KMAN PUBLISHING INSTITUTE
Journal Website

Article history:
Received 13 May 2025
Revised 03 July 2025
Accepted 12 July 2025
Published online 01 September 2025

Psychological Research in Individuals with Exceptional Needs

Volume 3, Issue 3, pp 1-10

E-ISSN: 3060-6713

The Effectiveness of Executive Function Training on the Dimensions of Metacognition in Students with Learning Disabilities

Negin. Bahrami[1], Nooshin. Taghinezhad[1*]

[1] Department of Psychology, BA.C., Islamic Azad University, Bandar Abbas, Iran

*** Corresponding author email address**: nooshintaghinezhad@iau.ac.ir

A r t i c l e I n f o

Article type:
Original Research

How to cite this article:
Bahrami, N., & Taghinezhad, N. (2025). The Effectiveness of Executive Function Training on the Dimensions of Metacognition in Students with Learning Disabilities. *Psychological Research in Individuals with Exceptional Needs, 3*(3), 1-10.
https://doi.org/10.61838/kman.prien.3.3.7

A B S T R A C T

This study aimed to investigate the effectiveness of executive function training on improving the dimensions of metacognition—positive beliefs about worry, thought controllability, cognitive uncertainty, need to control thoughts, and cognitive self-consciousness—among elementary students with specific learning disabilities in Bandar Abbas. This quantitative study employed a semi-experimental pretest–posttest design with a control group and a two-month follow-up. The statistical population included all elementary school students with learning disabilities in Bandar Abbas during the 2024–2025 academic year. Thirty students from the fifth and sixth grades were purposefully selected and randomly assigned to experimental and control groups (15 students each). The experimental group received ten sessions of executive function training, focusing on planning, self-monitoring, reflection, and cognitive flexibility, while the control group received no intervention. Data were collected using the Wells Metacognition Questionnaire (MCQ-30) and analyzed using descriptive statistics and multivariate covariance analysis (MANCOVA) with SPSS version 22. The results of MANCOVA showed a significant multivariate effect of the group on the combined metacognitive variables (Wilks' Lambda = 0.461, F = 4.440, p = 0.008, η^2 = 0.539). Univariate analyses indicated significant group differences in all metacognitive subscales at the posttest stage: positive beliefs about worry (F = 10.898, p = 0.003, η^2 = 0.322), thought controllability (F = 6.335, p = 0.019, η^2 = 0.216), cognitive uncertainty (F = 4.987, p = 0.036, η^2 = 0.178), need to control thoughts (F = 9.688, p = 0.005, η^2 = 0.296), and cognitive self-consciousness (F = 5.892, p = 0.023, η^2 = 0.204). Executive function training significantly enhanced metacognitive abilities in students with learning disabilities, improving their self-regulation, cognitive control, and reflective awareness. Integrating such interventions into educational programs may promote cognitive flexibility and academic adaptation in children with learning challenges.

Keywords: *Executive function training; Metacognition; Learning disabilities; Cognitive regulation; Self-awareness*

1. Introduction

Learning disabilities represent a significant challenge in childhood education, often characterized by deficits in executive functions, attention regulation, and metacognitive awareness, which collectively hinder academic performance and adaptive learning (Khan & Lal, 2023). Executive functions—encompassing cognitive flexibility, inhibitory control, and working memory—play a pivotal role in managing complex cognitive tasks, emotional responses, and goal-directed behaviors (Drigas & Karyotaki, 2019). In students with specific learning disorders, deficits in these functions often manifest as poor self-regulation, disorganized thinking, and difficulty in planning and monitoring learning processes (Baniasadi, 2024). Consequently, interventions that aim to strengthen executive functions and metacognitive skills have become central to educational and clinical efforts targeting cognitive and academic rehabilitation in this population (Davoodi et al., 2023).

Executive function training focuses on the enhancement of higher-order cognitive processes that enable individuals to plan, initiate, monitor, and adapt their behavior in dynamic environments (Fernandez-Duque et al., 2000). In neurocognitive frameworks, these skills are considered the control mechanisms that regulate other mental functions, forming the foundation for metacognitive processes such as self-awareness and strategic learning (Roebers, 2017). According to Fernandez-Duque and colleagues, executive attention acts as a supervisory system integrating metacognitive regulation with goal-oriented control (Fernandez-Duque et al., 2000). Similarly, Roebers proposed a unified framework in which executive functioning and metacognition represent two sides of cognitive self-regulation—one operational, managing mental activities in real time, and the other reflective, monitoring and evaluating cognitive performance (Roebers, 2017). When these regulatory systems malfunction, as in the case of students with learning disabilities, the capacity to monitor comprehension, correct mistakes, and apply problem-solving strategies diminishes dramatically (Khan & Lal, 2023).

Emerging research underscores that impaired executive functioning is closely tied to difficulties in metacognitive control, contributing to reduced academic motivation, poor attention span, and maladaptive emotional reactions (Cécillon et al., 2024). Cécillon et al. demonstrated that the interaction between executive dysfunctions and maladaptive metacognitive beliefs can exacerbate anxiety and impair emotion regulation, both of which influence academic achievement. These findings emphasize the interconnectedness of emotional and cognitive regulation systems in the learning process. Kraft et al. further confirmed that dysfunctional metacognitive beliefs, such as negative assumptions about one's ability to control thoughts, are associated with diminished executive control, suggesting a reciprocal influence between these domains (Kraft et al., 2017). This reciprocal relationship is central to understanding how metacognitive training can enhance executive regulation, as improved self-reflection and monitoring can strengthen task persistence and error correction.

Interventions designed to improve executive functions have shown considerable promise in enhancing academic performance and adaptive functioning in children with neurodevelopmental and learning disorders. For instance, Tamm et al. developed a metacognitive executive function training program for children with ADHD, which yielded significant improvements in attention regulation and working memory performance (Tamm et al., 2012). Similarly, Saleh Al Rasheed and Hanafy examined brain-based instruction strategies aimed at stimulating executive circuits and observed measurable gains in cognitive flexibility and habits of mind among children at risk for learning disabilities (Saleh Al Rasheed & Hanafy, 2023). These interventions often emphasize core elements of executive training—goal setting, monitoring, reflection, and cognitive restructuring—thereby enabling children to gain better control over their learning processes and responses to academic challenges (Drigas & Karyotaki, 2019).

Within the context of learning disabilities, the relationship between executive function and metacognition becomes especially critical. Students with specific learning disorders frequently display difficulties in initiating strategies, sustaining effort, and evaluating task outcomes (Khan & Lal, 2023). Research by Kokabi Rahman and colleagues demonstrated that instruction focused on cognitive and metacognitive strategies significantly improved academic motivation and engagement in students with learning disabilities, supporting the premise that interventions targeting both executive and metacognitive components can foster meaningful cognitive and behavioral improvements (Kokabi Rahman et al., 2023). Similarly, Esmaeilian Anvar et al. found that a lateral dominance enhancement training program led to significant improvement in executive functions and visual perception in

E-ISSN: 3060-6713

children with specific learning disorders, highlighting the neuroplastic potential of structured executive training in this group (Esmaeilian Anvar et al., 2024).

From a cognitive neuroscience perspective, executive functions and metacognition share overlapping neural substrates, particularly within the prefrontal cortex, anterior cingulate cortex, and parietal regions (Haugen et al., 2023). Haugen et al. observed that targeted metacognitive strategy training produced measurable changes in executive functioning among individuals at risk for psychosis, suggesting that cognitive regulation mechanisms can be strengthened through structured interventions. Likewise, neuropsychological research shows that deficits in executive functioning in learning-disabled children often result from underactivation in these same cortical networks, leading to impaired working memory and inhibitory control (Barua et al., 2020). Training interventions that stimulate prefrontal activity through repetitive cognitive tasks and strategic thinking exercises have been found to restore regulatory balance and enhance metacognitive awareness, thus facilitating better academic performance (Babaei et al., 2024).

Empirical findings support the idea that improvements in executive functions can lead to enhanced metacognitive performance, which, in turn, influences emotional well-being and cognitive endurance. Babaei et al. employed a hybrid SEM–ANN model to demonstrate that theory of mind mediates the relationship between executive functioning and emotional burnout, highlighting the complexity of the cognitive–affective interface (Babaei et al., 2024). Similarly, Lievore's work on children with autism and learning disorders revealed that deficits in executive functioning negatively affect the ability to recognize emotions from facial cues, which can further impair social cognition and emotional regulation (Lievore, 2024). These findings indicate that executive function training not only benefits cognitive performance but also contributes to the development of emotional intelligence and adaptive social behavior.

In educational settings, promoting metacognitive skills has been recognized as an effective strategy to enhance learning outcomes and self-efficacy. Zhou et al., through a meta-analytical study, found that metacognitive interventions significantly reduce procrastination and increase goal-directed academic behavior (Zhou et al., 2022). Similarly, Baniasadi's research highlighted that children with higher physical activity levels exhibit better executive function and working memory, suggesting that executive capacity can be strengthened through multimodal approaches combining cognitive, behavioral, and physical elements (Baniasadi, 2024). Furthermore, Davoodi et al. compared the effects of metacognitive versus executive training in patients with coronary artery disease and found that both modalities enhanced biological markers of self-regulation, reinforcing the idea that these cognitive domains are mutually reinforcing (Davoodi et al., 2023).

The theoretical foundation of the present study rests on the integrative model of executive function and metacognition, which conceptualizes these processes as hierarchical systems of cognitive regulation (Roebers, 2017). Executive functions are responsible for initiating and coordinating actions, while metacognition provides the reflective capacity to monitor and adjust those actions based on performance feedback (Fernandez-Duque et al., 2000). This dual-level framework supports the design of interventions that train both awareness and regulation, ensuring that students can consciously manage cognitive challenges and develop adaptive strategies for academic success (Drigas & Karyotaki, 2019).

The city of Bandar Abbas, with its diverse educational context, offers an appropriate setting for applying such interventions to address the challenges faced by students with specific learning disabilities. Given the increasing recognition of executive dysfunction and metacognitive deficits as key determinants of learning difficulties, designing evidence-based educational interventions becomes a national and pedagogical priority (Davoodi et al., 2023). The current study aims to assess the effectiveness of an executive function training program in improving various dimensions of metacognition—positive beliefs about worry, thought controllability, cognitive uncertainty, need to control thoughts, and cognitive self-consciousness—among students with learning disabilities.

2. Methods and Materials

2.1. Study Design and Participants

This research employed a quantitative semi-experimental design using a pretest-posttest framework with a control group and a two-month follow-up assessment. The independent variable was executive function training, which was administered exclusively to the experimental group, while its effects were evaluated through posttest and follow-up scores. The statistical population consisted of all elementary school students with specific learning disabilities in Bandar Abbas during the 2024–2025 academic year. The

E-ISSN: 3060-6713

sampling method was purposive and non-probabilistic, as the study aimed to examine the impact of executive function training among students formally diagnosed with learning disabilities.

The sampling process began with official coordination with the Department of Exceptional Education in Bandar Abbas and formal authorization from relevant educational authorities. Learning disorder centers willing to cooperate were identified, and one center was purposefully selected as the research site. After obtaining consent from administrators and parents, 30 students from the fifth and sixth grades were randomly chosen and equally divided into an experimental group and a control group, each containing 15 participants. In the first session, the researcher introduced the research objectives and procedures to the participants, followed by the administration of a pretest for both groups. Subsequently, the experimental group received structured executive function training sessions, while the control group did not receive any intervention. Upon completion of the training period, a posttest was conducted for both groups, and their pretest and posttest scores were compared to evaluate the intervention's impact.

Participants included only students who met specific inclusion criteria: a stable learning disorder in one or more academic domains such as reading, writing, or mathematics for at least six months; significant impairment in academic achievement that interfered with school performance or daily functioning; and the absence of intellectual disabilities, visual or auditory impairments, psychiatric disorders, neurological conditions, language or dialectal differences, or lack of access to adequate education. Additional inclusion criteria required an official diagnosis of a specific learning disorder based on DSM-5 standards, verified by a clinical psychologist at the respective center, and written parental consent for participation. Exclusion criteria included missing more than three training sessions (with tardiness exceeding 30 minutes considered an absence) and the presence of psychological disorders diagnosed by a clinical psychologist.

2.2. *Measures*

The principal instrument used for data collection was the Wells Metacognition Questionnaire (MCQ-30), developed by Wells in 1997. This 30-item self-report scale assesses individuals' beliefs about their thinking processes across five dimensions. Responses are rated on a four-point Likert scale ranging from 1 (do not agree) to 4 (agree very much). The subscales include positive beliefs about worry (items 1, 7, 10, 19, 23, 28), negative beliefs about uncontrollability and danger of thoughts (items 2, 4, 9, 11, 15, 21), cognitive confidence (items 8, 14, 17, 24, 26, 29), need to control thoughts (items 6, 13, 20, 22, 25, 27), and cognitive self-consciousness (items 3, 5, 12, 16, 18, 30). Higher scores on each subscale reflect stronger metacognitive beliefs within that dimension. In previous studies, Wells and Cartwright-Hatton (2004) reported Cronbach's alpha reliability coefficients ranging from 0.76 to 0.93 for the total scale and its subscales, with test-retest reliability reported as 0.75 overall and between 0.59 and 0.87 for the subscales. In Iranian samples, the overall Cronbach's alpha coefficient has been reported at 0.91, indicating excellent internal consistency. Subscale reliability coefficients for uncontrollability, positive beliefs, cognitive awareness, cognitive confidence, and need to control thoughts were 0.87, 0.86, 0.81, 0.80, and 0.71 respectively, confirming the instrument's cultural and psychometric validity for the local context. The questionnaire was administered as both a pretest and posttest to all participants under standard conditions in a quiet classroom setting, with the researcher available to clarify any questions.

2.3. *Intervention*

The intervention consisted of ten structured training sessions designed to enhance executive functions and metacognitive abilities among students with learning disabilities. In the first session, students were introduced to the researcher, the purpose of the program, and the importance of metacognitive strategies and working memory, explained in simple terms suitable for their age. The second session began with a review of the previous lesson, followed by a discussion of the students' personal and academic challenges. Two core metacognitive steps were introduced: pausing to think about a problem and identifying the nature of the situation, illustrated with practical examples such as difficulties in understanding a lesson or managing anger toward classmates. The third session expanded on steps three and four—generating possible solutions and predicting their outcomes—using examples related to planning daily tasks, speaking in groups, and reviewing class content. The fourth session introduced steps five and six, focusing on understanding others' feelings and linking past experiences to new situations, with examples of appropriate classroom behavior. The fifth session emphasized the seventh step, teaching students to

E-ISSN: 3060-6713

revise or change their approach when unsuccessful, followed by a comprehensive review of all previous steps. The sixth session shifted focus to working memory enhancement through rehearsal, mental repetition, and grouping strategies, supported by visual materials and memory exercises. In the seventh session, students practiced visualization techniques to strengthen memory retention by associating words and images, along with concentration exercises such as counting backward from twenty. The eighth session involved categorization and grouping activities to facilitate information storage and retrieval, including memory card games and numerical sequencing tasks. The ninth session concentrated on improving attention and observation skills through the description of objects and environments to develop cognitive awareness. Finally, the tenth session was devoted to reviewing, integrating, and consolidating all learned strategies, ensuring that students could apply executive function and metacognitive techniques independently in their academic and personal contexts.

2.4. Data Analysis

Data analysis was performed using both descriptive and inferential statistical methods. Descriptive statistics, including mean, standard deviation, frequency, and percentage, were used to summarize demographic and baseline characteristics of participants as well as pretest and posttest score distributions. Inferential analysis involved covariance analysis (ANCOVA) to test the main research hypotheses and to determine whether the intervention produced significant differences between the experimental and control groups after adjusting for pretest scores. Prior to conducting ANCOVA, the assumptions of homogeneity of variances and linear relationships were tested using Levene's test to ensure statistical validity.

All data were analyzed using SPSS software version 22. Effect sizes were computed to estimate the magnitude of training impact on metacognitive dimensions. In addition to the posttest comparison, a follow-up assessment was conducted two months after the posttest to examine the persistence of training effects over time. The use of both posttest and follow-up measures allowed for evaluating not only immediate improvements but also the durability of executive function training outcomes in students with learning disabilities.

3. Findings and Results

The findings of the present study aim to evaluate the effectiveness of executive function training on the metacognitive dimensions of students with learning disabilities. Descriptive statistics were first used to summarize the mean and standard deviation scores of both the experimental and control groups in the pretest and posttest stages. Table 1 presents the descriptive results of all metacognitive variables—positive beliefs about worry, thought controllability, cognitive uncertainty, need to control thoughts, and cognitive self-consciousness—across both measurement stages for each group.

Table 1

Descriptive Statistics of Metacognition Scores at Pretest and Posttest for Experimental and Control Groups

Group	Variable	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
Control	Positive beliefs about worry	11.53	3.998	11.93	4.061
Control	Thought controllability	13.47	3.357	13.93	3.127
Control	Cognitive uncertainty	12.43	3.461	12.94	3.497
Control	Need to control thoughts	10.53	3.270	10.89	2.960
Control	Cognitive self-consciousness	10.13	3.420	9.73	2.939
Control	Total metacognition	58.10	7.683	59.43	8.808
Experimental	Positive beliefs about worry	12.27	3.173	15.20	3.098
Experimental	Thought controllability	13.80	3.509	16.60	3.112
Experimental	Cognitive uncertainty	11.98	4.309	14.39	3.969
Experimental	Need to control thoughts	10.87	2.722	13.80	2.757
Experimental	Cognitive self-consciousness	9.60	3.225	12.20	3.895
Experimental	Total metacognition	58.51	5.995	72.19	7.772

The descriptive results in Table 1 show that the mean scores of all metacognitive dimensions increased in the experimental group after receiving executive function training, while the control group showed minimal changes between pretest and posttest. Specifically, the largest posttest improvements were observed in positive beliefs about worry (from 12.27 to 15.20), thought controllability (from 13.80 to 16.60), and total metacognition (from 58.51

E-ISSN: 3060-6713

to 72.19). In contrast, the control group exhibited only negligible increases, such as in total metacognition (from 58.10 to 59.43). These results indicate that the executive function training program effectively enhanced students' metacognitive abilities across all components, suggesting improved awareness, regulation, and control of cognitive processes as a result of the intervention.

Before conducting the main inferential analysis, the statistical assumptions underlying the use of covariance analysis (ANCOVA) were carefully examined to ensure the validity of the results. The normality of the data distribution for all metacognitive variables was assessed using the Kolmogorov–Smirnov test, which confirmed that the data were approximately normally distributed in both groups at the pretest and posttest stages. The assumption of homogeneity of variances was verified through Levene's test, indicating no significant differences in variance between the experimental and control groups across the dependent variables, thus confirming equality of variances. In addition, the assumption of homogeneity of regression slopes was examined and found to be satisfied, demonstrating that the relationship between pretest and posttest scores was consistent across groups. Furthermore, the linearity assumption between covariate (pretest scores) and dependent variable (posttest scores) was confirmed through scatterplot inspection. These diagnostic tests collectively verified that the data met the essential assumptions required for conducting ANCOVA, ensuring the robustness and reliability of the subsequent inferential analysis.

Table 2

Results of Multivariate Covariance Analysis (MANCOVA) for Comparing Metacognitive Dimensions between Experimental and Control Groups

Effect	Test	Value	F	df Effect	df Error	Sig.	Effect Size
Group	Pillai's Trace	0.539	4.440	5	19	0.008	0.539
	Wilks' Lambda	0.461	4.440	5	19	0.008	0.539
	Hotelling's Trace	1.168	4.440	5	19	0.008	0.539
	Roy's Largest Root	1.168	4.440	5	19	0.008	0.539

The results of the multivariate analysis of covariance (Table 2) showed a statistically significant multivariate effect of the group factor on the combined metacognitive variables, as indicated by all four multivariate test criteria (Pillai's Trace = 0.539, Wilks' Lambda = 0.461, Hotelling's Trace = 1.168, Roy's Largest Root = 1.168; F = 4.440, p = 0.008). These results suggest that, collectively, the executive function training program produced a significant overall improvement in the dimensions of metacognition compared to the control group.

Table 3

Tests of Between-Subjects Effects for Comparing Metacognitive Dimensions between Experimental and Control Groups at Posttest

Variable	Source	Sum of Squares	df	Mean Square	F	Sig.	Effect Size
Positive beliefs about worry	Between groups	57.102	1	57.102	10.898	0.003	0.322
	Error	120.509	23	5.240			
Thought controllability	Between groups	42.045	1	42.045	6.335	0.019	0.216

The univariate between-subjects analyses presented in Table 3 further clarified the specific dimensions affected by the intervention. Significant differences were observed between the experimental and control groups in all five dimensions of metacognition at the posttest stage: positive beliefs about worry ($F = 10.898$, $p = 0.003$, $\eta^2 = 0.322$), thought controllability ($F = 6.335$, $p = 0.019$, $\eta^2 = 0.216$), cognitive uncertainty ($F = 4.987$, $p = 0.036$, $\eta^2 = 0.178$), need to control thoughts ($F = 9.688$, $p = 0.005$, $\eta^2 = 0.296$), and cognitive self-consciousness ($F = 5.892$, $p = 0.023$, $\eta^2 = 0.204$). The reported effect sizes indicate that the largest impacts were found for positive beliefs about worry and need to control thoughts, suggesting that the training substantially improved students' adaptive metacognitive regulation. Overall, these findings confirm that the executive function training significantly enhanced all measured aspects of metacognition among students with learning disabilities, thereby supporting the main hypothesis of the study.

E-ISSN: 3060-6713

4. Discussion and Conclusion

The purpose of this study was to examine the effectiveness of executive function training on the metacognitive dimensions of students with learning disabilities in Bandar Abbas. The findings demonstrated that the intervention significantly improved students' overall metacognitive performance, as reflected in increased posttest scores across all dimensions—positive beliefs about worry, thought controllability, cognitive uncertainty, need to control thoughts, and cognitive self-consciousness. The multivariate analysis of covariance confirmed a strong overall group effect, suggesting that executive function training had a substantial impact on cognitive self-regulation and reflective awareness. This outcome supports the growing body of literature indicating that executive function enhancement can lead to broad improvements in metacognitive processes and academic self-management (Fernandez-Duque et al., 2000; Roebers, 2017).

The significant increase in total metacognition scores following the intervention implies that training executive functions fosters better planning, monitoring, and evaluation of thinking processes. These findings are consistent with theoretical models positing a hierarchical relationship between executive functions and metacognition, where the former provides the operational control necessary for implementing the latter (Roebers, 2017). Fernandez-Duque and colleagues emphasized that executive attention serves as the supervisory system through which individuals regulate their thought processes and emotional states (Fernandez-Duque et al., 2000). Similarly, Kraft et al. argued that dysfunctional metacognitive beliefs are often associated with diminished executive control, while improvement in one domain can catalyze the development of the other (Kraft et al., 2017). In this study, the observed improvements in metacognitive beliefs such as thought controllability and cognitive self-consciousness suggest that executive function training enhances the ability to reflect on, monitor, and modify one's cognitive strategies during learning activities.

One of the most notable findings of this research was the substantial increase in positive beliefs about worry and thought controllability in the experimental group compared to the control group. This result may reflect the capacity of executive function training to reduce cognitive rigidity and improve flexible thinking. According to Cécillon et al., there is a strong interrelation between metacognitive beliefs, emotional regulation, and executive control, where improvements in executive functioning can mitigate maladaptive beliefs about cognition and anxiety (Cécillon et al., 2024). The training sessions in the present study emphasized pausing, reflecting, evaluating possible outcomes, and modifying problem-solving approaches—core skills that foster cognitive flexibility and self-regulation. These mechanisms likely helped students reinterpret their worries and manage thought patterns more effectively, which explains the observed enhancement in adaptive metacognitive beliefs. Similar effects have been reported in neurocognitive studies, where executive function interventions were found to improve not only cognitive monitoring but also emotional regulation and resilience (Haugen et al., 2023).

Moreover, the significant improvement in the "need to control thoughts" and "cognitive self-consciousness" subscales indicates that executive function training promotes both awareness and acceptance of cognitive experiences. Drigas and Karyotaki emphasized that executive functioning and problem-solving share a bidirectional relationship, such that enhancement of one strengthens the other, leading to improved reflective awareness (Drigas & Karyotaki, 2019). Through guided reflection, goal setting, and cognitive monitoring exercises, participants in this study were likely able to internalize strategies for managing distractions, sustaining attention, and evaluating their mental performance. This aligns with the findings of Tamm et al., who demonstrated that metacognitive executive function training significantly improved working memory and attention regulation in children with ADHD (Tamm et al., 2012). The overlap between attention control and metacognitive monitoring may explain why students in the experimental group exhibited sustained gains across multiple cognitive domains.

The improvement in cognitive uncertainty observed among the participants reflects enhanced cognitive confidence—a key marker of metacognitive growth. In learning-disabled students, uncertainty often stems from a lack of self-efficacy and poor strategy awareness (Khan & Lal, 2023). The structured intervention in this study, which emphasized repeated reflection and problem-solving tasks, appears to have strengthened students' confidence in their cognitive processes. This finding is supported by Kokabi Rahman et al., who found that teaching cognitive and metacognitive strategies improved academic motivation and engagement in students with specific learning disorders (Kokabi Rahman et al., 2023). Likewise, Esmaeilian Anvar et al. observed that targeted training programs designed to enhance lateral dominance significantly improved executive

E-ISSN: 3060-6713

functioning and perceptual processing in children with learning disorders (Esmaeilian Anvar et al., 2024). Together, these studies reinforce the notion that structured executive training can foster both confidence and competence in cognitive regulation.

The results of the current study also contribute to the understanding of how executive function training impacts the emotional and motivational aspects of learning. Positive beliefs about worry and thought controllability are strongly related to the learner's perception of control over academic challenges. According to Saleh Al Rasheed and Hanafy, interventions that stimulate executive circuits through brain-based instruction can strengthen habits of mind and self-regulatory capacity in children at risk for learning disabilities (Saleh Al Rasheed & Hanafy, 2023). This parallels the outcomes of the present study, where the inclusion of reflection and self-assessment tasks may have enhanced participants' emotional regulation, helping them perceive learning challenges as manageable rather than overwhelming. Barua et al. similarly demonstrated that adolescents with obsessive-compulsive disorder who underwent metacognitive and executive control training exhibited reduced intrusive thinking and improved thought management strategies (Barua et al., 2020). Therefore, the observed gains in metacognitive beliefs among the current participants likely reflect a more adaptive balance between cognitive control and emotional processing.

Another important dimension of these results lies in the developmental relationship between executive functions and metacognition across the lifespan. Roebers proposed that executive and metacognitive processes develop interdependently, with improvements in working memory, inhibition, and cognitive flexibility leading to enhanced self-regulation and awareness (Roebers, 2017). The significant gains observed in the present study among primary school children indicate that these processes can be cultivated effectively at an early age, particularly through structured cognitive training. Baniasadi's research supports this developmental perspective, showing that children with higher levels of physical activity—a factor known to strengthen executive control—also exhibit better metacognitive performance (Baniasadi, 2024). Similarly, Davoodi et al. found comparable effects of both executive and metacognitive training on biological markers of self-regulation in adults, implying that these cognitive domains are mutually reinforcing across different populations (Davoodi et al., 2023).

Furthermore, the results of this study underscore the neurocognitive mechanisms linking executive function enhancement and metacognitive development. Haugen et al. highlighted that metacognitive strategy training modulates neural circuits associated with executive control, resulting in sustained cognitive improvements (Haugen et al., 2023). Such findings align with the assumption that the repetitive engagement of executive circuits during training sessions promotes synaptic efficiency in prefrontal regions, which in turn supports self-monitoring and reflective awareness. Lievore's recent study further elaborates on this neural association, showing that deficits in executive functioning hinder emotion recognition and social cognition among individuals with learning and developmental disorders (Lievore, 2024). In this context, the current study's findings suggest that executive function training contributes not only to academic performance but also to emotional and interpersonal competence through strengthened metacognitive processes.

The current results also resonate with recent findings that link theory of mind and executive functions as key mediators of adaptive learning and emotional adjustment. Babaei et al. demonstrated through a structural equation and neural network model that theory of mind mediates the relationship between executive functioning and emotional burnout (Babaei et al., 2024). This conceptual link supports the idea that executive function training indirectly enhances emotional self-regulation and social cognition, both of which are vital for students with learning disabilities. In the same vein, Zhou et al. showed that metacognitive awareness serves as a protective factor against procrastination and self-doubt, promoting goal-directed behavior in academic settings (Zhou et al., 2022). By fostering conscious reflection on thought processes and behavioral outcomes, the executive function training in the present study likely empowered students to approach learning tasks more proactively and confidently.

Overall, the convergence of findings across studies suggests that executive function training has a multidimensional influence on cognition, emotion, and behavior. The significant improvement in all five metacognitive subscales in this study mirrors earlier evidence that executive interventions can yield holistic cognitive gains. These outcomes reinforce Roebers's integrative framework of cognitive self-regulation, which proposes that metacognition and executive control operate as complementary systems facilitating adaptive learning (Roebers, 2017). The training model applied here—focusing

E-ISSN: 3060-6713

on reflection, self-monitoring, emotional awareness, and behavioral adjustment—successfully operationalized this theoretical model in a practical educational context.

Despite its promising results, this study has several limitations that should be acknowledged. The sample size was relatively small and limited to a single city (Bandar Abbas), which restricts the generalizability of the findings to broader populations. Additionally, the use of a quasi-experimental design with non-randomized group assignment may have introduced selection bias despite matching procedures. The reliance on self-report measures, such as the Wells Metacognition Questionnaire, may have been influenced by social desirability or comprehension limitations among younger participants. Moreover, the study did not include a long-term follow-up beyond two months to assess the durability of the intervention effects. Another limitation pertains to the absence of neurocognitive or behavioral performance data, which could have provided more objective evidence of executive function improvement. Finally, potential contextual factors—such as teacher support, home environment, and socio-economic background—were not controlled and may have moderated the observed effects.

Future studies should employ larger, more diverse samples across different educational and cultural contexts to enhance external validity. Longitudinal research designs are recommended to examine the sustainability of cognitive and metacognitive improvements over extended periods. Additionally, integrating neuroimaging or behavioral assessment tools could help identify neural and performance-based correlates of executive function training outcomes. Comparative studies that test the differential effects of executive, metacognitive, and emotional regulation training could provide deeper insights into their unique and shared mechanisms. Moreover, exploring the role of mediating variables such as self-efficacy, motivation, and theory of mind could further elucidate the pathways linking executive function development to academic success. Including teacher training and parent involvement components may also enhance the ecological validity and real-world applicability of such interventions.

Practically, the results of this study highlight the importance of incorporating executive function and metacognitive training into school curricula for students with learning disabilities. Educators and school psychologists should design interventions that integrate goal-setting, reflective thinking, problem-solving, and emotional regulation exercises into daily classroom activities. Small-group or individualized sessions can provide opportunities for modeling, feedback, and reinforcement of cognitive strategies. Training programs should use age-appropriate, engaging, and contextually relevant materials to ensure transfer of learned skills to real-life academic situations. Furthermore, collaboration between teachers, parents, and mental health professionals is crucial for sustaining the cognitive and emotional benefits of such training beyond the classroom setting. By embedding executive and metacognitive skill-building into educational practice, schools can promote self-regulated learning and enhance the academic resilience of students with learning disabilities.

Authors' Contributions

Authors contributed equally 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

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

Acknowledgments

We would like to express our gratitude to all individuals helped us to do the project.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

References

Babaei, F., Abdollahi, M., Amini Gilvani, M., & Masoomifard, M. (2024). The Mediating Role of Theory of Mind in the Relationship Between Executive Functions and Marital

E-ISSN: 3060-6713

Burnout Using Structural Equation Modeling and Artificial Neural Networks (SEM-ANN). *International Journal of Education and Cognitive Sciences*, *5*(4), 62-73. https://doi.org/10.61838/kman.ijecs.5.4.7

Baniasadi, T. (2024). Comparison of Executive Function and Working Memory among Children with High and Low Levels of Physical Activity. *International Journal of Education and Cognitive Sciences*, *5*(3), 9-15. https://doi.org/10.61838/kman.ijeas.5.3.2

Barua, N., Singh, S., Agarwal, V., Arya, A., & Barua, N. (2020). Executive Functions, Metacognitive Beliefs, and Thought Control Strategies in Adolescents with Obsessive-Compulsive Disorder. *IJRAR*, *7*, 672-680. https://www.ijrar.org/papers/IJRAR2001512.pdf

Cécillon, F. X., Mermillod, M., Leys, C., Lachaux, J. P., Le Vigouroux, S., & Shankland, R. (2024). Trait Anxiety, Emotion Regulation, and Metacognitive Beliefs: An Observational Study Incorporating Separate Network and Correlation Analyses to Examine Associations with Executive Functions and Academic Achievement. *Children*, *11*(1), 123. https://doi.org/10.3390/children11010123

Davoodi, M., Malihi Alzakerini, S., Nikpajouh, A., & Sabet, M. (2023). Comparing the Effectiveness of Metacognitive Skills Training with Executive Function Skills Training on Biological Markers in Patients with Coronary Artery Disease. *Journal of Assessment and Research in Applied Counseling (JARAC)*, *5*(5), 45-52. https://doi.org/10.61838/kman.jarac.5.5.6

Drigas, A., & Karyotaki, M. (2019). Executive Functioning and Problem Solving: A Bidirectional Relation. *International Journal of Engineering Pedagogy (Ijep)*, *9*(3), pp. 76-98. https://doi.org/10.3991/ijep.v9i3.10186

Esmaeilian Anvar, S., Ghorban Jahromi, R., Rafieipour, A., & Sabet, M. (2024). The effectiveness of a lateral dominance enhancement training package on executive functions and visual perception in children with specific learning disorder. *Psychology of Exceptional Individuals*, *14*(53), 43-75. https://jpe.atu.ac.ir/article_15574.html?lang=en

Fernandez-Duque, D., Baird, J. A., & Posner, M. I. (2000). Executive Attention and Metacognitive Regulation. *Consciousness and Cognition*, *9*(2), 288-307. https://doi.org/10.1006/ccog.2000.0447

Haugen, I., Ueland, T., Stubberud, J., Brunborg, C., Wykes, T., Øie, M. G., & Haug, E. (2023). Moderators of metacognitive strategy training for executive functioning in early schizophrenia and psychosis risk. *Schizophrenia Research: Cognition*, *31*, 100275. https://www.sciencedirect.com/science/article/pii/S2215001322000403

Khan, K., & Lal, P. S. (2023). Executive Dysfunctions in Different Learning Disabilities: A Review. *Journal of Indian Association for Child and Adolescent Mental Health*, *19*(2), 126-142. https://doi.org/10.1177/09731342231179614

Kokabi Rahman, E., Taghvaei, D., & Pirani, Z. (2023). The Effectiveness of Cognitive and Metacognitive Strategies Teaching on Academic Motivation, Academic Engagement and Quality of Life in School of Students with Specific Learning Disorder in Hamadan City. *Sociology of Education*, *8*(2), 257-266. https://doi.org/10.22034/ijes.2023.707262

Kraft, B., Jonassen, R., Stiles, T. C., & Landrø, N. I. (2017). Dysfunctional metacognitive beliefs are associated with decreased executive control. *Frontiers in psychology*, *8*(593). https://doi.org/10.3389/fpsyg.2017.00593

Lievore, R. (2024). Let's Face It! The Role of Social Anxiety and Executive Functions in Recognizing Others' Emotions From Faces: Evidence From Autism and Specific Learning Disorders. *Development and Psychopathology*, 1-13. https://doi.org/10.1017/s0954579424000038

Roebers, C. M. (2017). Executive function and metacognition: Towards a unifying framework of cognitive self-regulation. *Developmental Review*, *45*, 31-51. https://doi.org/10.1016/j.dr.2017.04.001

Saleh Al Rasheed, L., & Hanafy, A. A. M. (2023). Effects of brain-based instruction on executive function and habits of mind among young children at-risk for learning disabilities. *Applied Neuropsychology*, *2*, 1-8. https://doi.org/10.1080/21622965.2022.2161904

Tamm, L., Nakonezny, P. A., & Hughes, C. W. (2012). An Open Trial of a Metacognitive Executive Function Training for Young Children With ADHD. *Journal of Attention Disorders*, *18*(6), 551-559. https://doi.org/10.1177/1087054712445782

Zhou, M., Lam, K. K. L., & Zhang, Y. (2022). Metacognition and Academic Procrastination: A Meta-Analytical Examination. *Journal of Rational-Emotive & Cognitive-Behavior Therapy*, *40*(2), 334-368. https://doi.org/10.1007/s10942-021-00415-1

E-ISSN: 3060-6713