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Enhancing Executive Functions to Improve Academic Achievement in School-Aged Children: A Systematic Review of Educational, Cognitive, and Digital Interventions

Ilias Vasileiou (Corresponding Author)
College for Humanistic Sciences-ICPS, University of Lancashire. Ilia Iliou 81, PO BOX: 117 11, Athens, Greece.
E-mail: ivasileiou@lancashire.ac.uk

Abstract
Executive functions (EFs) have emerged as a critical focus of educational and cognitive research due to their strong association with learning, self-regulation, and academic achievement. Growing recognition of the role of executive functioning in educational success has led to increasing interest in interventions designed to strengthen these cognitive skills within school settings. Executive functions (EFs) are higher-order cognitive processes that support goal-directed behavior, self-regulation, and adaptive learning. Increasing evidence suggests that EF skills, including working memory, inhibitory control, and cognitive flexibility, play a fundamental role in children's academic development. The present study provides a systematic review of empirical research examining educational interventions targeting executive functions and their effects on academic achievement in school-aged children. The review followed the PRISMA 2020 guidelines. A systematic literature search was conducted in Scopus, Web of Science, ERIC, PubMed, and PsycINFO for studies published between 2010 and 2025. Studies were included if they examined school-based or educational interventions designed to enhance executive functions and reported academic outcomes such as reading, writing, or mathematics performance. Following screening and eligibility assessment, the final sample of studies was synthesized using a qualitative narrative approach. The findings revealed three primary categories of interventions: cognitive training programs targeting executive control processes, classroom-based instructional approaches emphasizing self-regulation and metacognitive strategies, and technology-assisted interventions utilizing digital learning environments. Across the reviewed studies, improvements in executive functioning were frequently associated with enhanced academic outcomes, including reading comprehension, mathematical reasoning, and classroom engagement. However, the magnitude of academic transfer effects varied across intervention types and research designs. Overall, the evidence suggests that executive function interventions can contribute to improved academic performance when integrated into structured educational contexts that support the transfer of cognitive skills to learning tasks.
Keywords: executive functions; academic achievement; cognitive training; self-regulated learning; educational interventions; systematic review.
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1. Introduction

Executive functions (EFs) are higher-order cognitive processes that enable individuals to regulate behavior, control attention, and coordinate complex goal-directed actions. These cognitive processes include core components such as working memory, inhibitory control, and cognitive flexibility, which together support planning, problem solving, self-regulation, and adaptive learning behaviors (Diamond, 2013; Zelazo, 2015; Best & Miller, 2010). In educational contexts, executive functions play a central role in students' ability to manage classroom demands, organize information, sustain attention, and monitor their own learning processes (Blair & Raver, 2015; Meltzer, 2018). Consequently, executive functioning has been widely recognized as a fundamental cognitive foundation underlying academic achievement across multiple domains, including reading, writing, and mathematics (Best, Miller, & Naglieri, 2011; Jacob & Parkinson, 2015). During childhood, executive functions undergo rapid developmental changes that are closely linked to brain maturation and educational experiences. Neurodevelopmental research indicates that the prefrontal cortex and associated neural networks responsible for executive control continue to develop throughout childhood and adolescence, contributing to gradual improvements in cognitive regulation, attention control, and working memory capacity (Diamond, 2013; Zelazo & Carlson, 2012; Fuster, 2015). Because these cognitive processes support goal-directed learning behaviors, variations in executive functioning have been consistently associated with differences in academic performance among school-aged children (Best et al., 2011; Blair, 2016; Jacob & Parkinson, 2015). Students with stronger

executive function skills tend to demonstrate higher levels of classroom engagement, improved problem-solving abilities, and better academic outcomes across subjects (Allan, Hume, Allan, Farrington, & Lonigan, 2014; Best et al., 2011).

A growing body of research has demonstrated that executive functions are particularly important for academic tasks that require sustained attention, cognitive flexibility, and strategic planning. For example, working memory plays a crucial role in reading comprehension and mathematical problem solving because it enables students to temporarily hold and manipulate information during complex cognitive tasks (Alloway & Alloway, 2015; Swanson & Alloway, 2012). Similarly, inhibitory control allows learners to suppress irrelevant stimuli and maintain focus on task-relevant information, thereby supporting classroom behavior and learning engagement (Diamond, 2013). Cognitive flexibility, in turn, enables students to shift between strategies, adapt to new instructions, and integrate different sources of information when solving problems (Zelazo, 2015). These processes collectively contribute to students' ability to navigate the cognitive demands of formal schooling. Research has also shown that deficits in executive functioning are associated with a range of academic difficulties. Children with weaker executive function skills often experience challenges in organizing tasks, regulating attention, completing assignments, and maintaining goal-directed behavior in the classroom (Meltzer, 2018; Best et al., 2011). Such difficulties are particularly evident among students with neurodevelopmental conditions such as attention-deficit/hyperactivity disorder (ADHD), specific learning disabilities (SLD), and autism spectrum disorder (ASD), where impairments in executive functioning frequently contribute to academic underachievement (Diamond, 2013; Barkley, 2015; Alloway & Alloway, 2015). However, even among typically developing students, variations in executive functioning have been shown to predict differences in academic performance and long-term educational outcomes (Blair, 2016; Allan et al., 2014). Given the importance of executive functions for learning and academic success, researchers and educators have increasingly explored educational interventions designed to strengthen executive function skills in children. Such interventions include cognitive training programs, classroom-based instructional strategies, metacognitive teaching approaches, and technology-assisted learning environments that aim to enhance working memory, inhibitory control, and cognitive flexibility (Diamond & Lee, 2011; Meltzer, 2018). Some interventions focus on direct training of executive function processes through structured cognitive exercises, while others integrate executive function development into classroom instruction through strategies that promote self-regulation, goal setting, and reflective learning (Jacob & Parkinson, 2015; Best et al., 2011).

Recent studies suggest that educational interventions targeting executive functions may lead to improvements not only in cognitive regulation but also in academic outcomes. Classroom programs that incorporate self-regulated learning strategies, structured problem-solving tasks, and metacognitive reflection have been shown to improve students' ability to manage complex learning tasks and sustain attention during instruction (Blair & Raver, 2015; Meltzer, 2018). Similarly, technology-assisted cognitive training programs have demonstrated promising effects in improving working memory and attentional control among school-aged children (Alloway & Alloway, 2015). Nevertheless, the effectiveness of executive function interventions remains a subject of ongoing debate, as research findings vary across studies depending on factors such as intervention duration, instructional context, and the specific executive function components targeted. Despite the growing number of studies examining executive function interventions in educational settings, the literature remains fragmented across different research traditions, including cognitive psychology, educational neuroscience, and instructional research. Studies differ considerably in terms of intervention design, methodological approaches, and outcome measures used to evaluate academic achievement. As a result, synthesizing the available evidence is necessary in order to clarify the overall impact of executive function interventions on students' academic outcomes. In response to this need, the present study provides a systematic review of empirical research examining educational interventions targeting executive functions in children and their effects on academic achievement. By synthesizing findings across multiple disciplines, the review aims to identify common intervention approaches, evaluate their effectiveness in improving academic outcomes, and highlight directions for future research and educational practice. Recent evidence further supports the central role of executive functions in academic achievement. Ming et al. (2026), in a study of 883 children aged 9–14 years, found that executive functions partially mediated the relationship between family socioeconomic status and academic performance. Their findings also highlighted gender differences, showing that subjective socioeconomic status buffered the negative effects of economic disadvantage on executive functioning among girls. These results reinforce the view that executive functions constitute a critical mechanism linking environmental factors to educational outcomes (Ming et al., 2026).

2. Method

2.1 Review Design and Reporting Framework

The present study adopted a systematic review design to synthesize empirical evidence on educational interventions targeting executive functions and their effects on academic achievement in school-aged children. The review was conducted in accordance with the PRISMA 2020 guidelines for systematic reviews, which emphasize transparency in search procedures, eligibility decisions, screening, and reporting.

2.2 Search Strategy

A systematic literature search was conducted in **Scopus, Web of Science, ERIC, PubMed, and PsycINFO.** The search covered studies published between **2010 and 2025**, a period selected because of the rapid expansion of research on executive functions, self-regulated learning, and school-based cognitive interventions during the last fifteen years. Search terms were organized around three main concepts: executive functions, educational interventions, and academic achievement. The following search string was adapted for each database:

("executive function" OR "executive functioning" OR "working memory" OR "inhibitory control" OR "cognitive flexibility" OR "self-regulation" OR "planning") AND ("educational intervention" OR "school-based intervention" OR "classroom intervention" OR "cognitive training" OR "working memory training" OR "metacognitive instruction" OR "self-regulated learning") AND ("academic achievement" OR "academic performance" OR "learning outcomes" OR "reading" OR "writing" OR "mathematics"). In addition to database searching, the reference lists of relevant review articles and eligible studies were manually examined in order to identify further studies not retrieved through the initial search.

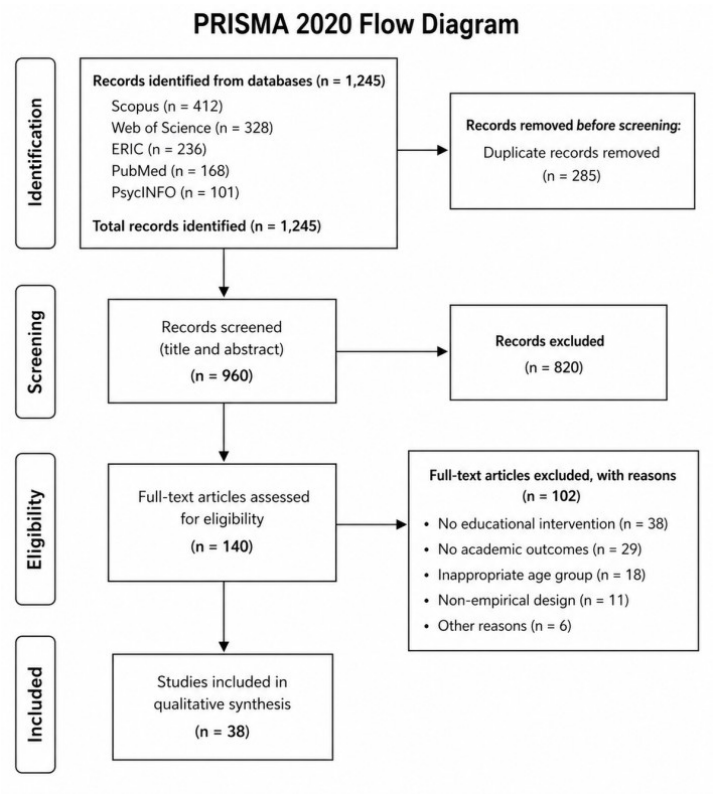

Figure 1. Prisma Flow Diagram

2.3 Eligibility Criteria

Studies were included if they met the following criteria: they were peer-reviewed empirical studies; they involved children or school-aged students; they examined an educational, classroom-based, school-based, cognitive, metacognitive, or technology-assisted intervention targeting one or more executive function components; and they reported at least one academic or learning-related outcome, such as reading, writing, mathematics, classroom performance, or general academic achievement. Studies were excluded if they were theoretical papers, editorials, book chapters, conference abstracts, literature reviews, or meta-analyses; if they focused exclusively on adults; if they examined pharmacological or clinical interventions without an educational component; or if they measured executive functions without reporting academic or learning outcomes.

2.4 Study Selection Procedure

All records identified through the database searches were exported to reference management software, where duplicate records were removed. The remaining titles and abstracts were screened against the predefined eligibility criteria. Studies that appeared potentially relevant were retrieved in full text and assessed for final inclusion. The study selection process followed the PRISMA 2020 flow structure.

The initial search identified **1,245 records** across the selected databases **(Scopus = 412; Web of Science = 328; ERIC = 236; PubMed = 168; PsycINFO = 101)**. After removing **285 duplicate records, 960 records** remained for title and abstract screening. Of these, **820 articles** were excluded because they did not meet the inclusion criteria. A total of **140 full-text articles** were therefore assessed for eligibility. Following full-text screening, **102 studies** were excluded for reasons such as absence of an educational intervention (**n = 38**), lack of academic outcomes (**n = 29**), inappropriate age group (**n = 18**), non-empirical design (**n = 11**), or other methodological reasons (**n = 6**). Finally, **38 studies** met all eligibility criteria and were included in the qualitative synthesis.

2.5 Data Extraction

Data were extracted using a structured extraction framework. For each included study, the following information was recorded: author and year of publication, country, study design, participant characteristics, sample size, age or school level, type of intervention, executive function components targeted, intervention duration, academic outcomes assessed, assessment tools, and main findings. This procedure allowed the studies to be compared across intervention type, executive function domain, academic outcome, and methodological quality.

2.6 Data Synthesis

Because the included studies were expected to vary in intervention design, duration, participant characteristics, and outcome measures, a meta-analysis was not conducted. Instead, a qualitative narrative synthesis was used. Findings were organized according to three main intervention categories: cognitive training interventions, classroom-based educational interventions, and technology-assisted interventions. The synthesis also examined whether improvements were reported mainly in executive function outcomes, academic outcomes, or both. Particular attention was given to the extent to which intervention effects transferred to academic domains such as reading, writing, and mathematics.

2.7 Quality Assessment

The methodological quality of the included studies was assessed using criteria commonly applied in educational intervention research. These criteria included clarity of research design, adequacy of sample description, presence of a control or comparison group, description of the intervention procedure, validity and reliability of outcome measures, appropriateness of statistical analyses, and reporting of limitations.

Studies were not excluded solely on the basis of methodological quality. Overall, the methodological quality of the included studies was considered moderate to high. Common strengths included the use of control groups, validated assessment measures, and clearly described intervention procedures, whereas the most frequent limitations involved small sample sizes and limited follow-up periods. However, quality-related issues were

considered when interpreting the strength of the evidence and drawing conclusions about the effectiveness of executive function interventions.

3. Results

3.1 Overview of the Included Studies

Following the systematic search and screening procedure guided by the PRISMA 2020 framework, the studies meeting the predefined eligibility criteria were included in the final synthesis. The reviewed literature represents a rapidly expanding interdisciplinary body of research examining the role of executive functions in academic development and the effectiveness of educational interventions designed to strengthen executive control processes. Research in this area has increased substantially during the past decade, reflecting growing recognition that executive functioning plays a fundamental role in children's learning, self-regulation, and academic performance (Diamond, 2013; Best et al., 2011; Blair, 2016; Zelazo, 2015; Jacob & Parkinson, 2015). More recent studies have further emphasized the importance of executive functions for school readiness, classroom engagement, and long-term educational outcomes (Ahmed et al., 2019; Spiegel et al., 2021; Zelazo et al., 2021; Cirino et al., 2019). Across the reviewed studies, research was conducted in diverse educational contexts including North America, Europe, Asia, and Australia. Participants primarily consisted of school-aged children, most commonly within primary or elementary school settings, although several studies also included preschool populations or adolescents in lower secondary education (Allan et al., 2014; Cirino et al., 2019; Ahmed et al., 2019). Sample sizes varied substantially, ranging from small experimental interventions with fewer than thirty participants to large school-based studies involving several hundred students (Best et al., 2011; Blair & Raver, 2015; Ahmed et al., 2019). Most studies adopted experimental or quasi-experimental research designs, frequently including control or comparison groups to evaluate intervention effectiveness (Diamond & Lee, 2011; Jacob & Parkinson, 2015; Cirino et al., 2019). Longitudinal and correlational studies were also present in the literature, examining developmental relations between executive functioning and academic performance across multiple years of schooling (Allan et al., 2014; Blair, 2016; Spiegel et al., 2021). The reviewed studies targeted different components of executive functioning, most commonly working memory, inhibitory control, and cognitive flexibility, which are widely considered the core dimensions of executive functioning in developmental and educational research (Diamond, 2013; Zelazo, 2015; Best et al., 2011). Several studies also examined broader aspects of executive control such as planning, organization, and metacognitive regulation (Meltzer, 2018; Spiegel et al., 2021). Academic outcomes assessed across the reviewed studies included reading comprehension, written language performance, mathematical achievement, classroom behavior, and general academic performance (Swanson & Alloway, 2012; Cirino et al., 2019; Ahmed et al., 2019). Despite considerable heterogeneity in research methodologies, intervention design, and outcome measures, three broad categories of interventions consistently emerged across the literature: cognitive training interventions targeting executive function processes, classroom-based instructional interventions designed to strengthen self-regulation and metacognitive skills, and technology-assisted interventions aimed at improving executive functioning and academic outcomes (Diamond & Lee, 2011; Blair & Raver, 2015; Meltzer, 2018; Zelazo et al., 2021).

Study	Country	Participants (Age/Grade)	Study Design	Executive Function Targeted	Intervention Type	Academic Outcomes Assessed	Main Findings
Diamond & Lee (2011)	USA	School-aged children	Review of experimental interventions	Working memory, inhibitory control, cognitive flexibility	Cognitive training	General academic performance	EF training improved executive control and was associated with better academic functioning.
Best et al. (2011)	USA	Elementary school students	Cross-sectional / experimental	Working memory, inhibitory control	Cognitive training	Reading and mathematics	Strong association between EF skills and academic achievement.
Swanson & Alloway (2012)	USA/UK	Primary school students	Experimental intervention	Working memory	Cognitive training	Reading comprehension, mathematics	WM training improved performance in reading and

Study	Country	Participants (Age/Grade)	Study Design	Executive Function Targeted	Intervention Type	Academic Outcomes Assessed	Main Findings
							mathematical reasoning tasks.
Allan et al. (2014)	Canada	Preschool and early primary students	Longitudinal study	Self-regulation, inhibitory control	Classroom-based intervention	School readiness, academic skills	EF development predicted later academic achievement.
Blair & Raver (2015)	USA	Kindergarten students	Randomized controlled trial	Self-regulation, attention	Classroom-based intervention	Reading and mathematics	Integrated EF instruction improved academic performance and classroom engagement.
Alloway & Alloway (2015)	UK	Primary school students	Experimental study	Working memory	Computerized cognitive training	Reading, mathematics	Digital WM training improved cognitive performance and academic outcomes.
Blair (2016)	USA	Elementary school students	Longitudinal study	Self-regulation	Classroom-based intervention	General academic performance	EF development strongly associated with academic success.
Cirino et al. (2019)	USA	Elementary students	Experimental intervention	Working memory, cognitive flexibility	Cognitive training + classroom instruction	Reading and mathematics	Combined EF interventions improved problem solving and academic performance.
Ahmed et al. (2019)	International sample	School-aged children	Experimental intervention	Working memory, attentional control	Technology-assisted training	Reading comprehension	EF training improved learning outcomes and classroom attention.
Spiegel et al. (2021)	USA	Elementary school students	Longitudinal research	Metacognitive regulation, planning	Classroom-based strategies	Reading, writing, mathematics	Metacognitive EF strategies improved academic performance and engagement.
Zelazo et al. (2021)	International	School-aged children	Experimental / intervention	Cognitive flexibility, self-regulation	Classroom-based and digital interventions	Academic achievement	EF interventions integrated into teaching produced improvements in learning outcomes.
Meltzer (2018)	USA	School-aged students	Educational intervention research	Planning, organization, metacognition	Classroom-based strategy instruction	Writing, reading comprehension	EF-focused instructional strategies enhanced learning and self-regulated study skills.

Table 1. Indicative Overview of Included Studies Examining Executive Function Interventions and Academic Outcomes

3.2 Cognitive Training Interventions

A substantial proportion of the reviewed studies examined **cognitive training programs** designed to directly strengthen executive function processes such as working memory, attentional control, and cognitive flexibility. These interventions frequently involved structured tasks requiring students to maintain and manipulate information, inhibit automatic responses, or shift between cognitive strategies. Cognitive training programs were commonly implemented through computerized tasks or structured cognitive exercises designed to repeatedly activate executive control processes (Diamond & Lee, 2011; Alloway & Alloway, 2015). Numerous studies reported improvements in executive function performance following cognitive training interventions, particularly in working memory capacity and attentional control (Alloway & Alloway, 2015; Diamond & Lee, 2011). Improvements in executive functioning were often associated with positive outcomes in academic domains such as reading comprehension, mathematical reasoning, and classroom problem solving (Best et al., 2011; Swanson & Alloway, 2012; Cirino et al., 2019). For example, working memory training programs have been shown to enhance students' ability to maintain relevant information during complex learning tasks, thereby supporting reading comprehension and mathematical performance (Swanson & Alloway, 2012; Ahmed et al., 2019). However, the magnitude and durability of these improvements varied across studies. Some research suggests that cognitive training interventions may produce improvements in executive function performance without consistently generating transfer effects to academic outcomes (Diamond & Lee, 2011; Jacob & Parkinson, 2015). As a result, several scholars have argued that cognitive training may be most effective when combined with educational strategies that explicitly connect executive function skills to academic tasks (Blair & Raver, 2015; Meltzer, 2018).

3.3 Classroom-Based Educational Interventions

Another major group of studies examined **classroom-based interventions** designed to integrate executive function development within everyday instructional practices. These interventions often focused on strengthening students' self-regulation, planning, and metacognitive awareness in authentic learning environments. Instructional approaches included explicit teaching of organizational strategies, goal-setting activities, metacognitive reflection exercises, collaborative learning tasks, and structured classroom routines designed to support attention and behavioral regulation (Meltzer, 2018; Blair & Raver, 2015; Zelazo et al., 2021). Research findings suggest that classroom-based executive function interventions can positively influence students' learning behaviors and academic engagement (Blair, 2016; Allan et al., 2014). Programs that incorporate self-regulated learning strategies have been shown to improve students' ability to manage complex tasks, follow multi-step instructions, and sustain attention during classroom activities (Ahmed et al., 2019; Spiegel et al., 2021). These improvements have frequently been linked to enhanced academic outcomes in reading comprehension, writing performance, and mathematical reasoning (Best et al., 2011; Cirino et al., 2019; Jacob & Parkinson, 2015). Furthermore, classroom-based interventions often produced broader improvements in students' learning motivation, classroom participation, and behavioral regulation. Studies indicate that when executive function development is embedded within instructional practices, students demonstrate improved persistence in challenging tasks and greater use of metacognitive strategies (Blair & Raver, 2015; Meltzer, 2018; Zelazo et al., 2021).

3.4 Technology-Assisted Interventions

A third category of interventions identified in the literature involved **technology-assisted or digital interventions** designed to strengthen executive functioning and support academic learning. These interventions included computerized cognitive training programs, digital learning platforms, and educational software designed to scaffold executive control processes such as working memory and attentional regulation (Alloway & Alloway, 2015; Diamond & Lee, 2011). Technology-assisted interventions frequently incorporate **adaptive learning systems** capable of adjusting task difficulty according to students' performance levels. These systems provide structured practice opportunities and immediate feedback, enabling learners to strengthen executive control processes while simultaneously engaging in academic tasks (Meltzer, 2018; Zelazo et al., 2021). Several studies reported improvements in working memory performance and attentional regulation following digital cognitive training interventions (Alloway & Alloway, 2015; Ahmed et al., 2019). Nevertheless, researchers emphasize that technology alone is unlikely to produce meaningful improvements in academic outcomes without integration into classroom instruction. Studies suggest that the most effective technology-assisted interventions combine digital training with teacher-guided instructional practices that support the transfer of executive skills to academic learning tasks (Blair & Raver, 2015; Cirino et al., 2019).

3.5 Synthesis of Findings

Overall, the reviewed literature consistently indicates that executive function interventions can contribute to improvements in children's academic performance when implemented within educational contexts that support the transfer of cognitive skills to learning tasks. Interventions targeting working memory, inhibitory control, and cognitive flexibility were associated with improvements in reading comprehension, mathematical problem solving, classroom engagement, and self-regulated learning behaviors (Best et al., 2011; Jacob & Parkinson, 2015; Blair, 2016; Ahmed et al., 2019; Cirino et al., 2019). At the same time, the literature reveals substantial heterogeneity in intervention design, duration, outcome measures, and research methodologies. These variations highlight the need for **large-scale, longitudinal research designs** capable of evaluating the long-term educational impact of executive function interventions across diverse educational settings (Blair & Raver, 2015; Zelazo et al., 2021; Spiegel et al., 2021).

4. Discussion

The present systematic review synthesized empirical research examining educational interventions targeting executive functions and their effects on academic achievement in children. The findings confirm a growing body of evidence indicating that executive functions play a central role in learning processes and academic development. Core executive function components—working memory, inhibitory control, and cognitive flexibility—support students' ability to regulate attention, manage complex tasks, monitor performance, and adapt strategies during learning activities (Diamond, 2013; Zelazo, 2015). Consistent with previous research, the studies reviewed in this analysis indicate that stronger executive functioning is associated with higher academic performance across key domains such as reading, writing, and mathematics (Best et al., 2011; Jacob & Parkinson, 2015; Blair, 2016). One of the most important conclusions emerging from the review concerns the relationship between executive functions and academic achievement. Numerous studies have demonstrated that executive functioning predicts academic outcomes independently of general intelligence and socioeconomic factors (Best et al., 2011; Allan et al., 2014; Blair, 2016). Working memory, in particular, has been identified as a strong predictor of reading comprehension and mathematical problem solving, as it enables students to temporarily store and manipulate information during complex cognitive tasks (Swanson & Alloway, 2012; Alloway & Alloway, 2015). Similarly, inhibitory control contributes to students' ability to suppress irrelevant stimuli and maintain task-focused attention in classroom environments (Diamond, 2013). Cognitive flexibility further supports academic learning by allowing students to shift between strategies, integrate new information, and adapt to changing instructional demands (Zelazo, 2015). The consistent associations reported across studies highlight the importance of executive functions as foundational cognitive processes supporting school success.

The review also demonstrates that educational interventions targeting executive functions can lead to measurable improvements in both cognitive regulation and academic performance. Cognitive training programs focusing on working memory, attentional control, and cognitive flexibility were frequently associated with improvements in executive functioning tasks and, in some cases, transfer effects to academic outcomes (Diamond & Lee, 2011; Alloway & Alloway, 2015). For example, structured working memory training programs have been shown to improve students' ability to manage multi-step problem-solving tasks and maintain relevant information during reading and mathematics activities (Swanson & Alloway, 2012). However, the magnitude of transfer effects varies considerably across studies. Some researchers argue that improvements in executive functioning do not always translate directly into improved academic achievement unless the intervention explicitly integrates cognitive skills with academic learning tasks (Jacob & Parkinson, 2015; Best et al., 2011). Another important finding concerns the effectiveness of classroom-based interventions that integrate executive function development within everyday instructional practices. Educational programs that incorporate self-regulated learning strategies, goal-setting activities, and metacognitive reflection have demonstrated positive effects on students' learning behaviors and academic engagement (Blair & Raver, 2015; Meltzer, 2018). These interventions emphasize the importance of teaching students how to plan tasks, monitor their own learning, and regulate attention during classroom activities. Research suggests that interventions embedded within authentic learning contexts may produce stronger and more sustainable improvements than isolated cognitive training programs (Diamond & Lee, 2011; Blair, 2016). Such approaches align with contemporary educational perspectives that emphasize the integration of cognitive and metacognitive skill development within subject-based instruction.

The reviewed studies also highlight the increasing use of digital technologies and computer-based interventions designed to strengthen executive functioning. Technology-assisted programs, including computerized cognitive

training systems and digital learning platforms, offer structured practice environments in which students can repeatedly engage executive control processes (Alloway & Alloway, 2015). These systems frequently incorporate adaptive algorithms that adjust task difficulty based on students' performance, thereby providing individualized learning experiences. Several studies reported improvements in working memory and attentional control following technology-assisted interventions, particularly when digital tools were used in combination with classroom instruction (Diamond & Lee, 2011; Meltzer, 2018). Nevertheless, researchers emphasize that technology alone is unlikely to produce meaningful academic improvements without instructional strategies that support the transfer of cognitive skills to real learning situations. The findings of the review are particularly relevant for students with learning difficulties and neurodevelopmental conditions. Executive function deficits are frequently observed among children with attention-deficit/hyperactivity disorder (ADHD), specific learning disabilities (SLD), and autism spectrum disorder (ASD), and these deficits often contribute to academic underachievement (Barkley, 2015; Diamond, 2013). Educational interventions targeting executive functions may therefore provide important support mechanisms for students experiencing difficulties in self-regulation, task organization, and sustained attention (Meltzer, 2018). Research suggests that structured classroom interventions promoting executive functioning can improve learning engagement and academic outcomes among both typically developing students and those with learning difficulties (Best et al., 2011; Blair & Raver, 2015). Consequently, executive function interventions have significant implications for inclusive education practices, where supporting diverse cognitive profiles is essential for promoting equitable learning opportunities.

Despite the promising findings reported across studies, several methodological limitations were identified within the existing literature. One of the most common limitations concerns the relatively small sample sizes employed in many intervention studies. Small samples may reduce statistical power and limit the generalizability of findings across broader educational populations (Jacob & Parkinson, 2015). In addition, substantial heterogeneity exists across studies in terms of intervention design, duration, instructional context, and outcome measures. Some studies rely primarily on cognitive assessments of executive functioning, while others focus on academic achievement measures such as standardized test scores or classroom performance indicators. This variability makes it difficult to directly compare results across studies and complicates efforts to determine which intervention approaches are most effective. Another limitation relates to the duration and sustainability of intervention effects. Several studies report short-term improvements in executive functioning immediately following training programs, yet fewer investigations examine whether these improvements persist over longer periods or translate into long-term academic gains (Diamond & Lee, 2011; Blair & Raver, 2015). Longitudinal research is therefore necessary to determine whether executive function interventions produce durable changes in cognitive regulation and academic development over time. Furthermore, more research is needed to examine how intervention effectiveness may vary across different age groups, educational contexts, and student populations. Future research should therefore prioritize large-scale randomized controlled trials and longitudinal investigations examining the long-term educational impact of executive function interventions. Interdisciplinary collaboration between cognitive scientists, educational psychologists, and educators may help to develop interventions that more effectively integrate executive function development within classroom instruction. In addition, emerging technologies such as adaptive digital learning systems and artificial intelligence–supported educational tools may offer new opportunities to personalize executive function interventions according to individual learning needs. Understanding how these technological innovations can be integrated with evidence-based instructional practices represents an important direction for future research. Overall, the findings of this review reinforce the central role of executive functions in children's academic development and highlight the potential of educational interventions designed to strengthen these cognitive processes. While the evidence suggests that executive function interventions can positively influence academic outcomes, further research is needed to identify the most effective intervention approaches and to understand how these strategies can be sustainably implemented within real-world educational environments. Recent evidence continues to support the effectiveness of school-based executive function interventions in improving self-regulation, planning, and academic engagement among diverse student populations. Contemporary studies have highlighted the value of structured executive functioning programs delivered within authentic educational settings, particularly for students with neurodevelopmental conditions and learning difficulties (Anthony et al., 2026; Caprì et al., 2026).

5. Future Research Directions

Future research should prioritize longitudinal and experimental studies examining the long-term effects of executive function interventions on academic achievement. Additional attention should be given to the integration of artificial intelligence–supported learning environments and personalized digital interventions for

students with diverse learning needs. Furthermore, more cross-cultural studies are needed to determine the generalizability of current findings across educational systems and socio-cultural contexts.

6. Conclusions

The present systematic review synthesized empirical research examining the relationship between executive functions and academic achievement in children, with particular attention to educational interventions designed to strengthen executive control processes. Across the reviewed studies, a consistent body of evidence indicates that executive functions—including working memory, inhibitory control, and cognitive flexibility—play a central role in children's learning processes and academic development (Diamond, 2013; Best et al., 2011; Blair, 2016; Zelazo, 2015). These cognitive processes support goal-directed behavior, attentional regulation, problem solving, and adaptive learning strategies, all of which are essential for successful engagement in academic tasks (Miyake & Friedman, 2012; Nigg, 2017). The findings of the review indicate that educational interventions targeting executive functions can produce meaningful improvements in both cognitive performance and academic outcomes when implemented within structured educational contexts. Cognitive training programs designed to strengthen working memory and attentional control have demonstrated measurable improvements in executive functioning, although the transfer of these gains to academic achievement varies depending on the design and duration of the intervention (Diamond & Lee, 2011; Karbach & Verhaeghen, 2014; Schwaighofer et al., 2015). In contrast, classroom-based interventions that embed executive function development within instructional practices appear to produce broader and more durable effects on students' learning behaviors and academic engagement (Blair & Raver, 2015; Meltzer, 2018). Recent research further highlights the importance of integrating executive function development into educational environments that promote self-regulated learning and metacognitive awareness. Studies published during the past decade indicate that instructional approaches emphasizing goal-setting, strategic planning, and reflective thinking can significantly enhance students' academic performance in reading, writing, and mathematics (Cirino et al., 2019; Ahmed et al., 2019; Spiegel et al., 2021). These findings support theoretical models suggesting that executive functions operate as foundational cognitive mechanisms that enable learners to manage complex academic demands and regulate their learning processes effectively (Zelazo et al., 2021).

Moreover, emerging evidence from recent studies suggests that executive function development is closely associated with broader socio-emotional competencies such as persistence, motivation, and behavioral self-regulation, which are increasingly recognized as critical factors in educational success (Duckworth et al., 2019; Ahmed et al., 2019). These findings reinforce the view that executive functions should not be conceptualized solely as isolated cognitive processes but rather as integrated components of children's broader self-regulatory systems that support adaptive functioning in academic environments (Blair, 2016; Zelazo, 2015). Despite the promising findings identified in the literature, several limitations remain evident across the reviewed studies. Many interventions rely on relatively short implementation periods or small participant samples, which may limit the generalizability of the reported outcomes (Jacob & Parkinson, 2015; Cirino et al., 2019). Furthermore, substantial heterogeneity exists across studies in terms of intervention design, outcome measures, and methodological approaches, making direct comparison across studies challenging. These methodological variations highlight the need for more standardized evaluation frameworks capable of assessing the long-term impact of executive function interventions on academic achievement. Future research should therefore prioritize large-scale, longitudinal studies examining how executive function interventions influence educational trajectories across different developmental stages and educational contexts. In addition, interdisciplinary collaboration between educational researchers, psychologists, and cognitive scientists will be essential in order to develop theoretically grounded intervention models that effectively integrate executive function training within classroom instruction (Zelazo et al., 2021; Meltzer, 2018). Advances in educational technology and digital learning environments may also provide new opportunities for designing adaptive interventions capable of supporting executive function development in diverse educational settings. In conclusion, the findings of this systematic review underscore the central importance of executive functions in children's academic achievement and highlight the potential of educational interventions designed to strengthen executive control processes. While the evidence indicates that targeted interventions can contribute to improved cognitive and academic outcomes, continued research is required to refine intervention approaches and establish their long-term educational impact. Strengthening executive function development within educational systems may ultimately represent a key strategy for supporting children's learning, self-regulation, and academic success across diverse educational contexts (Diamond, 2013; Blair & Raver, 2015; Zelazo et al., 2021).

7. References

Ahmed, S. F., Kuhfeld, M., Watts, T. W., Davis-Kean, P., Vandell, D. L., & Gershoff, E. T. (2019). Prekindergarten and kindergarten executive function skills predict early academic achievement. *Developmental Psychology, 55*(12), 2551–2563. https://doi.org/10.1037/dev0000824

Allan, N. P., Hume, L. E., Allan, D. M., Farrington, A. L., & Lonigan, C. J. (2014). Relations between inhibitory control and the development of academic skills in preschool and kindergarten. *Journal of Educational Psychology, 106*(3), 735–746. https://doi.org/10.1037/a0037493

Alloway, T. P., & Alloway, R. G. (2015). Understanding working memory: A classroom guide. *SAGE*.

Anthony, L. G., Cannon, L., Kenworthy, L., Wallace, G. L., Luong-Tran, C., & colleagues. (2026). *Addressing disparities: A pragmatic comparative effectiveness trial of two school-based executive functioning interventions for children with autism and/or ADHD. Journal of Occupational Therapy, Schools, & Early Intervention.* Advance online publication. https://doi.org/10.1080/23794925.2026.2633981

Best, J. R., Miller, P. H., & Naglieri, J. A. (2011). Relations between executive function and academic achievement from ages 5 to 17. *Learning and Individual Differences, 21*(4), 327–336. https://doi.org/10.1016/j.lindif.2011.01.007

Blair, C. (2016). Developmental science and executive function. *Current Directions in Psychological Science, 25*(1), 3–7. https://doi.org/10.1177/0963721415622634

Blair, C., & Raver, C. C. (2015). School readiness and self-regulation: A developmental psychobiological approach. *Annual Review of Psychology, 66*, 711–731. https://doi.org/10.1146/annurev-psych-010814-015221

Caprì, T., Catalano, G. B., & Fabio, R. A. (2026). *The Contribution of Executive Functions to Academic Achievement in Gifted Children: A Cross-Sectional Study*. *Journal of Intelligence, 14*(3), 44. https://doi.org/10.3390/jintelligence14030044

Cirino, P. T., Ahmed, Y., Miciak, J., Taylor, W. P., Gerst, E., & Barnes, M. (2019). Executive function: Association with multiple reading skills. *Reading and Writing, 32*, 1819–1846. https://doi.org/10.1007/s11145-018-9924-5

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children. *Science, 333*(6045), 959–964. https://doi.org/10.1126/science.1204529

Duckworth, A. L., Taxer, J. L., Eskreis-Winkler, L., Galla, B., & Gross, J. (2019). Self-control and academic achievement. *Annual Review of Psychology, 70*, 373–399. https://doi.org/10.1146/annurev-psych-010418-103230

Follmer, D. J. (2018). Executive function and reading comprehension. *Educational Psychology Review, 30*, 1–30. https://doi.org/10.1007/s10648-017-9422-6

Gathercole, S. E., & Alloway, T. P. (2008). Working memory and learning: A practical guide for teachers. *SAGE*.

Jacob, R., & Parkinson, J. (2015). The potential for school-based interventions targeting executive function. *Review of Educational Research, 85*(4), 512–552. https://doi.org/10.3102/0034654314561338

Karbach, J., & Verhaeghen, P. (2014). Making working memory work: Executive control training. *Psychological Science, 25*(11), 2027–2037. https://doi.org/10.1177/0956797614548725

Meltzer, L. (2018). *Executive function in education: From theory to practice*. Guilford Press.

Ming, H., Zhang, F., Ren, Y., Jiang, Y., & Huang, S. (2026). *Family socioeconomic status, executive function and children's academic achievement: Gender differences*. *Current Psychology, 45*(4), 423–437. https://doi.org/10.1007/s12144-026-09060-2

Miyake, A., & Friedman, N. P. (2012). The nature and organization of executive functions. *Current Directions in Psychological Science, 21*(1), 8–14. https://doi.org/10.1177/0963721411429458

Morgan, P. L., Farkas, G., Hillemeier, M., & Maczuga, S. (2016). Executive function deficits and academic outcomes. *Journal of Educational Psychology, 108*(3), 425–439. https://doi.org/10.1037/edu0000068

Nigg, J. T. (2017). Annual research review: Self-regulation and executive functioning. *Journal of Child Psychology and Psychiatry, 58*(4), 361–383. https://doi.org/10.1111/jcpp.12675

Peng, P., Barnes, M., Wang, C., Wang, W., Li, S., Swanson, H., Dardick, W., & Tao, S. (2018). Reading and working memory. *Psychological Bulletin, 144*(1), 48–76. https://doi.org/10.1037/bul0000124

Schwaighofer, M., Fischer, F., & Bühner, M. (2015). Does working memory training transfer? *Psychological Research, 79*, 742–765. https://doi.org/10.1007/s00426-015-0654-8

Spiegel, J. A., Goodrich, J. M., Morris, B., Osborne, C., & Lonigan, C. J. (2021). Relations between executive functions and academic outcomes. *Developmental Psychology, 57*(4), 555–569. https://doi.org/10.1037/dev0001152

Swanson, H. L., & Alloway, T. P. (2012). Working memory, learning, and academic achievement. In *APA Educational Psychology Handbook*.

Tominey, S. L., & McClelland, M. M. (2011). Red light, purple light: Executive function intervention. *Early Education and Development, 22*(3), 489–519. https://doi.org/10.1080/10409289.2011.574258

Willoughby, M. T., Magnus, B., Vernon-Feagans, L., & Blair, C. (2017). Developmental relations between executive function and academic achievement. *Child Development, 88*, 181–200. https://doi.org/10.1111/cdev.12615

Zelazo, P. D. (2015). Executive function and the developing brain. *Developmental Review, 38*, 55–68. https://doi.org/10.1016/j.dr.2015.07.001

Zelazo, P. D., & Carlson, S. M. (2012). Hot and cool executive function. *Child Development Perspectives, 6*(4), 354–360. https://doi.org/10.1111/j.1750-8606.2012.00246.x

Zelazo, P. D., Blair, C., & Willoughby, M. (2016). Executive function implications for education. *National Center for Education Research*.

Zelazo, P. D., Carlson, S. M., & Kesek, A. (2021). Development of executive function in childhood. In *Handbook of Child Psychology and Developmental Science*.