THE IMPORTANCE OF EXECUTIVE FUNCTIONS FOR LEARNING

https://doi.org/10.56238/sevened2025.018-025

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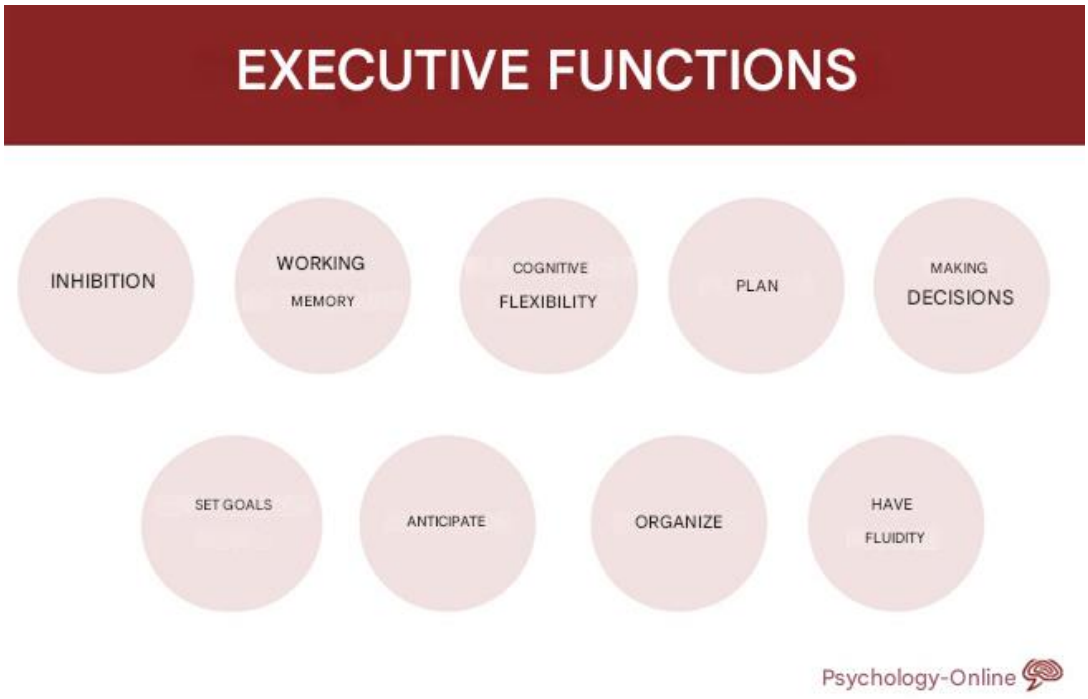
ABSTRACT

This article aims to review the literature on the importance of executive functions (EFs) in the learning process. Executive functions are essential cognitive skills that include inhibitory control, working memory, and cognitive flexibility, which are fundamental for academic success and child development. The justification for the study is based on the growing relevance of understanding how these functions can impact academic performance, especially in an educational context that demands increasingly complex and integrated skills. The methodology used was a literature review, with analysis of studies already published on the relationship between executive functions and learning in children and adolescents. Articles from scientific journals and specialized books that discuss the development and evaluation of executive functions, as well as educational interventions, were selected. The result of the review pointed out that children with more developed executive skills tend to perform better in subjects such as mathematics and reading, in addition to demonstrating a greater ability to solve complex problems. The review also highlighted the effectiveness of intervention programs that stimulate these skills, suggesting that executive function training can be a powerful tool to improve school performance and reduce behavior problems. It is concluded that executive functions play a crucial role in learning and should be incorporated into pedagogical strategies.

Keywords: Executive functions. Apprenticeship. Cognitive development. school performance.

INTRODUCTION

Executive functions (EFs) are a set of cognitive processes responsible for controlling and regulating goal-directed behaviors, such as planning, decision-making, inhibitory control, cognitive flexibility, and working memory (DIAMOND, 2013). These processes play an essential role in academic performance, as they facilitate the student's ability to organize thoughts, manage time, and deal with challenging situations, in addition to directly influencing self-regulation and problem-solving (BARKLEY, 2012).



The relationship between executive functions and learning has been widely studied, demonstrating that these skills are fundamental from early childhood to adulthood, especially in the school context. Studies indicate that children with better executive function skills tend to have superior academic performance, since they are able to concentrate more on complex tasks, plan their activities and maintain attention for prolonged periods (BEST; MILLER; NAGLIERI, 2011). In addition, the development of executive functions is directly related to academic progress in areas such as reading and mathematics (BLAIR; RAZZA, 2007). The ability to monitor and adjust behavior, through inhibitory control, for example, is crucial to avoid distractions and stay focused on cognitive activities that require attention and constant effort (ANDERSON, 2002). In this way, EFs contribute significantly to learning, being increasingly recognized as a central aspect in the educational process.

In the educational context, the improvement of executive functions is crucial, especially in school-age children, as these skills are fundamental for students to develop

skills such as autonomy, problem solving, and the ability to self-regulate emotionally and cognitively (ZELAZO; MÜLLER, 2002). By promoting the development of these skills, the school plays a vital role in preparing students to face academic and social challenges more effectively and independently. Working memory, for example, one of the main components of executive functions, allows students to manipulate relevant information during problem solving, being essential for learning new content and performing complex tasks (GATHERCOLE; ALLOWAY, 2008). Children with difficulties in working memory often have problems staying focused and following instructions, which negatively affects their academic performance (HOLMES et al., 2009). Thus, strategies aimed at developing this skill can be decisive for a significant improvement in school learning.

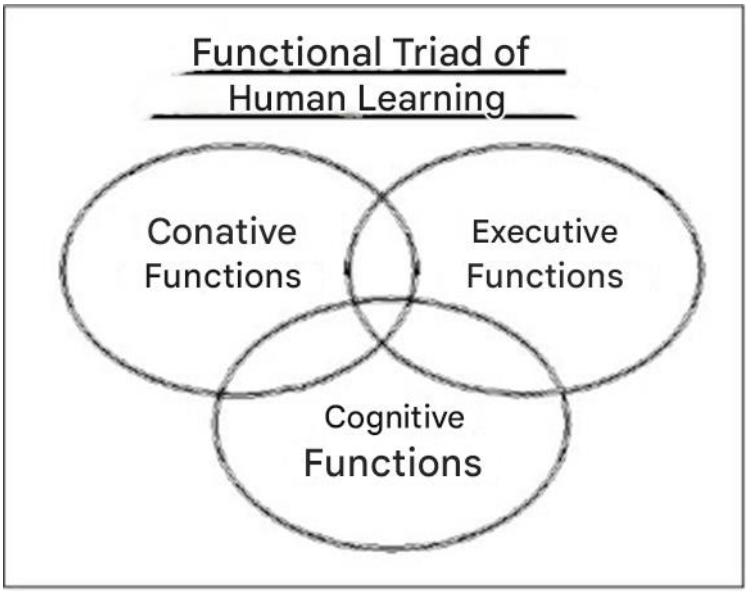


Figure 1 Functional triad of human learning. The interactivity and inseparability of cognition, conation and execution allow the emergence and sustenance of the human learning process.

Another relevant aspect is inhibitory control, which involves the ability to suppress automatic or impulsive responses so that a more appropriate action can be taken (MIYAKE et al., 2000). This executive function is particularly important in the school environment, as it allows students to resist distractions and keep their attention focused on educational activities, such as reading and solving mathematical problems (DIAMOND, 2013). Research suggests that well-developed inhibitory control is associated with better academic performance, as it promotes greater engagement with the learning process (BLAIR; DIAMOND, 2008). In addition, cognitive flexibility, which is the ability to adjust thoughts or behaviors in response to changes in the environment, also has a great impact on learning (DÉSY; POULIN-DUBOIS, 2021). This skill allows students to switch from one task or

strategy to another in an efficient manner, favoring adaptation to new concepts and different types of academic problems. Lack of cognitive flexibility can result in difficulties in solving problems, especially those that require adaptation to new conditions or reevaluation of previously used strategies (GIOIA; ISQUITH; GUY, 2001).

The interdependence of these executive functions reinforces the idea that the development of effective learning depends on the improvement of these cognitive skills. Mastery of executive functions not only improves academic performance, but also contributes to the formation of socio-emotional skills, such as empathy, resilience, and group cooperation, factors that are equally important for success in school life and beyond (DIAMOND; LEE, 2011). In view of this, the inclusion of pedagogical practices that stimulate the development of executive functions in schools can represent a powerful strategy to maximize students' learning potential, contributing holistically to their cognitive and emotional development. Investigating the role of executive functions in the school environment not only broadens the understanding of children's cognitive development, but also allows the implementation of more effective pedagogical interventions, aimed at improving these skills, promoting more autonomous and efficient learning.

The integration of executive functions into the teaching and learning process has implications for both students and educators. For teachers, understanding the workings of executive functions allows them to adapt their pedagogical practices in a way that better meets the needs of students, fostering a more inclusive and effective learning environment. Curricular structures that incorporate the development of these functions can facilitate the teaching of metacognitive skills, such as the ability to reflect on one's own thinking, which has been shown to be crucial for academic success (MCCLOSKEY; PERKINS; VAN DIVNER, 2009). In this sense, some educational approaches are already promising for strengthening executive functions. For example, programs aimed at teaching socio-emotional skills, such as the Path to Success (PATHS), have demonstrated positive impacts on students' self-control and emotional regulation, skills that are closely linked to the development of executive functions (DOMITROVICH et al., 2007). Another example is the use of games and activities that challenge working memory and inhibitory control, which help improve academic performance by developing students' ability to deal with complex problems and multitask (DIAMOND; LEE, 2011). In addition, learning environments that offer a balanced combination of cognitive challenges and emotional support also contribute to the development of executive functions. Situations in which students are encouraged to plan, monitor and adjust their actions in the face of difficulties promote an improvement in these functions, directly impacting their academic performance (BERG; LAURENT, 2018).

This approach can be applied both in the early grades, when executive functions are in development, and in more advanced stages, such as in high school and college, where these skills become essential for academic autonomy.

Another relevant aspect is the influence of executive functions on students' ability to engage in conflict resolution and group collaboration processes. Cognitive flexibility, for example, helps students deal with different perspectives and negotiate collective solutions, which is particularly useful in teamwork activities (ESPINET; ANDERSON; DIAMOND, 2013). In this way, the strengthening of executive functions not only improves individual academic performance, but also favors the development of social skills crucial for coexistence and collaborative work, characteristics valued in the contemporary world.

Finally, it is important to highlight that executive functions do not develop uniformly in all children. Factors such as family environment, socioeconomic level, and life experiences can affect the development of these skills, generating inequalities in academic performance (HACKMAN; FARAH; MEANEY, 2010). Children who grow up in more stressful environments or with fewer cognitive resources tend to have deficits in executive functions, which, in turn, negatively impacts their learning. This fact underscores the importance of early and well-targeted educational interventions to ensure that all learners have the opportunity to develop these fundamental skills.

Thus, the role of executive functions in learning is multifaceted, ranging from cognitive control of academic tasks to emotional and social regulation, essential elements for school and personal success. Therefore, by integrating the development of these skills into the school curriculum and teaching environment, it is possible not only to improve students' academic performance but also to prepare them to face future challenges with greater resilience and adaptive capacity.

METHODOLOGY

This study is characterized as a literature review, with the objective of identifying and analyzing research on the importance of executive functions in the learning process. The literature review was chosen because it is an effective method to synthesize the accumulated knowledge on a given topic, allowing the identification of gaps and pointing out paths for future research (GIL, 2008). This type of study is also relevant to consolidate existing scientific evidence and provide a comprehensive overview of the main theories and empirical findings related to executive functions and their impact on education.

The research was carried out through consultations with academic databases, such as Scielo, PubMed, ERIC and Google Scholar, using keywords such as "executive

functions", "learning", "inhibitory control", "working memory" and "cognitive flexibility". Articles published between 2000 and 2023, in Portuguese and English, that presented empirical studies or theoretical reviews on the subject, were selected. In addition, classic studies, such as the one by Miyake et al. (2000), were considered for their impact on the understanding of executive functions.

The inclusion criteria involved articles that addressed the relationship between executive functions and academic performance in children and adolescents, as well as studies that dealt with pedagogical interventions aimed at improving these skills. Articles that referred exclusively to clinical populations (such as individuals with ADHD or brain injuries) and that did not deal directly with the school context were excluded. The analysis of the selected articles followed the methodological guidelines of Bardin (2011) for content analysis, allowing the identification of the main themes and results addressed in the research. The categorization of the data allowed the grouping of information related to the different executive functions and their influences on academic performance, as well as the identification of effective interventions in the school environment.

Executive functions, understood as a set of cognitive processes responsible for controlling behavior and directing actions, have been recognized as crucial factors for learning. Among the most studied components are inhibitory control, working memory, and cognitive flexibility, which act together to allow individuals to plan, monitor, and adjust their behaviors according to contextual demands (MIYAKE et al., 2000). These processes are critical to academic success, as they help students manage multiple pieces of information, stay focused on tasks, and deal with complex cognitive challenges (DIAMOND, 2013). The scientific literature highlights the importance of these cognitive skills for learning in various disciplines, especially in the areas of reading and mathematics. Blair and Razza (2007), for example, observed that working memory is directly related to performance in mathematical activities, while inhibitory control has a strong correlation with reading comprehension. These findings are corroborated by Gathercole and Alloway (2008), who point out that the ability to hold and manipulate information in working memory is essential for problem solving, especially those involving logical reasoning and sequences.

In addition, research indicates that the development of executive functions is associated with self-regulation skills, such as the ability to manage emotions and behaviors adaptively (ANDERSON, 2002). Children with greater inhibitory control, for example, tend to be better able to suppress impulsive responses and stay focused on activities that require prolonged attention, which favors superior academic performance. On the other hand,

deficits in these skills can result in difficulties in following instructions, completing tasks, and actively participating in the learning process (BARKLEY, 2012).

Another relevant aspect discussed in the literature is the impact of pedagogical interventions on the development of executive functions. Diamond and Lee (2011) point out that activities that involve the training of cognitive and socio-emotional skills, such as the use of games that challenge inhibitory control and working memory, have positive effects on academic performance. In addition, programs that integrate mindfulness practices and physical activities, such as the Path to Success (PATHS), demonstrate benefits not only in improving executive functions, but also in students' emotional regulation and social behavior (DOMITROVICH et al., 2007). It is also worth highlighting the influence of environmental factors, such as the socioeconomic and family context, on the development of executive functions. Studies indicate that children from families with higher socioeconomic status tend to have better executive skills, due to greater access to cognitive stimuli and supportive environments (HACKMAN; FARAH; MEANEY, 2010). This suggests that educational interventions aimed at strengthening these skills can be especially effective in vulnerable populations, helping to reduce disparities in academic performance.

In summary, executive functions play a central role in learning, directly influencing students' academic performance and socio-emotional skills. The growing interest of the scientific community in this field reflects the importance of developing educational strategies that promote the improvement of these skills from the first years of school life, aiming not only at improving academic performance, but also at the integral development of the student.

RESULTS AND DISCUSSION

A review of the literature on the importance of executive functions for learning reveals a strong correlation between the development of these skills and academic performance in several areas, such as reading, writing, and mathematics. Studies such as those by Diamond (2013) and Miyake et al. (2000) highlight that executive functions, composed of skills such as inhibitory control, working memory, and cognitive flexibility, play a crucial role in managing the cognitive demands that students face in the school environment. Children with better executive skills tend to exhibit greater ability to concentrate, plan, and solve problems, which results in superior academic performance. In addition, the reviewed literature points out that executive functions are determinant for the development of socio-emotional and self-regulation skills, which are fundamental for school

success. Anderson (2002) points out that inhibitory control, for example, helps students avoid distractions and focus on school activities, while cognitive flexibility enables them to adapt to different learning situations. These processes allow students not only to perform complex cognitive tasks, but also to manage behaviors and emotions, improving classroom coexistence and the quality of social interactions.

Another relevant finding is the impact of executive functions on specific disciplines. Blair and Razza (2007) demonstrated that working memory is closely linked to performance in mathematics, especially in tasks that require the storage and manipulation of numerical information. Similarly, inhibitory control has been strongly associated with reading and comprehension of text, as students need to inhibit distractions and stay focused on the content they are reading. These results suggest that different components of executive functions play distinct roles in specific areas of the school curriculum. The findings of this review corroborate the growing evidence that executive functions play a central role in the development of children's academic and socio-emotional skills. As demonstrated by Diamond (2013), these skills not only allow students to manage complex cognitive tasks, but also influence their ability to regulate emotions, control impulses, and adapt to new challenges, which is crucial for educational success. In addition, the results indicate that the improvement of executive functions can be a predictor of long-term school success, as indicated by studies such as those by Best, Miller and Naglieri (2011), which identify a relationship between these skills and the academic performance of children of different ages.

An important point raised by the literature is the inequality in the development of executive functions, which can be influenced by socioeconomic factors. Hackman, Farah and Meaney (2010) suggest that children from families with lower socioeconomic status have more difficulties in developing these skills, which may contribute to the perpetuation of inequalities in school performance. This finding reinforces the need for targeted pedagogical interventions, especially in contexts of social vulnerability, to ensure that all children have the opportunity to develop their executive functions appropriately.

The review also highlights the effectiveness of interventions aimed at improving executive functions, such as those proposed by Diamond and Lee (2011). Educational programs that integrate cognitive and social-emotional development, such as the Path to Success (PATHS), have shown promising results by improving students' inhibitory control, working memory, and emotional regulation. Such interventions suggest that it is possible to strengthen these skills through planned pedagogical activities, which positively impacts both academic performance and student behavior in the classroom. On the other hand,

literature also raises challenges. Although executive functions play an important role in learning, their development does not occur in isolation. Factors such as the quality of the family environment, school experiences and children's mental health also influence the development of these skills (ANDERSON, 2002). Therefore, it is critical that schools and teachers are prepared to take a holistic approach that takes into account the emotional and social context of students when promoting the development of executive functions.

In summary, the results and discussion of this review point to the relevance of executive functions as a central element in school success. Interventions aimed at improving these skills from the earliest school years can not only improve students' academic performance, but also promote the development of essential skills for adult life. Thus, the integration of pedagogical practices that favor the development of executive functions should be considered a priority in educational planning.

Another relevant aspect in the discussion about the importance of executive functions for learning is the prolonged impact that these skills can have throughout the academic life of individuals. Studies by Diamond (2013) indicate that the ability to control impulses, stay focused, and plan strategically are skills that continue to influence academic and professional performance during adolescence and even into adulthood. According to the author:

> Executive functions are critical to achieving long-term goals, allowing individuals to overcome distractions, postpone immediate rewards, and persist in complex tasks. Its importance transcends the academic environment, directly impacting daily life and success in different spheres, such as work and interpersonal relationships (DIAMOND, 2013, p. 137)

This excerpt illustrates the breadth of the impact of executive functions, which is not restricted only to the school context, but also affects essential skills for adapting to social and professional demands. The review of the studies allows us to affirm that students with better development of these functions not only have greater success in academic activities, but also tend to be more resilient and able to deal with adverse situations, which contributes to a more balanced socio-emotional development (DIAMOND, 2013). Another important contribution to the discussion is the study by Barkley (2012), which relates deficits in executive functions with learning problems and behavioral difficulties. For Barkley, these deficits can lead to serious obstacles in the learning process, affecting the student's ability to follow instructions, maintain attention in complex activities, and manage impulsive behaviors. The author points out:

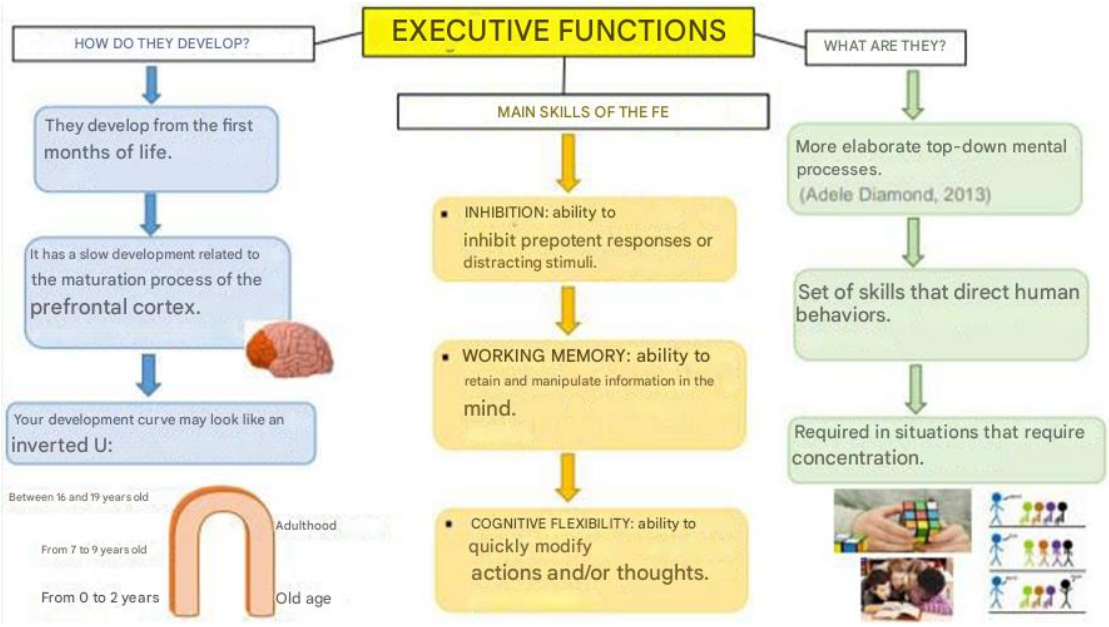
> Deficits in executive functions not only affect academic performance, but also have significant implications for social behavior and emotional development. Children with

> difficulties in these skills are more likely to have behavioral problems, such as the inability to regulate their emotions and deal with frustrating situations" (BARKLEY, 2012, p. 78)

This point is crucial to understanding the role of executive functions not only as facilitators of cognitive skills, but also as mediators of adaptive behaviors. This suggests that interventions aimed at improving executive functions may have a dual effect, benefiting both academic performance and children's social and emotional development. The discussion of the literature indicates, therefore, that executive functions are fundamental not only for immediate academic success, but also for the development of skills that last throughout life. The consensus among researchers is that the improvement of these cognitive skills should be a priority in pedagogical practices, especially in educational contexts where support for self-regulation and cognitive flexibility is limited. Scientific evidence points out that investing in the development of executive functions can be one of the keys to a more inclusive and effective education, benefiting all students, regardless of their socioeconomic conditions or family contexts (HACKMAN; FARAH; MEANEY, 2010). From the results presented and the highlighted citations, it is evident that executive functions play a central role not only in academic learning, but also in the development of social and emotional skills. The literature review suggests that these functions are crucial predictors for school success and for students' adaptation to different cognitive and behavioral challenges. Interventions focused on the development of executive functions have shown promising effects, as pointed out by Diamond and Lee (2011), by promoting significant improvements in inhibitory control, working memory, and cognitive flexibility.

The study by Diamond (2013) reinforces that these skills are essential for learning because they help students stay focused on important tasks, inhibit inappropriate responses, and adapt to new academic and social demands. This implies that children who develop strong executive functions are better able to cope with school demands and regulate their behaviors efficiently. These results suggest that schools, by promoting the development of these skills, contribute to the formation of more resilient and adaptable individuals, capable of dealing with frustrations and challenges throughout their school and life trajectory. In addition, the reviewed data indicate that there is a robust relationship between the development of executive functions and academic performance in areas such as reading, writing, and mathematics. Working memory, for example, has been shown to be instrumental in solving mathematical problems, which require students to manipulate and store information simultaneously. Similarly, inhibitory control is essential for reading comprehension, as students need to suppress distractions and focus on the text to make sense of the information (GATHERCOLE; ALLOWAY, 2008). These findings suggest that by

strengthening these cognitive functions, students can comprehensively improve their performance in various areas of knowledge.



Another important point to be discussed is the influence of the socioeconomic context on the development of executive functions. Studies such as those by Hackman, Farah and Meaney (2010) reveal that children from families in situations of socioeconomic vulnerability tend to have greater difficulties in developing these skills, which can aggravate educational inequalities. These children, often exposed to environments with less cognitive stimulation and emotional support, have fewer opportunities to develop robust executive functions, which can compromise their school performance and future prospects. These findings reinforce the need for educational policies that consider not only academic content, but also the development of cognitive skills essential for learning. Interventions in schools in disadvantaged communities can play a key role in reducing educational disparities by promoting the development of executive functions in an equitable manner. Hackman, Farah and Meaney (2010) highlight that early interventions, especially in contexts of vulnerability, can mitigate the effects of unfavorable socioeconomic conditions and promote long-term school success.

Therefore, the literature review indicates that the development of executive functions should be a priority both in pedagogical practices and in educational public policies. Executive functions are essential for students to be able to deal with the cognitive and emotional demands of the school environment, and their improvement can contribute significantly to academic success and the integral development of individuals. Investing in the development of these skills, especially in vulnerable populations, is an effective strategy

to promote a more inclusive and equitable education, offering all students the opportunity to reach their full academic and personal potential.

CONCLUSION

The literature review presented highlights the relevance of executive functions for the learning and academic development of children and adolescents. These skills, such as inhibitory control, working memory, and cognitive flexibility, are key to performing complex tasks, solving problems, and controlling impulsive behaviors, all of which are essential aspects of school success. The proper development of executive functions contributes to the improvement of cognitive and socio-emotional skills, directly impacting academic performance in areas such as reading, writing, and mathematics. The study also reveals that the socioeconomic environment exerts a strong influence on the development of these functions, evidencing the need for educational interventions aimed at equal opportunities. Students from contexts of social vulnerability tend to have greater difficulties in the development of executive functions, which increases educational inequalities and compromises their school performance.

Thus, the promotion of the development of executive functions from childhood should be seen as a priority both in pedagogical practices and in public educational policies. Interventions aimed at strengthening these skills can not only improve academic performance, but also contribute to the formation of more resilient individuals, capable of facing challenges and adapting to the demands of everyday life. By integrating the development of executive functions into the school curriculum, it is possible to promote a more inclusive, equitable, and effective education, providing all students with the opportunity to reach their full potential. This perspective points to an educational approach that goes beyond the teaching of traditional academic content. The development of executive functions not only favors school success, but also plays a crucial role in the integral formation of the individual, influencing aspects such as social behavior, problem-solving skills, and emotional regulation. Therefore, there is a consensus that these skills are not only "complementary" to learning, but also fundamental for cognitive development and for building a successful school trajectory.

It is important to consider that the role of executive functions in learning is not limited only to the formal classroom environment. Children who develop these skills are better prepared to face challenges that arise in varied contexts, such as social interactions, extracurricular activities, and even family and community responsibilities. Working memory, for example, facilitates the organization and planning of daily activities, while inhibitory

control allows the child to make more conscious and less impulsive choices, both in the school environment and outside it. In the educational context, this development should be encouraged intentionally, with the use of methodologies that promote students' cognitive engagement and challenge them to use and strengthen their executive functions. Teaching methods that integrate cognitive games, complex problem-solving, and collaborative work can be effective for this purpose. Likewise, an environment that favors emotional self-regulation and the development of social skills can be fundamental for the improvement of executive functions. This includes strategies such as explicitly teaching socio-emotional skills, creating consistent routines, and promoting a safe and welcoming environment where students feel comfortable experimenting, making mistakes, and learning.

In addition to pedagogical strategies, it is crucial that the development of executive functions is supported by public policies that recognize their importance. This is especially relevant in contexts of socioeconomic inequality, where the development of these skills can be hampered by external factors, such as a lack of educational resources and family support. Early interventions, such as early childhood education programs that aim to strengthen executive functions, can have a lasting impact on students' school development and quality of life. When reflecting on the role of executive functions in learning, it is evident that investment in their promotion offers benefits that go beyond school performance. By empowering students to manage their emotions, control their impulses, and deal with problems more effectively, executive functions create a strong foundation for success in different areas of life. In fact, individuals who have well-developed executive skills tend to be more successful not only in school, but also in their professional and personal lives, since they are better able to plan, organize, and make thoughtful decisions.

Finally, it is necessary to recognize that the development of executive functions is a continuous process that begins in childhood, but that it can be improved throughout life. While much of this development occurs in the early years of life, there is room for interventions at all stages of education, from preschool to higher education. These interventions should be tailored to the specific needs of each age group, promoting the continuous strengthening of these skills as cognitive and emotional demands increase.

In summary, the review of the studies points to the importance of executive functions in the educational context and the decisive role they play in learning and academic success. The incorporation of pedagogical strategies that promote the development of these skills, associated with public policies aimed at educational equity, has the potential to transform the way schools approach teaching and learning. This not only improves

students' academic performance but also contributes to the formation of individuals who are more capable, autonomous, and prepared to face the challenges of adult life.

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