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A comparative assessment of mathematical vocabulary, operations, and problem-solving in 5th grade children with ADHD and SLD: Cognitive profiles and implications for educational approaches to instruction and task design

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ABSTRACT

This study aimed to conduct a comparative assessment of mathematical competence, including vocabulary, operations, and mathematical problem-solving, in children diagnosed with Specific Learning Disabilities (SLD) and Attention-Deficit/Hyperactivity Disorder (ADHD). Individual assessments were administered to evaluate intelligence quotient (IQ), mathematical competence, reading, and written language for both groups (SLD: N = 17; ADHD: N = 17). The results revealed statistically significant differences between the groups in several WISC-IIIGR measures, including Verbal IQ, Information (factual knowledge, long-term memory, recall), Arithmetic (attention, concentration, numerical reasoning), Digit Span (short-term auditory memory, concentration), Picture Arrangement (planning, logical thinking, social knowledge), Verbal Comprehension Index (VCI), and Freedom from Distractibility Index (FDI), as well as in Mathematical Operations and Mathematical problem-solving. Both groups demonstrated challenges across several assessed domains. To explore these difficulties in greater depth, canonical correlation analyses (CCA) were conducted on three variable sets. Findings suggest that while both SLD and ADHD are associated with cognitive challenges, they present largely distinct patterns of cognitive deficits. Findings are interpreted in terms of differential cognitive profiles and their potential implications for differentiated instructional approaches. In particular, results are linked to the design of mathematical tasks in 5th-grade mathematics inclusive classrooms, aiming at reducing cognitive load and supporting mathematical learning in students with ADHD and SLD.

Keywords: mathematical vocabulary, operations, problem-solving, ADHD, SLD, educational implications

INTRODUCTION

Mathematics is a cornerstone of education, nurturing essential cognitive abilities such as logical reasoning, mathematical problem-solving, and cognitive flexibility that are critical for academic achievement and everyday functioning (Baker & Behrman, 2009; Geary, 2013). Additionally, research has shown that students' beliefs, attitudes, emotions, and other affective components are associated with their mathematical achievement (Essien & Davis, 2024). However, children with neurodevelopmental disorders, particularly Specific Learning Disabilities (SLD) and Attention-Deficit/Hyperactivity Disorder (ADHD), often experience significant challenges in developing mathematical competence (Crisci et al., 2021). Terms such as heterogeneity, homogeneity, and difference, as well as diversity, have recently become buzzwords in the existing discourse on mathematics education (Lüssenhop & Kaiser, 2024).

Furthermore, children with SLD typically struggle with foundational mathematical skills, including arithmetic operations, vocabulary, and mathematical problem-solving, due to difficulties in cognitive processes such as working memory, attention, and processing speed (Swanson & Jerman, 2006). In contrast, children with ADHD may exhibit age-appropriate or even strong conceptual understanding but have difficulty with sustained attention, executive functioning, and task organization. These difficulties often negatively affect performance on multi-step and attention-demanding mathematical tasks (Barkley, 2014; Shaywitz et al., 2002; Willcutt et al., 2005).

While both conditions can adversely affect math learning, the underlying cognitive mechanisms differ. Nevertheless, research comparing how SLD and ADHD uniquely impact specific mathematical domains remains limited. Furthermore, relatively few studies have explored how math-related difficulties in these groups relate to broader cognitive functions such as IQ, verbal comprehension, and executive control (Alloway & Passolunghi, 2011; Swanson & Sachse-Lee, 2001). This study addresses this gap by directly comparing mathematical performance in terms of mathematical vocabulary, arithmetic operations, and mathematical problem-solving in children with ADHD and SLD. The goal is to clarify the distinct cognitive characteristics of each condition (ADHD and SLD). Beyond identifying group differences, the study examines how distinct cognitive profiles may inform differentiated instructional approaches and task design in 5th-grade mathematics. In this sense, the study connects cognitive assessment findings with pedagogical decision-making in inclusive mathematics classrooms. Importantly, the present study adopts a cognitively informed educational perspective, aiming not only to identify differences in mathematical competence but also to explicitly translate these differences into instructional approaches and principles for mathematical task design. In this context, the study establishes a direct link between cognitive assessment findings and classroom practices in 5th-grade mathematics, contributing to a more transparent integration of research and pedagogy in inclusive educational settings.

Understanding SLD and ADHD in the Context of Mathematics

SLD is characterized by difficulties in learning and applying academic skills, including reading, writing, and mathematics, despite adequate intelligence and educational opportunities (APA, 2013). Children with SLD may struggle with math vocabulary (e.g., sum, difference, quotient), symbolic representation, and arithmetic operations. These difficulties typically stem from deficits in working memory, phonological processing, attention, and processing speed (Geary, 2011; Swanson & Jerman, 2006).

In contrast, ADHD is characterized by persistent symptoms of inattention, hyperactivity, and impulsivity that interfere with functioning across multiple settings (APA, 2013). In mathematics, children with ADHD often experience difficulty organizing work, maintaining sustained attention, and executing multi-step procedures, especially in mathematical problem-solving contexts (Barkley, 2014; Martinussen et al., 2005). Unlike children with SLD, their difficulties are less about core conceptual understanding and more about executive dysfunction.

Although both disorders disrupt math performance, they do so in qualitatively different ways. While prior research has focused more on reading difficulties (Catts et al., 2024), there is growing recognition of the need to explore math-specific challenges in these populations (Cirino, 2011; Fuchs et al., 2016a; Tosto et al., 2015). Few studies have directly compared how SLD and ADHD differentially affect math subdomains or how these effects relate to underlying cognitive skills such as working memory, verbal reasoning, and IQ (Swanson & Sachse-Lee, 2001; Toffalini et al., 2022; Viesel-Nordmeyer et al., 2023). Understanding these differences is critical for designing interventions that are tailored to the distinct profiles of each group (Geary, 2013). Effective educational strategies require nuanced insight into the cognitive foundations of mathematical competence.

Key Domains of Mathematical Competence

Mathematical vocabulary and conceptual understanding

Mathematical vocabulary is essential for comprehending instructions, solving word problems, and understanding symbolic representations. Children with SLD often struggle with this vocabulary due to weak phonological processing, verbal working memory deficits, and language-based learning difficulties (Fuchs et al., 2016b; Swanson & Jerman, 2006). These deficits interfere with the ability to parse and apply math terminology, leading to challenges in both understanding and solving word problems.

Conversely, children with ADHD may not exhibit core linguistic deficits but frequently struggle to apply math vocabulary accurately due to difficulties with attention and self-regulation (Fosco et al., 2020; Martinussen et al., 2005). Their inattentiveness may hinder the encoding and retrieval of mathematical terms during complex tasks. Interventions should therefore focus on phonological and memory support for children with SLD and attention-enhancing or task-structuring strategies for those with ADHD (Iglesias-Sarmiento et al., 2017; Lucangeli & Cabrele, 2006).

Arithmetic performance: Calculation and computational fluency

Arithmetic performance requires both factual knowledge (e.g., math facts) and procedural skills. Children with SLD frequently struggle in both areas due to deficits in number sense, slow processing speed, and working memory impairments (Andersson & Lyxell, 2007; Geary, 2011). These deficits may cause difficulties in recalling basic facts and executing multi-step operations. Children with ADHD, while often demonstrating intact conceptual understanding, commonly display disorganized work, frequent careless errors, and difficulties completing tasks due to attentional lapses (Kercood et al., 2004). Executive dysfunction, particularly related to working memory and inhibitory control, further exacerbates challenges with complex calculations (Alloway & Alloway, 2014; Friedman et al., 2018; Lucangeli & Cabrele, 2006; Rachanioti et al., 2024, 2025). Given these patterns, children with SLD benefit from interventions that strengthen arithmetic fluency and support memory processes. At the same time, those with ADHD may require structured environments, pacing strategies, and external aids to reduce error rates and improve consistency.

Problem-solving and executive functioning

Mathematical problem-solving tasks demand reasoning, planning, and cognitive flexibility. Children with SLD typically struggle due to weak conceptual understanding and poor number sense, even when executive skills are relatively preserved (Swanson & Sachse-Lee, 2001). Language-related processing deficits can also hinder their ability to decode and comprehend word problems. In contrast, children with ADHD often exhibit impairments in executive functions, especially working memory, inhibition, and shifting, which disrupt mathematical problem-solving accuracy and completeness (Barkley, 2014; González–Castro et al., 2016; Ozonoff & Jensen, 1999; Vessonen et al., 2025). These differences point to distinct intervention targets: ADHD

Table 1. Descriptive measures, two independent samples tests, and effect sizes for IQ, reading, written language, and mathematical competence for SLD and ADHD students

Measures	SLD (N=17)	ADHD (N=17)	Mann-Whitney U	p-value	Effect size	Effect size interpretation	Mean rank comparison
Descriptives							
Age (in months)	131.17 (2.89)	130.12 (2.77)					
Sex (girls/boys)	-/17	-/17					
Class level	5th Grade	5th Grade					
IQ							
WISC-III full scale IQ	98.88 (11.23)	91.29 (11.51)	87.00	.046	.34	Moderate	SLD=20.88 > ADHD=14.12
Reading							
Reading test-A	34.47 (17.35)	27.06 (22.42)	113.50	.283	.18	Small	SLD=19.32 > ADHD=15.68
Written language							
Written language test	20.47 (4.07)	19.23 (3.99)	122.50	.446	.13	Small	SLD=18.79 > ADHD=16.21
Mathematical competence							
Mathematical competence test	93.59 (13.45)	90.76 (11.87)	135.00	.743	.06	Small	SLD=18.06 > ADHD=16.94

interventions should emphasize metacognitive strategies, scaffolding, and executive function training; SLD-focused interventions should prioritize conceptual development, explicit instruction, and visualization of math principles (Fuchs et al., 2016b).

The role of working memory and cognitive functions

Working memory is crucial to all aspects of mathematical learning, supporting processes like number manipulation, procedural execution, and vocabulary comprehension. Children with both ADHD and SLD often exhibit working memory difficulties, though with differing profiles. ADHD is frequently associated with impairments in both phonological and visuospatial memory, impacting multitasking and planning (Gaye et al., 2025; Martinussen et al., 2005; Kofler et al., 2018). SLD is more often linked with limited capacity and reduced processing efficiency, particularly affecting math fact retrieval and concept retention (Swanson & Sachse-Lee, 2001).

These working memory impairments interact with other cognitive abilities such as IQ and verbal comprehension. Children with SLD may rely more on their verbal reasoning skills to compensate for mathematical difficulties. In contrast, children with ADHD may struggle to manage cognitive load due to weaker executive control. Interventions that target working memory, such as computerized training, chunking strategies, and task simplification, have shown promise across both groups (Melby-Lervåg et al., 2016). Recognizing the distinct cognitive landscapes of ADHD and SLD is essential for developing individualized strategies that foster long-term academic resilience.

Aim of the Study

This study aims to conduct a comparative analysis of mathematical vocabulary, arithmetic operations, and mathematical problem-solving skills in 5th-grade children diagnosed with ADHD and SLD. By examining how these two groups, each characterized by unique neurocognitive profiles, perform across key domains of mathematical competence, the study seeks to illuminate the underlying cognitive mechanisms that contribute to mathematical difficulties. In addition, the study explores the potential pedagogical implications of the identified cognitive and mathematical profiles for 5th-grade mathematics instruction. Specifically, the research addresses the following questions:

RQ1 Do 5th-grade children with ADHD and SLD demonstrate different attainment in terms of mathematical vocabulary, operations, and problem-solving?

RQ2 Could differences attributed to different areas of intelligence provide us with an interpretation for mathematical competence differences among 5th-grade children with ADHD and SLD?

RQ3 Are there relationships between different areas of intelligence and mathematical competence?

METHODS

Participants

The study sample included 34 5th-grade students, evenly divided into two groups of 17 students with SLD and an equal number of students with ADHD. All children had received an official diagnosis from the Center for Interdisciplinary Assessment, Counseling & Support. For all cases enrolled in the sample, no comorbidity was reported. Furthermore, not all participating children were enrolled in an intervention program. The groups were matched in age, with mean ages of 131.17 months (SLD) and 130.12 months (ADHD). All participants were boys, which prevented us from controlling for gender effects on cognitive and academic performance.

To exclude Intellectual Disabilities, only children with IQ scores above 85 on the WISC-IIIGR were included. This ensured the focus remained on ADHD and SLD without confounding cognitive impairments. **Table 1** outlines the assessment tools used to evaluate IQ, reading, writing, and mathematical competence, providing a broad view of the participants' academic and cognitive profiles.

Measures

WISC-III full scale IQ

To assess participating children's intelligence, we used the Greek version of the third edition of the Wechsler Intelligence Scale for Children (WISC-III^{GR}) for children aged from 6:00 to 16:11 years (Georgas et al., 1997). WISC-III^{GR} has three composite scores, namely Verbal IQ (VIQ), Performance IQ (PIQ), and Full-Scale IQ (FSIQ). The Full-Scale IQ is a composite of the verbal and performance scores, coming from a composite of eleven different subtests. Verbal IQ (VIQ) is assessed through 6 independent subsets, including Information (factual knowledge, long-term memory, and recall), Similarities (abstract reasoning, verbal categories, and concepts), Arithmetic (attention and concentration, numerical reasoning), Vocabulary (language development, word knowledge, and verbal fluency), Comprehension (social and practical judgment, common sense), and Digit Span (short-term auditory memory and concentration). Performance IQ (PIQ) (visual and vocal/visual-motor task) is assessed through 5 independent subsets, namely, Picture Completion (alertness to detail and visual discrimination), Coding (visual-motor coordination, speed, and concentration), Picture Arrangement (planning, logical thinking, and social knowledge), Block Design (spatial analysis and abstract visual problem-solving), and Object Assembly (visual analysis and construction of objects). The mean score on each subtest is 10, while the vast majority of typically developing children score between 7 and 13.

Also, through WISC-III^{GR}, three sub-scales, namely Verbal Comprehension (VCI), Perceptual Organization (POI), and Freedom from Distractibility (FDI), can be assessed. More specifically, the Verbal Comprehension Index (VCI) score is estimated with the use of the Information, Similarities, Arithmetic, and Comprehension subsets. Perceptual Organization (POI) is estimated with the use of Picture Completion, Picture Arrangement, Block Design, and Object Assembly subsets. Freedom from Distractibility (FDI) is estimated using the Arithmetic and Digit Span subsets.

Reading test-A

Reading Test-A (Padeliadou & Antoniou, 2008) is a standardized criterion that assesses children aged from 8:00 to 15:00 years. More specifically, Test-A assesses reading skills, including decoding, fluency, morphology-syntax, and comprehension. Each correct answer was scored with 1. For the needs of the study, we used the sum of the scores for the correct answers.

Written language test

Written Language Test (WLT) (Porpodas et al., 2008) is a standardized criterion that assesses children aged from 8:00 to 12.00 years. More specifically, WLT assesses domains of written language, including dictation, textual organization, deconstructed proposal restoration, and deconstructed text restoration.

Mathematical competence test

Mathematical Competence Test (MCT) (Barbas et al., 2008) is a standardized criterion that assesses children aged from 7:06 to 15.05 years. More specifically, the MCT assesses a set of 55 independent tasks. It consists of three sub-scales assessing aspects of school mathematics, namely mathematics vocabulary, operations, and problems. Each correct answer was scored with 1. The first subscale of MCT, namely mathematical vocabulary, includes 20 tasks; operations include 20 tasks, and the last subscale includes 15 tasks.

Procedure

Individual assessments were implemented at the Center for Interdisciplinary Assessment, Counseling & Support by a member of the research team. Total administration time varied from participant to participant but was required from 90 to 120 minutes, divided into two sessions for each participant (from 40th to 60th minute according to each participant's attention). The session took place in a quiet and familiar room. The research team obtained informed consent for each child's participation.

Data Analysis

Firstly, we estimated descriptive measures such as means and standard deviations for all measures for the two groups of participants (SLD and ADHD). Afterwards, we estimated two independent samples tests (Mann-Whitney U) and effect sizes (r) so as to identify differences between the two groups of participants for all measures. Importantly, we implemented Linear Discriminant Analysis (LDA). To assess the model's discriminative capacity, a Receiver Operating Characteristic (ROC) curve was generated for the full model. The resulting Area Under the Curve (AUC) was .80, indicating good classification performance between the ADHD and SLD groups (**Figure 1**).

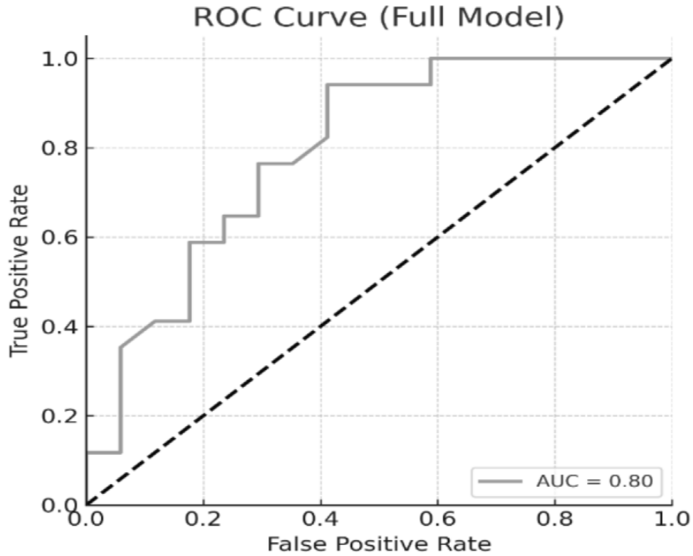

Figure 1. ROC Curve for the full discriminant model (AUC = .80) (Source: Authors' own elaboration)

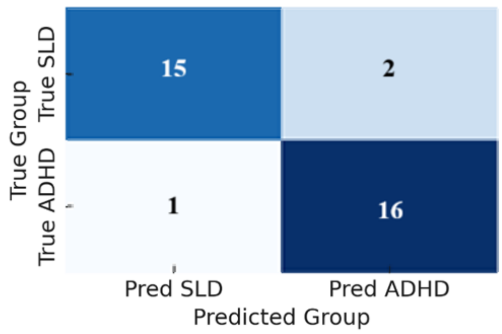

Figure 2. Confusion Matrix for the full discriminant model for SLD and ADHD participants (Source: Authors' own elaboration)

Moreover, we generated a Confusion Matrix for the full discriminant model. **Figure 2** presents the confusion matrix for the full Linear Discriminant Analysis (LDA) model. Based on cognitive and mathematical variables, the model correctly assigned 11 out of 17 children with SLD and 13 out of 17 children with ADHD to their respective diagnostic groups. In the remaining cases, the model assigned participants to the opposite group. Finally, we estimated a series of canonical correlations among sets of variables for which we previously identified statistically significant differences.

RESULTS

As can be seen in **Table 2**, the group of children with SLD displayed higher scores than the ADHD group for all measures assessing intelligence. Statistically significant differences between the group of SLD and ADHD children were found for WISC - Verbal IQ (m_{SLD} = 100.59, m_{ADHD} = 94.88, U = 78, p = .021, r = .39), Information (factual knowledge, long-term memory, recall) (m_{SLD} = 10.18, m_{ADHD} = 8.35, U = 57, p = .002, r = .53), Arithmetic (attention and concentration, numerical reasoning) (m_{SLD} = 10.24, m_{ADHD} = 8.71, U = 92, p = .038, r = .31), Digit Span (short-term auditory memory, concentration) (m_{SLD} = 7.29, m_{ADHD} = 5.94, U = 100, p = .011, r = .27), Picture Arrangement (planning, logical thinking, social knowledge) (m_{SLD} = 10.45, m_{ADHD} = 8.76, U = 92, p = .037, r = .31), Verbal Comprehension (VCI) (m_{SLD} = 40.29, m_{ADHD} = 36.35, U = 84, p = .035, r = .36), Freedom from Distractibility (FDI) (m_{SLD} = 17.53, m_{ADHD} = 14.65, U = 69.50, p = .009, r = .45).

Table 2. Descriptive measures, two independent samples tests and effect sizes for WISC-Verbal IQ, WISC-Performance IQ, WISC-III subtests, and WISC sub-scales for LD and ADHD students

Measures	SLD (N = 17)	ADHD (N = 17)	Mann-Whitney U	p-value	Effect size	Effect size interpretation	Mean rank comparison
IQ							
WISC - Verbal IQ	100.59 (9.35)	94.88 (7.44)	78.00	.021	.39	Moderate	SLD=21.41 > ADHD=13.59
Information: Factual knowledge, long-term memory, recall	10.18 (1,81)	8.35 (1.22)	57.00	.002	.53	Large	SLD=22.65 > ADHD=12.35
Similarities: Abstract reasoning, verbal categories, and concepts	11.18 (2.60)	10.82 (2.51)	135.50	.753	.05	Small	SLD=18.03 > ADHD=16.97
Arithmetic: Attention and concentration, numerical reasoning	10.24 (2.54)	8.71 (1.65)	92.00	.038	.31	Moderate	SLD=20.59 > ADHD=14.41
Vocabulary: Language development, word knowledge, verbal fluency	10.00 (1.46)	9.29 (1.36)	104.50	.157	.24	Small	SLD=19.85 > ADHD=15.15
Comprehension: Social and practical judgment, common sense	8.71 (2.64)	8.47 (2.24)	141.00	.903	.02	No effect	SLD=17.71 > ADHD=17.29
(Digit span): Short-term auditory memory, concentration	7.29 (2.41)	5.94 (1.60)	100.00	.011	.27	Moderate	SLD=20.12 > ADHD=14.88
WISC - Performance IQ	97.12 (13.72)	90.00 (16.31)	103.00	.152	.25	Small	SLD=19.95 > ADHD=15.06
Picture completion: Alertness to detail, visual discrimination	9.76 (3.21)	8.94 (3.17)	120.00	.394	.15	Small	SLD=18.94 > ADHD=16.06
Coding: Visual-motor coordination, speed, concentration	9.12 (2.78)	8.12 (1.83)	111.50	.250	.20	Small	SLD=19.44 > ADHD=15.56
Picture arrangement: Planning, logical thinking, social knowledge.	10.47 (1.97)	8.76 (3.47)	92.00	.037	.31	Moderate	SLD=20.59 > ADHD=14.41
Block design: Spatial analysis, abstract visual problem-solving	9.76 (2.79)	8.71 (3.37)	115.50	.311	.17	Small	SLD=19.21 > ADHD=15.79
Object assembly: Visual analysis and construction of objects	8.71 (3.19)	8.29 (3.10)	125.50	.509	.11	Small	SLD=18.62 > ADHD=16.38
Verbal comprehension (VCI)	40.29 (6.39)	36.35 (4.76)	84.00	.035	.36	Moderate	SLD=21.06 > ADHD=13.94
Perceptual organization (POI)	38.70 (8.48)	34.70 (10.40)	108.00	.208	.22	Small	SLD=19.65 > ADHD=15.35
Freedom from distractibility (FDI)	17.53 (3.43)	14.65 (2.23)	69.50	.009	.45	Large	SLD=21.91 > ADHD=13.09

Table 3. Descriptive measures, two independent samples tests, and effect sizes for decoding in reading, reading fluency, morphology-syntax, and for SLD and ADHD students

Measures	SLD (N = 17)	ADHD (N = 17)	Mann-Whitney U	p-value	Effect size	Effect size interpretation	Mean rank comparison
Reading							
Decoding in reading	35.00 (25.06)	33.53 (14.98)	134.50	.724	.06	Small	SLD=16.91 < ADHD=18.09
Reading fluency	16.65 (19.03)	13.06 (13.11)	137.00	.791	.06	Small	SLD=17.94 = ADHD=17.06
Morphology-Syntax	40.65 (29.38)	44.41 (29.47)	135.00	.741	.06	Small	SLD=16.94 < ADHD=18.06
Reading comprehension	28.82 (19.81)	27.94 (15.52)	142.50	.944	.01	No effect	SLD=17.38 = ADHD=17.62

Results on the reading measures (see **Table 3**) suggested that the two groups of participants (SLD and ADHD) had almost equal scores for the comprehension ($m_{SLD} = 28.82$, $m_{ADHD} = 27.94$) and the decoding ($m_{SLD} = 35.00$, $m_{ADHD} = 33.55$), and the reading fluency ($m_{SLD} = 16.65$, $m_{ADHD} = 13.06$). As for Morphology-Syntax, the group of ADHD participants scored higher than the SLD participants ($m_{SLD} = 40.65$, $m_{ADHD} = 44.41$). None of the differences previously mentioned were statistically significant.

As can be seen in **Table 4**, the group of children with SLD displayed higher scores than the ADHD group for all measures assessing written language, apart from deconstructed text restoration. More specifically, almost equal scores were reported for the dictation ($m_{SLD} = 5.18$, $m_{ADHD} = 4.47$), the textual organization ($m_{SLD} = 4.59$, $m_{ADHD} = 4.24$), the deconstructed proposal restoration ($m_{SLD} = 5.65$, $m_{ADHD} = 5.35$), and the deconstructed text restoration ($m_{SLD} = 5.06$, $m_{ADHD} = 5.18$).

Table 4. Descriptive measures, two independent samples tests, and effect sizes for dictation, textual organization, deconstructed, proposal restoration, and deconstructed text restoration for SLD and ADHD students

Measures	SLD (N = 17)	ADHD (N = 17)	Mann-Whitney U	p-value	Effect size	Effect size interpretation	Mean rank comparison
Written language							
Dictation	5.18 (1.67)	4.47 (1.42)	120.50	.384	.15	Small	SLD=18.91 > ADHD=16.09
Textual organization	4.59 (2.74)	4.24 (2.28)	137.50	.805	.04	Small	SLD=17.91 > ADHD=17.09
Deconstructed proposal restoration	5.65 (.99)	5.35 (1.06)	125.00	.483	.12	Small	SLD=18.65 > ADHD=16.35
Deconstructed Text restoration	5.06 (2.05)	5.18 (.88)	109.00	.177	.23	Small	SLD=19.41 = ADHD=19.59

Table 5. Descriptive measures, two independent samples tests, and effect sizes for mathematical vocabulary, mathematical operations, and mathematical problems for SLD and ADHD students

Measures	SLD (N = 17)	ADHD (N = 17)	Mann-Whitney U	p-value	Effect size	Effect size interpretation	Mean rank comparison
Mathematical competence							
Mathematical vocabulary	11.06 (3.03)	10.88 (2.52)	143.00	.958	.001	No effect	SLD=17.41 = ADHD=17.59
Mathematical operations	8.76 (2.51)	6.28 (2.59)	86.00	.032	.38	Moderate	SLD=19.18 > ADHD=13.82
Mathematical problems	8.88 (2.64)	6.59 (1.58)	72.00	.027	.41	Moderate	SLD=19.74 > ADHD=14.26

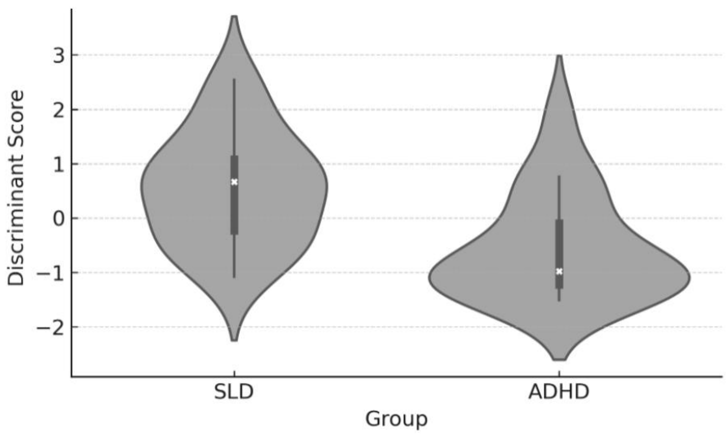

Figure 3. Violin plot of discriminant scores for SLD and ADHD participants (Source: Authors' own elaboration)

As can be seen in **Table 5**, the group of children with SLD displayed higher scores than the ADHD group for all measures assessing mathematical competence. Statistically significant differences between the group of SLD and ADHD children were found for the mathematical operations (m_{SLD} = 8.76, m_{ADHD} = 6.28, U = 86, p = .032, r = .38) and mathematical problem (m_{SLD} = 8.88, m_{ADHD} = 6.59, U = 72, p = .027, r = .41).

Discriminant Function Analysis

An exploratory LDA was conducted to examine whether a subset of cognitive variables could meaningfully differentiate between the ADHD and SLD groups. The optimal discriminant model included Arithmetic, Verbal IQ, and Digit Span. This model achieved an apparent classification accuracy of 71%, with a leave-one-out cross-validation (LOOCV) accuracy of 68%, indicating moderate and stable group-level discrimination. Structure coefficients revealed that Arithmetic (r = .75), Verbal IQ (r = .71), and Digit Span (r = .70) contributed to the discriminant function.

Figure 3 illustrates the distribution of discriminant scores derived from the optimal LDA model using a violin plot. The plot shows a clear shift in the central tendency of discriminant scores between the SLD and ADHD groups, with higher scores observed for the SLD group. Although partial overlap between the distributions is evident, the visualization supports meaningful group-level differentiation, rather than complete separation.

Figure 4 presents group centroids and confidence ellipses for the SLD and ADHD groups in the space defined by Arithmetic and Verbal IQ, two key contributors to the optimal LDA model. The figure demonstrates distinct group-level central tendencies alongside partial overlap, indicating that cognitive profiles differ on average but are not fully separable at the individual level. More specifically, the visualization of group centroids with confidence ellipses indicates distinct group-level central tendencies for the SLD and ADHD groups across Arithmetic and Verbal IQ, with higher mean values for the SLD group.

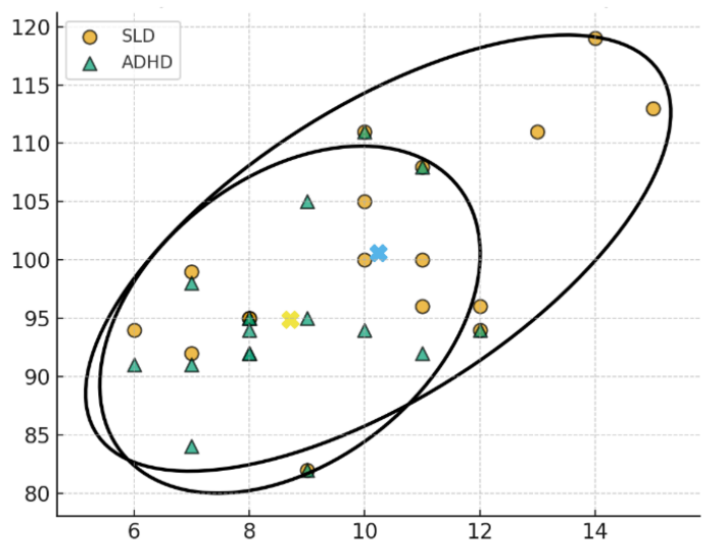

Figure 4. Group centroids and confidence ellipses for SLD and ADHD participants across Arithmetic and Verbal IQ (Source: Authors' own elaboration)

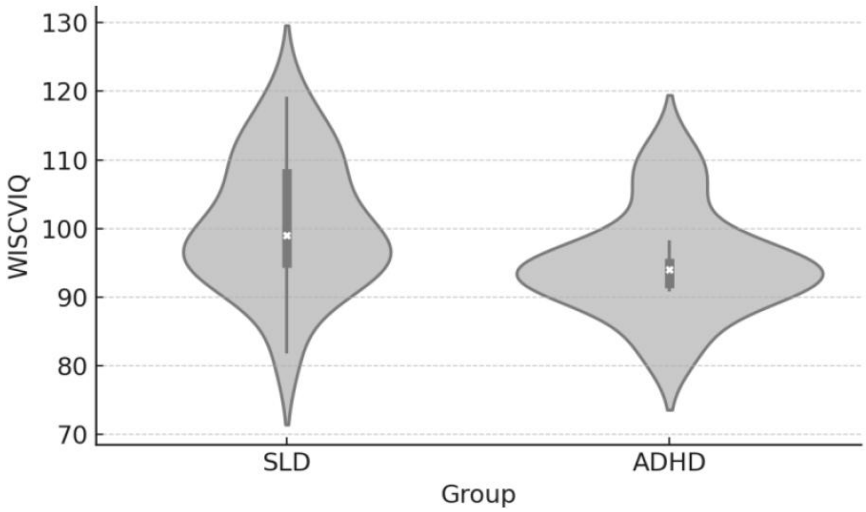

Figure 5. Violin plot showing the distribution of WISC-VIQ (Verbal IQ) scores for the SLD and ADHD (Source: Authors' own elaboration)

Figure 6 presents the distribution of Mathematical Competence scores for the SLD and ADHD groups. Similar to the WISC-VIQ scores in **Figure 5**, the SLD group tends to have higher scores on average, while the ADHD group shows a greater spread in performance. There is noticeable overlap in the distributions, suggesting variability within both groups.

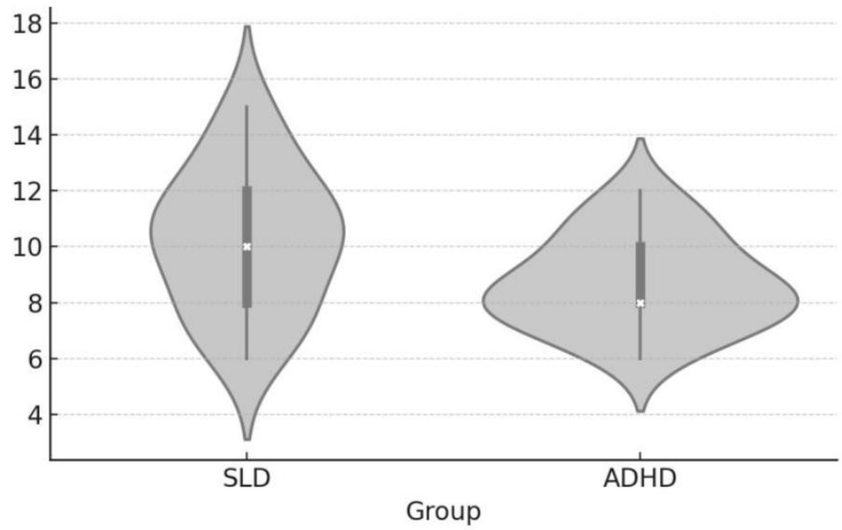

Figure 6. Violin plot showing the distribution of Mathematical Competence scores for the SLD and ADHD (Source: Authors' own elaboration)

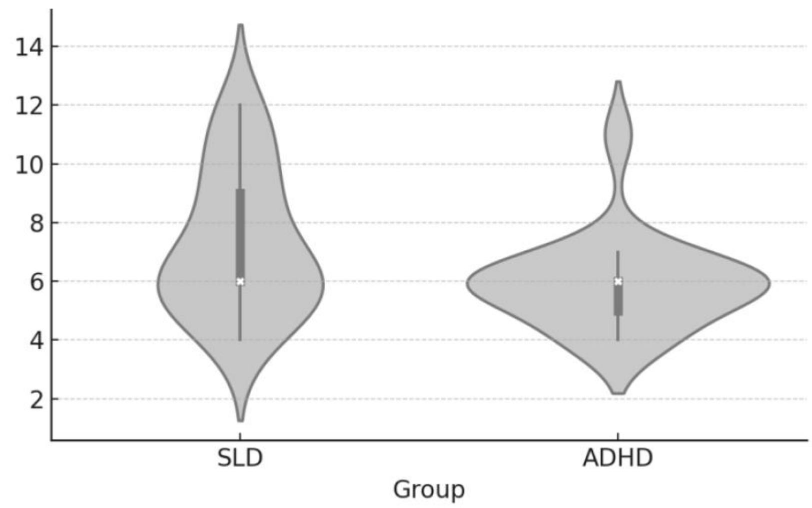

Figure 7. Violin plot showing the distribution of Digit Span scores for the SLD and ADHD (Source: Authors' own elaboration)

Figure 7 presents the distribution of VIQ scores for the SLD and ADHD groups. The SLD group again shows higher mean scores in this cognitive domain, although the ADHD group also demonstrates a broad range of performance. Overlap between the groups is observed, further emphasizing that cognitive profiles vary within both groups.

Mathematical Competence and Verbal IQ scores, revealing areas of higher concentration at moderate levels of both variables. The smooth and continuous density contours indicate overlapping cognitive profiles rather than distinct clusters, suggesting gradual variation in arithmetic and verbal abilities across participants (**Figure 8**).

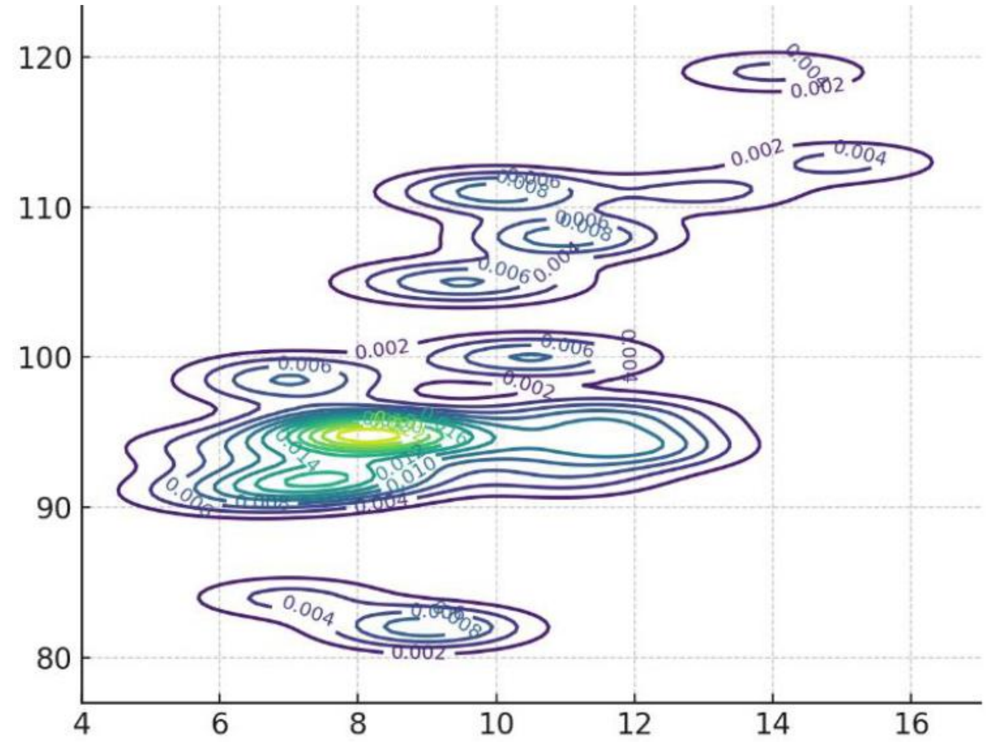

Figure 8. Kernel density contour plot illustrating the joint distribution of Mathematical Competence and Verbal IQ (WISC-VIQ) scores across participants (Source: Authors' own elaboration)

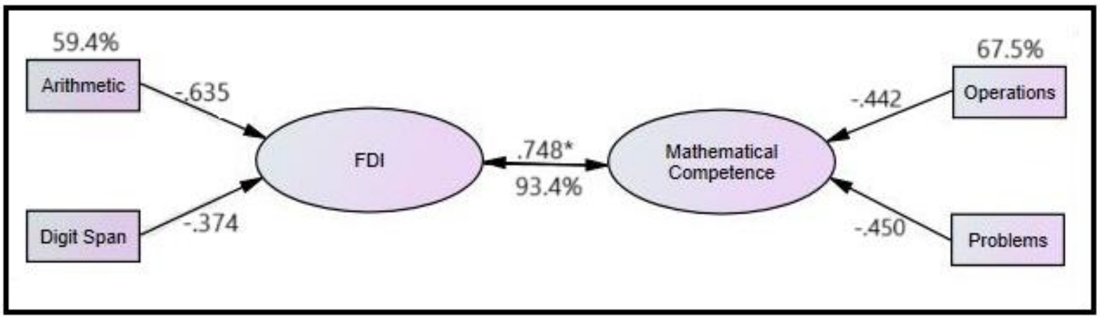

Figure 9. Correlation between the FDI variable set and the mathematical competence set (Source: Authors' own elaboration)

FDI and Mathematical Competence Measures

The set combination for FDI included arithmetic (attention and concentration, numerical reasoning) and digit span (short-term auditory memory, concentration), while mathematical competence included operations and problems. The correlation between the FDI variable set and the mathematical competence set was statistically significant and moderate ($r = .65 > .32$, $p = .049$). Results are graphically presented through the path diagram in **Figure 9**.

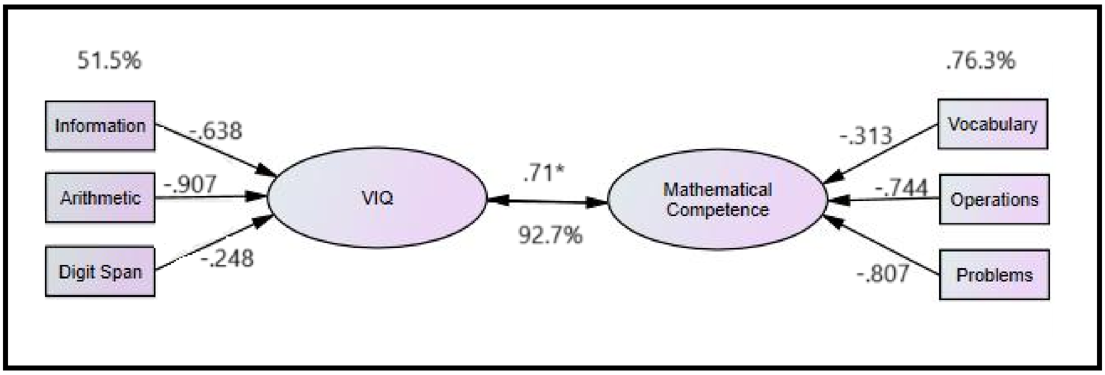

Figure 10. Correlation between the VIQ variable set and the mathematical competence set (Source: Authors' own elaboration)

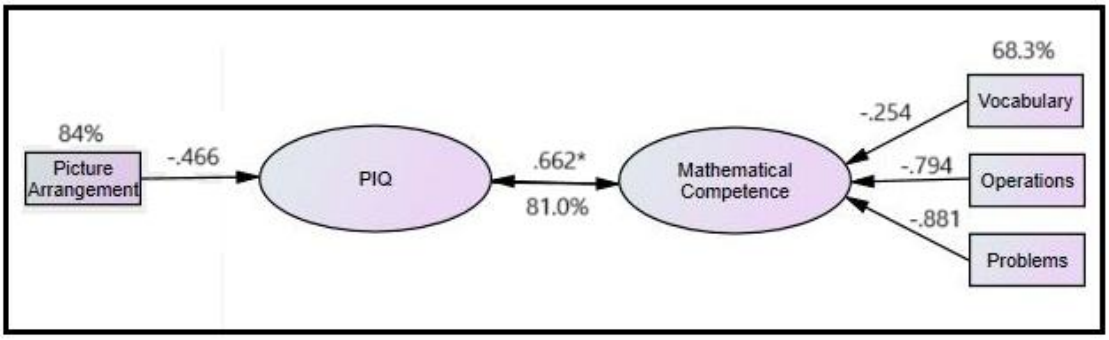

Figure 11. Correlation between the PIQ variable set and the mathematical competence set (Source: Authors' own elaboration)

VIQ and Mathematical Competence Measures

The set combination for VIQ included information (factual knowledge, long-term memory, recall), arithmetic (attention and concentration, numerical reasoning), and digit span (short-term auditory memory, concentration), while mathematical competence included vocabulary, operations, and problems. The correlation between the VIQ variable set and the mathematical competence set was statistically significant and moderate ($r = .71 > .32$, $p = .008$). Results are graphically presented through the path diagram in **Figure 10**.

PIQ and Mathematical Competence Measures

The set combination for PIQ included Picture Arrangement (planning, logical thinking, social knowledge), while mathematical competence included vocabulary, operations, and problems. The correlation between the PIQ variable set and the mathematical competence set was statistically significant and moderate ($r = .66 > .32$, $p = .023$). Results are graphically presented through the path diagram in **Figure 11**.

Finally, **Figure 12** provides a descriptive visualization of standardized (z-score) group profiles across selected cognitive and mathematical domains. The radar chart illustrates that, at the group level, children with SLD demonstrate higher mean standardized scores for VIQ, PIQ, Mathematical Competence (overall), operations, and problem-solving than children with ADHD. This visualization summarizes the group differences observed in the inferential analyses and is intended to depict overall performance patterns rather than individual-level classification.

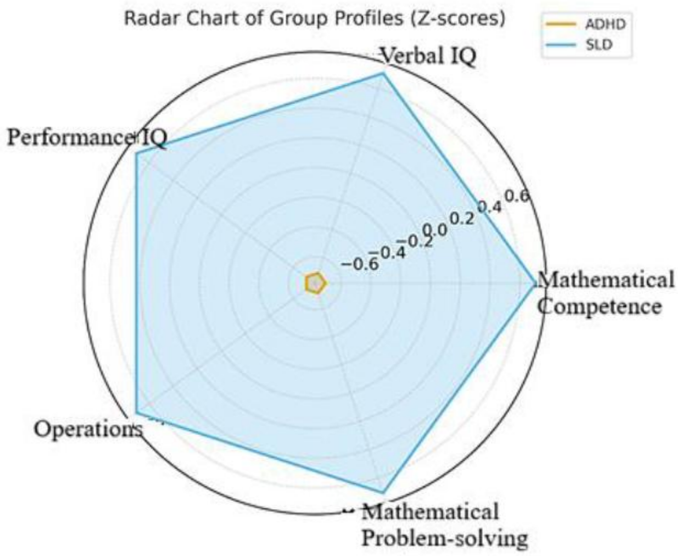

Figure 12. Radar chart illustrating standardized (z-score) group profiles for ADHD and SLD participants across cognitive (WISC-VIQ, PIQ) and mathematical competence variables (Source: Authors' own elaboration)

DISCUSSION

The present study aimed to conduct a comparative assessment of mathematical competence in fifth-grade boys diagnosed with SLD or ADHD. Additionally, it examined the relationship between cognitive abilities, as measured by the Wechsler Intelligence Scale for Children-Third Edition (WISC-III^{GR}), and mathematical performance through Canonical Correlation Analysis (CCA). The findings contribute meaningfully to the expanding literature on neurodevelopmental disorders by elucidating how distinct cognitive profiles shape mathematical learning outcomes. Beyond cognitive interpretation, the present study systematically examines how the identified cognitive differences can be translated into educational practice. Specifically, each major finding is interpreted in relation to its implications for instructional approaches and the design of mathematical tasks in 5th-grade mathematics classrooms.

Group Differences in Cognitive and Mathematical Performance

In line with Research Question 1 (RQ1), the results revealed clear group differences in cognitive performance and mathematical competence. Overall, students with SLD demonstrated stronger performance than their ADHD peers, particularly in areas tied to verbal reasoning, attention, and executive functioning. These findings reflect the complex nature of cognitive development in neurodivergent populations and align with previous research that emphasizes differential patterns of strengths and weaknesses across disorders (Pennington, 2009).

Specifically, the SLD group performed significantly better on several WISC-IIIGR subtests, including Verbal IQ, Information, Arithmetic, Digit Span, and Picture Arrangement. The elevated Verbal IQ and Information subtest scores suggest that children with SLD may retain greater access to crystallized knowledge, which helps compensate for their difficulties in decoding or phonological processing (Swanson & Jerman, 2006; Yang et al., 2021). Conversely, the ADHD group's lower performance on these indices aligns with prior research demonstrating pervasive difficulties in attention regulation, inhibitory control, and working memory that directly impact academic performance (Barkley, 1997; Martinussen et al., 2005; Willcutt et al., 2005).

The Freedom from Distractibility Index (FDI), composed of the Arithmetic and Digit Span subtests, further highlights these differences. Children with ADHD scored significantly lower on this index, suggesting difficulties in sustaining attention and managing mental computation abilities that are essential for solving mathematical problems (Rapport et al., 2000; Frazier et al., 2004). This supports the notion that ADHD-related difficulties in cognitive persistence and attentional control can substantially interfere with math learning (Swanson et al., 2012). From an educational perspective, these findings suggest that mathematics instruction for students with ADHD should be designed to reduce executive load, particularly in tasks involving multi-step computation and problem-solving. In 5th-grade mathematics, this may involve segmenting tasks such as fraction operations or decimal calculations into smaller procedural steps and embedding self-monitoring prompts (e.g., "Have I completed each step?") to support sustained attention and accuracy.

Importantly, results suggested no statistically significant group differences emerged in reading and writing measures, including decoding, comprehension, and morphology-syntax. Although minor trends were observed, such as slightly higher morphology-syntax scores in the ADHD group, these were not meaningful at the statistical level. This result supports earlier findings that, while both ADHD and SLD populations can demonstrate weaknesses in language-based tasks, their cognitive and neuropsychological underpinnings differentiate (Martinez-Lincoln et al., 2023; Mayes & Calhoun, 2006; Stewart et al., 2025; Yang et al., 2021).

Additionally, the SLD group outperformed the ADHD group in mathematical operations and problem-solving. While math difficulties are a core concern for many children with SLD, particularly in areas involving number sense and symbolic processing (Heyd-Metzuyanim, 2025; Geary, 2004), the ADHD group showed even more pronounced difficulties, especially in tasks requiring multi-step reasoning and sustained mental effort. These findings may reflect the compounded effects of executive dysfunction, distractibility, and impulsivity on math performance in children with ADHD (Swanson et al., 2012; Willcutt et al., 2005). The difficulties in working memory and inhibitory control characteristics of ADHD (Barkley, 2014) appear to significantly hinder performance on tasks demanding sequential logic and error monitoring.

Correlations Between Intelligence and Mathematical Competence (RQ2 & RQ3)

To address Research Questions 2 and 3, the study employed Canonical Correlation Analysis (CCA) to investigate how specific WISC-III^{GR} subtest scores relate to different aspects of mathematical competence in both groups of participants. The results revealed multiple significant correlations, suggesting that mathematics relies on a constellation of cognitive processes.

Freedom from Distractibility Index (FDI), comprised of Arithmetic and Digit Span, was strongly correlated with mathematical operations and problem-solving (r=.65, p=.049). This supports previous findings that arithmetic fluency and short-term memory are critical for carrying out complex calculations and managing multi-step procedures (Geary, 2011; Swanson & Beebe-Frankenberger, 2004). Existing findings in the field suggest that the FDI's predictive power emphasizes the importance of mental focus and sequential processing in math achievement, especially for children with ADHD. These instructional adaptations are particularly relevant in core 5th-grade mathematical domains, such as fraction operations, long division, and multi-step word problems, where sustained attention and sequential processing are essential for successful task completion.

The analysis revealed a statistically significant and moderate correlation (r=.71, p=.008) between the Verbal IQ (VIQ) variable set and mathematical competence measures. This suggests that children with either SLD or ADHD who excel in verbal intelligence tasks, such as factual knowledge, long-term memory recall, arithmetic reasoning, and short-term auditory memory, tend to perform better in mathematical competence tasks, including vocabulary, mathematical operations, and mathematical problem-solving.

The overlap between the VIQ tasks, especially in areas like attention, concentration, numerical reasoning, and memory, appears to align closely with skills needed for mathematical competence. For instance, the ability to quickly recall facts and process information (measured by the digit span task) may facilitate mathematical problem-solving and mathematical reasoning. Similarly, the arithmetic task, which focuses on numerical reasoning, has clear relevance to mathematical operations and mathematical problem-solving.

These findings align with earlier studies in typically developing children emphasizing the role of verbal mediation and linguistic comprehension in mathematics, particularly in tasks like decoding word problems, interpreting symbolic representations, and applying procedures to contextual problems (Jordan et al., 2003; Fuchs et al., 2006). Children with strong verbal reasoning abilities are often better equipped to understand math vocabulary and translate it into effective mathematical strategies. From an instructional perspective, this finding highlights the importance of explicitly teaching mathematical language in primary education. Rather than assuming that students acquire terminology implicitly, teachers should systematically introduce and reinforce key concepts such as numerator, denominator, factor, and multiple through repeated exposure, contextualized examples, and guided use in problem-solving tasks. This is particularly relevant for 5th-grade learners, where increased linguistic demands in word problems may otherwise impose additional cognitive load. This finding further suggests that instructional approaches in 5th-grade mathematics should integrate explicit language scaffolding within task design, ensuring that linguistic complexity does not become an additional barrier to mathematical understanding.

Performance IQ (PIQ) also emerged as a significant predictor of mathematical competence (r=.66, p=.023), particularly via the Picture Arrangement subtest in both groups of participants. This task evaluates visual sequencing and logical reasoning, both of which are critical in identifying mathematical patterns, interpreting graphs, or performing spatial transformations (Bull & Espy, 2006; Kyttälä & Lehto, 2008). This finding highlights the contribution of non-verbal reasoning and visual-spatial processing in math learning, a domain often underexplored in ADHD and SLD research. These findings further support the integration of visual scaffolding in mathematics instruction. In 5th-grade classrooms, the use of number lines, fraction bars, diagrams, and spatial representations can facilitate understanding of abstract concepts and reduce cognitive load. Such supports are particularly beneficial in tasks involving fractions, geometry, and multi-step problem-solving, where visual organization can enhance both reasoning and accuracy. From a task design perspective, this implies that mathematical activities should systematically incorporate visual structuring elements, particularly in domains such as fractions, geometry, and problem-solving, where spatial reasoning supports conceptual understanding.

These associations highlight the complex nature of mathematical cognition, which relies on the integration of various cognitive domains, such as verbal comprehension, executive function, attention, and visual-spatial reasoning (Cirino, 2011; Iglesias-Sarmiento et al., 2017; Swanson & Sachse-Lee, 2001). Importantly, these findings extend beyond cognitive description and provide a foundation for the development of differentiated instructional approaches and mathematically meaningful task designs. By aligning cognitive profiles with specific pedagogical strategies, the study supports a more systematic and evidence-based approach to mathematics instruction in inclusive 5th-grade classrooms.

CONCLUSION

This study sought to examine and compare the cognitive profiles and mathematical competence of 5th-grade boys diagnosed with either ADHD or SLD, with a particular focus on how cognitive abilities relate to various aspects of mathematical performance. The findings revealed that while both groups exhibit challenges in mathematics, the nature and origins of these difficulties differ substantially, shaped by distinct cognitive and neuropsychological factors.

Children with SLD consistently outperformed their ADHD peers across various cognitive domains, particularly in verbal reasoning, working memory, and executive functioning tasks. These strengths were mirrored in their performance on mathematical operations and mathematical problem-solving tasks, suggesting that although SLD is often associated with mathematics-related difficulties, the presence of more intact executive processes may constitute a relative advantage when compared to the cognitive constraints seen in ADHD. In contrast, children with ADHD struggled more significantly with tasks requiring sustained attention, inhibitory control, and complex sequential processing, deficits that are known to undermine mathematical performance, especially in multi-step tasks or those demanding sustained cognitive engagement.

The canonical correlation analyses (CCA) conducted in this study further illuminated the interconnectedness between specific cognitive dimensions and mathematical abilities. Verbal IQ, Freedom from Distractibility (FDI), and Performance IQ were each significantly correlated with core mathematical skills, including operations and mathematical problem-solving, in both groups of participants. These relationships support a growing body of literature in typically developing children suggesting that a single cognitive ability does not drive mathematical learning but is instead the product of a dynamic interplay among linguistic, attentional, memory-based, and visual-spatial processes (Abikoff & Gallagher, 2009; Cirino, 2011; Peng et al., 2020; Swanson & Sachse-Lee, 2001; Stewart et al., 2025; Yang et al., 2021). This integrative perspective moves beyond a narrow view of mathematics as a solely quantitative domain. It reinforces the idea that cognitive strengths or weaknesses in non-numerical areas can significantly influence mathematical success.

The implications of these findings are both practical and theoretical. From a pedagogical perspective, they emphasize the need to tailor instructional strategies to the unique cognitive profiles of learners. For children with ADHD, interventions should focus on enhancing executive function, with particular attention to working memory, attention regulation, and impulse control. Cognitive-behavioral interventions, task-structuring tools, and adaptive technologies may provide significant benefits for this group (Drljić & Doz, 2025).

In contrast, children with SLD, particularly those with verbal strengths, may benefit from language-rich, conceptually grounded approaches to math instruction. These methods should emphasize verbal mediation, explicit vocabulary teaching, and scaffolding of abstract mathematical concepts through dialogue and visual aids. Effective instruction should also incorporate multi-sensory strategies and interventions aimed at improving executive function and working memory (Dexter & Hughes 2011; Fuchs et al., 2016a). Tailored, evidence-based approaches are essential for helping children with ADHD and SLD achieve mathematical proficiency and long-term academic success.

From a clinical and diagnostic perspective, the results reaffirm the utility of comprehensive, standardized cognitive assessments such as the WISC-III^{GR}. These tools offer critical insight into individual learners' cognitive architecture and can differentiate between overlapping symptoms seen in ADHD and SLD, which often coexist but require distinct intervention strategies. By examining composite indices (e.g., FDI, VIQ, PIQ) in relation to academic skills, practitioners can move beyond superficial test scores to identify meaningful cognitive patterns that inform more accurate diagnoses and better-targeted supports (Iglesias-Sarmiento et al., 2017; Peterson et al., 2017; Toffalini et al., 2022).

Additionally, the study advocates for an integrative, multidimensional approach to assessment and intervention, one that considers academic performance and cognitive function as interdependent. Relying solely on traditional achievement scores may overlook underlying cognitive strengths or challenges that are crucial for effective instructional planning. When educators and clinicians adopt a holistic perspective, acknowledging the interplay among working memory, verbal reasoning, attention, and spatial processing, they are better equipped to design personalized learning pathways that foster both academic achievement and cognitive growth.

Importantly, the study extends beyond comparative cognitive assessment by providing a transparent link between identified cognitive profiles and educational approaches to instruction and task design. By explicitly connecting empirical findings with classroom practices in 5th-grade mathematics, the study contributes to the development of cognitively informed, differentiated, and practically applicable teaching strategies for students with ADHD and SLD.

Implications for Mathematics Education derived from the cognitive findings: Paradigms, Applications, and Task Design

In this section, instructional paradigms, classroom applications, and task design principles are explicitly derived from the cognitive and mathematical differences identified between the ADHD and SLD groups. The findings of the present study provide a direct empirical basis for defining differentiated educational approaches to instruction and mathematical task design in 5th-grade classrooms, particularly when interpreted through the framework of Cognitive Load Theory, which emphasizes the role of working memory limitations in learning. The observed differences between students with ADHD and SLD highlight the importance of managing cognitive load in mathematics instruction by aligning teaching practices, classroom applications, and task design with learners' cognitive profiles.

Instructional Paradigms: Managing Cognitive Load

The differential cognitive patterns identified between children with ADHD and SLD support a shift from uniform instructional models toward differentiated and cognitively responsive teaching paradigms. Specifically, a cognitive-informed instructional paradigm is warranted, in which teaching approaches are aligned with underlying processes such as working memory, attention regulation, and verbal reasoning.

For students with SLD, a structured and explicit instruction paradigm is particularly appropriate. This includes systematic instruction in mathematical concepts, cumulative review, and guided practice to strengthen conceptual understanding and procedural fluency. For example, in a 5th-grade lesson on fraction addition (e.g., $\frac{3}{4}+\frac{2}{3}$), instruction may be organized into clearly defined steps (finding a common denominator, converting fractions, and performing the addition), supported by visual representations such as fraction bars. More specifically, teachers should help children understand the concept of adding fractions. Instruction should emphasize that fractions represent parts of a whole that must be equal in size to be combined. Using visual or contextual models (e.g., partitioned shapes or familiar objects like food), learners are guided to recognize that unlike parts cannot be directly added. Instruction then focuses on transforming fractions into equivalent forms with a common denominator, enabling students to interpret addition as combining equal-sized units rather than applying a purely procedural rule. Such a structured sequencing reduces cognitive overload and facilitates schema development.

In contrast, for students with ADHD, a self-regulation and executive function-oriented paradigm is more effective, emphasizing attentional scaffolding, metacognitive strategies, and external supports to manage cognitive load. For instance, during multi-step arithmetic tasks (e.g., solving problems involving multiplication of two-digit numbers), students may be provided with checklists (e.g., "read carefully," "choose the operation," "check the result") and encouraged to pause and verify each step, thereby supporting attention regulation and task completion.

Importantly, the results also support the integration of a multimodal learning paradigm, combining verbal, visual, and procedural representations. For example, when teaching decimal numbers, students may simultaneously engage with number lines, symbolic representations (e.g., 0.25), and verbal explanations ("twenty-five hundredths"), reinforcing connections between language and mathematical reasoning.

From a CLT perspective, effective mathematics instruction should aim to balance intrinsic load (task complexity), extraneous load (inefficient instructional design), and germane load (learning-relevant processing). For students with SLD, difficulties in conceptual understanding and working memory suggest that intrinsic load should be carefully controlled through structured and explicit instruction. A scaffolded instructional paradigm that gradually increases task complexity, for example, beginning with simple fraction equivalence before progressing to operations, can help prevent overload and support schema construction. For students with ADHD, instruction should focus on minimizing extraneous cognitive load, for example, by simplifying instructions in word problems or reducing irrelevant textual information. A cognitively streamlined paradigm is particularly beneficial for maintaining engagement and task completion.

Classroom Applications

Translating these paradigms into practice, mathematics instruction should incorporate targeted classroom applications that address specific cognitive needs. For students with SLD, effective applications include explicit teaching of mathematical vocabulary through repeated exposure and contextual use. For example, when introducing terms such as "numerator," "denominator," or "multiple," teachers may pair each term with visual representations and repeated usage in problem-solving contexts. Additionally, visual tools such as number lines can support understanding of decimal comparisons (e.g., placing 0.4 and 0.35 on a number line to determine magnitude), reducing abstraction and supporting conceptual clarity. Guided modeling is also essential; for instance, the teacher may solve a word problem aloud ("First, I identify what is given, then I decide which operation to use"), making cognitive processes explicit.

For students with ADHD, instruction should emphasize clear and concise instructions with reduced linguistic complexity. For example, a multi-step problem involving quantities (e.g., "A shop sells 3 boxes with 24 pencils each…") may be broken into smaller sequential prompts, each focusing on a single operation. The use of external supports, such as visual cues, timers, or step-by-step prompts, can help students manage attention and working memory demands. Furthermore, incorporating active learning elements, such as the use of mini whiteboards or short interactive tasks, can sustain engagement and reduce passive processing. Frequent formative feedback and structured opportunities for self-monitoring are also critical, particularly in tasks requiring sustained attention and error control.

Mathematical Task Design

A key implication of the study concerns the design of mathematical tasks, which should reflect the cognitive demands placed on learners. For students with SLD, tasks should reduce linguistic ambiguity while explicitly supporting vocabulary comprehension. For example, a word problem may be adapted by highlighting key information, simplifying sentence structure, or accompanying the text with visual representations (e.g., diagrams showing quantities). Multi-step procedures, such as long division or fraction operations, may be scaffolded by providing partially completed steps or structured templates. Additionally, repeated and structured practice is essential for strengthening arithmetic fluency, for instance, through gradual progression from guided to independent problem-solving.

For students with ADHD, tasks should be concise and clearly structured in order to minimize unnecessary cognitive load. For example, instead of presenting a worksheet with multiple densely packed problems, tasks may be organized into smaller sections with clear boundaries. Built-in checkpoints (e.g., prompts such as "Have you checked your answer?") can support self-monitoring and reduce impulsive responding. Task variation, such as alternating between computation and short problem-solving activities, can help sustain attention without increasing cognitive overload.

Moreover, tasks involving mathematical problem-solving should be carefully designed to balance cognitive demands. For example, a complex 5th-grade word problem involving fractions (e.g., determining the portion of a quantity) may be presented stepwise, with intermediate questions guiding the solution process and visual supports (e.g., diagrams or fraction models) reducing executive load while preserving conceptual rigor.

Integrative Perspective

The observed associations between cognitive variables (e.g., Verbal IQ, working memory, and perceptual organization) and mathematical competence further suggest that mathematics education should adopt an integrative paradigm, where domain-specific instruction is complemented by support for underlying cognitive processes. In this context, instructional practices that combine language-based strategies with cognitive scaffolding are particularly effective. For example, teachers may use “think-aloud” strategies during problem-solving (“I need to find a common denominator before adding these fractions”), thereby supporting both verbal reasoning and procedural understanding. Similarly, providing memory aids, such as structured rules or visual summaries of procedures, can reduce working memory demands and support learning.

Implications for Teacher Education

Finally, these findings highlight the need for teacher education programs to incorporate training on cognitively informed instructional design, differentiation based on neurodevelopmental profiles, and effective task adaptation strategies. For instance, teachers should be trained to recognize signs of cognitive overload (e.g., incomplete tasks, random errors) and to respond by adapting task structure or reducing extraneous load. Equipping teachers with these competencies is essential for fostering inclusive mathematics classrooms that respond to diverse learning needs. In this way, the study establishes a transparent and systematic connection between cognitive findings and educational practice, reinforcing the role of cognitively informed instructional design in supporting mathematical learning in diverse classrooms.

Limitations and Future Research

This study provides valuable insights into the cognitive and mathematical profiles of children with ADHD and SLD. However, several limitations should be acknowledged and interpreted in context. First, the relatively small sample size (N = 34) limits statistical power and the generalizability of the findings. This issue is particularly relevant given the use of multivariate techniques such as Linear Discriminant Analysis (LDA) and Canonical Correlation Analysis (CCA), which typically require larger samples for optimal stability. Nevertheless, the study employed balanced group sizes and applied cross-validation procedures (leave-one-out cross-validation), which enhance the robustness and internal consistency of the findings. As such, the results can be considered exploratory yet methodologically grounded.

Second, the inclusion of only male participants restricts the generalizability of the findings across genders. However, this decision was intentional in order to control for potential gender-related variability in cognitive and academic performance, thereby increasing internal validity. Future research should extend these findings by including gender-diverse samples.

Third, although all participants had received official diagnoses, limited detail is provided regarding the diagnostic procedures. Despite this, diagnoses were obtained from specialized interdisciplinary centers, which supports their clinical validity. Future studies should further strengthen transparency by explicitly reporting diagnostic criteria and assessment protocols.

Fourth, the study did not control for background variables such as socioeconomic status (SES), parental education, or school context, which may influence cognitive and academic outcomes. Nonetheless, participants were assessed within similar educational settings, partially reducing environmental variability. Future research should incorporate these variables to allow for more precise modeling of contextual influences.

Fifth, the exclusion of comorbid cases, while reducing ecological validity, was a deliberate methodological choice aimed at isolating the distinct cognitive profiles of ADHD and SLD. This strengthens the interpretability of group differences, although future studies should also examine comorbid populations to better reflect real-world clinical complexity.

Sixth, the use of the WISC-III^{GR}, an earlier version of the instrument, may be viewed as a limitation in terms of contemporary assessment standards. However, its standardized adaptation for the Greek population and its extensive use in prior research support its validity and comparability. Future research may benefit from incorporating more recent versions (e.g., WISC-V) to capture a broader range of executive functions.

Seventh, the study involved multiple statistical comparisons without formal correction procedures, which may increase the risk of Type I error. However, the consistent pattern of results across related variables and the inclusion of effect size estimates provide additional support for the reliability of the findings. Future studies should consider more conservative statistical approaches or correction methods.

Finally, the cross-sectional design limits conclusions regarding developmental trajectories and causal relationships. Nevertheless, it provides an important snapshot of group differences and serves as a foundation for future longitudinal investigations that can examine how cognitive and mathematical profiles evolve over time.

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AI statement: The authors stated that no generative AI or AI-based tools were used.

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Data sharing statement: Authors declare that data will be available upon request and project completion.

REFERENCES

Abikoff, H., & Gallagher, R. (2009). Attention-deficit hyperactivity disorder and academic failure: The role of cognitive processes. In R. Barkley (Ed.), *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment* (3rd ed., pp. 520-548). Guilford Press.

Alloway, T. P., & Alloway, R. G. (2014). *The memory advantage: Train your brain to function stronger, smarter, faster*. Simon & Schuster.

Alloway, T. P., & Passolunghi, M. C. (2011). The relationship between working memory, IQ, and mathematical skills in children. *Learning and Individual Differences, 21*(1), 133-137. https://doi.org/10.1016/j.lindif.2010.09.013

American Psychiatric Association (APA). (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Andersson, U., & Lyxell, B. (2007). Working memory deficit in children with mathematical difficulties: A general or specific deficit? *Journal of Experimental Child Psychology, 96*(3), 197-228. https://doi.org/10.1016/j.jecp.2006.10.001

Baker, D. P., & Behrman, J. R. (2009). Population, education and development: The role of human capital. In R. A. Easterlin (Ed.), *Population and economic change in developing countries* (pp. 199-233). University of Chicago Press.

Barbas, G., Vermeulen, F., Kioseoglou, G., & Menexes, G. (2008). *Psychometric criterion of mathematical competence for children and adolescents*. In the context of the EPEAEK project "Psychometric–differential assessment of children and adolescents with learning difficulties".

Barkley, R. A. (1997). *ADHD and the nature of self-control*. Guilford Press.

Barkley, R. A. (2014). *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment* (4th ed.). Guilford Press.

Bull, R., & Espy, K. A. (2006). Working memory, executive functioning, and children's mathematics. In D. Berch, & M. M. M. Mazzocco (Eds.), *Why is math so hard for some children? The nature and origins of mathematical learning difficulties and disabilities* (pp. 93-114). Paul H. Brookes Publishing Co. https://doi.org/10.1016/B978-012554465-8/50006-5

Capodieci, A., & Martinussen, R. (2017). Executive functions and academic performance in children with ADHD: A meta-analytic review. *Child Neuropsychology, 23*(7), 726-757.

Catts, H. W., Terry, N. P., Lonigan, C. J., Compton, D. L., Wagner, R. K., Steacy, L. M., Farquharson, K., & Petscher, Y. (2024). Revisiting the definition of dyslexia. *Annals of Dyslexia, 74*(3), 282-302. https://doi.org/10.1007/s11881-023-00295-3

Cirino, P. T. (2011). The interrelationships of mathematical precursors in kindergarten. *Journal of Experimental Child Psychology, 108*(4), 713-733. https://doi.org/10.1016/j.jecp.2010.11.004

Crisci, G., Caviola, S., Cardillo, R., & Mammarella, I. C. (2021). Executive functions in neurodevelopmental disorders: Comorbidity overlaps between attention deficit and hyperactivity disorder and specific learning disorders*. Frontiers in Human Neuroscience, 15*. https://doi.org/10.3389/fnhum.2021.594234

Dexter, D. D., & Hughes C. A. (2011). Graphic organizers and students with learning disabilities: A meta-analysis. *Learning Disability Quarterly*, *34*(1), 51-72. https://doi.org/10.1177/073194871103400104

Drljić, K., & Doz, D. (2025). Digital tools and mathematics learning difficulties: A bibliometric analysis (1988-2024). *International Journal of Instruction*, *18*(2), 1-22. https://doi.org/10.29333/iji.2025.1821a

DuPaul, G. J., Gormley, M. J., & Laracy, S. D. (2013). Comorbidity of LD and ADHD: Implications of DSM-5 for assessment and treatment. *Journal of Learning Disabilities, 46*(1), 43-51. https://doi.org/10.1177/0022219412464351

Essien, N., & Davis, E. K. (2024). Exploring values implicit in Ghanaian Senior High School mathematics textbooks. *Asian Journal for Mathematics Education, 3*(1), 81-105. https://doi.org/10.1177/27527263241232712

Fosco, W. D., Kofler, M. J., Groves, N. B., Chan, E. S., & Raiker, J. S. (2020). Which 'working'components of working memory aren't working in youth with ADHD? *Journal of Abnormal Child Psychology, 48*, 647-660. https://doi.org/10.1007/s10802-020-00621-y

Frazier, T. W., Demaree, H. A., & Youngstrom, E. A. (2004). Meta-analysis of intellectual and neuropsychological test performance in attention-deficit/hyperactivity disorder. *Neuropsychology, 18*(3), 543-555. https://doi.org/10.1037/0894-4105.18.3.543

Friedman, L. M., Rapport, M. D., Orban, S. A., Eckrich, S. J., & Bolden, J. (2018). Executive functioning and academic achievement in children with ADHD. *Neuropsychology, 32*(4), 497-508.

Fuchs, L. S., Fuchs, D., Compton, D. L., Powell, S. R., Seethaler, P. M., Capizzi, A. M., & Schatschneider, C. (2006). The cognitive correlates of third-grade skill in arithmetic, algorithmic computation, and arithmetic word problems. *Journal of Educational Psychology, 98*(1), 29-43. https://doi.org/10.1037/0022-0663.98.1.29

Fuchs, L. S., Gilbert, J. K., Powell, S. R., Cirino, P. T., Fuchs, D., Hamlett, C. L., & Seethaler, P. M. (2016a). The role of cognitive processes and foundational math skill in predicting mathematics learning disability versus low achievement. *Current Directions in Psychological Science, 25*(6), 433-442.

Fuchs, L. S., Schumacher, R. F., Long, J., Namkung, J., Malone, A. S., Wang, A., Hamlett, C. L., Jordan, N. C., Siegler, R. S., & Changas, P. (2016b). Effects of intervention to improve at-risk fourth graders' understanding, calculations, and word problems with fractions. *The Elementary School Journal, 116*(4). https://doi.org/10.1086/686303

Gaye, F., Harmon, S. L., Cole, A. M., Marsh, C. L., Liu, Q., Mcintosh, A., & Kofler, M. J. (2025). Examining the roles of working memory and trait anxiety on math achievement in children with ADHD. *Neuropsychology*, *39*(3), 259-274. https://doi.org/10.1037/neu0000994

Geary, D. C. (2004). Mathematics and learning disabilities. *Journal of Learning Disabilities, 37*(1), 4-15. https://doi.org/10.1177/00222194040370010201

Geary, D. C. (2011). Cognitive predictors of achievement growth in mathematics: A five-year longitudinal study. *Developmental Psychology, 47*(6), 1539-1552. https://doi.org/10.1037/a0025510

Geary, D. C. (2013). Early foundations for mathematics learning and their relations to learning disabilities. *Current Directions in Psychological Science, 22*(1), 23-27. https://doi.org/10.1177/0963721412469398

Georgas, D. D., Paraskevopoulos, I. N., Bezevegis, H. G., & Giannitsas, N. D. (1997). *Greek version of Wechsler intelligence scale for children, WISC-III*. Ellinika Grammata.

González–Castro, P., Cueli, M., Areces, D., Rodríguez, C., & Sideridis, G. (2016). Improvement of word problem solving and basic mathematics competencies in students with attention deficit/hyperactivity disorder and mathematical learning difficulties. *Learning Disabilities Research & Practice*, *31*(3), 142-155. https://doi.org/10.1111/ldrp.12106

Heyd-Metzuyanim, E. (2025). Failure to teach/learn mathematics: a complexity-discursive perspective. *Educational Studies in Mathematics*, *119,* 515-533. https://doi.org/10.1007/s10649-025-10404-1

Iglesias-Sarmiento, V., Deaño, M., Alfonso, S., & Conde, Á. (2017). Mathematical learning disabilities and attention deficit and/or hyperactivity disorder: A study of the cognitive processes involved in arithmetic problem solving. *Research in Developmental Disabilities, 61,* 44-54. https://doi.org/10.1016/j.ridd.2016.12.012

Jordan, N. C., Hanich, L. B., & Kaplan, D. (2003). Arithmetic fact mastery in young children: A longitudinal investigation. *Journal of Experimental Child Psychology, 85*(2), 103-119. https://doi.org/10.1016/S0022-0965(03)00032-8

Kercood, S., Zentall, S. S., & Lee, D. L. (2004). Focusing attention to deep structure in math problems: Effects on elementary education students with and without attentional deficits. *Learning and Individual Differences, 14*(2), 91-105.

Kofler, M. J., Sarver, D. E., Harmon, S. L., Moltisanti, A., Aduen, P. A., Soto, E. F., & Ferretti, N. (2018). Working memory and organizational skills problems in ADHD. *Journal of Child Psychology and Psychiatry, 59*(1), 57-67. https://doi.org/10.1111/jcpp.12773

Kyttälä, M., & Lehto, J. E. (2008). Some factors underlying mathematical performance: The role of visuospatial working memory and non-verbal intelligence. *European Journal of Psychology of Education, 23*(1), 77-94. https://doi.org/10.1007/BF03173141

Lucangeli, D., & Cabrele, S. (2006). Mathematical difficulties and ADHD. *Exceptionality*, *14*(1), 53-62. https://doi.org/10.1207/s15327035ex1401_5

Lüssenhop, M., & Kaiser, G. (2024). Mathematics teaching for migrant students in German schools—How do teachers respond to their students' diverse needs? *Asian Journal for Mathematics Education, 3*(1), 60-80.

Martinez-Lincoln, A., Fotidzis, T. S., Cutting, L. E., Price, G. R., & Barquero L. A. (2023). Examination of common and unique brain regions for atypical reading and math: A meta-analysis. *Cerebral Cortex*, *33*(11), 6959-6989. https://doi.org/10.1093/cercor/bhad013

Martinussen, R., Hayden, J., Hogg-Johnson, S., & Tannock, R. (2005). A meta-analysis of working memory impairments in children with attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 44*(4), 377-384. https://doi.org/10.1097/01.chi.0000153228.72591.73

Mayes, S. D., & Calhoun, S. L. (2006). Frequency of reading, math, and writing disabilities in children with clinical disorders. *Learning and Individual Differences, 16*(2), 145-157. https://doi.org/10.1016/j.lindif.2005.07.004

Melby-Lervåg, M., Redick, T. S., & Hulme, C. (2016). Working memory training does not improve performance on measures of intelligence or other measures of "far transfer": Evidence from a meta-analytic review. *Perspectives on Psychological Science, 11*(4), 512-534. https://doi.org/10.1177/1745691616635612

Ozonoff, S., & Jensen, J. (1999). Specific executive function profiles in three neurodevelopmental disorders. *Journal of Autism and Developmental Disorders, 29*(2), 171-177. https://doi.org/10.1023/A:1023052913110

Padeliadou, S., & Antoniou, F. (2007). *Test Alpha (Reading test).* ΕΠΕΑΕΚ, ΥΠΕΠΘ. (Standardized test for reading disabilities in Greek).

Peng P., Lin X., Ünal Z. E., Lee K., Namkung J., Chow J., & Sales A. (2020). Examining the mutual relations between language and mathematics: A meta-analysis. *Psychological Bulletin*, *146*(7), 595-634. https://doi.org/10.1037/bul0000231

Pennington, B. F. (2009). *Diagnosing learning disorders: A neuropsychological framework* (2nd ed.). Guilford Press.

Peterson R. L., Boada R., McGrath L. M., Willcutt E. G., Olson R. K., & Pennington B. F. (2016). Cognitive prediction of reading, math, and attention: Shared and unique influences. *Journal of Learning Disabilities*, *50*(4), 408-421. https://doi.org/10.1177/0022219415618500

Porpodas, C., Diakogiorgi, K., Dimakos, I., & Karantzi, I. (2007). *Written language difficulties test*. Ministry of National Education and Religious Affairs – EPEAEK.

Rachanioti, E., Alevriadou, A., & Charitaki, G. (2024). Components of early executive functioning in the prediction of academic success in high-ability preschool children. *The International Journal of Early Childhood Learning, 32*(1), 1-15. https://doi.org/10.18848/2327-7939/CGP/v32i01/1-28

Rachanioti, E., Alevriadou, A., & Charitaki, G. (2025). Bidirectional associations between executive functions and early academic skills in preschool children with high abilities: A cross-lagged model analysis. *The International Journal of Early Childhood Learning, 33*(1), 1-22. https://doi.org/10.18848/2327-7939/CGP/v33i01/1-22

Rapport, M. D., Chung, K.-M., Shore, G., Denney, C. B., & Isaacs, P. (2000). Upgrading the science and technology of assessment and diagnosis: Laboratory and clinic-based assessment of children with ADHD. *Journal of Clinical Child Psychology, 29*(4), 555-568. https://doi.org/10.1207/S15374424JCCP2904_8

Shaywitz, S. E. (2003). *Overcoming dyslexia: A new and complete science-based program for reading problems at any level*. Knopf.

Shaywitz, S. E., Fletcher, J. M., & Shaywitz, B. A. (2002). Defining and classifying learning disabilities and attention-deficit/hyperactivity disorder. *Journal of Child Neurology, 17*(1_suppl), S1-S5.

Stewart, A. A., Scammacca, N., Lee, Y. R., & Cappelli, P. (2025). Exploring differences between cognition, reading, math, and attention scores in students with disabilities: A systematic review. *Learning Disability Quarterly*, *49*(1). https://doi.org/10.1177/07319487251318352

Swanson, H. L., & Beebe-Frankenberger, M. (2004). The relationship between working memory and mathematical problem solving in children at risk and not at risk for serious math difficulties. *Journal of Educational Psychology, 96*(3), 471-491. https://doi.org/10.1037/0022-0663.96.3.471

Swanson, H. L., & Jerman, O. (2006). Math disabilities: A selective meta-analysis of the literature. *Review of Educational Research, 76*(2), 249-274. https://doi.org/10.3102/00346543076002249

Swanson, H. L., & Sachse-Lee, C. (2001). Mathematical problem solving and working memory in children with learning disabilities: Both executive and phonological processes are important. *Journal of Experimental Child Psychology, 79*(3), 294-321. https://doi.org/10.1006/jecp.2000.2587

Swanson, J. M., Schuck, S., Porter, M. M., Carlson, C., Hartman, C. A., Sergeant, J. A., Clevenger, W., Wasdell, M., McCleary, R., Lakes, K., & Wigal, T. (2012). *Strengths and weaknesses of ADHD symptoms and normal behaviors rating scale (SWAN)* [Database record]. APA PsycTests. https://doi.org/10.1037/t30027-000

Toffalini, E., Buono S., & Cornoldi C. (2022). The structure, profile, and diagnostic significance of intelligence in children with ADHD are impressively similar to those of children with a specific learning disorder. *Research in Developmental Disabilities*, *129,* 1-11. https://doi.org/10.1016/j.ridd.2022.104306

Tosto, M. G., Momi, S. K., Asherson, P., & Malki, K. (2015). A systematic review of attention deficit hyperactivity disorder (ADHD) and mathematical ability: Current findings and future implications. *BMC Medicine*, *13,* Article 204. https://doi.org/10.1186/s12916-015-0414-4

Vessonen, T., Dahlberg, M., Hellstrand, H., Widlund, A., Söderberg, P., Korhonen, J., Aunio, P., & Laine, A. (2025). Individual characteristics associated with elementary school children's mathematical word problem-solving skills: A systematic review and meta-analysis. *Review of Education*, *13*(1), Article e70045. https://doi.org/10.1002/rev3.70045

Viesel-Nordmeyer N., Reuber J., Kuhn J., Moll K., Holling H., & Dobel C. (2023). Cognitive profiles of children with isolated and comorbid learning difficulties in reading and math: A meta-analysis. *Educational Psychology Review*, *35*(1), Article 34. https://doi.org/10.1007/s10648-023-09735-3

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of ADHD: A meta-analytic review. *Biological Psychiatry, 57*(11), 1336-1346. https://doi.org/10.1016/j.biopsych.2005.02.006

Yang, X., Yan, M., Ruan, Y., Ku, S. Y. Y., Lo, J. C. M., Peng, P., & McBride, C. (2021). Relations among phonological processing skills and mathematics in children: A meta-analysis. *Journal of Educational Psychology*, *114*(2), 289-307. https://doi.org/10.1037/edu0000710