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Grado en Maestro en Educación Primaria

Trabajo Fin de Grado

NEUROSCIENCE APPLIED TO EDUCATION TO IMPROVE ATTENTION AND LEARNING

NEUROCIENCIA APLICADA A LA EDUCACIÓN PARA MEJORAR LA ATENCIÓN Y EL APRENDIZAJE

Student: Lucía González Cañas

Tutor: Aoife Kathleen Ahern

Department of Foreign Language Didactics

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RESUMEN

Este TFG se centra en la aplicación de los principios de la neurociencia y la neuroeducación para mejorar los procesos de aprendizaje y memoria en alumnos de 6 a 12 años (Educación Primaria). Se desarrollan los conceptos esenciales para comprender mejor estos procesos, destacando las funciones ejecutivas, la plasticidad cerebral, la atención y la motivación, y se contribuye a desmontar algunos de los mitos asociados a la neuroeducación. El objetivo general de la propuesta es centrarse en el aprendizaje y la memoria para mejorar la experiencia educativa de los estudiantes desde una perspectiva holística en varias materias. Para ello, se desarrolla un conjunto de actividades para ser aplicadas en el ámbito educativo para las materias de inglés, matemáticas y educación física, las cuales están interconectadas y se complementan entre sí. En conexión con lo anterior, se desarrolla la metodología HERVAT y se propone su aplicación al inicio de cada lección. Además, se ha dirigido a educadores, por lo que la base científica está simplificada y es accesible.

ABSTRACT

This TFG focuses on the application of the principles of neuroscience and neuroeducation to improve learning and memory processes in students from 6 to 12 years old (Primary Education). The essential concepts are developed to better understand these processes, highlighting executive functions, brain plasticity, attention and motivation, and it contributes to dismantling some of the myths associated with neuroeducation. The overall objective of the proposal is to focus on learning and memory to improve the educational experience of students from a holistic perspective in various subjects. To this end, a set of activities is developed to be applied in the educational field for the subjects of English, mathematics and physical education, which are interconnected and complement each other. In connection with the above, the HERVAT methodology is developed and its application is proposed at the beginning of each lesson. Additionally, it is targeted toward educators, therefore the scientific basis is simplified and accessible to all.

PALABRAS CLAVE

Neurociencia, Educación Primaria, funciones ejecutivas, plasticidad, atención, HERVAT.

KEY WORDS

Neuroscience, Primary Education, executive functions, plasticity, attention, HERVAT.

1. INTRODUCTION

What do you call a skull without 86 billion neurons? A no brainer!

By the time you finish reading this paper you will most surely have forgotten about most of the information in it. However, this little joke might stick.

The brain is a powerful organ that stores information and is able to recall it when needed, but as you may know by now, some information is easier to recall. The dates from historical events and complex biological processes studied for exams have probably vanished by now. Yet, you still remember details of special moments such as the birth of your beloved or special trips that happened years ago.

Understanding some aspects of how the brain, the most complex and intricate organ, is structured and works can help teachers understand children's mental processes and allow them to present content in a way that their students will remember and learn.

One of the current difficulties faced by teachers in the classroom is the student's lack of attention. Without attention to the tasks developed, learning will not take place. To target this, it is essential to develop teaching strategies that boost student's attention and focus, and therefore their learning. However, when teaching children, there are no magic spells that will grasp everyone's attention and get them to work, but rather different techniques that help the process of learning and make it more interesting and pleasant.

This proposal is aimed at targeting the student's learning difficulties in regard to attention, understanding the functioning of the brain and presenting techniques that align with it, focusing on the executive functions and providing an educational proposal that encompasses all the ideas.

Nowadays, one of the key competences in the educational curriculum is "learning to learn". Although it might seem natural and easy to accomplish, it requires guidance and an accurate selection of strategies that will accompany students throughout their learning careers, in fact, during their entire lives. An educational proposal targeting three subjects, English as the focal point, mathematics and physical education to complement it, is proposed to develop metacognitive techniques interconnected with the executive functions, which allow for learning.

Keep reading to find out more about why out of the 86 billion neurons that form connections inside the brain, not all the information teachers wish students retained stays in their memory.

2. OBJECTIVES OF THE DISSERTATION

2.1. General objectives

A. To summarize and integrate the contents which reflect the competences acquired in the Primary Education Teaching Degree.

B. To apply the content and pedagogical learning strategies to different areas of knowledge.

C. To develop reflective (argumentative), critical (analytic and synthetic) and scientific (documented and terminologically accurate) thinking skills.

D. To develop a project which is at university education level.

E. To develop skills and techniques for appropriate oral and written communication.

F. To use ICT (Information and Communications Technologies) relevant to the teaching profession.

2.2. Specific objectives

a) To understand how the student's brain works and adapt the teaching techniques and methodologies to these principles based on neuroscience.

b) To target student's learning difficulties in regard to attention based on neuroeducation.

c) To boost the use of executive functions through different tasks presented in three subjects to enhance learning.

d) To provide an organized proposal on how neuroeducation can be implemented in English, mathematics and physical education subjects to boost attention, motivation and learning.

e) To interconnect three subjects that have benefits to each other.

f) To provide a proposal for implementing HERVAT across all cycles to boost attention.

3. THEORETICAL FRAMEWORK

The paper focuses on neuroscience to academic contexts (neuroeducation) to boost learning and attention in students. Section 1 focuses on neuroeducation, and describes the links between neuroscience and education, basic knowledge about the brain, and the executive functions. Section 2 revolves around learning, by describing the process and diving deeper into memory, how plasticity affects learning, the links between motivation, emotions, attention, curiosity and learning, scaffolding to learn better, and the impact of technologies and the Internet in learning. Several neuromyths are debunked in section 3, and some deeper reflection is made upon those related to language learning. Lastly, section 4 presents HERVAT, an educational program based on the principles of neuroscience by describing its anatomical and physiological bases, its essence and pedagogical implications.

3.1. Bridging neuroscience and education

Neuroscience is a discipline that studies the development, structure, functioning, pharmacology and pathology of the nervous system (Mora, 2021). It is a relatively new field that stems from biology, neurology, psychology and physiology, and is more widely known as “brain science” (Goswami, 2004). It established itself as an explicit discipline in the late 20th century, according to Shepherd (2009) and since then, it has developed numerous collaborations with other disciplines (Ocampo Alvarado, 2019). During the last decade of the past century, the study of the brain flourished and immense advances were made, leading to this time period being called the Decade of the Brain (Albright et al., 2000).

Three Nobel-prize winners are credited for laying the groundwork for modern neuroscience by researching the structure and function of the nervous system:

Santiago Ramón y Cajal (1852-1934), a Spanish doctor and scientist regarded as the father of modern neuroscience. He made groundbreaking discoveries regarding the anatomy of neurons and their role, earning him the Nobel Prize in Physiology and Medicine in 1906 (Llinás, 2003).

Camillo Golgi (1843-1926) shared the prize with Ramón y Cajal due to the development of the Golgi stain or silver staining technique, which allows for the visualization of individual neurons and their structures. Before the emergence of this technique, researchers were unable to adequately penetrate the networks of neural tissue (Saceleanu et al., 2022).

Finally, evolving from being a collector of shells and fossils to one of the most significant neurophysiologists in history, **Charles Scott Sherington** (1857-1952), researched synaptic transmission, reflexes and the integrative functions of the nervous system. This earned him the Nobel Prize in Physiology or Medicine in 1932 (Eccles and Gibson, 2012).

Since that time, a large amount of knowledge has accumulated about the brain and how it learns, from the development of brain cells before and after birth to how the adult brain continues learning and growing (Hardiman, 2012). Nevertheless, few links have been established between this knowledge and its application in educational policies and practice (Hardiman et al., 2012). Translating knowledge into educational practice is a difficult task, which takes high amounts of time and research. This is where neuroscience steps in, shedding light into learning itself (Blakemore and Frith, 2005).

Educational neuroscience has been described by Thomas et al. (2019) as an interdisciplinary field of research focused on translating research findings on the brain mechanisms that affect learning to educational practice and policy. Due to its potential, the connections between these two fields are being actively researched worldwide.

It was only in the 1960s when neuroeducation flourished (Ocampo Alvarado, 2019). One of its most relevant goals was to translate the findings from neuro- and cognitive sciences so that they can be interpreted and applied by educators in their classrooms (Hardiman et al., 2012). Also known as “mind, brain and education” or “educational neuroscience”, neuroeducation was at first focused on specific learning disorders such as dyslexia and dyscalculia in an attempt to provide students with an appropriate and adapted learning environment. However, due to its possibilities, it was expanded to the whole educational field, benefitting a wider range of learners (Ansari et al., 2012).

Additionally, the interaction between neuroscience and education can be direct, by considering the brain as an organ that learns when it is kept in optimal condition, or indirect, as neuroscience shapes the field of psychology and consequently this one influences education (Thomas et al., 2019).

The bidirectional links established between education and neuroscience have become tighter due to the availability of non-invasive methods such as the Electroencephalography (EEG) or the functional Magnetic Resonance Imaging (fMRI) that allow for the imaging of brain activity. These techniques permit measuring how school-taught skills reflect on the different brain regions and observing alterations, which helps understand the trajectories of development and the plasticity of the neural circuits in the brain in regard to the cognitive functions shaped by education (Ansari et al., 2012).

Additionally, numerous research programs have deciphered the neural bases of learning difficulties such as dyslexia, resulting in better knowledge of the functioning of the brain and therefore offering solutions and proposals based on neuroscience (Ylinen and Kujala, 2015).

3.2. Brain basics

The nervous system is divided into two parts, the central nervous system (CNS) and the peripheral nervous system (PNS). On the one hand, the PNS is made up of a large network of afferent nerves which carry information to the CNS, and efferent nerves that extract information from the CNS. These nerves transport information through all body systems. On the other hand, and more importantly for neuroeducation, the CNS is divided into the brain and spinal cord. The spinal cord carries the information between the body and the brain in both directions. The brain, which is in charge of making decisions, is subdivided into the cerebrum, cerebellum and brainstem, and is also divided into two hemispheres. The external structure of these is the cerebral cortex, and each hemisphere is subdivided into four lobes: frontal lobe, responsible for complex functions such as learning; parietal lobe, in charge of movements, recognition, orientation and calculation; temporal lobe, related to speech and word understanding; and occipital lobe, performs functions of visual recognition.

The nervous system is composed of a specific type of cells, neurons, which are specialized in the transmission of information and in network creation. They communicate with each other through synapses, allowing impulses to pass through (Jensen, 2003).

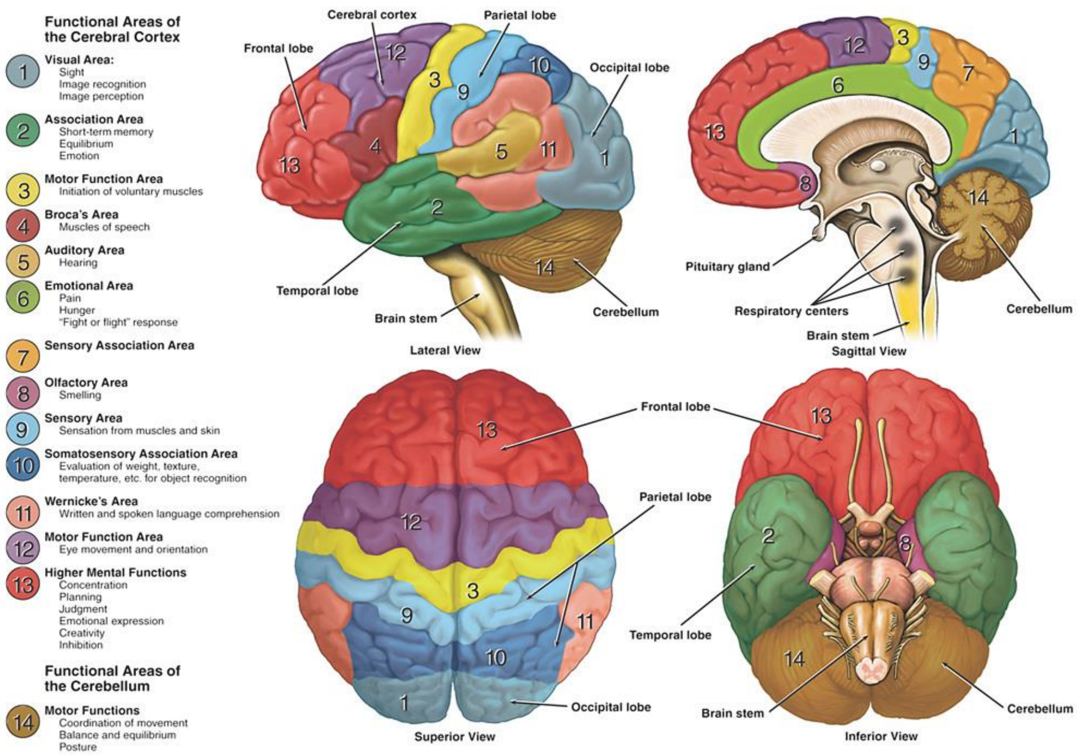

Figure 1: Functional areas of the cerebral cortex. From Neuroanatomy: The basics (2023), Dana Foundation. https://dana.org/resources/neuroanatomy-the-basics/

3.3. Executive functions

Adele Diamond, a world leader in Developmental Cognitive Neuroscience, is a professor at the University of British Columbia (Vancouver, Canada) and Tier I Canada Research Chair in Developmental Cognitive Neuroscience. Her eminent trajectory has led her to being a member of the Royal Society of Canada and one of the "2000 Outstanding Women of the 20th Century".

According to Diamond (2013), executive functions (EFs) are a set of mental skills that make possible the mental representation of ideas, thinking before acting, responding to challenges, staying focused and resisting temptations. The core executive functions are inhibition (self-control and interference control (selective attention), working memory, and cognitive flexibility (creativity, perspective taking and flexibility) (pp.135-168).

Inhibition involves controlling one's automatic urges (attention, thoughts, emotions or behavior) to do what is more appropriate. Without it, people would be driven by their impulses. Moreover, it allows humans to change and choose reactions instead of behaving like unthinking creatures of habit. Inhibition control of attention allows for selectively attending and focusing on specific stimuli and suppressing others. It is more developed in adults than in children, who struggle with slower and more inaccurate inhibition control (Diamond, 2020).

Working memory involves information retention and mental work with this information, and it is subdivided into content-verbal and nonverbal. It is part of everyday life, as it is involved in every task that requires remembering information. From making sense of reading or writing to solving mathematical problems or considering alternatives. It is what allows for reasoning, and for drawing connections between apparently unconnected items (Cowan, 2014).

Cognitive flexibility pivots around the other two EFs and is developed later. It enables us to shift perspectives interpersonally and spatially, requiring inhibition of the previous perspective and working memory to activate a new perspective. Additionally, it involves changes in thought (thinking outside the box). When something is not working, a different approach needs to be taken. It also involves adapting to change or requirements of each situation. Oftentimes, teachers blame students for not understanding their explanations, but they could be more cognitively flexible and think of different ways to explain it to target the issue (Davidson et al., 2006).

According to Diamond (2013), it is greatly important to help young children have a strong executive functioning from early life, as this is a predictor for lifelong achievement, quality of life, and health. EFs can be trained and improved at all ages, and repeated practice is crucial for it.

3.4. Learning

“To know is to classify and distinguish what is learned, to subdivide this knowledge and reclassify and deepen into it” (Mora, 2021, pp.99).

Learning does not have a simple definition. It is often referred to as the alterations in behavior as a result of experience, or as changes in the organism as a result of experience. However, these definitions are problematic, therefore De Houwer et al. (2013) defined learning from a functional perspective, as the alteration in the behavior of the organism as a result from regularities in its environment.

It is thought that learning is an innate process, specific to each species, but focused on the goal of survival (Marler, 1990). Learning is intrinsic to life; organisms learn to survive and adapt to their environment, making this skill crucial. At birth, learning is one of the first mechanisms to develop, allowing creatures to adapt to their environment. This includes all living organisms, from animals to humans (Mora, 2021). Regarding animals, the individual that learns the fastest and is the best at remembering is often regarded as the most adaptable, making it more intelligent (Pearce, 2013).

Moreover, learning is an adaptive process in which living organisms utilize their previous experience to ameliorate their outcomes of future choices. Both animals and humans select their actions according to their value and the future reward expected from it (Lee et al., 2012). This can be easily translated into an academic setting, where students do not improve their knowledge to survive, but rather to obtain an outcome. The goal of the current educational system is to help students flourish in all dimensions, making them participants of society and independent human beings.

Learning is not simple, nor fully understood by scientists. However, research has proven that learning can be classified into different types.

On one hand, explicit learning is conscious, meaning that the individual is aware that there is an undergoing knowledge acquisition process, and it can also be self-reported. It is rooted in the prefrontal and temporal cortex and the limbic system.

On the other hand, implicit knowledge does not imply conscious awareness of the subject, and it is rooted in the anterior cingulate cortex, basal ganglia, cerebellum, and premotor cortex. This learning process is automatic, and requires repetition and time to develop. For example, when riding a bicycle, visuo-motor abilities are used without the individual realizing. Similarly, a child does not know that he is learning through playing. What is more, these different types of learning interact with each other.

Memory is a cardinal component in the learning process, being fundamental for cognition, and enabling individuals to encode, store and retrieve information. What is more, it comprises several types that complement each other. Atkinson and Shiffrin proposed in 1968 the multi-store model of memory that consists of three stores: sensory memory, short-term memory (STM) and long-term memory (LTM).

The sensory memory retains raw sensory information for a few seconds (Sperling, 1963). STM retains information for short periods of time (approximately 30 seconds) and has limited capacity, making it more manipulable. This type of memory comprises the working memory (Baddeley, 1992).

LTM stores large amounts of information over prolonged periods, from a few minutes to a lifetime and it is subdivided into declarative or explicit memory, which involves the knowledge of personal information or general data that can be recalled or declared, and procedural or implicit memory, related to habits and skills. What is more, Tulving (1972) stated that declarative memory can be subdivided into episodic memory, related to the collection of information regarding situations, events and experiences, and semantic memory, which stores facts and general knowledge.

Learning is a laborious process which involves different cognitive factors. It is a process of information clarification and error rectification that takes time. Moreover, repetition allows for learning. During repetition, a re-evaluation of the new knowledge takes place, and errors appear. What is more, mistakes are intrinsic to the learning process. It is common to hear young children saying “let me do it on my own!”, because, although this conduct is automatic, the child is manifesting the willingness to learn. Repetition allows for trial and error, and once the desired result is attained, an emotional reaction appears, leading to reward and pleasure, and the settlement in memory (Metcalfe, 2017).

Another aspect that plays a key role in learning is the student’s circadian rhythms, which are the mental, behavioral and physical changes that take place in their organism over a 24-hour cycle. Normally, human’s circadian rhythms align with the typical day and night, resulting in chronotypes. Ashbrook et al. (2020) classify people into two groups based on their circadian rhythms: “morning larks” and “night owls”. Some children naturally wake up early and are active since the morning, therefore falling into the category of morning larks. Those who are more active at night and have a late wake up are designated night owls. Taking this into consideration allows teachers to best plan the content delivery throughout the day. Both types of students are found in each classroom, therefore a balance needs to be found. Studies show that midday, around noon, is the best time to teach and learn the more difficult content, as morning larks are still highly awake, and night owls have already become activated (Mora, 2021). Lastly, a good night's sleep plays a significant role in learning and memory, however, this factor can not be controlled from the classroom and it depends on each individual family.

3.4.1. Plasticity and learning

The brain is a powerful organ able to adapt and change based on experience. This experience, which leads to learning, is the target of educators. Gaining insight into the basics on how neural plasticity functions, allows teachers to understand the importance of providing accurate learning experiences to the students through thoroughly prepared lessons and resources.

Neural plasticity is, according to Zatorre et al. (2012), the capacity of the nervous system to adapt to both structural and functional changes through the creation, modification and removal of synaptic connections and brain networks. Neurons regenerate themselves as a consequence of environmental stimuli to adapt to the environment. It has been proven that regular activity in an enriched environment promotes the creation of synaptic connections between neurons, primarily in the hippocampus throughout the course of life (Greenwood and Parent, 2002). Recent research on neurocognitive science shows how the environment influences brain activity in both children and adults, therefore highlighting the importance of adequate neural stimulation through regular, repetitive and synchronized patterns to boost synaptic connections and dendritic growth (Glannon, 2014). Knowing the importance of adequate neural stimulation through a positive environment and repetitive exercises, teachers can plan lessons accordingly. The proposal presented ahead contains different activities that involve repetition, especially those focused on HERVAT (acronym for hydration, equilibrium, respiration, vision, audition and touch).

Neural plasticity, the brain’s ability to change, is what allows for learning. But what is learning? There is not just a single definition of learning, as it is not a simple process. Different authors define it in different ways, however, the essence prevails. Washburne (1936) interprets it as an increase in problem-solving ability as a consequence of experience. However, De Houvwer et al. (2013) describe it as the shifts in organism's behavior resulting from regularities in its environment. What is more, learning is influenced by many factors, highlighting the ones presented ahead: the senses, motivation, emotions, attention and curiosity.

3.4.2. Learning through the senses

The senses are the only connection between a human and its environment. From learning a new word to making fire, senses are key for human development. They yield a connection between the outside world and human’s brains. Therefore, learning can only occur through the senses. The information is perceived by the sensory organs: tongue, nose, eyes, skin and ears, and translated into particular stimuli such as physical vibrations, or light and sound waves, which are then processed in the brain (Collins, 2023). The brain is relentlessly processing signals sent through the senses. The input from the environment is processed by specialized sensory neurons and followingly transmitted to the brain through electrochemical signals. Nonetheless, these signals are categorized, so different brain regions decipher the message. Subsequently, the information is integrated allowing for its interpretation and appropriate response (Sterling and Laughlin, 2015).

In the Western world, individuals are accustomed to using the senses of sight and hearing to learn, leaving the rest of the senses (smell, taste and touch) in an unimportant position relative to knowledge acquisition. However, this phenomenon does not apply to all cultures. The

Desana people are an indigenous ethnic group native to the basin of river Vaupes (Colombia) who display a different sensory picture when learning. For this tribe, all senses play a key role in knowledge acquisition, seeing the colours and smelling the scents of the flowers, hearing the sounds of the bird calls, and tasting the fruit their trees produce. The main take from this, is that knowledge comes from full-bodied experiences with the environment using all senses, and not just from books or computers like modern West individuals are accustomed to (Classen, 1999).

Moreover, research suggests that sensory input needs to pass through the Reticular Activating System (RAS), which regulates behavioral arousal, consciousness and motivation, and is in charge of filtering the stimulus from the environment, and then be processed in the prefrontal cortex (Willis, 2010). This author also evidences that senses have a differentiated storage area in the brain, just like different types of memories, which are stored in different but still interconnected regions.

Multisensory or multimodal integration studies how the information from different senses is integrated by the nervous system. Although this field of study has recently exponentially increased in both diversity and volume, it has not yet fully matured (Stein et al., 2020). Learning through the senses plays a crucial role in the children’s development, therefore it has been thoroughly studied by neuroscience.

3.4.3. Motivation in learning

Motivation, also known as the ‘heart of learning’, plays a crucial role in human’s lives, leading to successes and achievements. It is a process in which a learner’s energies are directed toward its objective in his or her environment. Ultimately, motivation is the reason why people behave the way they do.

If motivation is adequate, it results in attention, interest, effort and reflection of the pupils promoting learning. However, to have this achieved, stimulation of the student’s learning activities is necessary. Due to its importance, it plays a central role in theories of human development and learning, and is highly significant in educational and psychological research (Borah, 2021).

Additionally, two types of motivation are described: intrinsic and extrinsic. On the one hand, intrinsic motivation (IM) is related to behavior that is satisfying, meaning that the motivated action does not go beyond the behavior itself. For example, children like playing because it is fun, and therefore satisfying. On the other hand, extrinsic motivation (EM) alludes to the performance of a behavior to attain an outcome; the outcome is separated from the action itself. For example, a student will do his homework to get good grades (Legault, 2020).

It is common to hear teachers complain about the lack of motivation of their students towards their subject. What is more, the view on motivation is often simplified, linking a lack of motivation to weakness and culpability. And although it is true that each learner differs in the kind and amount of motivation they show during lessons, teachers can alter it, by stepping in and enhancing it instead of reducing it (Lowman, 1990).

First and foremost, to boost the student's motivation, the teacher needs to be motivated (Pelletier and Rocchi, 2016). I personally believe that students are a mirror of their teachers. In my experience as a student, having a teacher who is excited about learning and developing educational activities, is highly motivating. However, teacher motivation may vary based on different factors, both extrinsic, such as administrative support or classroom resources, and intrinsic, such as passion toward education and interest in the subject. Having said this, the ultimate decision on the attitude toward learning resides in the student. Teachers may do everything in their power to help students, but the learners need to be willing to make an effort and be part of the educational process.

3.4.4 Relationship between emotions and learning

Emotions are all the different clouds in the sky of feelings, from happiness to anger, disgust or fear, and they suddenly change, just like the weather in springtime. Students, especially those who are younger, often externalize emotions, and they may go from calmness to nervousness in just a matter of seconds. Emotions are an inextricable part of human beings, therefore targeting them is crucial to understand oneself.

Fossati (2012) describes emotions as "episodic and synchronized changes in the organism reflecting the quick identification of salient stimuli in the environment and the production of adaptive behavioral and physiological responses".

The human being is an emotional creature due to its social nature, therefore emotions influence learning and even academic results (Li et al., 2020). What is more, they influence cognitive processes such as attention, decision-making, memory and perception which are decisive in education and learning (Dolan, 2002).

It is well known that humans do not remember every single experience in which they are involved, but those that evoke feelings, whether they are positive or negative (joy, pain, pleasure or sadness). This makes emotion the main currency in human relationships, in addition to being a motivational force that exposes human behavior to its fullest potential, from the best to the worst of the human being (Dolan, 2002).

Emotions have been part of humans since the beginning, and they have been reflected upon for centuries. Plato, the Greek philosopher stated the following: "Human behavior flows from three main sources: desire, emotion, and knowledge”. More recently, William James (1948), a 19th-century psychologist argued that “if we fancy some strong emotion, and then try to abstract from our consciousness of it all the feelings of its bodily symptoms, we find we have nothing left behind, no mind-stuff out of which the emotion can be constituted, and that a cold and neutral state of intellectual perception is all that remains". In this quote, he calls attention to emotions as psychological experiences with unique qualities: they are embodied and manifested uniquely and they correspond to specific behavioral patterns, they do not always align with the person’s intentions, and they highly impact the mental state of the individual (Dolan, 2002).

The Spanish professor and neuroscientist Francisco Mora has focused a large part of his professional career on understanding and studying how emotions work and how they affect learning processes. His vast research on the field could be wrapped up in the following quote: “only what is loved can be learned” (Mora, 2021), making emotions a basic part of cognitive processes. He argues that emotions are what lights up the spark of curiosity and attention, and therefore the interest to discover what is new to the individual.

In relation to it, Mora (2021) acknowledges the importance of words and their correct use, but also their intonation and effect on the receptor. If correctly produced, the sender can grasp the listener’s attention and use it toward its benefit. Accordingly, oratory has been a foundation stone for societies since ancient times. Stepping away from politics, the use of words is critical in the learning acquisition process. Teachers should select the right vocabulary, intonation and order of words to make an impact on the children and their emotions. When the students are paying attention and are interested in what the teacher is saying, the learning process is more proliferating.

3.4.5. Attention and learning

Attention has been metaphorically described by Mora (2021) as a light source that illuminates learning and memorization, and everything outside remains shadowy and gloomy.

It is a window that is opened in the brain, through which the learning and memorization of the information in the environment is acquired. Without attention there is no explicit memory, knowledge or learning. Ultimately, it is key to gaining consciousness. Attention is developed once the emotional spark that comes from curiosity is lit up. The attentional focus needs to be working for at least 65 to 250 milliseconds to record and remember information.

Learning should be presented as a story which begins with an introduction that promotes curiosity, an interesting development, and an ending that summarizes the content and creates interest toward the next lesson.

Counter to the thought of attention being a single neural mechanism, nowadays neuroscience has proved that there are various types of attention, which involve distinct brain processes that are not mutually exclusive, but rather interact in complex ways. Additionally, each kind of attention requires different neural networks and circuits, and different types of attention are required for different tasks and behaviors (Mora, 2021).

Selective attention involves the use of specific stimuli while simultaneously ignoring others, allowing individuals to concentrate on the relevant information without distractions. This type of attention is limited, as certain stimuli need to be selected, and it requires cognitive control mechanisms which inhibit irrelevant stimuli.

Sustained attention or concentration, on the other hand, refers to the maintenance of the attention focus over extended periods of time. It allows individuals to be focused for long periods without a decrease in performance, can be affected by factors such as fatigue or monotony, and allows the development of tasks that demand continuous monitoring.

Divided attention is that which requires simultaneously focusing on several subjects or tasks. However, it is limited by the finite capacity of cognitive resources, and the individual might allocate unequal attention to each task, but is essential for multitasking.

Lastly, focused attention is characterized by a narrow focus of awareness, as the individual focuses its attention on a single stimulus. It enhances the perception of relevant information while reducing interference from irrelevant stimuli and requires cognitive effort.

Moreover, psychological and medical studies have proven that with the right use of methods and tests, attention can be enhanced, especially in children with ADHD, Tourette Syndrome or Autism (Mora, 2021).

Mora (2021) suggests that the neural networks involved in learning peak between ages 4 to 7, creating a specific time window that is especially relevant to development. During these first years of development, student's neural plasticity is more flexible and better adapts to changes, making it easier to be moulded with the right stimuli. However, after this age period, the flexibility tends to decrease, between ages 8 to 12. Research has shown that attentional training during this window, which is analogue to Primary Education, improves children's attention capacity and their intelligence quotient.

Having said this, experts have not yet fully deciphered this intricate organ, the brain, therefore further research needs to be carried out.

3.4.6. Role of curiosity in learning

Learning, and more specifically abstract learning cannot be carried out unless the topic interests the subject. This does not only apply to young learners, but to all ages. For learning to be successful, an interesting initial stimulus is needed.

Curiosity, the desire to know more, is the motor of human behavior. From highly impacting discoveries to learning at school, curiosity is key. Charles Sherrington (1951), the father of modern neuroscience, described it as "sacred curiosity". What is more, playing is one of the first conducts children develop regarding learning through curiosity. It is innate, and it combines curiosity and pleasure. Recent research has shown that knowledge through studying and learning shares neural substrates with conducts such as the search for water or food, which are pleasurable and essential for human survival. From this, it follows that the curiosity that is satisfied through learning, roots from pleasure.

Mora (2021) indicates techniques to boost curiosity in the classroom: starting the lesson with something provocative that shocks the learners, creating an atmosphere open to dialogue, providing enough time to think and elaborate, active participation of all students, merit reinforcement and scaffolding.

Dewey (1910) relates curiosity to children's behavior, to the desire of living experiences fully. The starting point to it is exploration, predominantly carried out through experiencing with the whole body and all senses, not just verbally. Oftentimes, learning experiences are limited by the four walls that surround the classroom, however, there is a world outside which could be exploited to meet student's needs of learning and being curious using their body as a whole.

Nonetheless, although rich environments are crucial to boost children's curiosity, the teacher's role is also key. Numerous authors such as Chak (2010) suggest that children's behavior regarding exploration and curiosity is closely related to teacher's reactions and postures. Curiosity is often linked to younger children, especially in preschool age, however, according to expert's views, it seems to decrease as students grow older (Patrick and Mantzicopoulos, 2015).

By using different teaching approaches, key aspects for human's development and enrichment such as curiosity can be promoted (Pluck and Johnson, 2011). Moreover, sensory experiences have proven to be highly effective in nurturing children's curiosity (Heggen and Lynngård, 2021).

3.4.7. Scaffolding to aid learning

Recently, scaffolding has been a growing technique used in the teaching and learning process. More specifically, it has been focused on language learning. The origin of the term is construction-related; it refers to the temporary structures' builders used to work on buildings. The introduction of this term dates back to the 1970s, and is closely related to the sociocultural theory of Vygotsky (Gonulal and Loewen, 2018).

Vygosky's Zone of Proximal Development (ZPD) is a theory that contrasts what the individual can independently achieve with the potential achievements the same person could reach with support and guidance from an expert, also known as More Knowledgeable Other (MKO) (Vygotsky and Cole, 1978). In line with this idea, an instructional technique called scaffolding emerged. Wood et. al (1976) described the term scaffolding as a way in which the adults control the different elements of a task that are at first beyond the student's capacity allowing them to exclusively focus upon the elements that fall within the person's realm of competence. Progressively, the expert's help is diminished until the point in which the learner is able to develop the task on its own. It aims to help develop new skills or knowledge by building on the existing ones. Although at first the term scaffolding was used to describe parent-child interactions, in the 1980s it was extended to teacher-student interaction (Gonulal and Loewen, 2018).

ZPD is at the heart of scaffolding, and although theoretically they are very similar, Vygotsky never used this second one in his writing; they were introduced by Wood, Bruner, and Ross (1976).

3.4.8. How Internet and technologies impact learning

The Internet and new technologies have revolutionized 21st century society. Since the World Wide Web (WWW) was developed, numerous changes have been made regarding all aspects of human life. From medical to educational or political changes. What is more, it has led to shifts in human behavior patterns, as they have been adapted to the actual interconnected environment. Nowadays, human exchanges are produced at a great speed, leading to quick growth, immediate seek for rewards, and fast decision making. This leads to a disaffection, lack of empathy and distance, as the focus is not on relationships, but on speed. The faster the better (Male and Burden, 2014).

Although the Internet has some downsides, it has been a cultural revolution that has improved human's lives and processes, including education. Classrooms in developed countries often offer a wide variety of technological devices, from smartboards and computers to technology kits for experiments or even robots, providing an important teaching and learning complement to the users. Additionally, the use of media at school closed the gap between the students that have access to it and those who do not, as otherwise many would not be able to use them (Süss, 2013). However, children spend an average of 5 to 6 hours daily at school, making this 25 to 30 hours weekly. During these prolonged periods, technology can be used as an additional tool, but should not be used as the main or only one (Mora, 2021).

Studies have shown that Internet navigation requires short attention spans, which humans get accustomed to, resulting in a detriment to the development of sustained executive attention. What is more, it has been related to an increase in Attention-Deficit/Hyperactivity Disorder (ADHD) cases and even Internet-related addictions. It is a psychiatric condition that affects around 5% of children worldwide. Nonetheless, some experts claim that if correctly used, technology can aid ADHD children (Cibrian et al., 2021).

Having said this, the world keeps changing and innovations happen every second, so humans need to keep up with them. Adaptation to new stimuli is necessary, and thanks to the brain's plasticity and learning capacity this is possible. Taking the power of the Internet and technologies, they should be implemented in academic settings so students can take advantage of the possibilities they offer but always in a controlled and supervised manner (Livingstone et al., 2011).

3.5 Debunking neuromyths

The term neuromyth was coined in the 1980s by neurosurgeon Alan Crockard, who used it to describe misconceptions regarding brain functions in the medical discipline (Howard-Jones, 2014).

From the educational perspective, neuromyths have been described as "a misconception generated by a misunderstanding, a misreading, or a misquoting of facts scientifically established (by brain research) to make a case for the use of brain research in education and other contexts" (OECD, 2002).

Later, in 2007, this same organization, the Organization for Economic Cooperation and Development (OECD), warned about the misconceptions amongst teachers regarding brain functions, relating most neuromyths to the following subjects: the use of only 10% of the brain capacity, critical periods, left or right brained people and multilingualism (Torrijos-Muelas et al., 2021).

One of the most deeply rooted neuromyths is about the use of only 10% of brain capacity. It began when William James argued in 1907 that humans used physical and mental resources below their means (James, 1907). This enduring statement has prevailed for years. However, nowadays, scientific research has shown the improbability of this argument, as it is known that there is not a single brain area that can be fully disconnected, even if the person is asleep (Centre for Educational Research and Innovation and OECD, 2007).

The critical periods refer to specific maturating periods of infancy and childhood when the brain has a higher capacity of adjustment in response to experience. They were thought to be crucial and that regular development could not be carried out outside them. However, scientists have proved that these periods are not as sharp as previously thought, and are actually influenced by many factors (Centre for Educational Research and Innovation and OECD, 2007). Nowadays, authors such as Mora (2021) refer to them as sensitive periods.

Research using neuroimaging has been used to demonstrate that both hemispheres are in constant communication and are responsible for most procedures, although some of their functions differ (Ansari, 2008). In association to this research, other neuromyths have been debunked, such as the multiple intelligences, or left or right brained people (Geake, 2008).

Regarding multilingualism, three main neuromyths are widely extended: both languages compete for resources, knowledge acquired in a language is not accessible in the other one, and the first language should be well spoken before the second one is introduced.

Currently, multilingualism is regarded as beneficial rather than problematic as previously thought. However, several neuromyths like the ones previously mentioned, are still present in people’s minds. These three leading myths have a mistaken common underlying basis: languages are separated in the brain. Nowadays, scientific research and every-day observations have proven them erroneous.

Additionally, their origin merges three factors: politically motivated, linguistic phenomena and misjudgement of old studies. Languages are culturally and politically meaningful, therefore are linked with ideologies: some consider specific languages to be superior. Also, countries with multiple official languages often show one that prevails making the rest vanish. Immigration also causes linguistic changes, as several languages interact in different contexts. Even language blending can take place ("Spanglish"). Lastly, research carried out at the beginning of the 20th century wrongly presented bilingual people as less intelligent, as not all factors were taken into account when carrying out the investigations, for example socially difficult environments.

It is widely spread that two languages compete for resources. This is based upon the assumption that the human brain has a limited learning capacity. If the brain is filled with language, it will not allow space for the other one, or one should be lost. This neuromyth has been debunked by scientific research, however, its explanation is simpler. If it were correct, nobody would speak several languages well, as nobody's brain has that much space. Additionally, studies have shown that increased knowledge in one language results in an amelioration of the other languages the person speaks.

Another well-known neuromyth states that knowledge acquired in one language is not accessible for the other language. It is based on the erroneous assumption that the knowledge in the brain is stored in different compartments of the organ that are delimited. Contrary to this belief, scientists have proved that the more knowledge about languages the brain stores, the more space it develops. What is more, experts state that language representation overlaps in the brain, not distinguishing between different languages. However, different theories regarding this overlapping have been developed and the results are not fully clear, but the common point in them is that the overlapping does take place, therefore languages are not isolated in different areas that do not interact between them.

Last, the need to master the mother language before learning other languages has prevailed for a great number of years. It is based on the supposition that languages are learnt separately from each other to not get them mixed. Notwithstanding, there is evidence that children who master several languages have a better understanding of languages in general, as they are more conscious of structures and apply them more consciously. Additionally, multilingualism does not result in retarded language development. Children do make mistakes when learning, but it is a phenomenon necessary for learning, and it is not directly linked to the confusion between several languages (Mueller, n.d.).

3.6. Introduction to HERVAT

Tomás Alonso Ortiz is a Spanish professor that developed an educational program in which the principles of neuroscience were applied, resulting in a neuroeducational proposal denominated HERVAT, which stands for hydration, equilibrium, respiration, vision, audition and touch. It is based on the principles of physical well-being, bottom-up processes, synchronizing all the sensory systems and providing short timings and few contents for each activity (Ortiz Alonso, 2018).

Caring for the physical well-being of the learner involves several factors. The relationship between sleep, learning and memory consolidation is nowadays the focal point of numerous research studies. However, it is not a new topic of interest, as the Roman rhetorician Quintilian (I AD) had already noted the connection between sleep and memory (Stickgold, 2005). He would go to sleep after learning or reviewing a topic, and the following day, when he woke up, he would remember it even more clearly. Nonetheless, this relationship was not scientifically studied successfully until the late 1900s. Nowadays, it is widely accepted that the acquisition of new information is consolidated during sleep rather than forgotten, therefore making sleep a key factor in regard to memory (Stickgold, 2005). Additionally, the majority of the research findings corroborate that sleep facilitates working memory and memory consolidation in children, and that sleep deprivation directly affects performance in abstract and complex tasks that require higher brain functions (Kopasz et al., 2010).

Another factor involved in physical well-being is physical activity, which provides numerous benefits regarding brain activity, such as the facilitation of neuroplasticity, and the increase in learning and memory performance. Although some cognitive domains and brain areas are more influenced than others when performing physical activity, an overall improvement in the cognitive function is hosted (Erickson et al., 2015).

Nutrition and hydration also play a role in physical welfare. Drinking water regularly throughout the day in small doses is not only essential for homeostasis and survival, but also brain activity. Furthermore, specific cognitive functions and mood states are influenced by water intake, which directly impacts those with poorer fluid regulation such as children (Masento et al., 2014). The intake of balanced meals has similar effects to water in regard to cognition and emotion. Dietary factors have shown a close relationship with synaptic plasticity and neuronal function. Specifically, there are gut hormones that are either produced or enter the brain and directly influence cognition (Gómez-Pinilla, 2008). In connection to the balanced diet, the mammalian brain obtains energy from glucose, therefore its intake and regulation is crucial for brain physiology (Mergenthaler et al., 2013).

Additionally, science and education follow a similar process: bottom-up, meaning that an optimal physiological state of the organism, a good sensory information entry and motor organization are needed to achieve higher and more complex cognitive functions (Fuster, 2015).

Regarding the synchronization of the sensory systems, the brain responds to specific stimuli and cognitive processes by synchronizing millions of connections. Synchronization refers to the execution of several processes at the same time with the objective of completing a task, and this process is developed through repetition. The more a process is repeated, the faster it will occur and the more specialized it will get. Synchronization results in a stable neuronal firing pattern that activates and improves some synapses that are little or not at all functional.

The brain receives external stimuli (through neurons) that at first might seem chaotic and unorganized, however, with repetitive stimuli, a stable firing pattern is established. Additionally, research has shown that long lasting changes in neurons take place after they are stimulated four times within the same hour (Colicos et al., 2001).

According to Hebb, “cells that fire together wire together”, meaning that cells or systems that are repeatedly activated simultaneously, will become associated, leading to one activity facilitating the other one (Keysers and Gazzola, 2014).

Moreover, children’s brains work rapidly, and their attention span is short, therefore the activities should be adapted to these characteristics (Cowan et al., 2006).

3.6.1 Anatomical and physiological bases

HERVAT stands on a neuroscientific basis that combines different areas and functions of the brain. The reticular activating system (RAS) is a network of neurons located in the brainstem that works together with multiple neuronal circuits to allow the brain to modulate between slow and fast sleep rhythms (as seen on EEG). In particular, the nuclei of the RAS are highly significant in the coordination of these rhythms. Furthermore, and in relation to HERVAT, the groups of neurons that make up the RAS are also responsible for attention, arousal and ability to focus (Arguinchona, 2019).

The somatosensory cortex of the brain detects sensory information by receiving neural projections from the thalamus. The information received from the environment through the senses is combined in the brain to then respond to the stimuli (Kayser et al., 2005).

The prefrontal cortex (PFC) is located in the frontal lobe of the brain, and it is often categorized as a multimodal association cortex due to its function of integrating processed information from several sensory modalities (Siddiqui et al., 2008). Additionally, the PFC plays an important role in switching attentional control based on changing task demands (Rossi et al., 2009).

Working memory is also affected by the PFC, specifically the dorsolateral area. Studies have shown that the prefrontal cortex assists in maintaining information by directing attention to internal representations of sensory stimuli and motor plans that are stored in more posterior regions (Curtis and D'Esposito, 2003). This type of memory focuses specifically on the retention of minor amounts of information in an accessible form, therefore facilitating comprehension, reasoning, problem solving and planning (Cowan, 2014).

3.6.2 Essence of HERVAT

HERVAT is the acronym that stands for hydration, equilibrium, respiration, vision, audition and touch. The goal of the author was not only to propose a theoretical framework that linked neuroscience and education, but a practical proposal that could be implemented with learners (Ortiz Alonso, 2018).

Hydration is essential for many cognitive functions as previously stated, and in addition, drinking often at school generates positive future habits. To implement a regular drinking schedule in the classroom, the first few minutes of every lesson should be dedicated to it (a few sips of water every 45 minutes).

Equilibrium may not seem significant in relation to learning and brain function. However, it is an essential component. Balance is the result of the integration of sensory-perceptual-motor skills, which led to brain development, learning, and the improvement of attentional states. Moreover, it effectively activates the cerebellum. This brain area is involved in muscle control (balance and movement) and learning (Thach et al., 1992), but in addition, it carries out non-motor functions including emotion, cognition and behavior (Ito, 2008).

A slow and deep respiration has shown to be one of the multiple forms of relaxing, helping individuals improve their overall well-being and reducing stress (Toussaint et al., 2021).

There are many factors that influence the appearance of stress in children. In an academic context, students tend to feel overwhelmed and pressured when performing challenging tasks or taking tests (McDonald, 2001). Although stress is not always negative, as it can increase productivity, performance and motivation when correctly measured and overcome, it can be a risk factor if it is not correctly managed. Continuous stress has shown to have a negative impact on a learner's academic performance, education, sleep quality, and physical and mental states (Pascoe et al., 2020). Breathing exercises have proven to be effective to help children manage stressful situations from a young age, making them more independent by providing them with tools to self-manage and be independent. Breathing is focused on consciously directing the breath in a specific way; however, mindfulness and meditation also involve a cognitive process. Both can be implemented in the classroom to achieve optimal results regarding attention, focus and stress reduction in students. What is more, research shows that these techniques improve children's emotional and psychosocial quality of life in comparison to those who do not apply them, therefore adding them as part of the curriculum would be positive (Bazzano et al., 2018). Nasal respiration is interconnected with limbic brain areas in charge of cognitive functions (Zelano et al., 2016). Additionally, a regular breathing rhythm is key to attention and focus, as it helps oxygenate the brain. Breathing oscillations are related to higher brain functions such as cognition and perception, and the timing of the breathing has shown to modulate accuracy in cognitive tasks and specific cortical activity (Nakamura, 2023). The respiratory drive is automatically generated by the rhythmic bursts of pacemaker neurons located in the brainstem (Suess et al.,1980), however, they do not have a fixed pace, which is where other factors such as the emotional state and anxiety come into place (Boiten, 1998).

Vision is another of the elements of HERVAT. Exercises that require ocular following of a stimulus in all directions at a specific distance favour attention, alert and spatial orientation. Additionally, visual acuity is developed, which enables the child to perceive details quickly (Posner and Rothbart, 2009).

Auditory stimulation also impacts learning and memory. Research carried out by Timmermann et al. (1999) proved that repeated auditory stimuli produced changes in the distribution of neural frequencies that could augment verbal memory.

Lastly, tactile stimulation has shown to improve long-term neural plasticity (Roggeri et al., 2008).

3.6.3 Pedagogical implications of HERVAT

HERVAT involves repetitive, regular, precise and systematic activities that take place every day. This has some pedagogical implications such as an improvement in the capacity of response, a decrease in errors and an increase in success rates, decrease in response time, improvement in automatic processes that module conscious activity and increase in the unconscious processes implicated in daily behaviors.

Additionally, the activities require short timings (hippocampus). The benefits related to time management are the improvement in learning, decrease in fatigue and improvement in levels of sustained attention.

Pairing exercises and academic learning led to the improvement of learning speed, attentional processes, short term memory, and remembering time (Ortiz Alonso, 2018).

Creating a positive emotional environment also impacts learning. Ekman et al. (1990) described the impact of different types of smiles on individuals by conducting research in which subjects were presented with pleasant and unpleasant films and their reactions were studied. This resulted in the description of the Duchenne smile, in which the muscle around the eye is active simultaneously with the lip corner. This facial expression differs with the non-Duchenne smile in the activation of the muscle orbiting the eye. The first one was associated with enjoyment (pleasant films) while the second one was associated with the opposite. Additionally, Larsen et al. (1992) conducted a series of experiments in which they found out the influence of facial muscle contractions in subjective emotional experience, focusing on the effect of frowning in comparison to relaxing the forehead. Although the experiments differ, both showed that facial expression is linked to emotion and perception of the individual.

4. EDUCATIONAL PROPOSAL

This educational proposal, targeted toward the three cycles of Primary Education, focuses on three areas: English, mathematics and physical education. Moreover, it proposes the practice of HERVAT techniques to enhance learning in all areas. Firstly, the Spanish curriculum is described, focusing on the key competences that will be treated. Then the links between the activities and the theoretical framework are developed. Lastly, the activities corresponding to each cycle and their theoretical basis are explained.

Spanish Primary Education is regulated at national level by the *Real Decreto 157/2022*, and by the *Decreto 61/2022* for the Autonomous Community of Madrid. The proposal ahead is based on this second one.

The *Decreto 61/2022* establishes in article 7 the areas of the Primary Education stage. Accordingly, the proposal is targeted toward three areas: Foreign Language (English), Mathematics and Physical Education. These have been chosen due to their cross-curricular nature, and the affordances they offer to interconnect the knowledge and techniques to benefit from one another.

According to article 6 from the *Decreto 61/2022,* the key competencies and exit profile focus on transversality. Correspondingly, the educational proposal developed ahead focuses on all the competencies (table 1, available in section 8. Appendices). However, due to the nature of the proposal, some competencies are especially relevant (table 2), but all are developed to some extent.

The educational proposal presents different activities for three subjects: English, Mathematics and Physical Education based on the principles previously developed. Its objective is not just to create learning as a way of survival (Marley, 1990), but to allow the students to personally flourish in all dimensions. The main executive functions are developed through a series of activities in all subjects that complement each other. Although the activities go according to each subject and the Spanish curriculum requirements, they are targeted toward a holistic approach in which the learnings from one complement each other. The main focus is not on what is learned, but on how it is learned. Learning is enhanced through the creation of curiosity and the involvement of the student's emotions. It is known that emotions affect learning (Dolan, 2002) and academic results (Li et al., 2020), therefore it is key to create a positive learning environment in which everyone feels well. The teacher will have the main responsibility for this, however, each individual student from the class will do their own bit to contribute. Moreover, emotions are linked to motivation, especially extrinsic motivation, which is crucial for learning. The students need to feel motivated during the class, but also outside it, so linking learning to emotions will boost motivation and willingness to keep learning. Additionally, techniques proposed by Mora (2021) are implemented: provocative lessons that shock the learner (unusual activities), a positive and open learning environment (where everyone is welcome and valued), enough time to develop the tasks (the teacher will adapt it to the student's needs), promotion of active participation (every student has a role), merit reinforcement (recognizing student's achievements) and scaffolding (presenting the activities from less to more complex and exponentially withdraw teacher support). The activities proposed require repetition, taking into account its importance for creating synaptic connections and dendritic growth leading to learning (Glannon, 2014). This way, the knowledge about both content and learning strategies will be stored in the student's long-term memory (LTM). The HERVAT activities will be more repetitive than the rest. However, all are targeted toward creating positive learning habits that benefit the students.

Furthermore, technologies are introduced, but not as a main focus, as the students need them to participate in society, but studies have shown the negative impact of their overuse with regard to attention, especially in young children. The proposal includes them but without letting them vanish the attention boost promoted through the rest of the activities. Lastly, the student's circadian rhythms are taken into account. As Mora (2021) explains, teachers need to find the right time to promote learning in all students in accordance with their internal rhythms, therefore it is suggested to develop the more complex activities at around noon (English and Mathematics). This way both night owls and morning larks will learn best. When all aspects work together, attention is created, and the ultimate goal is achieved: to enhance the learning process. For this, activities for each cycle of Primary Education are developed for three subjects: English, Mathematics and Physical Education.

4.1. HERVAT

Having explained the great impact of HERVAT techniques on learning, the students will develop two one-minute activities at the beginning of each lesson. It will not take away much classroom time, but the benefits in the student's attention will be notable. Every time, the goal for these starting activities will be different (breathing, motor activity, ocular motility, balance and listening). Additionally, the students will be encouraged to drink water, especially during this starting period of the lesson, but also to keep the water bottle on the table to regularly drink. The HERVAT techniques go according to the personal, social and learning to learn competence from the *Decreto 61/2022.*

HERVAT	
Breathing	- smelling imaginary flowers - balloon breaths - guided breathing with timings
Motor activity	- 4 corners game - dance - hopscotch
Ocular motility	- follow your partner's finger drawing in the air - draw geometric shapes with your sight
Balance	- one-leg stand - walk on floor lines - yoga pose
Audition	- close eyes and listen for sounds in the environment - listen to a short story

4.2. English

The activities proposed for the English subject are focused on metacognitive strategies, closely related to the personal, social and learning to learn, multilingual, and linguistic communication competences (*Decreto 61/2022*), as the students reflect upon their learning process through the use of a English as a second language. Moreover, they are targeted toward promoting explicit learning and helping students be aware of their learning process.

The proposal is based on the specific competencies for the three cycles of Primary Education from the *Decreto 61/2022* for English as a Foreign Language. On the lower courses, the expectations are lower, and on the higher courses, the expectations and complexity rise. Moreover, all the content blocks described in the *Decreto 61/2022* are developed (table 3).

Learning strategies are commonly described as what is done to learn. However, the learning possibilities are immense, therefore two main groups can be identified: metacognitive strategies, used to regulate learning (more generalized), and cognitive strategies, more task specific and involve subject manipulation. These strategies, often used for language learning (English), can be applied to all subject areas, and students should be reminded of this. The transfer of strategies across subjects allows for an overall awareness in every aspect of learning (Ellis and Brewster, 2014).

Ellis and Brewster (2014) describe the steps for each in “Tell it Again! The Storytelling Handbook for Primary English Language Teachers”. Metacognitive strategies involve thinking about learning, and can be divided into different tasks:

1. Planning learning: the teacher is responsible for planning it; however, the students can be involved by following the teacher’s model and thinking about what they already know, what they want to know, and set some learning goals.
2. Hypothesising: students are encouraged to plan ideas that then will be tested.
3. Comparing: pupils compare and analyze the differences and similarities between L1 and L2 (English). Through this, curiosity and language awareness are developed.
4. Self-questioning: students ask themselves questions regarding their learning.
5. Self-assessment: students complete self-assessment sheets where they reflect upon their learning process and outcomes. This allows to monitor progress, maintain motivation and show the strong and weak points.

6. Self-correction: pupils are given the opportunity to check their own work and take responsibility for their learning and mistakes.
7. Reviewing: systematically reviewing enhances retention and provides awareness of strengths and weaknesses.
8. Selecting activities: pupils are given different activities to choose from based on their interests and needs, allowing them to individually plan their work.

One of the main points of education is teaching learners how to effectively learn, memorize and solve problems through a range of strategies and methods. Metacognitive strategies help learners achieve the desired aims by facilitating learning, reminding and memorizing (Saied and Mehrabi, 2013). Flavell (2005) describes metacognition as a re-identification of cognition. It consists of making the students aware of their learning process. What is more, research has shown that students who are taught these strategies have a greater metacognitive awareness, leading to better learning outcomes and academic results (Baker, 2013). Therefore, Fooladvand et al., (2017) suggest including metacognitive strategies as part of the academic curriculum.

Additionally, some activities involve arts and crafts, as, according to Huotilainen et al. (2018), this discipline helps control stress and strengthens relaxation, enabling us to safely fail and handle emotions correctly. Moreover, the proposal for the third cycle is targeted from an interdisciplinary perspective linking social sciences (geography) and English. To accommodate the needs of society, schools should provide interdisciplinary teaching to enhance the process and outcome of learning, for example by focusing on geography and its links to everyday life to increase functional learning (Živković et al., 2017),

The activities presented ahead are focused on promoting attention by motivating the students and capturing their feeling through not just a set of activities, but a learning experience.

ENGLISH
FIRST CYCLE
The whispering treasure chest
The students are introduced to pirates by seeing short clips of the Pirates of the Caribbean movies. **1. Planning learning:** each student is given a treasure map which shows several islands, each including one learning objective. They are read aloud and discussed, and after reaching an agreement, some new objectives related to the original ones are added. Then each student is given time and materials to decorate its own map. **2. Hypothesizing:** the students embark on the Neverland Boat and their adventure starts. They sail for hours in heavy rain, and just when the first sun ray hits the ship bow, one of the buccaneers finds something floating on the water. As they get close they are able to see a broken coble with a blurry inscription that says C. Shark. Inside, a body is found and then taken inside the student's boat (The teacher will dress up as a pirate and act like so). The pirate is alive, but seems a bit lost. Captain Shark has lost his memory! The students need to pay attention to all the cues in the scenario and come up with a hypothesis about what happened to him and how he can be helped. Once they ask the right questions and figure out a solution, Captain Shark rewards them with an old key. **3. Comparing:** the students keep sailing until they reach the mainland, and head to the "Mysterious Caverns of Vocabulary", where they encounter a giant crab. The only way to fight it and get out is by beating him in a vocabulary battle. The crab will show them flashcards with pictures of different objects, and the students will have to say the Spanish and English names for them and then argue if they are similar or different. When a similarity in both languages is found, the students will scream "arr!". Having completed all the flashcards, the crab will let them pass through, and their journey will continue. **4. Self-questioning:** back in the boat, they keep sailing. When they get to the next shore, they disembark and find something rolling in between the waves. A message in a bottle! Each student gets one and opens it, finding two questions: What have I learned? How can I

learn more? Each of the students will have to think and write the answer on the papyrus and throw it back to the water.

5. Self-assessment and self-correction: then the adventure keeps going as they walk deeper into the island. At some point they sit down to rest, and look back at their maps. They reflect upon their adventure, and talk about the challenges encountered in each island and how they were solved. Each student has to be sincere and make a check in each of the islands if they succeeded in every step. In case mistakes were made, they will reflect upon them and suggest improvements for the future. Then, using tablets, this information is written and shared in a common pirate-themed Paddlet document. Having rested, they keep walking following the map toward the last location, and after walking for hours, they encounter a large cross on the sand, just like the one on their maps. They dig deep until they find something hard. The treasure box! It is taken out and opened with the key given by Captain Shark at the beginning of the adventure. The prizes and chocolate coins are then shared between the students.

6. Reviewing: the adventure and the learnings will be included in the classroom diary. After a couple of weeks, the outline of the adventure will be reread and the students will recall the challenges and how they were overcome using their knowledge.

7. Selecting activities: for the last step of the pirate adventure, the students are asked to create a portrait of themselves as pirates. They are given complete freedom for this, therefore they can use arts and crafts materials to make it or words and sentences. It can be a physical or psychological portrait, by describing how they felt.

SECOND CYCLE

I feel, you feel, we feel, Hopkins feels

Hopkins the frog, the new class plush puppet, is introduced to the students. The teacher brings the plush frog inside a box, and once everyone is sitting in a circle on the carpet, the teacher tells them to guess what could be inside. The teacher guides the guesses toward the answer, and once they guess it, Hopkins hops out of the box into some of the student’s heads. The students should be surprised and engaged by the unexpected addition to the class. Once everyone is immersed in the learning situation proposed, the adventure begins.

1. Planning learning: the teacher gives voice to Hopkins, and asks why the students think he has chosen their class as its new home. Then, the frog explains that he is feeling different emotions, but needs help, because he does not understand them, nor does he know how to manage them. Having said this, the teacher comes back to being himself, and asks the students if they want to help Hopkins and take care of him in their class. Firstly, they have to think about what they can do to help their new friend, and then write it on post-its that will be hung in a visible spot in the class. Once everyone has made a proposal, the ideas will be read out loud, and some will be chosen to be developed.

2. Hypothesizing: the students know that Hopkins has an issue dealing with his emotions, but they are not sure of which, because the frog has no knowledge about them. The students are organized into pairs and told to think about what emotion the frog might be feeling and why. For this, they will choose a coloured paper that relates to the emotion, and on one side of the paper they will write the name of the emotion in big capital letters, and on the other side, they will write an explanation of why Hopkins might be feeling that way. Some of the emotions might be repeated, but the teacher will encourage the students to use different ones so there is greater variety. The teacher will encourage the students to develop this last part, as they have to put themselves in the frog's shoes and guess or invent reasons. For this, they will first relate the emotion to themselves, and then apply it to the frog's life. Having written on both sides of the paper, the class will take turns to share it with both their classmates and the frog, and then all the coloured papers will be hung up in the class wall with the word side facing outwards. When each pair presents, they will talk directly to Hopkins, and the teacher will characterize it and say a few words.

3. Comparing: having some basic knowledge about emotions, Hopkins will be curious to know if emotions are the same in Spanish and English. The frog will ask the students if they are, and in what way. The goal is for the students to understand the difference between signifier and signified. Even though the name of the emotion (signifier) changes depending on the language chosen, the mental concept (signified) remains the same. From this, diversity will be targeted, and the frog will say how it does not matter the background, culture or language spoken, everyone feels the same.

4. Self-questioning and self-assessment: each student will keep track of the emotions that are developed in the class in their "emotionary". This is a notebook that will accompany the students throughout the development of the activities, and at the end of each, they will have to write the key learnings in relation to the following questions: what have I learned?

Have I ever felt this way? When have I felt this way? Do I have any doubts? In case the last question is affirmative, the student would approach the teacher to solve it.

In addition, a small space at the end of each page will be devoted for the self-assessment, in which they will have to track their own performance by stating a positive thing they did during that lesson to contribute to their learning and one that could be improved.

The “emotionary” will be developed individually, and by the end, the students will have their own personalized emotion diary.

5. Self-correction: each student will be provided with a checklist with the main items that they should have accomplished and will be responsible for identifying their degree of acquisition. This will be glued to the end of the emotionary notebook.

6. Reviewing: Hopkins will gift each student a set of flashcards with the emotions developed in class so that from time to time, the students can review the key emotions. On one side of the cards there is an emoji, and on the other one, the name of the emotion can be found. The students will set them up with the picture side facing upwards, and will say out loud the name for each emoji. This review can be done individually, by pairs or in small groups. Moreover, fast finishers can use them throughout the course to review emotions when they are done with the work proposed.

7. Selecting activities: using tablets, the students will be shown a selection of online games that target emotions. First, Hopkins will remind the students the rules for using technology: only using apps with teacher permission, holding the tablet with both hands, using a respectful volume, and asking the teacher when not sure about something. Then, they will choose their favorite and will play for half an hour. During this period, the teacher will supervise the games and the correct use of tablets.

THIRD CYCLE

First class flight to fun: learning around the world

Firstly, the students are introduced to the learning situation by being given a travel passport. This will be their booklet of exercises, but also a tool to keep track of their learning progress. On the first day, the teacher will dress up as a flight attendant or pilot and will pull all the passports out of a suitcase and then deliver one to each student.

1. **Planning learning:** having filled out their personal information on the passport, the students will turn the page to find a KWL chart. Here, they will organize and plan their knowledge. In the first part, they will write what they already Know and then, what they Want to know. The final part, what they have Learned, will be developed at the end of the learning situation. To guide these first ideas that the students will write under the letters K and W, the teacher might ask them to brainstorm by providing some basic concepts that need to be studied and will get students on the right track: countries, passive voice and means of transport.
2. **Hypothesising:** the students will be sitting in a circle on the floor, and in the middle, there will be some spread out flashcards that include both pictures of countries (studied in social sciences), and means of transport. However, none will be labelled. Each student will be given a dry-erase marker, and will be told to take two flashcards, one related to transports, the other one related to countries, and label them using the marker. Moreover, the two cards taken need to be related, and this relationship should be explained to the rest of the class. Some mistakes may appear, but the students should solve them and help their classmates. In case the students are having difficulties, the teacher may intervene by providing some clues.

   Example: I have chosen a bicycle for the Netherlands, as the Dutch benefit from the plain terrains and short distances to both be ecological and practice a sport.

3. **Comparing:** the students are paired up to create announcements for different transports. The focus of this activity is on the passive voice. The students will make comparisons in two ways: on the one hand, they will compare and discuss the use of the active and passive voice for making general announcements, and then will compare it with their native language. Is the passive voice used in Spanish to make general announcements).

   Example: all passengers are required to show their personal identification before boarding the plane. This would be said at an airport.

4. **Self-questioning and self-assessment:** the students use a blank space in their travel passports to propose questions related to their learning and answer them using the passive voice to create an essay. Knowing the structure of the paper required and being familiarized with how self-evaluation works, they should be able to reflect upon their learning outcomes and propose ideas of improvement if needed.
5. **Self-correction:** having written the essay, they swap passports with another classmate, and the new person underlines the mistakes he or she observes. They

are not corrected, just highlighted. This swap is repeated two more times to make sure most mistakes are found. Then the passport returns to its owner and this student corrects his or her own mistakes using the feedback and cues provided by the other classmates.

6. **Reviewing:** each student will use one tablet and create a Kahoot with the main contents of the unit following these guidelines: 10 questions, multiple choice with four options and 30 seconds to answer each question. By the end, each student will have one, and will share it with another classmate. Every time this revision is developed, each student will get a different kahoot from one of their classmates. Additionally, if the player recognizes mistakes, the creator should be told and they should be corrected.
7. **Selecting activities:** the passport booklet includes a series of activities that help concentration and focus attention from which the students can choose when they finish tasks early, during free time, or when desired by the teacher. They include a variety of crosswords, puzzles, labyrinths and painting by numbers. These do not have a content learning goal, but rather focus on allowing students to self-regulate when needed.

4.3. Mathematics

Mathematics will be approached both in a conventional way through the use of the tangram and an unconventional way through the use of the operations hopscotch. Success in learning mathematics relies on a wide range of factors. However, research suggests that executive function skills play a crucial role, from monitoring and manipulating information (working memory) to suppressing unnecessary stimuli (inhibition) or flexible thinking (shifting) (Cragg and Gilmore, 2014).

A tangram is a Chinese geometrical puzzle which contains seven pieces that are assembled together to create a square: 5 triangles, 1 parallelogram and 1 square. Neuroimaging studies have been carried out where participants were presented with geometric problem sets involving the tangram which require executive planning and visuospatial reasoning. The neural effects of this activity were monitored through optical brain imaging, showing the implication of prefrontal and parietal cortices when solving mathematical problems (Ayaz et al., 2012). Other authors from the field suggest that in addition to enhancing executive functions, the use of the tangram has numerous benefits. Recent studies carried out in lower elementary school students in which the data was analyzed through observation show the use of these geometric puzzles boost creativity (Herdiana et al., 2023). Moreover, Ayaz et al. (2012) suggests the application of these geometrical puzzles in classrooms to optimize learning. The use of the tangram requires attention and concentration on the task, as several cognitive functions are involved. Perception and visual memory are key to identify the pieces of the puzzle and copy the designs provided by the templates. In connection, the visuomotor coordination is developed by simultaneously activating hand and eye movements. Creativity is another aspect developed through the puzzle, as the student does not only have to find ways to copy the example, but also create their own figures. Executive functions such as planning and flexibility are crucial. The student needs to find different ways to assemble the pieces to create the desired figures, and plan strategies to lay them out. Fine motricity is required to assemble the pieces in the right positions. Nonetheless, Primary Education students should not have difficulties handling the pieces.

Additionally, the operations hopscotch is closely related to some of the HERVAT principles, mainly coordination and balance. The first one is developed through the mental and bodily coordination to express the answer by stepping on the right numbers with the feet. Balance is required for holding the position when the answer is given, especially when the student is standing on a single leg.

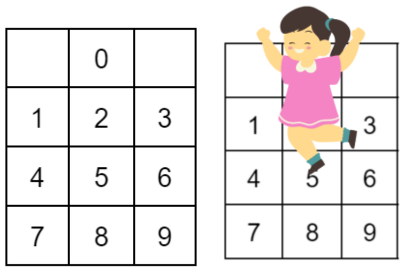

Figure 2: Operations hopscotch design

The activities proposed for the area of mathematics go according to the *Decreto 61/2022*, which establishes the specific competencies and contents for the mathematics area in the Primary Education Curriculum. They are described in detail in table 4.

MATHEMATICS
FIRST CYCLE
Operations hopscotch → mental operations The teacher will use tape to create a floor grid with numbers from 0 to 9 in each of the squares. A simple addition or subtraction will be written on the board, and the student will show the answer by jumping on the right numbers of the hopscotch. The answers might be from one digit, therefore the student will hold balance on one foot, or two digits, leading to simultaneously stepping on one number with each foot.
Tangram Each student will be given a tangram and a booklet with shapes that they will copy. In the tangram, each shape has a different colour, so the students will be provided with examples that show the pieces assembled with each of the colours. - Identification of the figures that make up the tangram: 5 triangles, 1 parallelogram, 1 square - Creation of basic figures Position of the pieces (up, down, close, far…) - Basic movements of the pieces
SECOND CYCLE
Operations hopscotch → mental operations A simple multiplication or division will be written on the board, the student will do the operation mentally, and jump on the right numbers of the hopscotch to show the answer.
Tangram The students will copy different figures using their tangram, but to increase the difficulty, the examples from the booklet will be in black and white. The delimitations between the shapes will be shown, but not the colours of each, so the students will have to think further.

THIRD CYCLE
Operations hopscotch → mental operations The operations hopscotch will be used for mentally solving simple problems. The teacher will recite it or show it on the board, and within a few seconds, the student will calculate with the answer and jump on the hopscotch numbers.
Tangram Having worked with the tangram for several cycles, the students will be given a booklet that shows pictures in black and white with no shape delimitations, therefore they will have to figure out which shape goes where.

4.4. Physical education

Physical education (PE) is the school subject that enables students to develop foundational movement skills and basic knowledge of healthy and active lifestyles. However, it is progressively becoming more marginalized in the primary school timetable around the globe, being given less priority than core subjects such as mathematics and science. The main reason for this decrease in hours is based on the attainment of cognitive knowledge that the core subjects provide. More hours of these should lead to better results and more intelligent children. Nevertheless, this short-sighted position does not take into account the possibilities PE brings to enhance the overall subjects (Rudd et al., 2019).

The executive functions work collaboratively in the acquisition of movement skills, including problem solving, decision making, planning, coordinating, perceiving and acting. Ultimately, movement enables better circulation and increased oxygen supply to the brain, allowing learning to take place (Rudd et al., 2019). Moreover, it is highly recommended to play music during the development of these activities, as, according to Loui and Guetta (2018), it promotes attention; a subset of executive functioning.

The proposal for the physical education area goes according to the specific competencies and content blocks presented in the *Decreto 61/2022,* and is detailed in table 5.

PHYSICAL EDUCATION (PE)

FIRST CYCLE

Coordination:

- Pacman tag is a game played on a basketball court. It consists of a tag game in which all players can only run through the lines, not being able to jump from one to another or step outside the line. One or two catchers (sharks), depending on the difficulty wanted, will run to catch their peers, and when they get caught, they turn into the shark.

- Balloon balance. Students are paired up and while facing each other, a balloon is put in between their heads. The goal of the game is to get from one side of the court to the other as fast as possible without dropping the ballon. If the balloon is touched by something other than the student's foreheads, the pair will restart the race.

- Don't get eaten by the sharks. The teacher will use different materials (mats, cones, hoops, benches) to create an obstacle course that the students will have to overcome. The goal is to get from one side to the other without falling on the ground, which will represent the water full of sharks. Whenever this happens, they restart.

Yoga: awareness of body and mind + breathing

- Animal yoga poses. The students will be introduced to the practice of yoga through poses inspired by animals. While everyone is seated or lying on mats, the teacher will exemplify each pose and everyone will hold it for one minute while relaxing music is being played.

- Yoga alphabet. The teacher will say a letter of the alphabet and the students will have to mimic it using their bodies and hold each pose for 30 seconds.

- Yoga story time. The teacher will develop storytelling meanwhile the students develop the poses of the main elements of the story using their bodies.

Senses:

- Nature bingo. While being in nature, the students will be provided with a list of items to interact with using their senses. Every time they correctly develop each item, they will cross it off their bingo sheets and move on to the following. They will choose the order.

- sight: find a pattern + look for something yellow
- sound: listen for the wind + a bird sound
- smell: smell a flower + a herb
- taste: try some mint
- touch: feel the texture of a rock + bark of a tree

SECOND CYCLE

Coordination:

- Mirror movements. The students will be grouped into pairs and will stand facing each other. One will be the other's reflection, therefore every time the first one moves, the second one will copy its actions using the opposite side of the body, imitating a mirror reflection.

- Don't drop the hot potato. The teacher will toss an inflated balloon and the students will hit it using their bodies to avoid it from touching the ground. Once they master a single balloon, the teacher will introduce more, making the game more complex.

- Dribbling soccer balls. The students will have to, individually, dribble soccer balls around an obstacle course.

Yoga:

- Yoga warrior challenge. The students will go through a series of stations and in each they will have to complete a challenge. Holding a plank for 30 seconds, breathing mindfully for 2 minutes or balance on a foot with eyes closed for one minute.

- Acroyoga. The students will be grouped and perform yoga poses and acrobatic movements while breathing mindfully and holding each pose. The teacher will first provide some examples in flashcards and then the students will create their own.

Senses:

- Sensory tag. Tag games will be played using different sensory cues to enhance and differentiate the experience. The catcher will be wearing a blindfold and the other students will carry musical instruments to guide the catcher toward them.

THIRD CYCLE
Coordination: - Juggling. The students will learn how to juggle using lightweight balls, bean bags or scarves. It also enhances hand-eye coordination and concentration. - Shadow tag. Following the dynamics of a regular tag game, the catcher does not have to touch the other person's body, but rather step on its shade. - Human knot. Students stand forming a circle and then reach across to hold hands with other classmates. Once everyone is part of the circle, the students try to unthread their bodies without letting go of others' hands.
Yoga: - Copy yoga. The students pick a small object from a bag with their eyes closed and have to imitate its shape with a yoga pose and hold it for one minute. Then they move on to the next figure and the process is repeated. - Yoga practice. The teacher guides the students through a whole yoga lesson including meditation. - Add one yoga pose. Similarly to the "Simon Says" game, one student will start by creating a yoga pose that everyone else will imitate for 10 seconds. Then, another person will add a pose, and each will be done for 10 seconds. The game keeps going on and more figures are added. However, the trick is that the person who will introduce the new pose has to remember all the previous ones before adding its own, which requires concentration and memory.
Senses: **-** The students will be paired up. One of them will wear a blindfold, and the other one will make a pose using its whole body. Through touch, the person wearing the blindfold will figure out the shape his pair is doing and will imitate it with its own body.

5. CRITICAL REFLECTION

5.1. Level of fulfilment of the objectives and competences

The general objectives stated in section 2.1 were accomplished, being integrated in the creation of the educational proposal. These are further developed in detail in the table in 5.3. Additionally, several methodologies are presented, mostly related to HERVAT and the development of the executive functions. Regarding the specific objectives described in section 2.2, they have also been attained. From developing a basis on how the brain functions when learning and proposing methodologies grounded on neuroscience (a), to targeting the students attention deficit through the neuroscience field (b), providing and organized proposal focused on developing the executive functions in three interconnected subjects to improve the learning process and its outcomes (c, d and e), and proposing HERVAT methodologies to enhance learning and boost the results attained through the activities developed in the content areas. All have successfully been accomplished at a similar degree, as their importance was equivalent and all were prioritized.

With regard to the degree competencies, they have also been developed. Taking into account the biological and psychological development (CG1), the processes of learning of children ages 6 to 12 (CG2), and the characteristics and principles of Primary Education (CG3), a proposal based on neuroscience has been proposed, with its subsequent design, plan and evaluation of activities (CG4). Additionally, the importance of social factors and their impact on the educational processes (CG5) has been targeted through an educational proposal aimed at promoting a calm learning environment and focus for dealing with social factors such as stress that may affect learning outcomes. In addition, the development of the paper required the knowledge and application of data (CG6) explicitly and implicitly. Tutorial action and orientation (CG7) has been focused on promoting children's autonomy as an area of development that cross-cuts the whole curriculum. The educational proposal is focused on the following subjects: English (CG8.4), mathematics (CG8.3), and physical education (CG8.7). Additionally, social science (CG8.2), music (CG8.5) and arts and crafts (CG8.6) have been included within the target subjects from an interdisciplinary perspective.

5.2. Limitations of the study and future directions

In developing the Final Dissertation Thesis, certain limitations and difficulties have arisen.

First and foremost, neuroscience is a highly intricate field that requires a strong background that comprehends neurological, biological and scientific basis. Being a Primary Education student, I had knowledge on the basis of learning and simple mental processes, but some of the research papers consulted exceeded my degree of comprehension. A great number of them were focused on field experts, therefore understanding the results and experiments was not simple. Consequently, I wrote a proposal intended to be easily accessible to those who have no prior knowledge on the topic, making accessibility a priority, both in the theoretical framework and educational proposal.

Secondly, neuroeducation is a constantly evolving field of science and new discoveries and trends are continuously released. Keeping updated in neuroeducation requires commitment and effort of the educators who decide to implement this approach in their classroom.

In regard to personal difficulties, the initial development of the paper was not easy. I had started researching and developing a different topic, which was related to one of the English subjects taken at the university the previous year. Although it was interesting and showed effective results when applied in a classroom, I was not able to find enough relevant information that aligned with my objectives and ideas, so I had to switch topics and start from scratch.

Then, once I had clearly stated my topic and was confident about it, I developed my theoretical framework, but when I got to the development of the educational proposal, numerous doubts arose. There were numerous ways in which it could be implemented in a classroom, so I had a hard time deciding which to choose, as I had no previous experience with the application of any of the strategies or activities in a real setting. Although on this occasion it was not possible due to time limitations, for future times I would implement a short trial at a school to observe which subjects would benefit the most from this perspective. Nevertheless, taking into account the research I have done and experiments I have read; I do think that I have correctly selected key subjects and that if applied, would bring positive results.

Lastly, the perfectionism on my part resulted in constant revision and rewriting of the paper. I doubted myself and thought it could be further improved every time, nonstop. This resulted in great mental stress, as perfection is almost impossible to achieve. However, this taught me that as long as I am being constant, doing research and staying on track, I should not doubt myself as much. During these four years that took me to get my degree, I have learned almost everything I need to be a teacher and create educational proposals with a strong theoretical basis, therefore self-trust is key.

5.3. Conclusions and personal reflection

How common is it to enter a class and observe that a good amount of the students is distracted and not developing the required task? Teachers encounter this issue on a daily basis and try to fight against it, but it is not easy. The lack of attention of students is a widespread issue that affects educational institutions worldwide, and directly impacts the student's academic results. Students are not focused on the lesson; therefore, they disturb the class, and even more students engage the disturbance. Oftentimes, teachers target this issue from a disciplinary perspective by punishing the incorrect behavior once it has happened. But what if this behavior was prevented from the beginning? This way teachers would not have to constantly call students' attention and learners would not be frequently penalized. Furthermore, it affects students' personal lives and development. In a world of continuous stimuli from different sources, most often technological, children are overstimulated and lack concentration. Targeting this issue from a neuroeducational perspective allows educators to implement teaching strategies that align with the actual knowledge on the brain and the neural processes involved in learning. Understanding how the brain, the machine that drives students, works, will allow teachers to design adequate strategies to enhance the teaching and learning process, creating deeper and long-lasting knowledge.

The neuroeducation expert Tomás Ortiz Alonso (2009, p. 258) stated the following:

“We know how important it is to use the brain, and to use it well in this school stage of life, among other reasons, because brain plasticity makes us have more capacity to expand our connections and neural networks on the one hand, and on the other hand, to maintain and enhance what we already have very well established. On the one hand, we have more capacity to expand our connections and neural networks, and on the other hand, to maintain and enhance what we already have very well established; if we have developed during the school stage a good system of neural networks and their acquisition, the future of our brain is assured”.

The goal of implementing neuroscience-based pedagogical approaches in schools is to provide a personalized learning experience that meets the demands of the 21st century. Children do not only need to learn, but also need to learn how to learn. This competence, contemplated by the law, is often undervalued and taken for granted. However, teachers should implement specific activities that target it. The students should hold accountability for their own learning progress, and learn to self-regulate using different techniques. Although it seems like a new approach, it is far from it. In the learning process, teachers should be there to support students, but at the same time help them become independent learners who understand their own brain and can benefit from this knowledge.

Overall, the process of writing this TFG has been challenging, yet immensely fulfilling. This journey has allowed me to target an upcoming issue in schools that has affected me both as a student and as a teacher, taking into account the learnings acquired at the university, and linking it to the degree competencies.

If scientific research has already proven that the use of metacognitive techniques when learning, water drinking, the use of the senses and other neuroscience related techniques have great effects on learning results, why not actually implement them in schools?

5.4. Linking of the degree competencies within the dissertation

Table 1.Visibility of the degree competencies within the dissertation

General degree competencies:	Section in the TFG:	References-information sources	
		Primary sources	Secondary sources
CG1. To understand the evolutionary process in the biological and psychological development of children between the ages of 6 and 12.	3.1. 3.2. 3.4. 3.4.1. 3.4.1. 3.4.2. 3.4.2. 3.4.2. 3.4.5.	Hardiman (2012), 8 Jensen (2003), 9 Ashbrook et al. (2020), 13 Zatorre et al. (2012), 13 Greenwood and Parent (2002), 14 Collins (2023), 14 Sterling and Laughlin (2015), 14 Willis (2010), 15 Mora (2021), 18	

General degree competencies:	Section in the TFG:	References-information sources	
		Primary sources	Secondary sources
	3.4.6.	Patrick and Mantzicopoulos (2015), 19	
	3.4.8.	Cibrian et al. (2021), 21	
	3.5.	Howard-Jones (2014), 21	
	3.5.	Torrijos-Muelas et al. (2021), 22	
	3.5.	James (1907), 22	
	3.5.	Mora (2021), 22	
	3.5.	Ansari (2008), 22	
	3.6.	Stickgold (2005), 24	
	3.6.	Kopasz et al. (2010), 24	
	3.6.	Masento et al. (2014), 24	
	3.6.	Gómez-Pinilla (2008), 24	
	3.6.	Mergenthaler et al. (2013), 24	
	3.6.	Fuster (2015), 24	
	3.6.	Keysers and Gazzola (2014), 25	
	3.6.	Cowan et al. (2006), 25	
	3.6.1.	Arguinchona (2019), 25	
	3.6.1.	Kayser et al. (2005), 25	
	3.6.1.	Siddiqui et al. (2008), 25	
	3.6.1.	Rossi et al. (2009), 25	
	3.6.1.	Curtis and D’Esposito (2003), 26	

General degree competencies:	Section in the TFG:	References-information sources	
		Primary sources	Secondary sources
	3.6.1. 3.6.2. 3.6.2. 3.6.2. 3.6.2. 3.6.2. 3.6.2. 3.6.2. 3.6.2. 3.6.2. 3.6.2.	Cowan (2014), 26 Thach et al. (1992), 26 Ito (2008), 26 Toussaint et al. (2021), 26 Zelano et al. (2016), 27 Nakamura (2023), 27 Suess et al. (1980), 27 Boiten (1998), 27 Posner and Rothbart (2009), 27 Timmermann et al. (1999), 27 Roggeri et al. (2008), 27	
CG2. To understand the processes of learning in children between 6 and 12 years old.	3.1. 3.3. 3.3. 3.3. 3.3. 3.4. 3.4. 3.4.	Blakemore and Frith (2005), 8 Diamond (2013), 10 Diamond (2020), 11 Cowan (2014), 11 Diamond (2013), 11 De Houwer et al.(2013), 11 Marler (1990), 11 Mora (2021), 12	

General degree competencies:	Section in the TFG:	References-information sources	
		Primary sources	Secondary sources
	3.4.	Pearce (2013), 12	
	3.4.	Lee et al. (2012), 12	
	3.4.	Atkinson and Shiffrin (1969), 12	
	3.4.	Sperling (1963), 12	
	3.4.	Baddeley (1992), 12	
	3.4.	Tulving (1972), 13	
	3.4.	Metcalfe (2017), 13	
	3.4.	Mora (2021), 13	
	3.4.1.	Washburne (1936), 14	
	3.4.1.	De Houvwer et al. (2013), 14	
	3.4.3.	Legault (2020), 16	
	3.4.4.	Fossati (2012), 16	
	3.4.4.	Li et al. (2020), 17	
	3.4.4.	Dolan (2002), 17	
	3.4.4.	Mora (2021), 17	
	3.4.5.	Mora (2021), 17	
	3.4.5.	Mora (2021), 18	
	3.4.6.	Sherrington (1951), 19	
	3.5.	Mueller (n.d.), 23	
	3.6.	Erickson et al. (2015), 24	

General degree competencies:	Section in the TFG:	References-information sources	
		Primary sources	Secondary sources
CG3. To know the foundations, principles and characteristics of Primary Education	3.6.2.	McDonald (2001), 26	
CG4. To design, plan and evaluate learning and teaching processes in the context of the school as an educational institution.	3.3. 3.4.6. 3.4.6. 3.4.8. 3.4.8. 3.6. 3.6.2. 3.6.3. 4. 4.	Davidson et al. (2006), 11 Mora (2021), 19 Pluck and Johnson (2011), 20 Mora (2021), 21 Livingstone et al. (2011), 21 Ortiz Alonso (2018), 24 Ortiz Alonso (2018), 26 Ortiz Alonso (2018), 28 Real Decreto 157/2022, 28 Decreto 61/2022, 28	
CG5. To analyze the importance of social factors and their influence on educational processes	3.4.6. 3.4.6. 3.4.7. 3.4.7.	Dewey (1910), 19 Chak (2010), 19 Gonulal and Loewen (2018), 20 Vygotsky and Coyle (1978), 20	

General degree competencies:	Section in the TFG:	References-information sources	
		Primary sources	Secondary sources
	3.4.7. 3.4.8. 3.4.8. 4.6.2. 3.6.3.	Wood et al. (1976), 20 Male and Burden (2014), 21 Süss (2013), 21 Pascoe et al. (2020), 26 Larsen et al. (1992), 28	
CG6. To know and apply techniques for the gathering of data through observation or other strategies in the processes of investigation, evaluation and innovation.	3.1. 3.1. 3.4.1. 3.4.2. 3.4.3. 3.5. 3.5. 3.5. 3.6. 3.6.2. 3.6.3.	Thomas et al. (2019), 8 Ylien and Kujala (2015), 9 Glannon (2014), 14 Willis (2010), 15 Borah (2021), 15 OECD (2002), 21 Centre for Educational Research and Innovation and OECD (2007), 22 Geake (2008), 22 Colicos et al. (2001), 25 Bazzano et al. (2018), 27 Ekman et al. (1990), 28	
CG7. To understand tutorial action and orientation in the	3.4.3.	Lowman (1990), 16	

General degree competencies:	Section in the TFG:	References-information sources	
		Primary sources	Secondary sources
frame of education, students and developmental contexts.	3.4.3	Pelletier and Rocchi (2016), 16	
CG8.1. To design didactical strategies appropriate to the nature of the specific field, starting from the Primary curriculum, for the area of natural sciences.	n.a.	This educational proposal is focused in other areas of the Primary Education curriculum.	
CG8.2. To design didactical strategies appropriate to the nature of the specific field, starting from the Primary curriculum, for the area of social sciences.	4.2.	Živković et al. (2017), 32	
CG8.3. To design didactical strategies appropriate to the nature of the specific field, starting from the Primary	4.3.	Cragg and Gilmore (2014), 38 Ayaz et al. (2012), 42 Herdiana et al. (2023), 42	

General degree competencies:	Section in the TFG:	References-information sources	
		Primary sources	Secondary sources
curriculum, for the area of mathematics.			
CG8.4. To design didactical strategies appropriate to the nature of the specific field, starting from the Primary curriculum, for the area of language and literature.	4.2.	Ellis and Brewster (2014), 31 Saied and Mehrabi (2013), 32 Flavell (2005), 32 Baker (2013), 32 Fooladvand et al. (2017), 32	
CG8.5. To design didactical strategies appropriate to the nature of the specific field, starting from the Primary curriculum, for the area of music.	4.4.	Loui and Guetta (2018), 41	
CG8.6. To design didactical strategies appropriate to the nature of the specific field, starting from the Primary curriculum, for the area of arts and crafts.	4.2.	Huotilainen et al. (2018), 32	

General degree competencies:	Section in the TFG:	References-information sources	
		Primary sources	Secondary sources
CG8.7. To design didactical strategies appropriate to the nature of the specific field, starting from the Primary curriculum, for the area of physical education.	4.4.	Rudd et al. (2019), 41	

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7. INDICES

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8. APPENDICES

Table 1: Key competencies

KEY COMPETENCIES
a) Competence in linguistic communication. b) Multilingual competence. c) Mathematical competence and competence in science, technology and engineering. d) Digital competence. e) Personal, social and learning to learn competence. f) Citizenship competence. g) Entrepreneurial competence. h) Competence in cultural awareness and expression.

Table 2: Most relevant key competencies

MOST RELEVANT KEY COMPETENCIES	
a) Competence in linguistic communication (Competencia en comunicación lingüística, CCL)	CCL1. Expresses facts, concepts, thoughts, opinions or feelings in oral, written, signed or multimodal form, with clarity and appropriateness to different everyday contexts of their personal, social and educational environment, and participates with respect in communication interactions, both to exchange information and create knowledge and to build personal bonds. CCL2. Understands, interprets, and values simple oral, written, signed, or multimodal texts from personal, social, and educational

	settings, with punctual accompaniment, to participate in everyday contexts to build knowledge. CCL3. Locates, selects and contrasts, with appropriate accompaniment, simple information from two or more sources, evaluating its reliability and usefulness according to the reading objectives, and integrates and transforms it into knowledge to communicate adopting a creative, critical and personal point of view. CCL4. Reads diverse works appropriate to their maturity development, selecting those that best suit their tastes and interests; recognizes literary heritage as a source of enjoyment and learning; and mobilizes their personal and reading experience to construct and share their interpretation of works and to create texts of literary intent from simple models. CCL5. Puts their communicative practices at the service of coexistence, the dialogic management of conflicts and the equal rights of all people, to favor an effective and non-discriminatory use of the different communication systems.
b) Multilingual competence (Competencia plurilingüe, CP)	CP1. Uses at least one language, in addition to his/her own language, if applicable, and Spanish, to respond to simple and predictable communicative needs, in a manner appropriate to his/her development and interests as well as to everyday

	situations and contexts in the personal, social, and educational spheres. CP2. From their experiences, recognize different languages and experiment with strategies that, in a guided manner, allow them to make simple transfers between different languages to communicate in everyday contexts and expand their language repertoire. CP3. Knows and respects the variety of languages present in their environment, recognizing and understanding their value as a factor of dialogue, to improve coexistence.
c) Mathematical competence and competence in science, technology and engineering (Competencia matemática y competencia en ciencia, tecnología e ingeniería, STEM)	STEM1. Uses, in a guided way, some inductive and deductive methods of mathematical reasoning in known situations, and selects and uses some strategies to solve problems reflecting on the solutions obtained. STEM2. Uses scientific thinking to understand and explain some of the phenomena that occur around them, using appropriate tools and instruments, asking questions and performing simple experiments in a guided way. STEM3. Performs, in a guided way, projects, designing, manufacturing and evaluating different prototypes or models, adapting to uncertainty, to generate a creative product with a specific objective, seeking the participation of the whole group.

	STEM4. Interprets and transmits the most relevant elements of some scientific, mathematical and technological methods and results in a clear and truthful way, using the appropriate scientific terminology, in different formats (drawings, diagrams, graphs, symbols...) and taking advantage of the digital culture in a critical and responsible way to share and build new knowledge. STEM5. Participates in scientifically based actions to promote health and preserve the environment and living beings.
e) Personal, social and learning to learn competence (Competencia personal, social y de aprender a aprender, CPSAA)	CPSAA1. Is aware of own emotions, ideas and personal behaviors and employs strategies to manage them in situations of tension or conflict, adapting to changes and harmonizing them to achieve their own goals. CPSAA2. Knows the most relevant risks and the main assets for health, adopts healthy lifestyles, and detects and seeks support in negative situations. CPSAA3. Recognizes and respects the emotions and experiences of others, participates actively in group work, assumes assigned individual responsibilities and employs strategies aimed at achieving shared objectives. CPSAA4. Recognizes the value of effort and personal dedication for the improvement of their learning and adopts critical postures in guided reflection processes.

	CPSAA5. Plans short-term objectives, uses autonomous learning strategies and participates in self-evaluation and joint evaluation processes, recognizing their limitations and knowing how to seek help in the process of knowledge construction.

Table 3: Content blocks and specific competencies extracted from the *Decreto 61/2022* for the English area

ENGLISH	
CONTENT BLOCKS	**SPECIFIC COMPETENCIES**
A. Communication B. Multilingualism C. Interculturality D. Syntactic-discursive contents	- Understand simple information using different strategies. - Produce simple texts both orally and written. - Participate in predictable citations using a range of strategies. - Interact with others in everyday situations. - Recognize and use personal linguistic repertoires to improve communication. - Appreciate and value diversity.

Table 4: content blocks and specific competencies extracted from the *Decreto 61/2022* for the mathematics area

MATHEMATICS	
CONTENT BLOCKS	**SPECIFIC COMPETENCIES**
A. Numbers and operations a. Counting b. Quantity c. Operations d. Relationships e. Financial education B. Measure a. Magnitudes b. Measurements c. Estimation and relationships C. Geometry a. Geometric figures in 2D and 3D b. Localization and representation systems c. Visualization, reasoning and geometric modeling D. Algebra a. Patterns b. Mathematical model c. Relationships and functions d. Computational thinking E. Statistics and probability a. Data organization and analysis F. Attitudes and learning a. beliefs, values and personal assessment b. Teamwork, inclusion, respect and diversity.	- Interpret everyday situations using mathematics. - Solve problems using different strategies. - Explore, formulate, and test simple conjectures. - Use computational thinking in everyday situations. - Recognize and use connections between mathematics and other areas of everyday life. - Communicate and represent mathematical procedures. - Develop personal skills to face mathematical challenges. - Develop social skills to respect others and foment personal and social growth.

Table 5: content blocks and specific competencies extracted from the *Decreto 61/2022* for the physical education area

PHYSICAL EDUCATION	
CONTENT BLOCKS	**SPECIFIC COMPETENCIES**
A. Active and healthy lifestyle. B. Organization and management of physical activity. C. Problem resolution in motor situations. D. Emotional regulation and interaction in motor situations. E. Manifestations of motor culture. F. Efficient and careful interaction with the environment.	- Adopt an adequate and healthy lifestyle. - Adapt personal physical abilities to everyday motor practices. - Develop regulation and interaction abilities to promote coexistence. - Recognize and practice different forms of physical activity in everyday life. - Value different natural and urban contexts for motor practice.