IMPLICATIONS OF THREE NEUROSCIENTIFIC THEORIES IN THE TEACHING-LEARNING PROCESS

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Abstract
Neuroscientific theories related to learning focus on understanding how the brain functions during the acquisition, processing, and storage of information. This article highlights three of the most relevant neuroscientific theories: the Triune Brain, the Whole Brain, and the Multiple Intelligences Theory, and their effects on learning. The aim of this article is to demonstrate the applicability of each theory in the learning of higher education students. Its content is the product of a qualitative study based on document review. To do this, we briefly present each theory, as the way in which they relate to each other, and at the end, we present the mental mapping as a strategy that can be implemented by this type of learners. Likewise, throughout the document, it gives importance to the mediating role of the teacher in this level of education.
Keywords*. Neuroscientific theories, learning, education, teaching strategy, mind mapping.*

INTRODUCTION

In the fascinating and complex world of learning, various studies have been conducted, particularly focusing on the learner, who is immediately responsible for this process. However, this article highlights the role of the teacher, who also plays a crucial role in knowledge management as a tutor or guide (Kaur, 2019). It represents the intangible capital of intellectual capital, specifically managerial or entrepreneurial capital, as they are the figure that directly or indirectly guides the teaching-learning process in the classroom (Murkatik, Harapan, and Wardiah, 2020). This is done through clear strategies based on their knowledge, experience, and resource utilization, as well as leveraging what their students possess, keeping human, structural, and relational capital cohesive in any project. (Van Dijk et al, 2020).

Every individual experience their own life, learns in different ways, and shares their knowledge in various forms, and all this information forms the basis of meaningful learning. In the case of university, it is crucial to initially understand that students are young adults and as such, they are motivated to learn as they experience interest and fulfill learning needs. Guidance for them is centered on the application of knowledge to life problems. Their own experience or prior knowledge is the main source of learning (Main, 2021).

Consistent with this vision of learning, it is necessary to consider the strategies a teacher should employ to inquire about the information that their students bring (Dubinsky et al, 2019). Even understanding the functioning of their brains, since this knowledge from neuroscience becomes a very useful tool that allows, among other advantages: combating each stress factor in students, taking practical measures to make the classroom environment more efficient in terms of learning, and maintaining a high level of interest in students.

This review will present three neuroscientific theories: the Triune Brain, the Whole Brain, and Multiple Intelligences, explaining what each one is about, how they can be applied in higher education students' learning, and emphasizing the teacher's role as a mediator.

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Brain and Learning

The human brain, although anatomically very similar in most cases, it is uniquely particular. From this, we can deduce that teachers in their classrooms face educational situations with a diversity of students, which manifests in different attitudes, behaviors, rhythms, and learning styles. Sabando, Moya y Meza (2019) emphasize the significance of the brain in both learning and teaching processes, drawing insights from various scientific disciplines to underscore the importance and evolution of knowledge.

In this scenario, the so-called neurosciences emerge, which are interested in the study of the chemical, pharmacological, and pathological aspects of the nervous system, particularly the brain. Neuroscience is defined as the scientific study of the structure and cognitive functions of the brain regarding processing data, making decisions, and interacting with the environment (Fan et al., 2020). It combines different disciplines, such as physiology, anatomy, molecular biology, cytology, psychology, physics, computer science, chemistry, medicine, statistics, mathematical modeling, etc. (Samanci et al., 2022). In recent decades have been gaining momentum in the field of education.

Among the theories forged from neurosciences for a better study of the human brain are the Triune Brain, the Whole Brain, and Multiple Intelligences, which are described below.

The Triune Brain

Firstly, the theory of the Triune Brain, proposed by MacLean, suggests that the human brain is composed of three brains in one: the reptilian brain (basic brain), the limbic system (middle brain), and the neocortex (cerebral cortex). Each of them performs different functions that ultimately are responsible for human behavior (Persaud, 2021; Navarro & Marijuán, 2022).

The reptilian brain, the most basic of them, is formed by the basal ganglia, the brain stem, and the reticular system. It is responsible for automatic or programmed behavior, such as species preservation and the necessary physiological changes for survival (Ardila, 2007). One of its functions is self-regulating the organism, so this brain cannot think or feel; its function is to act when the state of the organism demands it.

In the reptilian brain, primary, non-verbal experiences of acceptance or rejection are processed. Here, functions related to doing and acting are organized and processed, including routines, habits, territoriality, personal space, conditioning, addictions, rituals, rhythms, imitations, inhibitions, and security. In summary, this brain is characterized by action (Ardila, 2007).

On the other hand, the middle brain or limbic system is located physically above the reptilian brain and is made up of six structures: the thalamus (pleasure-pain), the amygdala (nutrition, oral activity, protection, hostility), the hypothalamus (care for others, mammalian characteristics), the olfactory bulbs, the septal area (sexuality), and the hippocampus (long-term memory). The limbic system is associated with the ability to feel and desire. In these areas are the most important endocrine glands for humans: pineal and pituitary (Cai, 2018).

Finally, the third brain consists of the neocortex, which is where the two hemispheres that develop higher intellectual processes are located: the left hemisphere and the right hemisphere of the brain. Seijo and Barrios (2012) tell us that the left hemisphere is the seat of rational intelligence, it is sequential, linear, step-by-step, allowing reasoning and relating thoughts sequentially and logically". And about the right hemisphere, they affirm that it is the associative, creative, and intuitive intelligence; it is holistic, free to express feelings, relating more to the world of sensations and emotions than with verbally logical codes.

Understanding this conceptualization of brain function has significant implications for education, as it can serve as a theoretical basis for a more appropriate interpretation of the interactive process occurring in the classroom and for developing an integrated instruction system that considers the different areas of the brain.

The Whole Brain

Secondly, there is the Whole Brain Theory attributed to Herrmann (1989), who conceives the brain as divided into four areas or quadrants, each with its functions, but interacting with each other to

generate, throughout the human brain, a comprehensive and operational action of neural masses (Shin, Lee & Bong, 2022).

The Whole Brain model results from the integration of the hemispheric specialization theory and McLean's Triune Brain theory. In addition to the left and right halves represented by the hemispheres, there would be the upper (cerebral) and lower (limbic) halves, giving rise to four parts or quadrants, all directly or indirectly connected by the corpus callosum and other commissures (Maniglia, & Seitz, 2018). The quadrants, called A, B, C, and D, correspond to four specific, distinct, and independent modes of differential information processing, detected especially by the cluster method and with empirical support from a multitude of rigorously processed data (Gardié, 1998).

This model has great influence in academic settings for its holistic and creative vision of education. Thus, "creativity, intelligence, learning, decision-making, and problem-solving require the concerted action of the entire brain: no style, ability, or strategy is privileged to the detriment of others" (Gardié, 1998). Having this knowledge is very helpful for teachers, as it allows stimulating learning in an integral way in their students.

Theory of Multiple Intelligences

Thirdly, there is the Theory of Multiple Intelligences, proposed by Howard Gardner in 1983. This theory reinforces the idea that there are different ways in which people learn, represent, process information, and understand the world around us. These global learning tendencies of the individual are not fixed and immutable but are in continuous evolution. Gardner redefines intelligence as a multidimensional capacity; that is, knowledge can be acquired through different means; moreover, this perspective associates the concept with a skill that can be developed, without ignoring genetic and cultural influences (Morgan, 2021).

Gardner (1991) states that cognitive research shows that students have different abilities to learn, remember, act, and understand. Until 1997, these abilities were divided into seven types. Today, Gardner asserts that there are at least eight intelligences or capacities and that, although they are genetically determined, they can be developed and improved through practice and learning.

The following table summarizes the eight intelligences Gardner speaks of:

Table 1 The eight intelligences proposed by Howard Gardner

Intelligence	Description
Linguistic (or Verbal-Linguistic)	Skills to use oral and written language with great clarity and sensitivity, as well as to respond to it.
Logical-Mathematical	Skills for complex reasoning, cause-effect relationships, abstraction, and problem-solving.
Visual-Spatial	Skills to perceive the world and create mental images from visual experience.
Motor (or Kinesthetic)	Skills to use the body to learn and to express ideas and feelings. This includes mastery of physical skills such as gross and fine coordination, balance, strength, flexibility, and speed.
Musical (or Rhythmic)	Skills to know how to use and respond to different musical elements (rhythm, timbre, and tone).
Intrapersonal (or Individual)	Skills to understand oneself and use this knowledge to operate effectively in life.
Interpersonal (or Social)	Skills to interact with and understand people and their relationships.
Naturalist	Skills for scientific thinking, to observe nature, identify patterns, and use it productively.

Note. The information in this table is adapted from Morgan, 2021

From all the above, we can infer that the theory of multiple intelligences has a great influence on education due to the vast number of possibilities it opens to the creativity of both teachers and their students. Knowing the model is very useful for those who are protagonists in the teaching and learning processes.

The theory of multiple intelligences can be most accurately described as a philosophy of education, an attitude towards learning, or even as an educational meta-model in the spirit of John Dewey's ideas about progressive education. It is not a program of fixed techniques and strategies. Thus, it offers educators a very broad opportunity to creatively adapt its fundamental principles to any number of educational contexts (Morgan, 2021).

These three theories are not mutually exclusive; rather, they are complementary. Velásquez, Calle, and Remolina (2006) opine that "educational experience has shown that it is necessary to use the whole brain; for this, teachers must employ learning techniques and strategies that connect the two hemispheres of the brain, to optimize the search for and construction of knowledge" (p. 28).

All these theories converge in the development of the cognitive, ethical, and affective aspects, and this task largely rests with the teacher who is responsible for educational change, which must be accompanied by reflection, research, and a permanent update of knowledge and evaluation, without forgetting the context and recognizing the influence of other disciplines in the dialogue that will improve their practice (Collante, 2013a).

This implies that the teacher must know their learners to maximize their talents (Collante, 2013b).

The Mediating Role of the Teacher

In the university context, it is important to remember that teachers at this level interact with young adults and adults, and therefore, their approach should be andragogical. Hence, it is crucial to emphasize that their role is a mediator, and their activities should revolve around andragogy strategies. This is because,

The andragogical approach is a method of teaching adults. Through the andragogy approach, learners do not feel lectured but are given the freedom to explore their learning needs so that they become more independent, active, and motivated to learn. (Novita & Hiryanto, 2023, p. 335).

Therefore, the professor must be conscious in the application of strategies, which can be designed and applied based on the scientific theories described above and which help them become a comprehensive teacher, effectively committed to their significant educational role, with a visible social sensitivity, to not lose their impact on the students' learning process (Perozo, 2012).

Among the essential strategies that can be used are pre-instructional strategies understood as "those that generally prepare and alert the student regarding what and how they are going to learn, that is, they produce the activation and relevant prior experiences, and allow them to place themselves in the learning context" (Perozo, 2012, p. 77). In this sense, questioning is a good alternative for the teacher to extract and revisit the information that allows students to understand, assimilate, and interpret new information.

Teaching-learning strategies are essential in developing competencies for learning (Main, 2022). Thus, the teacher must employ efficient didactic strategies to address the shortcomings found in their students. The first step is to determine the difficulty the learners present and make them aware of their failings so they can move forward.

In this regard, "Effective classroom management practices and pedagogical teacher skills are fundamental in ensuring disruptive behaviors do not adversely affect classroom learning" (Franklin & Harrington, 2019, p. 8) since the effectiveness of the learning process depends on them.

In the construction of knowledge in the classroom, where the elaboration of meaning and the attribution of sense to learning take place, the mediation by the teacher or a peer with advantages in the students' activities, involving both their cognitive level and various emotional aspects such as interests, motivations, attitudes, and expectations prior to learning, is indispensable; that is, as Ausubel and Novak say, for the student to learn meaningfully, they must construct new knowledge based on their mental structure that integrates knowledge and feelings.

Learning seen from this perspective reveals that it is a social event supported by Vygotsky's sociocultural theory, which postulates that a person's development depends on social interaction and support. In this regard, Collante (2006) opines that when students employ not only cognitive strategies but also social and affective ones in learning activities such as collaboration, co-construction, and scaffolding, i.e., guided, distributed, and joint participation, it contributes to the creation of a new or richer understanding of the tasks and is what Bruner considers the foundations of true constructivist learning.

This directs attention to collaborative learning, which is based on sociocultural theory where learners interact as peers in constructing knowledge. Many educational experiences have been conducted around this form of learning; however, there are still some reasons why many teachers fear working in groups or teams because they see it as a loss of classroom control and because it promotes the dispersion of students' attention and even claim that some students do not like to work in groups. Although this last point may be somewhat true, if viewed from the perspective of learning styles theory, it should not be an excuse to combine strategies in the teaching-learning process.

In this sense, teachers must face the challenges of today's education where their role is that of a cognitive mediator and instructional designer. The teacher as a cognitive mediator should not influence the student's learning by telling them what to do or how to think, but rather should do it in such a way that it leads them to the main axis of thought (Dai, 2022). The teacher must create the initial conditions for the work once the objectives, contents, competencies, in short, what, how, and what to evaluate and how to evaluate, have been determined.

In sum, the university professor must know how to plan, guide, and evaluate their work, keeping in mind the characteristics of their students, who are adult learners and as such have different needs from children, thus shifting their role from facilitator to mediator.

METHOD

A qualitative methodology based on document review was employed to study the pedagogical implications of neuroscientific theories through the analysis of relevant documents. This allowed for a deep and contextual understanding of how neuroscientific theories have been interpreted and applied in the educational field, specifically in our case, in higher education. Snyder (2019) says that literature reviews are important in underpinning various research endeavors. They form the bedrock for knowledge advancement, offer frameworks for policy and practical applications, furnish evidence of impact, and, when conducted effectively, can stimulate fresh ideas and avenues for a specific domain.

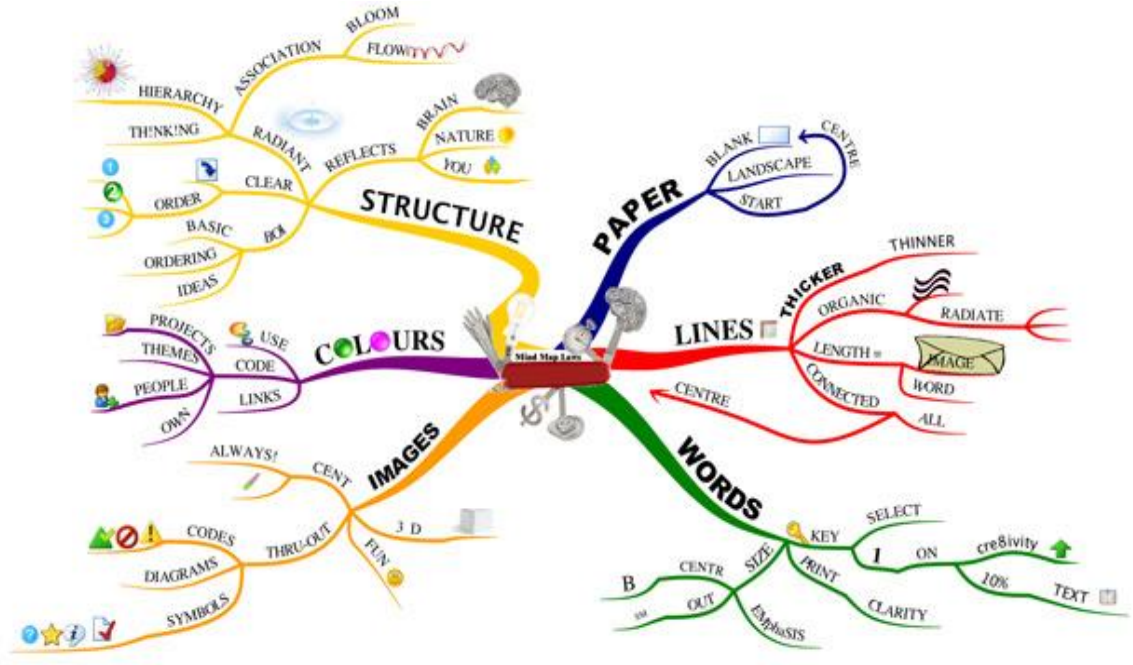
Results

After the documentary review of the three neuroscientific theories applied to teaching and learning, the result was that it is possible to implement pedagogical strategies based on the triune brain model, the whole brain theory and educational interventions informed by the theory of multiple intelligences as an integration of Neuroscience in Education. It improves personalized learning, increase the motivation and commitment of students, but this responsibility must be assumed both by learners and teachers. Teachers must begin with training in neuroscience to achieve pedagogical innovations using technology and various digital tools to apply neuroscientific knowledge in the classroom, as well as the promotion of teaching strategies that contribute brain plasticity and meaningful learning, which for this study has been found to be mind mapping as an ideal strategy for this purpose.

Mind Maps: a strategy that involves neuroscientific theories to facilitate learning.

A good strategy that combines brain development is Buzan’s mind mapping, as its application does not restrict mental operations to express and associate ideas. It uses color, shapes, images, and not just words as Novak and Gowin’s concept map does. Being freer allows more options to create, to construct meanings.

Figura 1
Mind mapping



Taken from: http://www.tonybuzan.com/about/mind-mapping/

Buzan, the inventor of this resource, defines it as follows:
A mind map is a powerful graphic technique that provides a universal key to unlocking the potential of the brain. It harnesses the full range of cortical skills – word, image, number, logic, rhythm, color, and spatial awareness – in a single, unique, and powerful manner. By doing so, it gives you the freedom to roam the infinite expanses of your brain. The mind map can be applied to all aspects of life where improved learning and clearer thinking will enhance human performance (Buzan, n.d., online).
This technique can be applied in collaborative contexts where all participants contribute and feel comfortable with the task. Thus, those inclined towards drawing, color, and shape will express their ideas without difficulty, just as those who are not as creative and are more logical and use words to express themselves will. In this way, the mind map becomes an efficient strategy to facilitate learning by combining the various neuroscientific theories discussed in this document.

DISCUSSION

More and more, teachers have access to information and tools that allow them to better develop their role as educators and trainers. This is due to the advances from medicine, psychology, sociology, pedagogy, and many other sciences that are constantly evolving, delving into the details of their respective objects of study that directly influence global education.
Neuroscientific theories show us, from the study of the brain, various perspectives that allow us to better understand some aspects related to learning processes.
For a teacher, it is very useful to know the models of the triune brain, the whole brain, and multiple intelligences, as this will facilitate the design of activities and strategies that correspond to the needs and particular styles of their students.
The challenge is to explore their creativity and responsibly and didactically use all the resources at their disposal to perform their job better. They can start with some strategies that have proven to be very efficient and effective, such as using questioning as a pedagogical resource and creating mind maps through which the student can unleash their creativity while acquiring or constructing knowledge meaningfully.

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