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Executive functions in the learning of university students

Funciones ejecutivas en el aprendizaje de estudiantes universitarios

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Abstract

The article addresses the topic of executive functions and learning in university students. It is considered relevant at the present time, due to the diverse affectations that are perceived in the academic performance after the pandemic; problems to regulate their learning, the little capacity to look for relevant information and difficulties to abstract significant aspects of the data of interest are more and more evident. From here, the relevance of better understanding the role of executive functions in learning is raised, for which, we start presenting several definitions that coincide in characterizing them as those that regulate, control, mediate the higher and more complex activities performed by the brain; they are located in the frontal cortex and have different rates of development throughout the life cycle, from childhood to young adulthood when they reach their full development. In addition to this, the components of executive functions are described, since they vary depending on the authors and their relationship with learning. The approach is eminently neuropsychological, but there is a brief dialogue with the philosophy of Heidegger, Hume, and Locke. It concludes with several suggestions of possible activities that can be carried out to develop these functions in students.

Keywords

Cognition, learning, university student, comprehension, knowledge, educational strategies.

Resumen

El artículo aborda el tema de las funciones ejecutivas (FE) y el aprendizaje en estudiantes universitarios. Se considera relevante en el momento actual, debido a las diversas afectaciones que se perciben en el rendimiento académico luego de la pandemia, siendo cada vez más evidentes los problemas para regular el aprendizaje, la poca capacidad para buscar información relevante y las dificultades para abstraer aspectos significativos de los datos de interés. Desde aquí se plantea la relevancia de comprender mejor el papel de las FE en el aprendizaje, para lo cual, se inicia con varias definiciones que coinciden en caracterizarlas como aquellas que regulan, controlan y mediatizan las actividades superiores y más complejas que realiza el cerebro; se las ubica en el córtex frontal y tienen diversas tasas de desarrollo a lo largo del ciclo vital, desde la infancia hasta la adultez joven, en la que alcanzan su pleno desarrollo. Agregado a esto, se describen los componentes de las FE, puesto que son variados dependiendo de los autores y su relación con el aprendizaje. El enfoque es eminentemente neuropsicológico, pero se realiza un breve diálogo con la filosofía de Heidegger, Hume y Locke. Se concluye con varias sugerencias de posibles actividades que pueden llevarse a cabo para desarrollar estas funciones en los estudiantes.

Palabras clave

Cognición, aprendizaje, estudiante universitario, comprensión, conocimiento, estrategias educativas.

Introduction

This article discusses the topic of learning and the role of executive functions (EF) have to achieve it, particularly in university students. This implies considering biological and psychic aspects in the training process and its relationship with the teaching task.

Based on these ideas, it is established as a primary objective to consider the relationship between learning in university students with cognitive functioning, focusing especially on what is called EF. When EFs are well developed, students tend to experience more effective learning and

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better academic performance. Difficulties in EF can negatively affect a student's ability to face academic demands. It is important to note that the relationship between EF and learning is two-way: a stimulating and challenging educational environment can also influence the development and improvement of students' EF.

In recent years, particularly after the pandemic, endless situations have been observed that have affected the very essence of the human being confronted with death; thus, there are several reasons to ask about the very meaning of existence and everything that involves living and learning in a different way (Ortega, 2021). From education, it has been perceived that students have suffered a cognitive and emotional impact. Regarding the first level, there is more difficulty among university students to select important aspects in the accumulation of information they have, often limiting themselves to just repeating what they find *without processing* the data; there is no detailed analysis of the information received from the different sources, thus revealing an impairment of the control and monitoring functions, which are the basis of adequate cognitive performance. For the second level, no detailed analysis will be done, since this work will focus on cognitive functions.

It is significant to rethink learning considering the biological and psychic aspects that are at the base of more complex mental processes. The teacher as a relevant educational agent when teaching in any field -particularly from the university- must take these elements into account when planning so that learning is possible, moving away from a practice in which teaching is only interested to realize the multiple determinants that intervene in the process and that come both from students in their condition of biological, psychic, social and historical beings, as the teachers, the institution and the society in which the process occurs.

Understanding the neuropsychological aspects can contribute to improve the ability of students to learn, i.e., to assimilate the information they receive, process it in their mind and use it in an appropriate way to find alternatives to the problems they face, both personally and professionally.

This challenge is relevant at all educational levels, whether with children or adolescents, and is more relevant with adults-young, since they are training for future professional performance, acquiring the skills and abilities necessary to carry out actions linked to their career, in which they will require skills specific to their future work and personal that help them to develop in an increasingly complex environment (Morin, 1999). This is a necessary aspect, due to the necessary integration that the disciplines must have in order to face the challenges of modern society (Varona, 2020).

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In this way, it is essential that a teacher takes into account these particular conditions of the students to then rethink and propose the contents to be addressed, so that it can better reach the student and facilitate a meaningful learning process (Palacios and Guisado, 2016).

The topic is current and new due to the impact that, at this moment, neuroscience provides, both in the educational context and in others, in which it is helpful to understand the cognitive processes settled in the brain.

This article has been prepared following a methodology based on the qualitative approach, systematic review type, for which the literature review was used as a technique. As for the instruments, due to their marked nature, bibliographic managers were used to collect the information, which was then organized, analyzed and interpreted, taking into account the essential aspects of the topic. Then, it was contrasted and expanded with the positions and approaches of authors who have been interested in similar topics. The procedure used was the collection of information, its organization, the selection of relevant data and its composition in an appropriate text.

The topic of EF is approached for conducting this work, considering some definitions, its components as well as the changes it undergoes throughout the life cycle. In this way, EF is characterized, and some models are considered to better understand them. Finally, some considerations about learning are raised.

The executive functions

Since its origin, humanity has been interested in understanding both the world around it and what happens inside it, especially in the brain, so there has always been great interest in certain cognitive functions such as thought, language, intelligence or learning, which have had a characteristic space in the approaches of all philosophers throughout the centuries (Rábano, 2018).

According to Ramos and Lozada (2015), one of the most interesting and widely developed fields in the cognitive field is the interest to understand the way in which a human being is able to regulate and control his behavior and face everyday situations. All this is linked to a group of functions that have been called "executive", i.e., they are related to the realization-execution and monitoring or control of actions and activities. Functions such as verbal fluency, working memory, planning, organization, inhibition, flexibility and impulse control are essential for

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the cognitive performance of people and even more so of university students, since they help to organize information in such a way that there is a coordinated and coherent response of what exists in the mind with what happens in the context of development.

For a better understanding of these functions, an interdisciplinary approach to the neuropsychological aspects involved in cognitive processes is required, as a result of the interaction between the biological base — the person's own— and the social environment in which it develops (Sastre, 2006), so it is necessary to make some definitions.

The term "executive functions" was originally used by Muriel Lezak in his article "The Problem of Assessing Executive Functions", published in 1982 in the *International Journal of Psychology*. Here they are defined as "the mental abilities essential to conduct effective, creative and socially accepted conduct" (p. 90). It amended its definition in 1995 (Lezak, 1995), considering them as "abilities that enable a person to function independently, for a particular purpose, with self-sufficient behavior and satisfactorily" (p. 38). Apparently, functions such as planning, organization, inhibition, flexibility and impulse control are intimately related to what is considered specifically human and that define actions and reactions of each individual in the environment in which he or she operates.

According to Sastre (2006), there is no single definition of EFs, so we will mention some of the most interesting, such as the one that points out that they group a series of "central self-regulatory skills that orchestrate basic processes or specific domain in order to achieve a goal flexibly [39], and that relate to the activity of cortical and subcortical regions that collaborate with the prefrontal cortex" (p. 144). These EFs are essential to the learning process, as they enable students to organize information, set goals, adapt to new circumstances, and regulate their behavior efficiently. Students who have a good functioning of these EFs tend to face academic demands more effectively and have a stronger performance in their studies.

Authors such as Barroso and León (2002) consider the EFs as those abilities that, jointly present in the human brain, can transform thought into actions, thanks to which each human being functions organized, flexible and effectively. The consequence of this operation is the adaptation to the conditions that are presented to each individual. It is a superordered system, in other words, made up of several elements to which it regulates, controls, supervises, directs and evaluates, while performing its functions, so that the human being can carry out a behavior or inhibit it if necessary.

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From another definition, they are characterized as "processes that associate ideas, movements and actions and guide them to problem solving" (Tirapu Ustárroz *et al.*, 2012, p. 90). In a way, it could be said that they are metaschemas, i.e., designs that orient the way in which the representations that each person has will unfold. Considering this definition, the authors extend their proposal conceiving EFs as:

> A set of skills that are involved in the generation, supervision, regulation, execution and readjustment of appropriate behaviors to achieve complex objectives, especially those that are considered by the individual as novel and require a creative solution (p. 91).

This definition is shared by other authors such as Verdejo and Bechara (2010), who emphasize the importance of these functions to manage and modulate the complex activities performed by an organism, linking information coming from the internal environment and assimilating it from the outside to give coherent and adequate answers to the difficulties of daily life, i.e., the EFs facilitate the adaptation of the human being to his context.

For university students, these skills are essential, as they must adapt to a number of new circumstances in a different environment, and they often do not always have adequate planning to respond to increasingly complex and demanding tasks. All these aspects can generate conflicts and problems for which some of the students must formulate creative responses, since there is no established guide or guidance. At university, many young people face known situations such as doing homework or studying for a test, but there are others that involve developing EF-related skills, such as monitoring their learning process or realizing the ways in which they best acquire information. Also, some tasks require little cognitive effort, such as making a mental map of known information, but others may be more demanding, such as solving a problem involving a task force and the teacher who sent it. These levels of complexity require learning other skills, which are linked to the EF, so that the student can adapt better in the university environment.

The role of the EF is essential in university students to manage the multiple stimuli from different sources, so it is possible to detail what are its components.

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Components of executive functions

According to the proposed definitions, it is possible to establish that there is no single classification of EFs, since, depending on the authors, they include several elements. However, there is consensus in pointing out that "the executive system" is constituted by related blocks, as expressed by Batista Núñez (2012) and Flores and Ostrosky-Shejet (2012), who point out that there are two: the first initiates, anticipates, plans and sets goals, monitoring the issued behaviors and making a forecast of the consequences they may have; while in the second block there are the capacities that modulate, activate or inhibit cognitive abilities.

Other authors such as Barroso and León (2002) consider that the executive functioning has four essential components and that they manifest themselves in the form of a process that goes from the approach of goals, the necessary planning to achieve them, the development of appropriate actions and their execution. Each of these components has distinct and specific objectives:

Table 1
Components and objectives of executive functions

Component	Objective
Formulation of goals	Identify needs and resources. Generate and select states that the person aspires for the future.
Planning	Select the steps required to achieve a goal. Anticipate possible changes and propose alternatives. Discussion of possible alternatives. Anticipate consequences of decisions.
Development or implementation of plans	Start, hold, stop, or switch between planned actions.
Execution	Monitor and correct activities. Regulate the intensity and timing of the action. Assess whether the objectives have been met and the expected results achieved. Choose the appropriate time to implement actions.

Source: own production from Barroso and León (2002, p. 30).

As mentioned, these skills are essential when controlling, supervising and regulating the cognitive and emotional activity of a subject so

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they have aroused great interest to know their role in learning, both in children, adolescents and adults. Therefore, it can be stated that there is extensive research in the area (Portellano and García, 2014; Ramos Galarza *et al*., 2018; Ramos Galarza and Pérez Salas, 2017). All these investigations show that EFs are not the same throughout the life cycle, so it is interesting to know the changes that appear over the years.

Executive Functions During the Life Cycle

The EF experience variations throughout the life cycle of the individual, since according to Lozano and Ostrosky (2011), its greatest development occurs in childhood and adolescence, essentially, thanks to the maturation of the prefrontal cortex, and cortical area in which they are distributed, and they manifest and specialize in young adulthood when its maximum potential has been reached (if the conditions have existed) (Papalia *et al*., 2010). It is worth mentioning that childhood and what happens in it is crucial to lay the foundations for a good development of the EFs. In this regard, Sastre (2006) says:

> Changes occur in the structure and functioning of the frontal lobe and in the prefrontal cortex [...]. These structural and functional changes of the brain are related to relevant gains in the first cognitive competences, in executive functions [15-17] and in the logical organization of action and knowledge [18,19] (p. 144).

Thus, cognitive development and subsequent performance in the formative years are the result of the more or less coherent conjugation of the information assimilated by the child (Piaget, 2007) with the maturity and action of EFs and the influence of social interaction (Sastre, 2006).

It should be noted that the development and maturation of the prefrontal cortex is related to social interaction. It is imperative to note that some years ago we know the impact that this has on the brain, for example, cortisol (the stress hormone) leaves a great imprint on cognitive structures (Olza, 2008). Likewise, it is known the profound influence that the characteristics of the people around them have on the child and their ways of reacting to their needs, determining, in many cases, their current and future social and relational development.

The age of 6 to 8 years is crucial in the cognitive development of children, because the capacities involved in executive functioning are activated (Barroso and León, 2002). This activation of new cognitive functions arises due to the neurobiological development achieved, as the

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father and mother decrease the control they have over the activities of children, so they become more autonomous to carry out their learning activities and, consequently, require better control of their performance.

Skills such as inhibition, working memory, cognitive flexibility, motor control, planning and organization are gradually being improved, as children's physical growth occurs and their involvement is increasing in learning activities. Between the ages of 6 and 12, boys and girls are learning the bases of knowledge they will need for their future training, both at the middle and university levels. This shows that it is the stage in which the foundations for good cognitive performance are consolidated (Linares, 2007).

In this development, the stage of adolescence is also relevant because it allows the total maturation of the prefrontal cortex when confronting the subject to all the changes that occur in the physical, psychic and social areas and that require a profound modification of their being and identity (Erikson, 1985). Thus, adolescence is a crucial stage in which a series of changes are taking place at the physical level — with the appearance of secondary sexual characteristics — at the psychic level — with the development of an identity of its own — and at the social level — with adequate interpersonal performance. In this development is crucial the role of the prefrontal cortex that becomes the area par excellence that allows the control and regulation of the behavior of the adolescent.

The prefrontal cortex "acts as a conductor, and in it are found the functions of the human being that most differentiate him from other living beings and that best reflect his specificity" (Tirapu Ustárroz *et al.*, 2012, p. 90). It is a cluster of neurons that harbor those higher and much more complex and advanced functions that human beings possess.

Locke (1994) and Hume (1984, 1994) have provided clear and concise positions about these ideas. Locke (1994) stated—long ago—that ideas come from two sources: *sensation* and *reflection*, and that their accumulation generates knowledge. Ideas that come directly from sensory experience have to do with the characteristics of objects, such as size, weight, shape, color and so on; this is called *simple ideas*. The *complex ideas* are based on reflection and refer to three levels:

- The *modes* that are combinations of simple ideas that do not contain the existence of things in themselves, like the ideas of numbers, triangles or melodies.
- The *substances* that are combinations of simple ideas that represent the existence of particular and concrete things, like the ideas of a car, a door or a flower.

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- Relationships are combinations of ideas that express the connections between various ideas, such as ideas of causation, kinship, or friendship.

On the other hand, Hume (1981, 1994) proposes that the origin of ideas is found in impressions, on the one hand, that coincide with the sensations of Locke (1994) and the ideas themselves that arise from "weak images of impressions, when we think and reason" (p. 87) that coincide with the reflection proposed by Locke (1994). In addition, Locke (1994) points out that for ideas to appear in the mind of a human being, the first step is perception and then memory, which he considers the "store of ideas" (p. 129), adding that ideas are fixed in the mind thanks to other processes such as attention and the subsequent repetition of the idea; just like other sensations (*i. e.* pleasure and pain). The author mentions other aspects, such as discernment and abstraction, that favor the construction of ideas and help distinguish them from each other, and although Locke (1994) has not defined them as EFs, because of the regulatory or control role they have, they could well be understood as such.

According to Rosales Sánchez (2019), "for Hume, sensations, understood as impressions, produce simple ideas. Then the mind makes combinations with different simple ideas that produce complex ideas" (p. 134). It is a cumulative process, on the one hand, and hierarchical on the other, since the ideas built are grouped into segments, each time larger, of information that allow the organization of increasingly complex information.

This process completes in childhood with the ability to prioritize information, which is the necessary basis to organize the various aspects that children will have to learn throughout their training process. This will be a necessary condition to understand what is learned throughout life, from the multiple ways of doing it. As seen, here are the foundations of the learning regulation so necessary for good cognitive performance, and then activated in students at the university level.

It can be said that sensations are part of the defining entity of the human, i.e., they are a constitutive part of the essence of humanity. It implies recognizing the centrality of sensory experience in the construction of reality and human self-understanding. The human cannot be conceived outside of what he perceives not only with his senses, but with his *intellect*, the main faculty that differentiates him from other beings. Likewise, as far as perception is concerned, Bello (1881) states that:

> It is, in general, an act in which the soul acquires knowledge of a particular quality or state of an object, by virtue of a certain action that the object currently exercises in it. We do not try to define perception, but

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> only to point it out or to manifest the circumstances in which this faculty is realized (p. 16).

Perception is a basic cognitive process on which all the possibility of assimilating information and converting it into useful data for the cognitive performance of a person is based. Children perceive certain aspects of the world around them based on their cognitive development. This suggests that the way children interpret and understand the environment is influenced by their level of mental and cognitive development at that specific point in their lives. This idea highlights the close relationship between cognitive development and the perception of the world in childhood. Adolescents in turn modify this perception because they have developed the hypothetical-deductive thinking capacity that empowers them to assimilate what they perceive, but then to order it, question it and use it for their best performance. As adolescents acquire this cognitive ability, they are able to process and assimilate perceived information in more complex and abstract ways. In college students, these skills are further enhanced because of the environment in which they find themselves and which empowers them to the limit, their learning and the resources they have to regulate.

According to Oliveira and Mourão (2013), there are two main currents of thought about these psychic sensation and perception processes: rationalism and empiricism.

> Rationalists base their knowledge entirely on reason, which is why they attribute great value to mathematics as an instrument for understanding reality. The human mind is, in rationalism, the only instrument capable of reaching the truth (p. 42).

The origin of ideas and, deductively, the relationship between them can be deduced from the position of these great philosophers thanks to the EFs that, as previously pointed out, do not always develop at the same time (Flores Lázaro *et al*., 2014). Some of the EFs appear very early as is the case of the detection of risk situations that are already present in childhood; other processes such as inhibitory control appear early as is middle childhood; while functions such as working memory or mental flexibility and even planning appear later; while verbal fluency and abstraction appear late.

In a study carried out in Medellín (Castañeda *et al*., 2022), it was concluded that the level of schooling has a great impact on the progress of certain EFs, especially those of regulation, working memory, verbal fluency and information processing, among others. These results allow us to conclude that the educational process has a great influence on the development and maturity of the different EF.

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Other studies have focused on the mediating role of EFs in memory problems (Molina 2018), finding that these and stress explained 57 % of subjective complaints regarding memory. The EFs most involved in this mediating role are executive control, attention, and regulation of social behavior.

Another research (Gutiérrez Ruiz *et al*., 2020) highlights that some EFs can better predict student performance at the university level, such as working memory, verbal fluency, cognitive flexibility and categorization. Out of these three functions, it seems memory has the greatest impact in university years, since it involves essential tasks for academic achievement and the fulfillment of goals: following instructions, sustaining attention, controlling the quality of the tasks performed and generating solutions to problems that are essential when performing academically.

Although cognitive flexibility and abstraction are linked to academic achievement, however, they are not as important as working memory. These two functions have to do with the assimilation of new concepts and the construction of different abstractions as answers to new information so they are necessary to order the information that students receive in academic training but their use will be much more enhanced in professional performance. Academic performance is more closely linked to information retention operations and their use in managing day-to-day student activities. The connection between academic performance, information retention and its application in the management of daily activities highlights the importance of not only memorizing data, but also understanding and using information in a meaningful way. Memory and the practical application of information play a central role in student performance.

As seen, there is a clear association between individual development and the use of EFs by students. Each life cycle has different demands and requirements, so it is logical that some functions should be developed before others. The academic world, on the other hand, requires more use of memory aspects -to integrate the information received- than other functions such as planning that will be evidenced, in a clearer way, in professional performance. Due to these differences, it is necessary to review some characteristics of the EF.

Characteristics of executive functions

Given the above, EFs are essential when selecting relevant information, planning, executing and evaluating a given course of action, i.e., they have some characteristics that allow them to act on other instances of cognitive functioning to regulate and guide it.

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Tirapu Ustárroz *et al*. (2012) have pointed out that EFs have some characteristics, such as *input* independence, regulation, information retrieval and the interrelation that makes them that "conductor" of cognitive functioning and human learning. Following these authors, we will describe these properties and make brief mentions of the implications for learning in university students.

First, EFs combine information from various areas such as perceptions, memory, emotions, and relationships with output systems, both perceptual and motor. The information that goes to the frontal lobe does not determine what is going on in the frontal lobe. This characteristic has been called *the independence of input*, which means that the prefrontal cortex combines relevant information that comes from several sectors and not only reacts to it.

This function is very useful for learning since it allows to combine information already existing in the brain with that which is assimilated in classrooms and, the person, can choose, the type of information to which he wants to react. This gives students some leeway to respond so that they are not just reaction beings, but can stop and reflect on the course of their actions.

As mentioned, EFs regulate internal (thoughts, memories, emotions) and external (behavior) processes, so that the system has greater viability and adapts better to the environment in which it operates. This is the second characteristic of EFs and is called *regulation*. This aspect is key in learning, since it is essential to order the activity and cycles that will be dedicated to tasks, study and leisure. Failure to do so would imply a predominance of chaos and disorder, which may ultimately affect performance.

The third feature is *information retrieval*, which is complementary to regulation, since regulation is only possible because the person is able to retrieve information stored in memory about known aspects and generate predictable responses to new situations. In addition, by doing so, the person can foresee a particular course of action based on the information available. This feature of the EF is key to learning, since teachers can make a review of previous information that the students have to be able to link it with the new information they will review. In addition, this action allows students to envision different responses and behavioral possibilities to broaden their field of action and reaction.

All these aspects are more enhanced and developed during youth, due to the theoretical and conceptual richness that young people learn in university classrooms. The new information that they assimilate allows

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the construction of different thought schemes, which influence decisively in their action. In addition, young people understand that they can have different options and act better accordingly.

Fourth, there is the characteristic of *interrelation*, which implies that the EF are in permanent interaction with other cognitive processes essential to carry out their activities, such as working memory and attention without which they could not carry out monitoring and review behavior and responses to problems experienced by a person. This feature is helpful since it helps the students to realize the ways in which they learn best and empower them to facilitate the assimilation of the new knowledge that they are reviewing throughout their student years.

In addition to the aforementioned characteristics, Barroso and León (2002) emphasize that they are "adaptive and directed to a goal" (p. 31), i.e., they favor the adaptation of students to the university environment and are activated to lead the person to the achievement of goals and objectives valuable to him. To better understand them, some models have been proposed. One of them is reviewed below.

Executive Role Model

Due to the interest by EF, authors such as Tirapu Ustárroz *et al*. (2017) have proposed a model to organize them in a better way. This model mentions that EFs are made up of three levels (Figure 1).

The first level, called *self-awareness* or *self-analysis*, allows to carry out two relevant actions: representing experiences by linking them with previous learning and controlling mental activity by using the knowledge that already exists to solve current problems and guide the decision-making process.

The second level encompasses functions that contribute to *the resolution of problems*. It combines the activities by which a person anticipates events, selects goals based on this, formulates and pre-plans possible solutions, and initiates appropriate responses. In addition, it shows the possible consequences, an essential skill when planning tasks and activities related to knowledge and its construction, in the case of a research, for example (Morales *et al*., 2018). These functions allow executive control of the remaining cognitive functions.

The third level consists of two skills: *management and temporary organization*. The first one allows the beginning and maintenance of a mental or motor activity and the second one favors the maintenance

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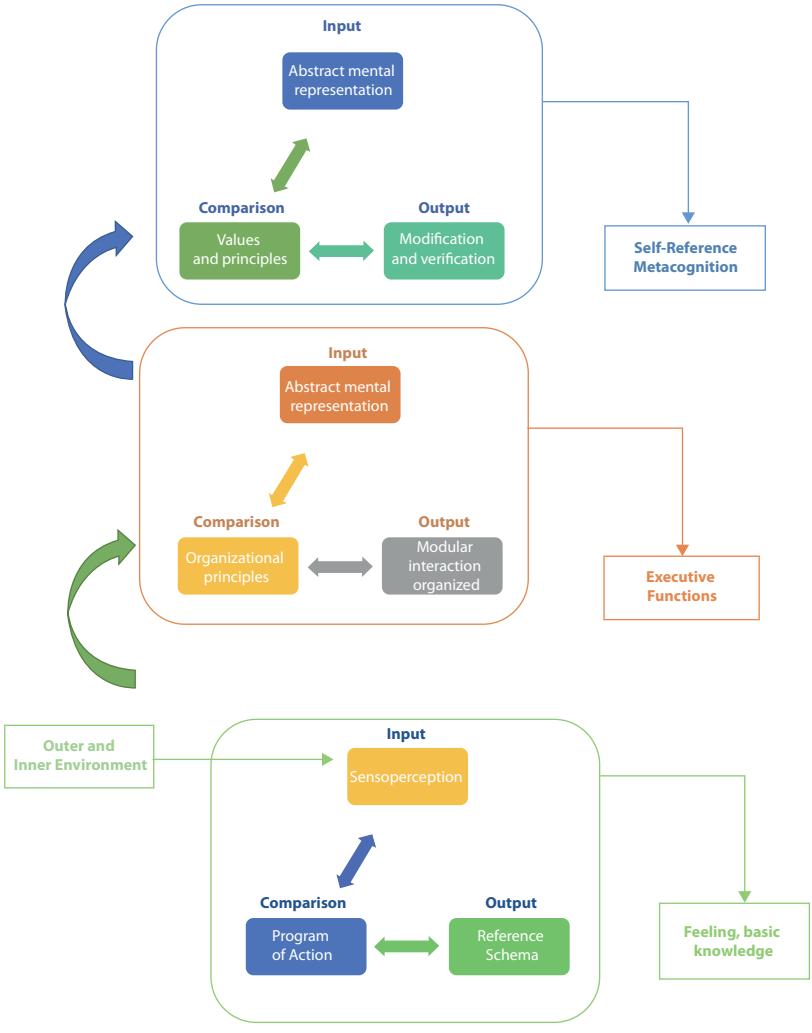
of successive chains of information and the perception of the passage of time. At the same time, each of these levels maintains a procedural scheme consisting of an input system, a comparison system and an output system that interact with the other levels and feed back to each other.

Figure 1
Model of executive functions



Source: own production from Tirapu Ustárroz *et al.* (2012, p. 93).

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The basis of this whole process lies in the feelings and perceptions that each individual has about the world and himself (Oliveira and Mourão-Júnior, 2013; Rosales Sánchez, 2019). The information obtained at this level is then consolidated and organized thanks to the support of other functions such as memory and thus constitute the second level of organization, formed by the EF. The cognitive process ends with the level of more complexity in which self-reference and metacognition are found, abstract abilities that determine the action of each individual.

Cognitive development reaches its most complex level when individuals acquire the capacity of self-reference and metacognition. These abstract abilities are essential for self-knowledge, self-regulation and continuous adaptation, which significantly impacts the actions and decision-making of each individual. Therefore, it is possible to carry out a deep and wide exploration of EF to make predictions about the functional capacity of the subject (García Molina *et al.*, 2007).

Tirapu Ustárroz *et al.* (2017) have carried out studies on some of the best known EFs, such as the following:

1. *Verbal fluency*, which retrieves the long-term information stored in the corresponding memory and carries out the activation of the processes of search, retrieval and emission of the words. This function must be expanded and improved in students, confronted with all kinds of verbal expositions and tasks that require verbal communication.

2. *Working memory*, able to record, encode, retrieve and use the information assimilated by the subject and which must be empowered in students to remember the most basic aspects associated with their academic performance and their profession.

3. *Processing speed*, referring to the ability of a person to handle information that helps him to carry out his cognitive operations, which can be affected by the multiplicity of stimuli that young people have around them in all types of electronic devices, especially their phones.

4. *Inhibition*, considered as the ability to retain a given response at a given time and avoid interference from other stimuli that could affect it. According to Sastre (2006):

> Inhibition relates to control and planning: (a) it stops the execution of a predominant action or the processing of irrelevant information; (b) it selects the relevant actions and representations in an activity; and (c) it favors the consequent *shifting* or effective activation after a stop signal (p. 145).

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Inhibition is an ability that favors the emergence of new schemes or their management, as well as resistance to internal and external interference that arise. When inhibition decreases, perseverance appears in a dominant behavior or response, which can affect the academic performance of a university student by preventing this progress considering other aspects different from a given situation.

5. *Dual execution*, which is a capacity that allows people to simultaneously pay attention to two or more situations at once, and perform several tasks at the same time, usually one verbal and one visospatial; which is highly developed by young people since they are very often connected to several devices at the same time.

6. *Cognitive flexibility*, understood as: "The ability to alternate between different tasks and behaviors, when the situation requires it [...] or to keep two or more plans in action, alternating the focus of attention between one plan and another, until reaching the respective goals" (Fernández Cordero, 2015, pp. 27, 28).

This capacity is being formed and consolidated as a person advances in their training process. From the initial moment in which are seen only two possible answers (black or white), through a moment in which many options are feasible, until the moment when it is realized that there is not a single path to solve the situation, but that there are different alternatives that lead to possible scenarios.

Cognitive flexibility is enhanced by developing the *ability to plan*, i.e., to think about a viable course of action. The planning establishes the possibility of carrying out tests in the mind regarding the possible solution alternatives to a problem. It is an ability to think about various possible courses of action and, as far as possible, about the consequences of such processes. This allows a better control of responses and actions to the problems raised. This ability is increasing as the years of study progress, since a student is confronted little by little to fulfill different demands related with the tasks he must perform and the activities he must fulfill during his training process.

7. *Decision-making*, understood as a complex process involving cognitive but emotional variables. It determines the responses that an individual gives to a given situation. Here it is relevant to consider the issue of emotions and their role in the *sui generis* way of being of each person, since they influence their process of knowledge, since it is one of the main elements of this work, as expressed by Morales *et al*. (2018), and in the variety of human actions.

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It was Descartes who pointed out the importance of thought in human action, since humans can base their best certainties on their cognitive functioning (as long as there is no mental problem). This certainty is synthesized in its famous phrase: "*Cogito ergo sum*", which gives priority to thinking about existing.

Traditionally, logical-discursive knowledge has been given a lot of importance and the way to approach the sciences has been through cognitive abilities. However, human beings can learn through emotions, i.e., the emotional brain — as well as the cognitive and pragmatic brain — can favor a better performance during the teaching process (Joaqui and Ortiz, 2019).

Heidegger (1997), for whom *dasein* cannot evade the moods, is the author who most delved into the topic of emotions, from a philosophical point of view: *dasein* cannot evade the moods, since they are manifested simply in the being, as *dasein*: when it comes into contact with the world, with objects and with others, it is always submerged by a state of mind, otherwise *dasein* would be impossible, since existing necessarily implies an emotional experience.

Heidegger (1997) spoke of "affective dispositions" that contribute to a direct existential opening to the world. They are the preferential link established between *dasein* and the world, precisely because they have direct access and have no intermediation of reason. Therefore, the *dasein* can let itself be carried away and give in to moods, since it is always submerged by one of them; otherwise, its existence and being in the world would be impossible, as they imply, necessarily, an emotional experience. According to Heidegger (1997): "In the affective disposition, *dasein* is always placed before itself, it has always been found, not in the form of a self-perception, but in that of an affectively disposed being" (p. 160).

This characteristic of direct existential openness to the world that enables the affective dispositions of impregnating the being, without being able to be completely owners of them, determines its ontological character: the opening of the condition of thrown, i.e., being in the world as a whole and being given to the world from which can arise what concerns us and for the control and supervision of these states, it is undoubtedly required the action of the EFs, especially those of regulation of these emotional states.

If this organization does not occur, the student may be immersed by his emotions, which will prevent him from acting properly. The notion of "cast" emphasizes the fundamental existential condition of human beings, the connection with the world, the surrender to it and the aware-

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ness of what concerns us in our existence. Supervision and control, in this context, refer more to an understanding and accountability rather than an active and direct domain.

After considering the different EFs that a student may develop during his training, it is possible to review, briefly, the implications of these functions in learning.

Executive Functions in Learning

The EFs intervene or are part of a series of interconnected processes that constitute the neuropsychological basis of the own activities of the human being, so its analysis and understanding is very relevant in the educational context, being intimately linked to learning. The EFs determine the social and academic performance of students, so they constitute an area of special interest for professionals who work with people during the training cycle and relationship with themselves and with the other (Joaqui and Ortíz, 2019); taking into account that these skills have a preponderant role in decision-making, function as a filter for the selection and recording of information obtained in the environment and are basic when planning, organizing and regulating action.

There are studies that point out the role of inhibitory control and supervision on the regulation of learning, whose absence or impairment generates behaviors that influence learning, since the person is characterized by "difficulties in impulse control, act automatically and without an awareness of the consequences of the acts performed, limitations in the proper supervision of tasks, abandonment of activities without ending them" (Ramos and Lozada, 2015, p. 30).

There are reports that affect the regulation of their learning (Tene and Piedra, 2013) and show low academic performance (García and Muñoz, 2000), although apparently this happens more frequently in childhood (Fonseca *et al*., 2016), since there are other reports (Barceló *et al*., 2006) that indicate that there is not much difference in EF when evaluating students with different performances (high and low), except in language tests, in which the results show different skills in this area and others.

It should also be taken into account that EFs are related to two cognitive processes important for learning, such as attention and memory (Gross, 2012). In order for the latter to function and have access to the information it possesses, it is necessary to maintain a certain degree of focused attention and avoid the stimuli that can hinder the task. If this is

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not possible due to some interference or affectation, the memory will be prevented from recording the new information that comes to it and this will undoubtedly affect learning.

Similarly, attempts have been made to generate proposals that contribute to learning considering the EFs (Yoldi, 2015). Most of these actions consider essential tasks such as the early detection of students who present difficulties in any function and then their permanent monitoring throughout the training process, in order to help them develop the function with the deficit.

According to Yoldi (2015, p. 14), the activities mostly mentioned are the following:

- Working in small groups to improve the attention and response level given by students.
- Minor modifications in the environment in such a way that visual or auditory interference is reduced.
- Offering clear rules of behavior, through brief regulations that can even be made visible through posters in the classroom.
- Dividing complex tasks into smaller, sequential activities so that students can understand the process of solving the most complex task.
- Establishing and implementing routines during the class to favor impulse control and monitoring of the work done.

Other authors, such as Payer (2009), propose to promote work among peers of different skill levels, so that they become benchmarks for those with less skill and thus can use the "near development zone" proposed by Vygotski or the use of modeling for learning, both by the teacher and more advanced peers, and then practiced by all students.

As observed, there are different practices that, being focused on the use of FE, contribute to develop these practices in university students. There are specific educational approaches and learning strategies designed to enhance and strengthen students' EFs. EFs are superior cognitive skills that play a crucial role in planning, organizing, self-monitoring, decision-making, and other complex mental activities.

Such is the case of Osses Bustingorry and Jaramillo Mora proposal (2008), which emphasizes the use of metacognitive skills in all academic tasks, which promote the development of superior skills of reflection and self-regulation. Therefore, there are many small activities that teachers can carry out that favor and consolidate the different EFs. By implementing educational strategies that take these functions into account, the objective is to improve the ability of students to face academic challenges and promote more effective and autonomous learning.

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Conclusions

The study and use of EF in learning are the most interesting fields of analysis and understanding, due to the impact they have on the academic performance of university students. They do not have a single definition, but it seems that the EFs encompass all those skills related to control, supervision, analysis of the environment, synthesis and abstraction that make a human being something special and different.

The components of EF and their importance for regulating the activities carried out by a person during the training process have been analyzed, for that reason the changes experienced in these functions throughout the life cycle have been considered.

The main characteristics of EF have been raised and the different models to understand EF have been pointed out. Most of them present them in interrelated blocks that, in turn, are linked to other cognitive functions such as language, sensations and perceptions, which contribute to the functioning of the organism as an organized and unitary whole.

Finally, it has been considered the relationship between EF and learning in university students, so it is significant to take into account these functions in the teaching practice, to perform a practice that allows the development of these skills in students, which will facilitate their adaptation to the environment around them and their development in the tasks related to their professional practice.

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