Graduate School of Education - and elsewhere show that the dispositional side of thinking (e.g., alertness to opportunities for thinking and the motivation to do so) is also critical (Perkins et al., 2000; Mughini & Panzavolta, 2020).

One of the main goals of teaching learners to think is to help them develop different kinds of understanding in different subject areas. Some types of thinking are specific to certain disciplines e.g., evaluating the reliability of a source in history or developing proof in mathematics. However, the Visible Thinking research team also identified certain types of high-leverage thinking moves that are likely to support the development of understanding across disciplines (i.e. observing closely and describing what's there; building explanations and interpretations; reasoning with evidence; making connections; considering different viewpoints and perspectives, etc.). If understanding is one of the primary purposes of school and training, then the thinking moves are an attempt to identify the kinds of high-leverage thinking involved in developing understanding. Once teachers have articulated where they and their students are headed, thinking routines provide a way to help make learner thinking visible and to deepen their understanding. Thinking Routines (TRs) are tools that teachers can use to support specific thinking moves such as activating prior knowledge or using metaphors to make connections. They also provide purposeful and easy-to-learn structures and language that can help learners become more metacognitive about their thinking.

VT, like many other PZ frameworks, are designed to support:

- Transformational as well as technical learning (Mezirow, 1995). Technical learning refers to the application of proven knowledge and skills in practice; i.e., doing something better; transformational learning refers to questioning fundamental assumptions and beliefs and developing new theories; i.e., doing something different).
- Adult learning as much as student learning. This is the reason why it was decided to use one of the PZ TRs within this course.
- The shift from a transmission to a more inquiry-based model of learning.

In line with neuroscientific attempts to apply brain-based research to educational contexts (Immordino-Yang, 2016), in the context of socio-constructivist theories, it is useful to integrate the evidence from studies on mirror neurons as competencies can be defined as flexible repertoires directed to a purpose, representations relevant to the context built by the convergence of actions ("*what I have done and thought"*) and perceptions ("*what I have perceived as a result and how this made me feel/think*") (Gazzaniga, Ivry, & Mangun, 2005).

Furthermore, effective teaching is about modeling efficient, appropriate and flexible skills, so that the objectives become evident to students. If students do not recognize that the teacher's actions are directed to a purpose, they will not be able to simulate or internalise the teacher's thoughts and actions, because his/her actions will seem random rather than meaningful and easy to remember.

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1 In 2017, Project Zero (www.pz.harvard.edu) and Indire, Istituto Nazionale di Documentazione Innovazione e Ricerca Educativa (www.indire.it) in Italy, began a new collaboration—Making Learning and Thinking Visible in Italian Secondary Schools (MLTV)—to determine how two of Project Zero's pedagogical frameworks—Making Learning Visible (MLV) and Visible Thinking (VT)—could be adapted with integrity in Italian public secondary schools. The results of the joint research have been published in a Monograph: "MLTV - Rendere visibili pensiero e apprendimento", published by Carocci in 2020.

It appears evident, also from the contribution of other brain-based studies, how using thinking structures can help to make thinking and learning explicit and make it visible in a clear way (and easy to memorise) so that the intention of the teacher can be embedded in a repertoire of meaningful practices. The resulting "facing tasks, tests, and reasoning" allows learners to internalise a modus operandi for making a plan of action, where perception, action, and reflection on action interact, as for all the actors involved in the learning process.

4. THE RESEARCH-TRAINING CONTEXT AND THE AIMS OF THE STUDY

The "Neuroscience for education continuity" project is a participatory and collaborative research model, based on the analysis of practice as one of the central activities for the professional development of teachers (Magnoler, 2012). In accordance with the perspectives of co-research and research training (Asquini, 2018; Mortari & Ghirotto, 2019) both qualitative and quantitative investigation techniques were used (Creswell, 2003). The purpose of the research is therefore both descriptive and evaluative.

The research started from an online professional development course for teachers aimed at stimulating their reflection on learning/teaching practices. The course is made up of 3 modules, each of which is divided into 7 video-lessons lasting about 25 minutes each, accompanied by in-depth materials and tasks to be carried out. The first and last modules are addressed to all teachers of the three schools participating in the research, regardless of students' age; the second module has been split into 2 sections, one addresses teachers in the kindergarten and in the first classes of primary school, the other addresses teachers engaged in the last classes of primary school and lower secondary school.

The team of researcher-trainers who designed the course is multidisciplinary, as also suggested by Rivoltella (2018), in order to activate a process useful for neurodidactic research: it is composed of two psychologists and one pedagogue.

Lecture content was structured from the main frameworks on educational and affective neuroscience described above.

In the first module, the following topics were covered:

- the memory system;
- brain adaptations and neuroplasticity;
- the factors that influence learning;
- the mechanisms that regulate attention;
- emotions;
- motivation in school;
- intelligence.

In the second module, addressing kindergarten and the first classes of primary school teachers, were covered contents such as:

- the importance of play;
- the development of musical and artistic intelligence;
- the movement and the brain;
- the power of storytelling;
- the attachment theory.

For teachers in the upper grades, the following contents were provided:

- learning to learn;
- formative evaluation;
- the neuroscientific basis of active learning;
- creating a good classroom climate;
- digital tools to support brain-friendly teaching;
- autonomous learning and peer tutoring;
- the neurobiological basis of metacognition.

The third module - focussing on instructional design - addressed the following topics:

- the importance of mistakes and the feedback;
- the principles of Universal Design for learning (Rose, 2000);
- making learning visible;
- working in small groups, brains and social skills;
- research material for teaching.

Recorded video lectures were alternated with webinars with researchers and activities were suggested aimed at reflection sharing and collaboration among teachers.

The course model also foresees a course tutor, available for further clarifications and active in moderating online discussions.

In this context, the roles of teachers and of researchers are synergistic: researcher-trainers carrying out a synthesis and a connection with theory, proposes teaching suggestions drowing on brain-based research; teachers experiment, observe, triangulate and return interpretations in order to prepare lesson plans and learning opportunities based on brain-based research.

On the basis of the contents outlined in the training we would like to answer the following question: "*How can neuroscience promote innovative teaching and improve educational practices?*". We would like to highlight the issues of greatest interest to teachers in this area and assess what further aspects could be explored in order to promote effective learning design

Analysis of the teachers' initial profiling questionnaire revealed high expectations of the course for learning new teaching strategies: the greatest interest was directed towards the relational and emotional aspects of learning processes (Mori, et al 2021). Promoting an educational design that takes into account the connection between cognitive and emotional aspects is one of the theoretical assumptions illustrated in the previous paragraphs: these assumptions guided the design of this training research. In this sense, the initial expectations of the teachers well fit with the proposed course. Before the training the MESI (Motivation, Emotion, Strategy and Teaching) battery (Moè, Pazzaglia, & Friso, 2010) was also administered to understand the teaching practices used by the teachers: the results show a high focus on teaching strategies that promote active participation (time for discussion and questions) and strong monitoring of students' retention of attention. Less use of summarising activities, sharing schemes and definitions emerges (Mori, et al, 2021).

This paper is aimed at illustrating the results of the activity proposed to the teachers at the end of the second module, that is, at the end of the theoretical video lectures on content (e-tivity A and B described below in the tools section). To "make visible" the teachers' learning, it was chosen to use one of the TR: they were asked to reflect on how much and how the training had changed their previous knowledge and what perspectives they had. Within this context the research questions are: "*which of the contents proposed in the training course had a greater impact on the new knowledge and skills acquired by the teachers?*", "*How did the topics related to neuroscience*

and neurodidactics provide innovative insights into their actions, according to their perception?". Through the analysis of the contents of the TRs, we therefore intend to highlight the core areas of interest for teachers and the elements of greatest educational innovation. At the same time, the use of TRs improves the awareness and learning of the teachers themselves.

5. METHODOLOGY

5.1. Participants

The three participating schools were chosen because their head teachers had joined previous research initiatives. An average of 15 teachers per school were involved to facilitate and stimulate peer collaboration.
There are 40 participants in this research: 39 females and 1 male.

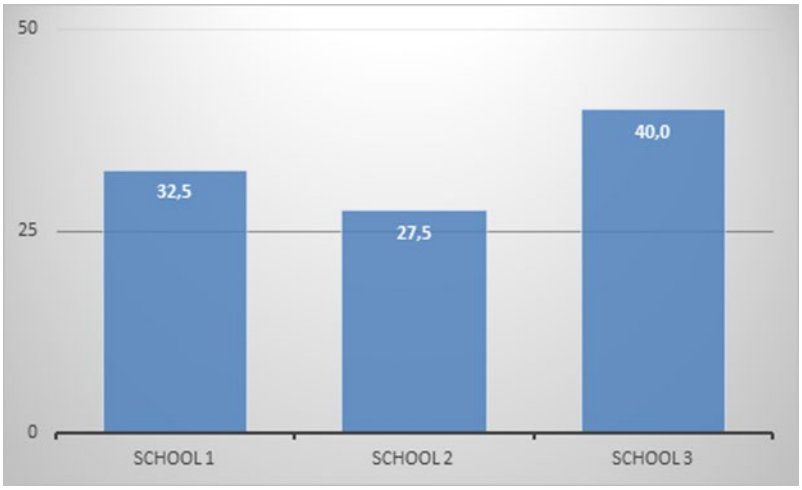

Figure 1. Distribution of teachers in the three schools.

Thirteen teachers are teaching in School 1, 11 in School 2, 16 in School 3. Most of the teachers (24) are from primary school, 8 from lower secondary school, and 3 from kindergarten (Figure 1). As for the age, 17.5% are under 40 years and most are between 40 and 60 years; only two are over 60 years.
Among the participants, 17 (42,5%) completed the e-tivity on kindergarten and early primary content (called e-tivity A); 23 (57,5%) completed the e-tivity regarding the contents of the last classes of primary and secondary school (called e-tivity B).

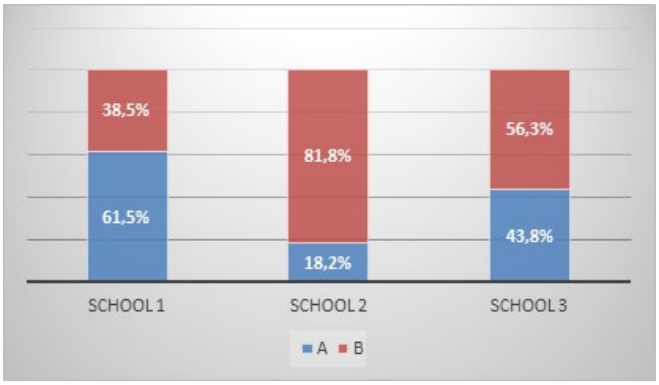

Figure 2. E-tivities A and B carried out in the 3 schools (X2 (2, n = 40) = 1101,629 p< 0.01).

Each participant had to choose between one of the two online activities, A or B. In each school, there are teachers that have carried out both activities. An analysis of the association between the two variables (schools and chosen activities) was carried out by means of chi-square statistics: it compares the joint distribution of the observed variables with the theoretical joint distribution that would occur if there were no association between the two variables. As can be seen from the percentages, the association between the two variables is statistically significant (Figure 2). In school number 2, the one with the smallest number of participating teachers, it was chosen mainly the e-tivity B.

5.2. Tools

Within the course "Neurosciences for educational continuity" it was decided to use the Thinking Routine "Connect-Extend-Challenge". A double possibility for the same tool was given: one addressed to pre-school and early primary school teachers (e-tivity A), the other to teachers of the last years of primary and secondary school (e-tivity B).

Thinking Routines are simple, easy-to-learn strategies for accessing learners' thinking and making it visible in the classroom (Ritchhart et al., 2011). The Routines typically entail a short series of steps or questions intended to jumpstart thinking across grade levels and content areas. Although the Routines can be used individually, they are designed to capitalise on the benefits of learning in a group.

This Routine is to be used to make explicit connections to something previously learned or experienced (in this case, "*how neuroscience can promote innovative teaching and learning approaches and improve educational practices"*). Since it is designed to help people process new information actively, it works well as the conclusion to a module in which learners have been reading, watching videos, or otherwise taking in new information. Another approach is to use the Routine to close the discussion of a topic or unit of study in order to help learners synthesise the information.

It was decided to propose this TR individually as one of the mid-term tasks to be performed by teachers. According to the indications provided by PZ, when learners are working individually, they could document their responses in written form.

The form provided in the training platform had 2 components. The first component was made up of the 3 points highlighted in this TR:

- Connect. With reference to the contents of the first two modules, where we have presented the fundamentals of the functioning of the brain in relation to learning (memory, attention, emotions,

motivation, intelligence) and some connections to the different developmental ages (pre-primary-primary and primary-lower secondary school), we ask you to indicate in a synthetic way or even by using a concept map, how are the ideas and information of the modules connected to those you already knew?

- Extend. What new ideas, information, insights have you received from video lessons, webinars and in-depth materials, which have broadened your horizons and pushed your thinking in new directions?
- Challenge. What would you still like to deepen or clarify better? What questions, curiosities or concerns do you have now? What challenges do you foresee in your teaching practice as you try to translate the information and ideas learned so far into operational steps?

5.3. Data analysis procedures

The Thinking Routine worksheets were analysed using quantitative methods in the context of content analysis. "*Textual analysis is a way for researchers to gather information about how other human beings make sense of the world*" (McKee, 2003, p. 1). In this perspective, the texts produced in a specific cultural context represent the empirical evidence of sense attribution practices (Pillera, 2017). Content analysis also makes it possible to broaden the overall view of the object of study by bringing out sometimes unexpected semantic and thematic dimensions, highlighting the point of view of the teachers who presented their reflections.

In this case for the calculation of percentages, teachers were considered as statistical units and the words as variables. The individual words counted are the values of the variable.

Words have been then quantified (articles, prepositions, and words with frequencies below 3 were excluded) and the most frequent considered in their relations with other words. Then words were recontextualized by re-reading the original texts in order to understand their meaning in their proper and original context.

In this research Lexi-co was used. Lexi-co is a software for automatic text analysis that contains all the main functions of research and lexicometric statistical analysis (frequency vocabulary, concordances, etc.) Lexi-co was set up to recognise that each answer was a unit in itself and then the words found in each sentence were counted by using the counting function.

Concerning the procedure rationale, e-tivity A (aimed at pre-school and early primary school teachers) and e-tivity B (aimed at teachers of the last years of primary and secondary school) were analysed separately.

We believe that maintaining this rationale was functional to a more structured contextualization of the contents.

Within the texts prepared for every single module, the 3 sections of the Thinking Routine (connect, extend and challenge) were analysed separately. In this way, we tried to avoid the risks related to the decontextualization of words and possible excesses of automatism.

6. RESULTS

In this paragraph we present the data collected through e-tivies A and B elaborated by the teachers.

6.1. Text analysis in e-tivity A

The first area considered is called “Connect”, where teachers were asked to link ideas and information from the modules with the knowledge they already had (Figure 3).

One aspect highlighted by all the teachers is how the topics covered complemented their own knowledge, allowing them to look at some aspects from a different perspective.

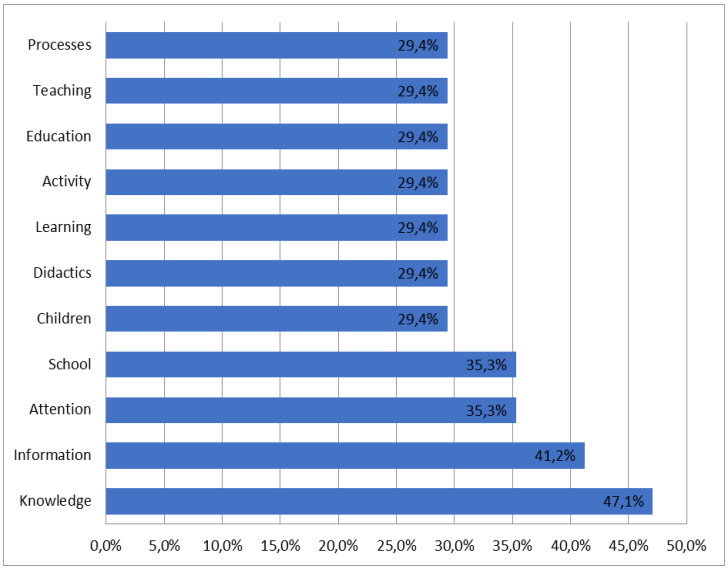

Figure 3. E-tivity A. Terms used in the “Connect” section.

In this regard, one teacher stated “*I recovered in my memory some information that I had already encountered during my studies or training. Some knowledge became deeper and more specific*”. The most relevant information to teaching practice in this age group refers above all to the centrality of emotions in the educational relationship and strategies for eliciting attention.

The terms “didactics”, “activity” and “process” refer to how teachers were able to embed the proposed contents and examples into their daily practice. The concepts of “learning” and “education” mentioned in their answers refer to the school environment and to the well-being of the classroom through a multitude of possible stimuli.

It is interesting to quote one teacher: “*Another aspect that I have always had is ‘making the classroom a learning environment’, an objective that was present in the ‘old’ Primary School Programmes but which I consider to be crucial and which I have found in both modules when they talk about creating an environment rich in stimuli and new experiences to propose, precisely because experience shapes the brain*”.

The term “school” is mentioned several times by teachers and refers to an engaging school for children where physical movement and brain development are allies in growth. One teacher wondered about this and wrote “*I have asked myself how I can enhance the value of movement in each educational proposal that I decide to propose*”.

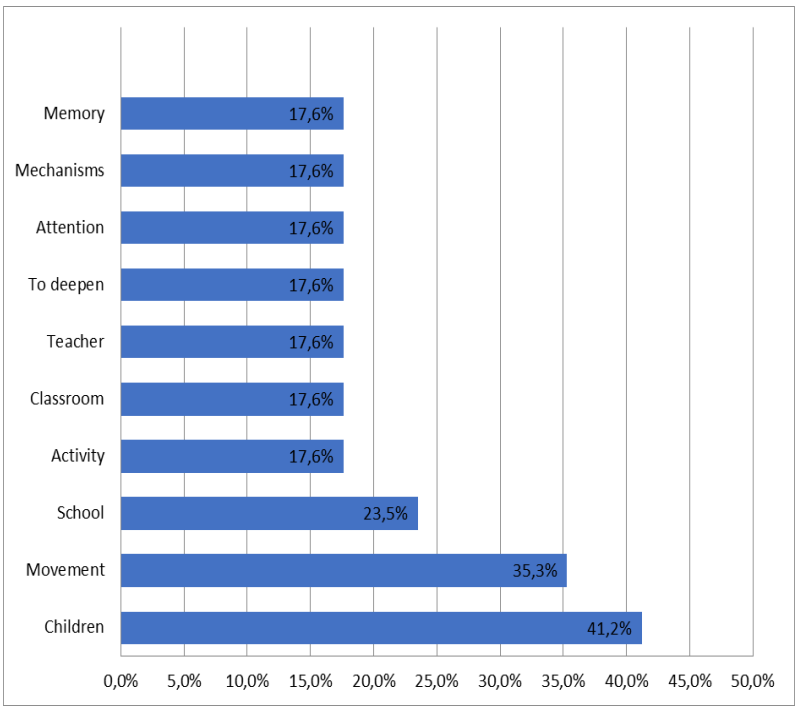

Figure 4. E-tivity A. Terms used in the "Extend" section.

Concerning the ideas and information acquired through the course that broadened the teachers' horizons ("extend" section, Figure 4), the most frequently used term was "children", both about how the brain works and the centrality of emotions in learning processes. The concept of "movement" is the second most frequently used term in this field. The correlation between learning processes and movement from a neuroscientific perspective was particularly explored in the course given the age group in question.

A teacher highlights a prior and cross-cutting awareness and states: *"Through the course, I was able to receive confirmation of the importance of nurturing children with art, music, movement and play".*

The term "school" refers to the opportunity to rethink physical spaces to facilitate teaching and support learning processes. The choice of working in the perspective of continuity has also supported primary school teachers in valuing the spatial organisation of preschool settings, which are traditionally organised to support children's cognitive activity. A primary school teacher said: *"On this issue (organisation of space), I think that having kindergarten spatial organisation as a model for primary school would be very beneficial".*

On the contrary, the concept of "class" refers to the class group. When the term "teacher" is mentioned, the group refers to its potential to act within the educational context. Related to professional development, teachers identified different areas that they want to explore. Among other statements on this subject, one is worth mentioning: *"I am particularly interested in learning more about mindfulness techniques for managing emotions".* The notion of "activity" was used in the declination of the teaching activity, highlighting how the design of the course had been conceived to embed neuroscientific theories into educational practices. One of the teachers said *"They have allowed me to systematise and strengthen activities that I carry out in the classroom with the children".*

The concepts of "mechanisms" and "attention" were mentioned as being associated as the course explored the mechanisms that regulate attention. On this aspect a teacher said: *"For example, the module on the mechanisms that regulate attention was very interesting"*. Finally, the contents related to memory were mentioned as being

particularly appreciated and considered functional. The last section ("Challenge" area Figure 5) refers to the future perspectives of the teachers and their challenges after the course.

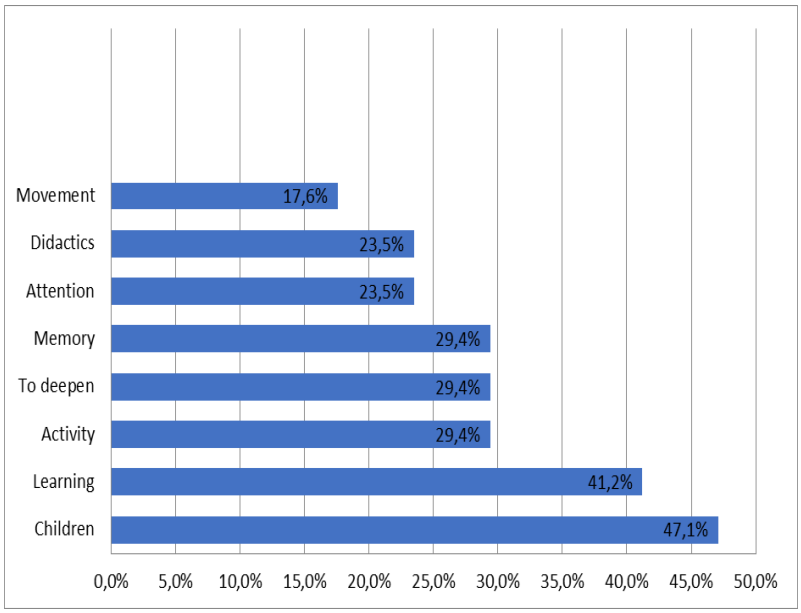

Figure 5. E-tivity A. Terms used in the "Challenge" section.

The teachers stated that they would like to learn more about the contents they learned, especially about different children's needs, as for bilingual pupils. *"It would be very interesting to find out how a bilingual brain learns from a neuroscientific point of view"*.

The concept of "learning" was declined within this last section with multiple contextualization, highlighting how this remains the first objective of all teachers. Such learning was considered in the important perspective of building a positive and growing climate for children.

A teacher highlights: "*Creating a positive learning environment should be the first objective, rather than contents and the programs*".

The concept of "activity" is related to the educational practice and the possible implications for teachers to design educational and didactic activities inspired by neuroscience.

At the same time, the teachers, having applied the principles of neurodidactics within their work contexts, identified several areas for further study.

Memory (29,4%) and attention (23,5%) remain two open questions for the teachers, who think these elements need to be further explored, especially in an operational and teaching perspective (23,5%).

The movement is also considered important given the end of the pandemic period and the need to give new fuel to this area, which is currently limited by safety regulations.

6.2. Text analysis in e-tivity B

This section analyzes the answers given in the e-tivity by teachers working in the last classes of primary school and the first classes of secondary school. In this case 23 worksheets were collected.

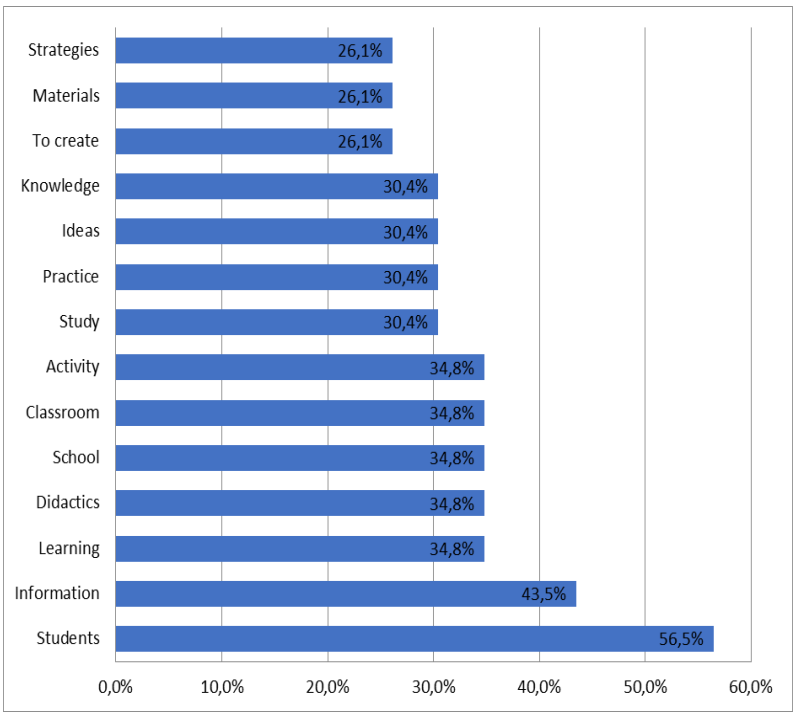

Figure 6. E-tivity B. Terms used in the "Connect" section.

The teachers declared that they confirmed previous knowledge ("Connect" section, Figure 6). Firstly students (56,5%) are considered as a complex human 'system', where cognitive and emotional aspects are intertwined. A teacher said: "*Creating an environment in which students can interact engagingly, creating an emotional bond based on sociability, acceptance and empathy, helps students to recognise their state of mind and communicate it".* Reflecting on the contents of the course, the teachers repeatedly referred to the concept of "information", highlighting the soundness made by researchers to build on teachers' pre-knowledge. It is interesting to note that in some cases the course enabled the teachers to re-organize their previous knowledge and experiences. A teacher underlined: "*Many of the information conveyed by the materials and lessons proposed made it possible for me to 'give a name' or, say, a definition to concepts, ... which I had previously internalised*".

The term "learning" is connected to learning strategies, cognitive styles and students' autonomous and meaningful learning. These contents of the course found immediate application in the teachers' educational practice, as they were perceived as needs, as stated by one participant: *"The teacher has to stimulate pupils to monitor how their mind works, to reflect on how they learn".*

The term "didactics" refers to the teachers' intention to use what they learnt about brain functioning to identify the most adequate teaching strategies. In addition, the term "didactics" is not used to mean subject teaching, rather the personalisation of learning and the best study strategies for students. The concept of "study" was also used in this context. The teachers pointed out that what was proposed in the course meets their sensibility, and especially as for hands-on activities, suggestions were easily inserted into their daily practice. Unlike the activities analysed above, the term "school" has a more general meaning and mainly refers to the school level, while the references to the "class" refer to the group of students. Also, in this case the most evident correlation recalled by the teachers is the interest to create (26,1%) a collaborative and friendly climate, and consequently the well-being of the class. The concepts of "activity" and "practice" are used to indicate the educational proposals carried out by the teachers

to achieve the educational objectives. These terms have been used concerning the strategies proposed in the modules. *"In recent years I have been able to realise 'mind-wandering' activities in my daily practice".* "Idea" and "knowledge" were mentioned by 30,4% of teachers. The concept of "idea" is used as a synonym of intuition, both about teachers and pupils. Furthermore, ideas are in opposition to knowledge, which refers to the body of information obtained in previous training activities. In this respect a teacher pointed out that *"Routines help to make connections between new ideas and prior knowledge".*

Finally, the term "materials" mainly refers to the course tools rather than teacher-generated contents: *"The study of the proposed materials and the video lessons helped me to understand how many things I have used and improved over the years, consciously and unconsciously*".

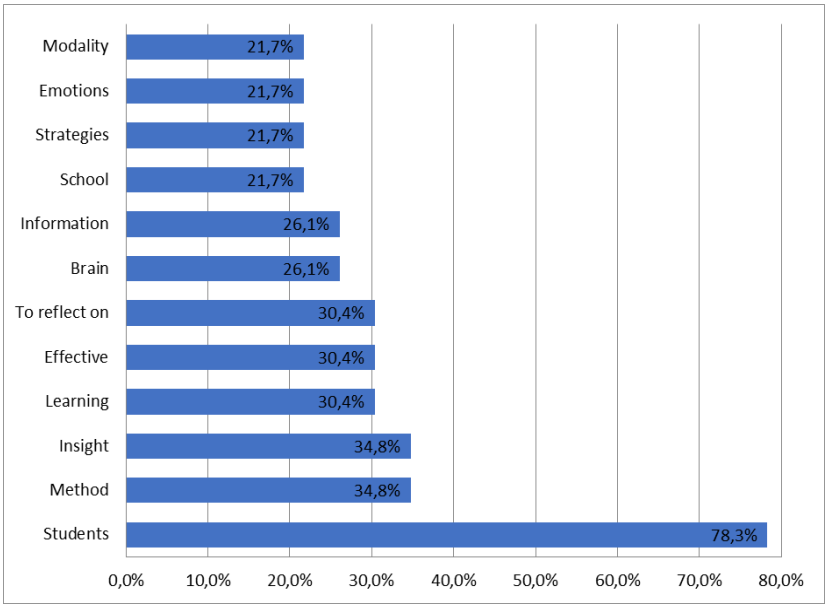

Figure 7. E-tivity B. Terms used in the "Extend" section.

Also for the section "extend" the most cited term is "students" both in relation to personalisation processes and to the relationship between emotions and learning (Figure 7): *"The correlation between the emotional involvement of the students and the effectiveness of learning has led me to take more these aspects into account, which are often neglected".* The term "method" recalls again the interest to develop actions to work with the students on the study method. The term "effectiveness" refers to the study, learning and communication processes enhancing the most authentic aspects of the educational relationship. In 8 cases the teachers claim to have gained insights and reflections from the course which they intend to reconsider later. *"I received several hints that I need to have time to elaborate better to design a more effective teaching action".*

The term "reflection" refers to feelings of growth in the teaching profession. Teachers consider the opportunity to reflect and analyse their work, by integrating it with new and diversified activities, as an important opportunity for professional development. *"It made me think about how important the balance between challenges and competences is".*

The brain and the studies related to its functioning are the subject of many of the proposed materials and for this reason the term "brain" has been mentioned several times (26,1%) and can be considered as the most innovative aspect for teachers. Consequently, it is one of the topics they intend to work on shortly. The information that has broadened my horizons is related to the functioning of the learning brain and the importance of emotions.

The term “information” is used to refer to course content that is considered important to be embedded in the learning context. Among the most appreciated information are those related to cognitive strategies (21,7%), the brain functioning (21,7%) and learning strategies.

The term “school” concerns the educational culture at school (Figure 8). According to the teachers, within the school, the aspects concerning the influence of emotions (21,7%) and motivation on learning should be more taken into account.

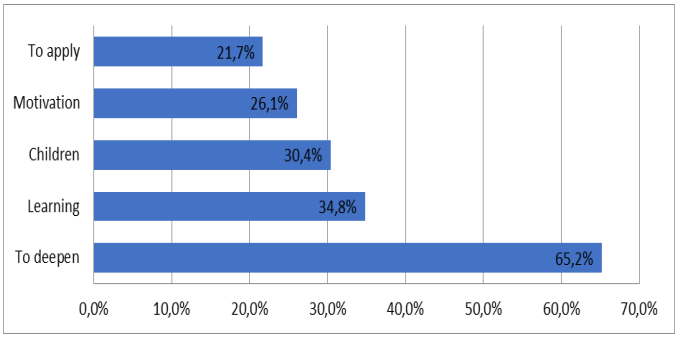

Figure 8. E-tivity A. Terms used in the “Challenge” section.

Through the participation of this course, the teachers broadened their knowledge especially regarding strategies to support learning (34,8%) and motivation processes (30,4%) within a positive affective context focused on children's autonomy and well-being. Finally, the teachers highlighted the strategies they intend to contextualise and apply in everyday teaching. With a view to the future, one teacher stated: *“I will try to progressively apply the information I have learnt so as to become more confident and pass what I have learnt to the children”.*

7. DISCUSSION

From the analysis of the teachers’ reflections on the three sections of the Connect-Extend-Challenge Thinking Routine, main trends can be highlighted.

In the “Connect” section, the majority of teachers appreciated the fact that the contents of the videos had a sort of awareness-rising impact. The impact is twofold. On the one hand, they stated the contents could be linked to previous studies (at the University or in Confining Professional Development), thus retrieving them from, say, unused “brain shelves" and making them ready-to-use knowledge for their future lesson plans. We could sum-up the first impact as “*making dead content live again*”.

On the other hand, some also stated that the connections they could create with the lesson contents were useful to name and label learning processes, mechanisms or behavioural patterns they observed in their daily practices but that they didn’t know could have a theoretical description or literature reference. We could sum-up this second type of impact as “*giving a name to observable processes*”.

These two main outcomes are very important in the experience of adult learning (Mezirow, 1991; 2000) as for transformational processes, both in attitude/disposition and behavioural changes. Another reason is that they make it possible for teachers to put theory into practice and practice into theory (Magnoler, 2012), upskilling their teaching repertoire.

The contents that are most known/recalled by teachers are the constructs of “warm cognition” (Immordino-Yang, 2016) - or the crucial role of emotions in content acquisition - and the importance of motivation in active learning.

"*It is literally neurobiologically impossible to think deeply about things that you don't care about*", Immordino-Yang states (Ibid, p. 22). There are not many differences in the A and B e-tivities in this section and all teachers made similar connections.

As for the "Extend" section, what most struck the teachers' attention was the focus on the importance of movement in learning processes, especially for those in preprimary and primary schools. As for teachers in the final years of primary school and lower secondary schools (e-tivity B), the area mentioned by the majority was how to sustain an effective study method and the importance of emotions. All those elements have a great impact on the way they can structure their lessons. Together with memory and attention, they pointed out that other area of interest are learning personalization and the adoption of the best inclusive, engaging strategies (Sousa, 2016; Dehaene, 2019). As Ames (1990; 1992) says, lesson structure is one of the main components for effective teaching.

Finally, as for the "Challenge" section, recalling previous section reflections, teachers stated that one main challenge is combining all those components together to transform a lesson into an effective learning experience. Many aspects have to be taken into account: the physical space, the possibility to have the children freely moving, the respect of memory and attention limits, the balance among different stimuli. The objectives are well expressed in A e-tivities, where high-order skills and general conditions are called for, such as student autonomy, well-being and learning motivation.

Interestingly enough, some concepts well explained and recalled in the video lessons were not mentioned by teachers, as is the case of preprimary and primary teachers (e-tivity A) - who did not mention the term "curiosity" or "creativity" - and in the case of older students teachers (e-tivity B) who did not refer to "autonomy" or "peer education".

8. CONCLUSION

This contribution aimed at describing the state of the art of the research project "Neuroscience for educational continuity", carried out within the Telematic University of Studies (IUL), which is completely web-based. The project is made up of two phases, following co-research and research-training models (Magnoler, 2021; Mortari & Ghirotto, 2019). After Phase 1 - dedicated to the introduction of educational neurosciences (Gazzaniga et al., 2005, Immordino-Yang, 2007; 2016; Geak, 2009; Hurrington et al. 2021), teachers were asked to embed and apply what they learnt into their daily teaching. What authors present here is the feedback they received, as designers of the course contents, from participants. Feedback was shaped into a specific task, or the CEC Thinking Routine (Ritchhart et al., 2011). Teachers were asked to reflect on the contents they were exposed to and imagine embedding them into their teaching practices. This means challenging one's personal beliefs and re-organize one's mindset, accepting and integrating both known - but unused - knowledge and new information. This also means accepting to leave their "comfort zone" and embrace a transformational perspective that might be time-consuming and somewhat emotionally demanding.

From the data gathered so far it turns out that teachers appreciated the contents, found them useful and inspiring and got positively surprised by them, since they could reactivate previous knowledge, approach new information, and be inspired by brain-based research for their future classroom activities. Some of the topics turned out to be more interesting for them (i.e. brain-based indications for domain-specific development) and will help researchers to better shape the next phases in terms of content to deepen or areas to better investigate together.

The upcoming months will be dedicated to analyse teachers' lesson plans based on educational neurosciences and to carry out classroom observations in order to showcase a series of brain-based practices scaffolding educational continuity. The final output of this research is intended to be practical guidelines with examples to be provided to pre-primary, primary and lower secondary teachers in order to inspire innovative learning opportunities drawing on brain-based research.

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