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Relationship Between Math Anxiety and Problem-Solving in Dyscalculic Children: Mediating Role of Working Memory

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A B S T R A C T

Purpose: The present study aimed to examine the relationship between math anxiety and problem-solving ability in children with developmental dyscalculia, with a specific focus on the mediating role of working memory.

Methods and Materials: This research employed a descriptive correlational design. A sample of 400 students diagnosed with dyscalculia was selected from elementary schools in Tehran using stratified random sampling, based on the Morgan and Krejcie table. Data were collected using three validated instruments: the Mathematics Anxiety Rating Scale for Elementary Students (MARS-E), the Working Memory Rating Scale (WMRS), and the Problem-Solving Inventory for Children. Data analysis was conducted using SPSS-27 for descriptive statistics and Pearson correlation analysis, while Structural Equation Modeling (SEM) was performed using AMOS-21 to test the hypothesized mediational model.

Findings: Results revealed that math anxiety was negatively correlated with both working memory ($r = –.46$, $p < .001$) and problem-solving ability ($r = –.39$, $p < .001$), while working memory had a significant positive correlation with problem-solving ($r = .51$, $p < .001$). SEM results indicated a good model fit ($\chi^2/df = 2.06$; CFI = 0.96; RMSEA = 0.051). Math anxiety significantly predicted working memory ($\beta = –.46$, $p < .001$), and working memory significantly predicted problem-solving ability ($\beta = .51$, $p < .001$). The direct path from math anxiety to problem-solving was weak but significant ($\beta = –.09$, $p = .031$), while the indirect effect through working memory was stronger ($\beta = –.23$, $p < .001$), confirming partial mediation.

Conclusion: The findings demonstrate that working memory plays a significant mediating role in the relationship between math anxiety and problem-solving in dyscalculic children. Educational interventions aimed at enhancing working memory and reducing math anxiety may be effective in improving problem-solving skills in this population.

Keywords: *Developmental dyscalculia, Math anxiety, Working memory, Problem-solving.*

1. Introduction

Developmental dyscalculia, a specific learning disorder affecting numerical processing, continues to challenge educators and psychologists due to its complex cognitive and emotional underpinnings. Although traditionally framed as a deficit in numerical comprehension, contemporary research has shifted toward examining the interplay of executive functions, emotional states, and cognitive resources in shaping mathematical competencies. Among these, working memory and math anxiety emerge as particularly salient factors influencing the problem-solving performance of children with dyscalculia (Devine et al., 2018; Mammarella et al., 2021).

Dyscalculia affects approximately 3–6% of school-aged children and is characterized by severe difficulties in understanding arithmetic concepts, performing calculations, and solving math-related problems despite average intelligence and appropriate educational opportunities (McCaskey et al., 2017; Witzel & Mize, 2018). While earlier theories suggested a core deficit in magnitude representation, more nuanced accounts propose that impairments in domain-general cognitive functions—such as working memory—play a pivotal role in dyscalculic children's mathematical struggles (Wilkey et al., 2020). Indeed, working memory, defined as the ability to hold and manipulate information over short periods, is foundational for executing multi-step problem-solving tasks and maintaining focus during complex cognitive activities (Ellis et al., 2020; Zafar et al., 2025).

Emerging research has increasingly highlighted the mediating function of working memory between affective factors such as math anxiety and performance outcomes. Math anxiety, a form of emotional distress specifically tied to math-related situations, has been shown to undermine students' ability to retrieve relevant information and sustain cognitive control during problem-solving (Devine et al., 2018; Scheibe et al., 2023). In particular, the *Regulated Attention in Mathematical Problem Solving* (RAMPS) model posits that math anxiety depletes attentional resources by increasing intrusive thoughts and emotional reactivity, thereby constraining working memory capacity and impairing task execution (Scheibe et al., 2023). For children with dyscalculia, who already struggle with cognitive processing, this dual burden can be especially debilitating.

Working memory not only influences arithmetic accuracy but also facilitates strategy generation and selection, making it essential for success in non-routine problem-solving scenarios. Numerous studies have demonstrated that low working memory capacity correlates with poor mathematical performance in both typical learners and those with learning disorders (Baniasadi, 2024; Galitskaya & Drigas, 2021). Moreover, working memory is not a unitary construct—it includes subsystems such as the phonological loop, visuo-spatial sketchpad, and central executive, all of which may be differentially affected in dyscalculic populations (Asadi Rajani, 2023; Xing et al., 2019). As these children attempt to navigate multi-step problems that require shifting between representations and operations, the integrity of these working memory subsystems becomes critically relevant.

In Iranian educational contexts, the need to better understand the cognitive and emotional challenges faced by dyscalculic learners is urgent. Research in Iran has identified significant associations between math-related anxiety, self-esteem, and overall life satisfaction among students with dyscalculia, suggesting that the disorder affects not only academic outcomes but also emotional well-being (Rajabi et al., 2012). These findings highlight the importance of addressing both cognitive and affective domains in intervention and assessment frameworks for dyscalculic children.

While the literature has extensively addressed the direct effects of working memory and math anxiety on math achievement, the nature of their interaction—particularly the potential mediating role of working memory—remains underexplored in the context of problem-solving performance. Problem-solving in mathematics, especially in novel or unfamiliar tasks, demands the activation of metacognitive monitoring, planning, inhibition, and flexible thinking, all of which are tied to executive functioning (Alfonso & Lonigan, 2021; Schäfer et al., 2024). When children experience anxiety, their ability to engage in such high-order processes may be hindered unless cognitive supports like working memory intervene to buffer emotional interference (Scheibe et al., 2023).

Furthermore, the role of working memory as a mediator has been empirically supported in studies linking cognitive load and academic performance under emotional pressure. For instance, a study by Al-Shamy (2020) on gifted students in Saudi Arabia found that working memory served as a conduit through which creative problem-solving was optimized, even under stress (Al-Shamy, 2020). Similarly, Utami and Warniasih (2019) emphasized that low-ability students struggled with math problem-solving tasks primarily due to working memory limitations, reinforcing its

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central role in academic performance (Utami & Warniasih, 2019).

In this regard, the Iranian educational system presents both a challenge and an opportunity. While math anxiety is highly prevalent among Iranian students, especially those with learning disabilities, culturally responsive instructional approaches like cognitively guided instruction have been found to significantly reduce anxiety and improve self-regulation (Vasheghani Farahani & Rostaminejād, 2021). However, such pedagogical shifts must be grounded in empirical models that elucidate how cognitive and emotional factors interact to affect learning outcomes in math.

Given this theoretical background, the present study seeks to contribute to the literature by empirically examining the mediating role of working memory in the relationship between math anxiety and problem-solving ability in children with dyscalculia.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a descriptive correlational design to investigate the relationship between math anxiety and problem-solving ability in dyscalculic children, with working memory examined as a mediating variable. The study population included school-aged children diagnosed with developmental dyscalculia in Tehran. Using the Morgan and Krejcie (1970) sample size determination table, a total of 400 participants were selected through stratified random sampling to ensure representation across gender and grade levels. Inclusion criteria comprised a clinical diagnosis of dyscalculia confirmed by educational psychologists, enrollment in elementary school (grades 3–6), and the absence of any comorbid intellectual or neurological disorders.

2.2. Measures

To assess problem-solving ability in dyscalculic children, the study utilized the Problem Solving Inventory for Children developed by Heppner and Petersen (1982), which has been adapted and validated for use with child populations. This inventory is designed to evaluate perceived problem-solving behaviors rather than objective performance, providing insight into children's cognitive-emotional engagement with problem-solving tasks. The instrument contains 35 items across three subscales: Problem-Solving Confidence, Approach-Avoidance Style, and Personal Control. Respondents rate each item on a 6-point Likert scale ranging from 1 (strongly disagree) to 6 (strongly agree), with higher scores indicating less effective perceived problem-solving ability. The inventory has demonstrated strong internal consistency and construct validity in numerous studies, including research conducted in Iran, where Cronbach's alpha coefficients for the subscales ranged from 0.78 to 0.88, confirming its psychometric reliability for the intended age group.

Working memory was measured using the Working Memory Rating Scale (WMRS) developed by Alloway, Gathercole, and Kirkwood (2008). This teacher-completed behavioral rating scale is specifically designed for children aged 5 to 11 and consists of 20 items that assess everyday behaviors associated with working memory failures. The items are grouped into a single-factor structure reflecting overall working memory performance. Each item is rated on a 4-point Likert scale from 0 (does not apply) to 3 (applies very frequently), with higher scores reflecting greater working memory difficulties. The WMRS has been translated and standardized for use in Iranian settings, where it has shown high internal consistency (Cronbach's alpha = 0.89) and acceptable concurrent validity when compared with direct working memory assessment tools such as the Automated Working Memory Assessment (AWMA). This confirms its suitability for classroom-based evaluations of cognitive functioning in Iranian children with learning difficulties.

Mathematics anxiety was assessed using the Mathematics Anxiety Rating Scale for Elementary Students (MARS-E) developed by Suinn, Taylor, and Edwards (1988). This child-friendly version includes 26 items measuring anxiety in response to various math-related situations, such as taking tests, doing homework, or answering questions in class. Items are rated on a 5-point Likert scale ranging from 1 (not at all nervous) to 5 (very nervous), with higher scores indicating greater levels of mathematics anxiety. The scale encompasses two main subscales: Mathematical Evaluation Anxiety and Learning Math Anxiety. The MARS-E has been widely used in both international and Iranian studies, and its Persian version has demonstrated strong psychometric properties. Studies conducted in Iran have reported Cronbach's alpha values above 0.85 and confirmed its construct validity through exploratory and confirmatory factor analyses, supporting its appropriateness for measuring math anxiety in Iranian school-aged populations.

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2.3. Data Analysis

Data analysis was conducted using SPSS version 27 for descriptive and inferential statistics. Pearson's correlation coefficients were calculated to assess the bivariate relationships between the dependent variable (problem-solving ability) and the independent variables (math anxiety and working memory). To examine the mediating role of working memory in the relationship between math anxiety and problem-solving ability, structural equation modeling (SEM) was performed using AMOS version 21. Model fit was assessed using multiple indices, including Chi-square (χ^2), Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR), with acceptable thresholds based on Hu and Bentler (1999).

3. Findings and Results

Out of the 400 participants, 217 were boys (54.25%) and 183 were girls (45.75%). Regarding grade level, 101 students (25.25%) were in grade 3, 103 (25.75%) in grade 4, 97 (24.25%) in grade 5, and 99 (24.75%) in grade 6. The average age of participants was 10.44 years (SD = 1.02), with ages ranging from 9 to 12 years. Most participants (72.50%) were from public schools, while the remaining 27.50% attended private institutions.

Table 1

Means and Standard Deviations of Research Variables (N = 400)

Variable	Mean (M)	Standard Deviation (SD)
Math Anxiety	3.87	0.71
Working Memory	2.94	0.63
Problem-Solving	3.12	0.66

The results presented in Table 1 indicate that participants had a moderately high level of math anxiety (M = 3.87, SD = 0.71), while their working memory capacity was below average (M = 2.94, SD = 0.63). Problem-solving ability scores also appeared moderate (M = 3.12, SD = 0.66), reflecting the cognitive difficulties commonly experienced in dyscalculic children.

Prior to conducting correlational and SEM analyses, statistical assumptions were examined. Normality of the data was assessed using skewness and kurtosis values, which for all variables fell within the acceptable range of ±1.5 (e.g., skewness for math anxiety = 0.84, kurtosis = –0.91). Linearity and homoscedasticity were confirmed through visual inspection of scatterplots and residual plots. Multicollinearity was ruled out, as the Variance Inflation Factor (VIF) values ranged from 1.02 to 1.31, well below the threshold of 10. The assumption of absence of outliers was verified using Mahalanobis distance, with no extreme values exceeding the critical chi-square value for $p < .001$ at df = 3 ($\chi^2 = 16.27$). These results confirmed that the data met the necessary assumptions for conducting Pearson correlation and SEM analyses.

Table 2

Correlation Matrix of Research Variables (N = 400)

Variables	1	2	3
1. Math Anxiety	—		
2. Working Memory	–.46** (p < .001)	—	
3. Problem-Solving	–.39** (p < .001)	.51** (p < .001)	—

As shown in Table 2, math anxiety was negatively correlated with both working memory ($r = –.46$, $p < .001$) and problem-solving ($r = –.39$, $p < .001$). Meanwhile, working memory showed a positive and statistically significant correlation with problem-solving ability ($r = .51$, $p < .001$). These results suggest that greater math anxiety is associated with lower cognitive performance and problem-solving, while better working memory relates positively to problem-solving.

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Table 3

Model Fit Indices for the Structural Model

Fit Index	Value	Recommended Threshold
χ^2 (Chi-Square)	84.29	—
df	41	—
χ^2/df	2.06	< 3.00
GFI	0.94	≥ 0.90
AGFI	0.91	≥ 0.90
CFI	0.96	≥ 0.95
TLI	0.95	≥ 0.95
RMSEA	0.051	≤ 0.06

The SEM results in Table 3 reveal a good model fit. The chi-square/df ratio was 2.06, well below the recommended maximum of 3.00. Additionally, other indices including GFI (0.94), AGFI (0.91), CFI (0.96), TLI (0.95), and RMSEA (0.051) all met or exceeded accepted thresholds, supporting the structural model's adequacy in explaining the observed data.

Table 4

Total, Direct, and Indirect Effects Between Variables in the Structural Model

Path	b	SE	β	p
Math Anxiety → Working Memory	–0.48	0.06	–.46	< .001
Working Memory → Problem-Solving	0.55	0.07	.51	< .001
Math Anxiety → Problem-Solving	–0.11	0.05	–.09	.031
Math Anxiety → WM → Problem-Solving (Indirect)	–0.26	—	–.23	< .001
Total Effect (Math Anxiety → Problem-Solving)	–0.37	—	–.32	< .001

Table 4 reveals that math anxiety had a significant negative direct effect on working memory ($\beta = –.46$, $p < .001$) and that working memory had a strong positive direct effect on problem-solving ($\beta = .51$, $p < .001$). The direct path from math anxiety to problem-solving was small but statistically significant ($\beta = –.09$, $p = .031$). More importantly, the indirect path from math anxiety to problem-solving through working memory was also significant ($\beta = –.23$, $p < .001$), highlighting the partial mediating role of working memory. The total effect of math anxiety on problem-solving was $\beta = –.32$ ($p < .001$), indicating that both direct and mediated paths contribute to the overall impact.

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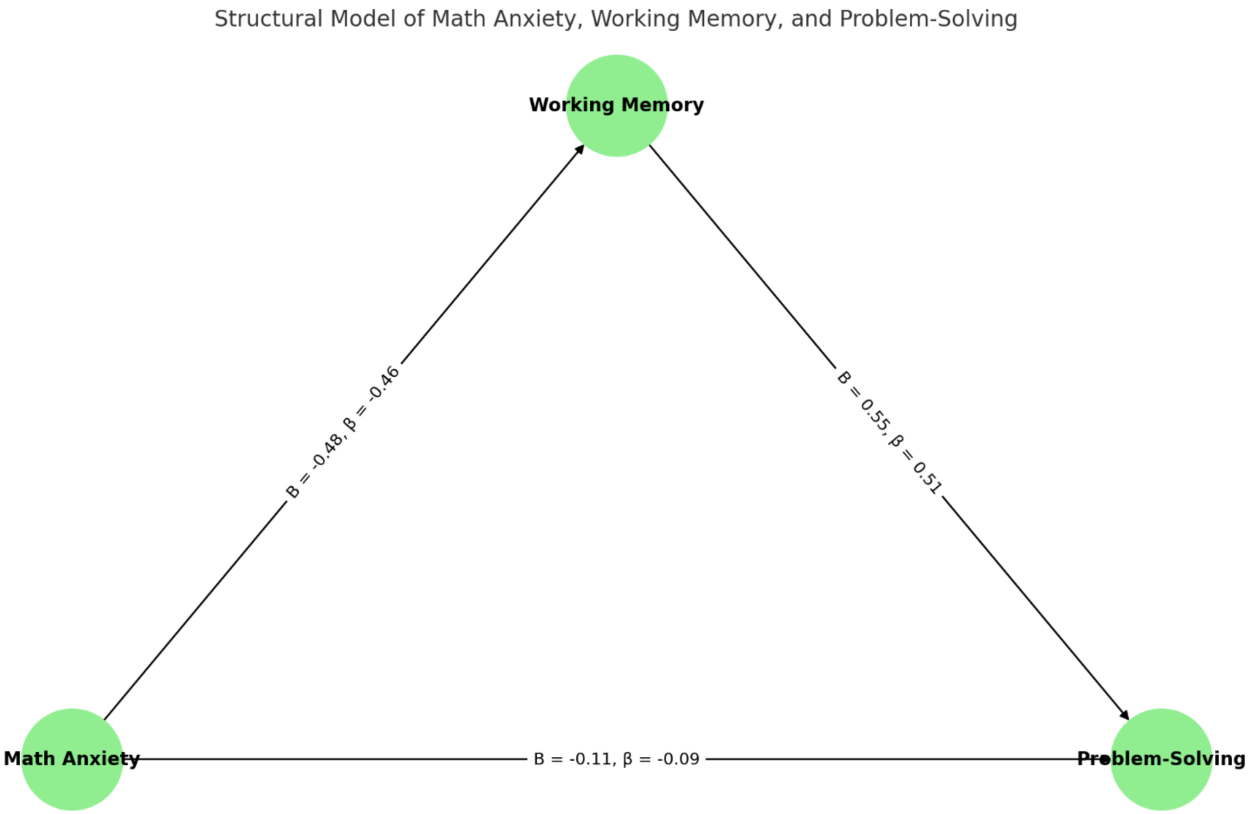
Figure 1

Model with Path Coefficients



4. Discussion and Conclusion

The present study investigated the relationship between math anxiety and problem-solving ability in children diagnosed with developmental dyscalculia, with a focus on the mediating role of working memory. The statistical findings indicated significant negative correlations between math anxiety and both working memory and problem-solving performance, while a significant positive correlation was found between working memory and problem-solving ability. Structural equation modeling (SEM) confirmed that working memory significantly mediates the effect of math anxiety on problem-solving performance. These findings contribute to a more nuanced understanding of how cognitive and emotional variables interact to affect mathematical learning and performance in children with dyscalculia.

The observed negative association between math anxiety and problem-solving ability is consistent with extensive prior research emphasizing the debilitating impact of emotional distress on mathematical functioning (Devine et al., 2018; Rajabi et al., 2012). Math anxiety has been shown to impair working memory processes by increasing intrusive and self-referential thoughts, leading to cognitive overload and reduced problem-solving efficiency. This cognitive interference was evident in our study, where higher levels of math anxiety were associated with lower working memory scores and reduced ability to manage and execute multi-step mathematical tasks. This aligns with the RAMPS framework, which explains that anxiety disrupts regulated attention and exhausts cognitive resources needed for complex tasks (Scheibe et al., 2023).

The finding that working memory significantly predicts problem-solving ability further reinforces the foundational role of executive functions in mathematical reasoning. Consistent with prior studies, our results highlight that children with dyscalculia often struggle not only with numerical comprehension but also with maintaining and manipulating task-relevant information over time (Galitskaya & Drigas, 2021; Wilkey et al., 2020). In particular, the SEM results provide evidence that working memory serves as a cognitive bridge that partially buffers the negative effects of math anxiety on problem-solving, thus supporting its mediating role. Similar conclusions were drawn by Zafar et al. (2025), who emphasized that working

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memory is a critical determinant in both problem-solving accuracy and decision-making under pressure (Zafar et al., 2025).

These findings also align with Schäfer et al. (2024), who demonstrated that executive functions—particularly working memory, inhibition, and cognitive flexibility—are key contributors to science problem-solving performance in children (Schäfer et al., 2024). In the context of our study, the executive burden imposed by high-anxiety states appeared to directly undermine these very functions, especially in students with existing cognitive vulnerabilities. Our results also support the findings by Ellis et al. (2020), who argued that individual differences in working memory capacity significantly predict analytic reasoning and multiply-constrained problem-solving in demanding tasks (Ellis et al., 2020).

Moreover, the mediating role of working memory identified in this study is supported by the findings of Utami and Warniasih (2019), who showed that low working memory capacity was a primary barrier to mathematical problem-solving in students with lower academic ability (Utami & Warniasih, 2019). Similarly, Xing et al. (2019) found that working memory updating ability significantly influenced success in insight-based problem-solving, reinforcing the idea that this cognitive mechanism underpins flexibility and adaptation in learning contexts (Xing et al., 2019).

The interplay between math anxiety and working memory further illustrates the emotional-cognitive duality of dyscalculia. Al-Shamy (2020) found that even among gifted students, efficient working memory function was a precondition for creative problem-solving, especially under emotionally demanding conditions (Al-Shamy, 2020). This suggests that working memory functions as a resilience mechanism that allows individuals to cope with emotionally taxing cognitive tasks, a mechanism that appears to be impaired in children with dyscalculia, particularly those with high levels of math anxiety.

Interestingly, the absence of a direct path from math anxiety to problem-solving in the SEM model—once working memory was accounted for—suggests that the cognitive impairment caused by anxiety operates almost entirely through the working memory channel. This finding is in line with the theoretical proposition by Scheibe et al. (2023), who demonstrated that students with high levels of math anxiety failed to self-regulate attention due to disrupted metacognitive cues and diminished working memory resources (Scheibe et al., 2023). Additionally, the current findings resonate with Baniasadi (2024), who reported that children with higher levels of physical activity demonstrated superior working memory function and executive control, implying that enhancing cognitive control may mitigate the emotional burden experienced during mathematical tasks (Baniasadi, 2024).

From a developmental perspective, our findings support the conclusions of Mammarella et al. (2021), who challenged the notion of a singular core deficit in dyscalculia and argued instead for a heterogeneous model involving domain-general cognitive processes such as working memory (Mammarella et al., 2021). Similarly, McCaskey et al. (2017) found that adolescents with dyscalculia do not necessarily exhibit deficits in all types of magnitude processing, suggesting that specific executive dysfunctions are more predictive of math-related difficulties (McCaskey et al., 2017).

In the Iranian context, the findings align with Rajabi et al. (2012), who showed that math anxiety negatively correlates with life satisfaction and self-esteem among students with learning disabilities, emphasizing the emotional toll of persistent academic struggles (Rajabi et al., 2012). Moreover, Vasheghani Farahani and Rostaminejād (2021) found that cognitively guided instruction could reduce math anxiety and promote self-directed learning, which supports the idea that instructional design can indirectly enhance working memory function by lowering emotional interference (Vasheghani Farahani & Rostaminejād, 2021).

These converging lines of evidence affirm the central thesis of this study: that working memory serves as a critical mechanism by which emotional states like math anxiety influence problem-solving performance in dyscalculic children. As such, interventions aimed at enhancing working memory capacity—whether through cognitive training, physical activity, or instructional design—may have dual benefits in mitigating anxiety and improving mathematical competence.

Despite its contributions, the present study is not without limitations. First, the cross-sectional design restricts causal inferences about the directional relationships among variables. Although SEM provides robust statistical evidence for mediation, longitudinal studies are needed to confirm developmental trajectories over time. Second, the sample was limited to students from Tehran, which may restrict the generalizability of the findings to other cultural or educational contexts. Third, the reliance on self-report and teacher-report measures may introduce response biases, particularly in assessing internal states like anxiety. Finally,

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the study did not control for other potential mediators such as metacognition, attentional control, or socioeconomic factors that might also influence problem-solving performance.

Future research should explore longitudinal pathways to establish how math anxiety and working memory evolve together and influence learning outcomes over time. It would also be beneficial to replicate the study across diverse regions and include neuropsychological assessments or experimental manipulations to validate the mechanisms identified here. Additionally, integrating other cognitive-emotional constructs—such as inhibitory control, self-regulated learning, and emotional regulation—into the model could yield a more comprehensive understanding of learning processes in dyscalculic populations. Examining gender differences and comorbid learning difficulties (e.g., dyslexia or ADHD) may also uncover nuanced patterns that warrant targeted interventions.

Based on the findings, educators and psychologists should prioritize interventions that simultaneously target working memory enhancement and anxiety reduction. Classroom strategies that reduce cognitive load, provide emotional reassurance, and scaffold complex tasks can support problem-solving in children with dyscalculia. Incorporating mindfulness, physical activity, and cognitively guided instruction may strengthen executive functioning and resilience. Screening for math anxiety and executive deficits early in schooling could enable the implementation of personalized learning plans that optimize both cognitive and emotional well-being.

Authors' Contributions

All authors significantly contributed to this study.

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.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the study and participated in the research with informed consent.

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