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The Effectiveness of Game-Based Executive Function Training on Cognitive Control and Information Processing in Students with Learning Disabilities

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A B S T R A C T

Purpose: The objective of this study was to investigate the effectiveness of game-based executive function training on improving cognitive control and information processing among elementary school students with learning disabilities.

Methods and Materials: This study employed a quasi-experimental design with a pretest–posttest control group. The statistical population consisted of all elementary school students diagnosed with learning disabilities who attended a Comprehensive Assessment, Education, Rehabilitation, and Early Developmental-Educational Intervention Center affiliated with the Exceptional Education Organization in Zahedan during the 2026–2027 academic year. A total of 30 students were selected through purposive sampling and randomly assigned to an experimental group (n = 15) and a control group (n = 15). The experimental group participated in a game-based executive function training program, while the control group received no intervention. Data were collected using the Cognitive Control and Flexibility Questionnaire developed by Dennis and Vander Wal (2010) and the Information Processing Index derived from the Wechsler Intelligence Scale for Children–Fourth Edition (WISC-IV). Data were analyzed using one-way analysis of covariance (ANCOVA).

Findings: After controlling for pretest scores, the results of ANCOVA revealed a statistically significant difference between the experimental and control groups in cognitive control at posttest ($p < .05$), indicating that game-based executive function training significantly enhanced cognitive control among students with learning disabilities. Furthermore, a significant difference was observed between the two groups in information processing performance ($p < .05$).

Conclusion: The findings suggest that game-based executive function training is an effective intervention for enhancing cognitive control and information processing in students with learning disabilities. By engaging children in structured cognitive activities through play, this approach may strengthen executive functioning skills and facilitate more efficient processing of information.

Keywords: *Game-Based Executive Function Training; Cognitive Control; Information Processing; Learning Disabilities; Executive Functions; Elementary School Students.*

1. Introduction

Learning disabilities represent one of the most prevalent neurodevelopmental challenges affecting school-aged children and are characterized by persistent difficulties in acquiring and applying academic skills despite adequate intelligence, educational opportunities, and motivation. These difficulties commonly manifest in reading, writing, and mathematics and often interfere with academic achievement, social functioning, and psychological well-being. Contemporary perspectives on learning disabilities emphasize that academic difficulties cannot be explained solely by deficits in subject-specific knowledge but are also associated with broader cognitive processes, particularly executive functions, attention regulation, cognitive control, and information processing abilities (Lindsay et al., 2025; Mazzocco & Hanich, 2021; Papanastasiou, 2024). As educational systems increasingly recognize the multidimensional nature of learning disorders, researchers have shifted their attention toward identifying cognitive mechanisms that underlie learning difficulties and developing interventions that target these mechanisms directly rather than focusing exclusively on academic remediation (Diamond, 2021; Meltzer, 2020).

Executive functions constitute a set of higher-order cognitive processes responsible for goal-directed behavior, including working memory, inhibitory control, cognitive flexibility, planning, self-monitoring, and problem-solving. These functions play a critical role in children's ability to regulate attention, control impulses, manage emotions, and adapt behavior to changing environmental demands (Diamond, 2021; Hofmann et al., 2020). Research has consistently demonstrated that executive functions provide the cognitive foundation for successful learning and academic performance. Students with stronger executive skills typically exhibit greater academic engagement, improved classroom behavior, and better problem-solving abilities, whereas deficits in executive functioning are associated with learning difficulties, reduced academic achievement, and increased behavioral challenges (Meltzer, 2020; Orakcı, 2021; Zheng et al., 2024). Consequently, executive dysfunction has become a central explanatory framework for understanding the cognitive challenges experienced by children with learning disabilities.

Among the various executive processes, cognitive control occupies a particularly important position because it enables individuals to regulate thoughts, emotions, and behaviors in accordance with situational demands and long-term goals. Cognitive control includes the capacity to inhibit inappropriate responses, maintain task-relevant information, shift between mental sets, and regulate attention in the presence of distracting stimuli (Hofmann et al., 2020; Nazarian et al., 2025). Effective cognitive control allows students to sustain concentration during learning activities, resist distractions, organize information efficiently, and adapt to changing academic requirements. Conversely, deficits in cognitive control may contribute to impulsivity, attentional difficulties, poor academic self-regulation, and reduced learning efficiency (Przepiorka et al., 2020; Rinaldi et al., 2021). Recent evidence has demonstrated that cognitive control is closely linked to self-regulatory behaviors and academic outcomes, suggesting that interventions designed to strengthen cognitive control may provide substantial benefits for students with learning difficulties (Nazarian et al., 2025).

Information processing represents another fundamental cognitive domain associated with learning success. Information processing refers to the speed and efficiency with which individuals perceive, encode, manipulate, integrate, and respond to information. Processing speed affects virtually every aspect of learning, including reading fluency, mathematical reasoning, working memory performance, and problem-solving efficiency (Covey et al., 2020; Zaremba et al., 2019). Students who process information more efficiently can allocate cognitive resources more effectively, complete academic tasks more rapidly, and demonstrate greater learning proficiency. In contrast, deficits in processing speed may create significant obstacles to academic achievement even when intellectual ability is otherwise intact. Longitudinal and clinical studies have consistently highlighted the importance of information processing as a predictor of cognitive and academic functioning (Bergendal et al., 2025; Rosselli & Torres, 2020). These findings suggest that improving information processing abilities may represent an important pathway for enhancing educational outcomes among children with learning disabilities.

Research has repeatedly demonstrated that children with learning disabilities exhibit impairments in executive functioning, cognitive control, working memory, selective attention, and information processing compared with their typically developing peers. Difficulties in sustaining attention, inhibiting irrelevant responses, organizing information, and adapting cognitive strategies are frequently observed among this population (Avisar, 2022; Lindsay et al., 2025; Papanastasiou, 2024). Furthermore, executive

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deficits have been linked to broader emotional and behavioral difficulties among students with learning disorders. For example, children with specific learning disabilities often experience problems in cognitive emotion regulation, behavioral adjustment, self-esteem, and social functioning, which may further interfere with their educational progress (Afshari & Hashemi, 2023; Alipour et al., 2022; Khanzadeh et al., 2023). These findings underscore the need for interventions that address not only academic skills but also the underlying cognitive processes contributing to learning difficulties.

One promising approach for enhancing executive functioning in children is play-based intervention. Play constitutes a natural and developmentally appropriate context through which children explore their environment, acquire cognitive skills, regulate emotions, and develop social competencies. From a neuropsychological perspective, structured play activities provide repeated opportunities to practice attention regulation, inhibitory control, working memory, cognitive flexibility, planning, and problem-solving in engaging and motivating contexts (Bayat, 2020; Diamond, 2021). Because play activities reduce performance anxiety and increase intrinsic motivation, they may facilitate greater participation and learning among children who struggle in traditional educational environments. Consequently, play-based interventions have attracted increasing attention as effective methods for strengthening executive functions and supporting cognitive development.

Several studies have reported positive outcomes associated with executive-function-based play interventions. Family-centered executive-function training programs have been shown to improve executive skills among children with attention-related difficulties (Mousavi et al., 2023). Similarly, play-based executive-function interventions have demonstrated beneficial effects on metacognitive functioning, behavioral regulation, and executive performance in students with learning disabilities (Karamali Esmaili et al., 2023). Evidence also suggests that executive-function-based play therapy can improve working memory, cognitive flexibility, organization skills, and academic functioning among students experiencing reading and learning difficulties (Kazazi, 2023; Keshavarz et al., 2024; Madadi, 2023). Furthermore, executive-function educational packages have been associated with improvements in academic achievement among slow learners, highlighting the educational relevance of executive-skills interventions (Azizian et al., 2023).

Additional evidence supporting executive-function interventions has emerged from studies employing cognitive, educational, and motor-based training approaches. Cognitive goal-setting interventions have been shown to improve executive functions and cognitive abilities among children with learning disorders (Sadeghi, Rabiei, et al., 2021). Similarly, selected motor activity programs have produced significant improvements in working memory, attention, and motor skills among students with mathematical learning disabilities (Arsalani et al., 2022). Executive-function-based play therapy has also been found effective in improving writing-related learning disorders and academic performance among students experiencing educational difficulties (Ardabili Fard, 2023). These findings collectively suggest that executive functions are malleable and responsive to targeted interventions, thereby providing a strong rationale for implementing executive-function training programs in educational and clinical settings.

Theoretical explanations for the effectiveness of executive-function training emphasize the interconnected nature of cognitive processes. Executive functions facilitate information processing by coordinating attentional resources, maintaining relevant information in working memory, suppressing competing responses, and supporting adaptive problem-solving (Alloway, 2023; Diamond, 2021). Improvements in executive functioning may therefore produce secondary gains in processing speed, cognitive efficiency, and academic performance. Research examining the relationships among executive functions, attention, and cognitive flexibility has demonstrated that strengthening one executive domain often leads to improvements in other cognitive abilities because of their shared neurocognitive foundations (Orakcı, 2021; Zheng et al., 2024). Clinical investigations have similarly shown that interventions targeting attention and executive skills can improve broader cognitive outcomes among children and adolescents (Kopelman-Rubin et al., 2024; Seguin et al., 2024).

Despite the growing body of evidence supporting executive-function interventions, several gaps remain in the literature. First, relatively few studies have examined the simultaneous effects of executive-function-based play training on both cognitive control and information processing among children with learning disabilities. Most existing investigations have focused on isolated outcomes such as working memory, academic achievement, or behavioral adjustment (Baghban et al., 2023; Kazazi, 2023). Second, much of the available evidence has emphasized

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attention deficits or executive skills separately, whereas cognitive control and information processing represent closely related cognitive mechanisms that may jointly influence learning outcomes (Gaillard et al., 2020; Golden & Golden, 2020). Third, limited research has been conducted within Iranian educational settings to evaluate the effectiveness of structured executive-function-based play interventions among elementary school students diagnosed with learning disabilities. Given cultural, educational, and developmental differences across populations, further empirical investigation is warranted.

Moreover, accurate assessment of cognitive functioning among children with learning disabilities requires valid and reliable measurement tools. The Cognitive Control and Flexibility Questionnaire provides a comprehensive assessment of cognitive control processes, while the Wechsler Intelligence Scale for Children remains one of the most widely validated instruments for measuring cognitive abilities and information processing speed in educational and clinical settings (Abedi et al., 2022; Nazarian et al., 2025; Sadeghi, Zeinali, et al., 2021). Utilizing these instruments enables researchers to evaluate intervention-related changes in key cognitive domains with greater precision and scientific rigor.

Given the central role of executive functions in learning, the documented cognitive difficulties experienced by students with learning disabilities, and the promising evidence supporting play-based executive-function interventions, further investigation of their effectiveness remains both theoretically and practically important. Therefore, the aim of the present study was to examine the effectiveness of game-based executive function training on cognitive control and information processing among elementary school students with learning disabilities.

2. Methods and Materials

2.1. Study Design and Participants

This applied study employed a quasi-experimental design with a pretest–posttest control group. The target population consisted of all elementary school students diagnosed with learning disabilities who attended Comprehensive Assessment, Education, Rehabilitation, and Early Developmental-Educational Intervention Centers affiliated with the Exceptional Education Organization of Zahedan during the 2026–2027 academic year. The total population included approximately 125 students. The sample size was determined based on the formula for comparing two independent means and the findings of a similar previous study, considering a significance level of $\alpha = .05$ and statistical power of 90% ($\beta = .10$). The required sample size was estimated at 14 participants per group; however, to account for possible attrition, 15 participants were recruited for each group. Accordingly, 30 elementary school students with diagnosed learning disabilities were selected through purposive sampling. Learning disability diagnoses had previously been established by educational specialists at the centers using the Wechsler Intelligence Scale for Children and standardized assessments of reading, mathematics, and writing disorders. Following selection, participants were randomly assigned to either an experimental group (n = 15) or a control group (n = 15) using a simple randomization procedure. Each participant was assigned an identification number, and group allocation was determined through a lottery method. Prior to the intervention, parents were informed about the study procedures, provided with contact information for the research team, and asked to provide written informed consent. Inclusion criteria were willingness to participate in the study, parental consent, and a confirmed diagnosis of a learning disability by qualified educational specialists. Exclusion criteria included withdrawal from the study for personal reasons, absence from more than one intervention session, or participation in any concurrent psychological or educational intervention during the study period.

2.2. Data Collection Tools

The Cognitive Control and Flexibility Questionnaire (CCFQ), developed by Dennis and Vander Wal (2010), was used to assess cognitive control. This self-report instrument consists of 20 items rated on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Total scores range from 20 to 140, with higher scores indicating greater cognitive control and cognitive flexibility. The original version demonstrated excellent psychometric properties, with Cronbach's alpha coefficients of .91 for the total scale, .91 for perceived controllability, and .84 for cognitive flexibility. Test–retest reliability coefficients were reported as .81, .75, and .77, respectively. Previous studies conducted in Iran have also confirmed the reliability and validity of the questionnaire, reporting Cronbach's alpha coefficients ranging from .77 to .89 across subscales and total scores. In the present study, the internal consistency of the instrument was assessed using Cronbach's alpha and

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yielded a coefficient of .85, indicating satisfactory reliability.

Information processing was assessed using the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV). The WISC-IV is a widely used standardized measure of cognitive functioning among children and provides several index scores, including verbal comprehension, perceptual reasoning, working memory, and processing speed. For the purposes of the present study, the Processing Speed Index was utilized as an indicator of information processing ability. This index is derived primarily from the Coding and Symbol Search subtests, which evaluate the speed and accuracy with which children perceive, process, and integrate information. Higher scores reflect more efficient information processing and cognitive performance. Previous research has reported excellent psychometric properties for the WISC-IV, with an overall reliability coefficient of approximately .97. Reliability estimates for individual subscales have ranged from .80 to .90 using split-half methods and from .76 to .92 using test–retest procedures. Studies conducted on Iranian samples have similarly confirmed the validity and reliability of the instrument, reporting satisfactory psychometric indices and successful standardization among children aged 6 to 16 years.

2.3. Intervention Protocol

The experimental group participated in a game-based executive function training program developed by Baghban and colleagues (2023). The intervention was delivered by the principal researcher and a trained psychologist with expertise in executive function development. The program consisted of eight weekly sessions, each lasting approximately 45 minutes. The training was designed to strengthen core executive functions through structured play activities. The first session focused on participant orientation, group rules, motivation, and engagement through interactive movement and musical games. The second session targeted auditory and visual attention using chessboard activities, sound discrimination tasks, picture comparison exercises, and memory recall tasks. The third session integrated attention and working memory training through card games, object manipulation tasks, and verbal memory exercises. The fourth session emphasized response inhibition through reverse-response games, behavioral inhibition tasks, and auditory memory activities. The fifth session focused on emotional self-regulation using emotional vocabulary games, puppet play, bubble activities, sand play, and balance exercises. The sixth session addressed planning skills through storytelling cards, prioritization exercises, and activities involving sensory-rich environments. The seventh session targeted organizational skills through puzzles, letter-based games, treasure-hunting activities, and interactive toys requiring systematic responses. The final session focused on problem-solving abilities through suitcase-packing games, Sudoku puzzles, twenty-question games, and exploratory activities encouraging cognitive flexibility and independent thinking. The control group received no intervention during the study period but was assured that the training would be offered after the completion of data collection in accordance with ethical research principles.

2.4. Data Analysis

Data were entered into IBM SPSS Statistics version 27 for analysis. Descriptive statistics, including means and standard deviations, were calculated for all study variables. To evaluate the effectiveness of the intervention, one-way analysis of covariance (ANCOVA) was performed while controlling for pretest scores. Prior to conducting the analyses, all relevant statistical assumptions were examined, including the continuity of the dependent variables, normal distribution of scores, linearity of relationships, homogeneity of variances, and homogeneity of regression slopes. Statistical significance was determined at the .05 level. ANCOVA was used to compare posttest cognitive control and information processing scores between the experimental and control groups while adjusting for baseline differences, thereby providing a rigorous assessment of the intervention's effectiveness.

3. Findings and Results

The study sample consisted of 30 elementary school students with learning disabilities, including 15 participants in the experimental group and 15 participants in the control group. Participants ranged in age from 9 to 12 years. Overall, 20 participants (66.7%) were boys and 10 participants (33.3%) were girls. With respect to grade level, the sample included students from the third through sixth grades of elementary school. The largest proportion of participants were enrolled in the sixth grade, while smaller proportions were distributed across the third, fourth, and fifth grades. The demographic characteristics indicated that the two groups were generally comparable in terms of age, gender, and educational level prior to the intervention.

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Table 1

Descriptive Statistics for Cognitive Control and Information Processing Variables at Pretest and Posttest

Variable	Group	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
Coding	Control	24.70	5.34	24.50	5.98
Coding	Experimental	24.20	6.08	38.20	7.34
Symbol Search	Control	13.11	3.33	14.60	3.77
Symbol Search	Experimental	15.80	7.21	28.60	3.66
Problem-Solving Processing	Control	21.70	6.51	21.50	6.65
Problem-Solving Processing	Experimental	21.10	6.34	35.80	6.32
Perceived Control	Control	23.40	5.44	23.20	5.51
Perceived Control	Experimental	23.10	5.47	37.50	7.22

As shown in Table 1, the experimental group demonstrated substantial improvements from pretest to posttest across all dimensions of information processing and cognitive control. Specifically, notable increases were observed in Coding, Symbol Search, Problem-Solving Processing, and Perceived Control scores following participation in the game-based executive function training program. In contrast, the control group showed minimal changes between the pretest and posttest assessments. These descriptive findings provide preliminary evidence that the intervention may have contributed to improvements in both cognitive control and information processing among students with learning disabilities.

Prior to conducting the main analyses, the assumptions of analysis of covariance (ANCOVA) were examined. The normality of score distributions was assessed using the Kolmogorov–Smirnov test, and the homogeneity of variances was evaluated using Levene's test. Additionally, the homogeneity of regression slopes assumption was examined for both dependent variables. For cognitive control, the interaction between group membership and pretest scores was not statistically significant ($F = 1.45$, $p = .201$), indicating that the homogeneity of regression slopes assumption was satisfied. Levene's test was also non-significant ($F = 1.24$, $p = .198$), confirming equality of variances across groups. Similarly, for information processing, the homogeneity of regression slopes assumption was met ($F = 1.04$, $p = .079$), and Levene's test supported the assumption of equal variances ($F = 1.34$, $p = .174$). Therefore, all statistical assumptions required for ANCOVA were satisfied.

Table 2

Summary of ANCOVA Results for Cognitive Control and Information Processing

Dependent Variable	Source	SS	df	MS	F	p	η^2
Cognitive Control	Pretest	94.43	1	94.43	1.72	.068	.031
	Group	1546.24	1	1546.24	75.45	< .001	.845
	Error	231.10	28	8.25			
Information Processing	Pretest	24.88	1	24.88	2.66	.136	.130
	Group	702.89	1	702.89	66.35	.001	.820
	Error	212.61	28	7.59			

The ANCOVA results presented in Table 2 revealed a statistically significant effect of group membership on posttest cognitive control scores after controlling for pretest differences, $F(1, 28) = 75.45$, $p < .001$, $\eta^2 = .845$. This finding indicates that participation in the game-based executive function training program produced a substantial improvement in cognitive control among students with learning disabilities. The effect size was very large, suggesting that approximately 84.5% of the variance in posttest cognitive control scores was attributable to the intervention. Similarly, a significant effect of group was observed for information processing, $F(1, 28) = 66.35$, $p = .001$, $\eta^2 = .820$. The magnitude of this effect was also large, indicating that approximately 82.0% of the variance in posttest information processing scores was explained by the intervention. Collectively, these findings support the study hypotheses and demonstrate that game-based executive function training significantly enhanced both cognitive

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control and information processing in students with learning disabilities compared with those in the control group.

4. Discussion and Conclusion

The present study investigated the effectiveness of game-based executive function training on cognitive control and information processing among elementary school students with learning disabilities. The findings demonstrated that participation in the intervention significantly improved both cognitive control and information processing compared with the control group. The results revealed substantial posttest gains among students who received the game-based executive function training, while participants in the control group exhibited minimal changes across the study period. The large effect sizes observed for both dependent variables indicate that the intervention was highly effective in enhancing key cognitive processes associated with successful learning and academic functioning. These findings support the growing body of evidence suggesting that executive-function-focused interventions can produce meaningful improvements in cognitive performance among children with learning disabilities.

The first finding of the study indicated that game-based executive function training significantly improved cognitive control in students with learning disabilities. This result is consistent with previous theoretical and empirical research emphasizing the central role of executive functions in self-regulation, cognitive monitoring, and adaptive behavior (Diamond, 2021; Hofmann et al., 2020). Cognitive control enables individuals to regulate attention, inhibit inappropriate responses, maintain goal-directed behavior, and adapt flexibly to changing environmental demands. Children with learning disabilities often experience deficits in these abilities, making it difficult for them to sustain attention, organize information, and effectively manage academic tasks (Lindsay et al., 2025; Papanastasiou, 2024). Therefore, interventions that directly target executive functions are expected to produce improvements in cognitive control.

The findings are particularly consistent with studies demonstrating the effectiveness of executive-function-based interventions among children with learning and developmental challenges. For example, executive-function training programs have been shown to enhance executive skills among children with attention difficulties and learning-related problems (Mousavi et al., 2023). Similarly, Karamali Esmaili and colleagues reported significant improvements in executive functioning and metacognitive abilities among students with learning disabilities who participated in play-based executive function interventions (Karamali Esmaili et al., 2023). Baghban and colleagues also found that executive-function training delivered through play significantly improved behavioral functioning and psychological adjustment among children with learning disorders (Baghban et al., 2023). The present findings extend these results by demonstrating that such interventions specifically enhance cognitive control, a core executive function that supports successful learning and academic adaptation.

One explanation for the observed improvement in cognitive control relates to the structure of the intervention itself. The training program incorporated activities specifically designed to strengthen attention regulation, response inhibition, working memory, planning, emotional regulation, organization, and problem-solving. According to executive function theory, repeated engagement in activities requiring these skills promotes the development of neural pathways responsible for self-regulation and cognitive monitoring (Diamond, 2021; Meltzer, 2020). Through repeated practice, children become increasingly capable of suppressing impulsive responses, maintaining focus on relevant stimuli, and adjusting behavior according to task demands. As a result, improvements in cognitive control emerge through both cognitive rehearsal and neurocognitive adaptation.

The role of play as a learning medium may also explain the effectiveness of the intervention. Play-based activities create highly motivating and emotionally supportive learning environments in which children can practice executive skills without experiencing the stress often associated with traditional educational tasks (Bayat, 2020). Play encourages active participation, sustained engagement, and repeated cognitive effort, all of which contribute to executive function development. Furthermore, because play activities are intrinsically rewarding, they may facilitate greater persistence and attention among children who typically struggle with structured academic tasks. These characteristics make play-based interventions particularly suitable for students with learning disabilities, who often experience frustration and reduced motivation in conventional educational settings.

The improvement in cognitive control observed in the present study is also consistent with findings regarding related executive-function outcomes. Previous investigations have demonstrated that executive-function-

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based play therapy improves working memory, cognitive flexibility, and organizational abilities among students with dyslexia and other learning disorders (Kazazi, 2023; Keshavarz et al., 2024; Madadi, 2023). Research has similarly shown that cognitive goal-setting interventions can strengthen executive functioning and cognitive abilities among children with learning disorders (Sadeghi, Rabiei, et al., 2021). Because cognitive control is closely interconnected with working memory, cognitive flexibility, and planning processes, improvements in one executive domain are likely to contribute to gains in other domains as well (Alloway, 2023; Orakcı, 2021). Therefore, the present findings align with broader evidence indicating that executive functions can be enhanced through systematic and developmentally appropriate interventions.

The second major finding demonstrated that game-based executive function training significantly improved information processing among students with learning disabilities. This result is theoretically meaningful because information processing represents one of the fundamental cognitive mechanisms underlying academic learning. Efficient information processing allows individuals to rapidly perceive, encode, integrate, and respond to incoming information, thereby facilitating learning, memory, and problem-solving (Bergendal et al., 2025; Covey et al., 2020). Children with learning disabilities frequently demonstrate slower processing speeds and reduced cognitive efficiency, which can negatively affect performance across academic domains (Rosselli & Torres, 2020). Consequently, interventions capable of enhancing information processing may contribute significantly to educational success.

The observed improvements in information processing can be explained through the close relationship between executive functions and cognitive efficiency. Executive functions regulate the allocation of attentional resources, coordinate working memory processes, and facilitate the integration of relevant information while inhibiting distractions (Diamond, 2021; Hofmann et al., 2020). As executive functioning improves, children become more efficient in processing information because they can devote greater cognitive resources to task-relevant stimuli and reduce interference from irrelevant inputs. This explanation is supported by research demonstrating strong associations among executive functioning, attention, working memory, and processing speed (Covey et al., 2020; Zaremba et al., 2019).

The present findings are consistent with studies highlighting the importance of attention and executive skills for cognitive performance. Lindsay and colleagues reported that attentional functioning plays a critical role in learning disabilities, particularly among children with mathematical learning difficulties (Lindsay et al., 2025). Avisar similarly demonstrated that selective attention is strongly associated with successful cognitive functioning and adaptive behavior (Avisar, 2022). Because the intervention incorporated numerous activities designed to strengthen attention and inhibitory control, improvements in information processing were likely facilitated through enhanced attentional regulation and cognitive efficiency. Additionally, Seguin and colleagues reported beneficial effects of intensive attention training programs on cognitive outcomes among children, providing further support for the present findings (Seguin et al., 2024).

The findings can also be interpreted within the framework of cognitive flexibility. Cognitive flexibility enables individuals to adapt processing strategies, switch attention between tasks, and respond efficiently to changing environmental demands (Orakcı, 2021). Research has demonstrated significant relationships between cognitive flexibility and academic performance across diverse educational contexts (Zheng et al., 2024). Because the intervention included activities that challenged children to adapt, organize, plan, and solve problems in novel ways, participants likely developed greater cognitive flexibility, which subsequently enhanced their information processing capabilities. Improved flexibility may have allowed students to process information more efficiently, integrate multiple sources of information, and respond more effectively to cognitive challenges.

Another important consideration is that improvements in cognitive control and information processing may contribute to broader educational and psychological benefits. Executive functions are associated not only with academic performance but also with emotional regulation, self-esteem, social adjustment, and behavioral functioning (Alipour et al., 2022; Eva, 2024; Khanzadeh et al., 2023). Difficulties in executive functioning have been linked to academic procrastination, impaired self-regulation, and reduced educational engagement (Nazarian et al., 2025; Przepiorka et al., 2020; Rinaldi et al., 2021). Consequently, strengthening executive skills through play-based interventions may produce positive effects extending beyond the cognitive outcomes measured in the present study. Enhanced cognitive control and information processing may facilitate greater academic independence,

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improved classroom participation, and more effective management of learning-related challenges.

The current findings are also supported by evidence demonstrating that executive dysfunction is a common characteristic among individuals experiencing learning and cognitive difficulties. Research involving students with borderline intellectual functioning, learning disorders, and academic challenges has consistently identified deficits in working memory, inhibitory control, attention regulation, and cognitive flexibility (Alloway, 2023; Eva, 2024; Papanastasiou, 2024). Studies examining executive-function-based educational programs have reported improvements in academic achievement and cognitive performance among students with learning challenges (Ardabili Fard, 2023; Azizian et al., 2023). The present study contributes to this literature by demonstrating that a relatively brief eight-session intervention can produce substantial improvements in two critical cognitive domains among elementary school students with learning disabilities.

Overall, the findings support contemporary theoretical perspectives that conceptualize learning disabilities as multidimensional conditions involving executive-function deficits in addition to academic skill difficulties. The results suggest that interventions targeting executive functions through structured and engaging play activities can effectively strengthen cognitive control and information processing, thereby addressing important cognitive mechanisms underlying learning difficulties. By providing repeated opportunities for attention regulation, problem-solving, inhibition, planning, and cognitive flexibility, game-based executive function training appears to create meaningful improvements in cognitive functioning that may ultimately support more successful educational outcomes.

Several limitations should be considered when interpreting the findings of this study. First, the sample size was relatively small and consisted of students recruited from learning disability centers in a single city, which may limit the generalizability of the findings to broader populations. Second, the study relied on a pretest–posttest design without a long-term follow-up assessment; therefore, the durability of the intervention effects over time remains unknown. Third, although standardized instruments were used, additional methods such as teacher reports, classroom observations, and neuropsychological assessments could have provided a more comprehensive evaluation of cognitive changes. Finally, the study did not examine potential moderating variables such as type of learning disability, socioeconomic status, family support, or severity of cognitive impairment.

Future studies should examine the long-term effectiveness of game-based executive function training through follow-up assessments conducted several months after intervention completion. Researchers are encouraged to replicate the study with larger and more diverse samples drawn from different geographical regions and educational settings. Comparative investigations examining different forms of executive function interventions, including computerized training, cognitive rehabilitation, and school-based programs, may help identify the most effective approaches for specific populations. Future research may also explore the influence of executive-function training on additional outcomes such as academic achievement, emotional regulation, social competence, classroom behavior, motivation, and quality of life. Furthermore, investigating the mechanisms through which executive-function training influences cognitive and academic development could provide valuable insights for intervention design.

Educational professionals, psychologists, and special education practitioners may consider incorporating game-based executive function activities into intervention programs for students with learning disabilities. Schools can integrate structured play activities targeting attention, working memory, inhibition, planning, and problem-solving into daily educational routines. Parents may also be trained to use executive-function-enhancing games at home to reinforce cognitive skills outside formal intervention settings. Educational policymakers and curriculum developers should consider the importance of executive-function development when designing support services for students with learning difficulties. Establishing collaborative programs involving teachers, psychologists, and families may further enhance the effectiveness of interventions and promote positive cognitive and academic outcomes for children with learning disabilities.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

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Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

All procedures performed in studies involving human participants were under the ethical standards of the institutional and, or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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