

The Cognitive and Psychological Foundations of Mathematical Difficulties: " A Theoretical Perspective"

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Abstract:

This study examines mathematical learning difficulties (dyscalculia) as a developmental disorder arising from cognitive neurological, and emotional factors. It explores its theoretical foundations, behavioral and cognitive manifestations, causes, and strategies for diagnosis and intervention. Dyscalculia is linked to deficits in numerical representation and processing rather than low intelligence. Early diagnosis through observation, assessments, and error analysis is emphasized. Effective teaching should guide learners from concrete to abstract understanding, strengthen working memory, and support emotional motivation. The study advocates for inclusive education that respects individual learning differences.

Keywords: Learning difficulties, mathematical learning disability, dyscalculia, diagnostic mechanisms, intervention strategies

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1. INTRODUCTION

The ability to perform mathematical operations constitutes a fundamental component of human cognitive activity. It serves as a mental tool that enables individuals to organize their daily experiences, make decisions, and interact effectively within social and educational contexts. Learning mathematics has therefore received special attention in schools, as it represents a cornerstone in developing academic competence and higher-order thinking skills.

However, a subset of students exhibit notable difficulties in acquiring basic numerical and arithmetic skills, despite possessing average or even above-average intelligence. This recurrent inability to manage numbers, symbols, and problem-solving processes in a logical sequence often hinders their academic progress. In educational psychology literature, this phenomenon is referred to as mathematical learning difficulty or dyscalculia , recognized as one of the developmental and academic learning disorders.

The significance of addressing this topic lies not only in its relation to academic achievement but also in its deep connection to the individual's cognitive structure and the development of their self-perception as a capable or incapable learner. A child who struggles to comprehend numerical relationships or to retain arithmetic rules within working memory may gradually withdraw from learning situations, hesitate to participate in class, and eventually become overwhelmed by feelings of inadequacy, anxiety, or rejection.

Therefore, understanding the cognitive and psychological causes underlying mathematical difficulties is not merely a diagnostic necessity; it also represents a preventive and therapeutic approach. Such understanding enables schools to provide appropriate

educational support that prevents these difficulties from escalating into psychological distress or chronic academic failure.

Cognitive and neuroscientific studies have demonstrated that mathematical difficulties do not stem from mere educational shortcomings or insufficient practice. Rather, they are associated with subtle impairments in the mechanisms of numerical information processing, value discrimination, retrieval of arithmetic facts, and the organization of logical problem-solving steps.

Moreover, these difficulties often intertwine with psychological factors such as math anxiety, low motivation, and learned helplessness. Consequently, mathematical difficulty emerges as the outcome of a complex interaction between the child's cognitive structure and emotional experience within the broader context of school and family environments.

Providing a comprehensive theoretical perspective on mathematical learning difficulties requires examining their conceptual foundations, identifying their main features and symptoms, and analyzing the cognitive and psychological mechanisms that explain their emergence. It is equally important to highlight their impact on both academic performance and the learner's psychological adjustment.

From this standpoint, the present article seeks to outline an analytical framework that clarifies the factors associated with dyscalculia, and to illuminate the developmental path through which such difficulties arise. This approach aims to support the design of educational interventions that are not only more effective but also more empathetic and responsive to the learner's human experience.

1- Learning Difficulties

1-1- Definition of Learning Difficulties



Learning difficulties are disorders that affect the fundamental cognitive and psychological processes responsible for attention, perception, concept formation, memory, and problem-solving. These disorders result in reduced ability to acquire essential academic skills such as reading, writing, or arithmetic, leading to underachievement across various school subjects. Importantly, such difficulties are not attributable to intellectual disabilities, psychological disorders, or environmental deprivation (Dweikat, 2019).

Learning difficulties refer to a group of developmental disorders that hinder an individual's ability to acquire and use fundamental academic skills—such as reading, writing, and arithmetic—despite possessing intelligence within the normal range and having relatively adequate environmental and educational conditions. These difficulties are typically specific to certain domains of learning and cannot be explained by a general cognitive deficit or limited learning opportunities alone. Rather, they reflect a functional impairment in the cognitive processing systems responsible for receiving, organizing, and retrieving information when needed (Khuja, 2019).

This definition challenges simplistic explanations that attribute learning difficulties solely to lack of attention or low motivation, and instead situates them within the realm of disorders with cognitive and developmental origins. It is crucial to distinguish between difficulties arising from external factors—such as limited educational resources—and those stemming from internal functional impairments in cognitive processing mechanisms.

Understanding this distinction is essential for guiding appropriate educational responses: should the focus be on improving instructional methods and learning environments, or on implementing specialized diagnostic and therapeutic interventions that target specific cognitive processes?

1-2- Manifestations and Symptoms of Learning Difficulties:

The manifestations of learning difficulties vary according to their nature and specific domains; however, they share a common feature—they hinder the learner's academic and behavioral performance despite normal or above-average intelligence. The main manifestations can be summarized as follows:

❖ Weakness in Retrieval and Recall of Facts:

Learners who experience difficulties in this area often display limited ability to remember linguistic rules or basic arithmetic operations, even after repeated practice and exposure. They tend to struggle when required to retrieve learned concepts at the moment of need, which hinders their capacity to apply acquired knowledge in new contexts. This weakness becomes particularly evident in tasks that demand rapid recall of information, such as oral reading or performing mental arithmetic.

❖ Symbolic Recognition Disorder:

This disorder is one of the defining characteristics of learning difficulties, as the child struggles to connect written symbols with the meanings or outcomes they represent. For instance, the learner may find it challenging to associate a numeral with its symbolic form or a letter with its corresponding sound. Such weaknesses hinder the acquisition of reading and writing skills and disrupt the linguistic encoding process, which forms the foundation of comprehension and understanding.

❖ Executive Difficulties in Problem Solving:

These difficulties manifest as weaknesses in cognitive organization and an inability to sequence the steps required to complete academic tasks. Learners often appear confused when solving mathematical

problems or analyzing written texts, as they lose the logical order of operations or struggle to determine the next step in the task. Such deficits are frequently linked to limitations in working memory or mental planning skills, resulting in performance that is disorganized and fragmented.

❖ Discrepancy Between General Ability and Academic Achievement:

One of the key indicators of learning difficulties is a noticeable gap between a child's overall intellectual ability and their academic performance. A learner may demonstrate strong competence in everyday and social situations, effectively solving practical problems, yet struggle with specific academic tasks such as reading comprehension or performing arithmetic operations. This discrepancy reflects a dysfunction in cognitive processing mechanisms rather than a deficiency in general intellectual capacity.

These manifestations highlight that learning difficulties do not stem from low intelligence or lack of effort, but rather from specific disorders in the neurological and cognitive processes that underpin learning. This understanding calls for the implementation of individualized instructional strategies that take into account the unique characteristics and needs of each learner (Al-Musaad, 2023).

The manifestations described above are not merely surface-level symptoms but rather reflections of deficits in specific cognitive domains—namely, working memory, processing speed, executive organization, and symbolic representation . For instance, weakness in recall does not simply indicate poor memory; it may stem from inadequate encoding during learning or from difficulty accessing stored knowledge due to disrupted neural connections among information units. Therefore, when a single symptom is observed, it is

essential to broaden the assessment to determine whether it forms part of a broader cognitive pattern or results from a specific underlying mechanism.

2- Classification of Learning Difficulties:

Learning difficulties are classified according to the nature of the functional deficit and the affected academic domain, as their manifestations vary depending on which cognitive processes are impaired. The main categories are outlined below, along with their defining characteristics:

2-1- Reading Difficulties (Dyslexia):

Dyslexia is among the most common forms of learning difficulty. It is characterized by a disorder that affects essential reading skills such as word recognition accuracy, reading fluency, and text comprehension. Learners with dyslexia often exhibit slow decoding of linguistic symbols and difficulty converting written forms into corresponding sounds, which disrupts reading comprehension. They may also struggle with spelling and distinguishing between similar letters, challenges that frequently extend to writing performance. This disorder is typically associated with dysfunctions in brain regions responsible for language processing rather than deficiencies in intelligence or motivation.

2-2- Writing Difficulties (Dysgraphia):

Dysgraphia manifests as weakness in written expression and the ability to organize ideas coherently on paper, often accompanied by difficulties with spelling, punctuation, and sentence construction. Affected learners may write slowly or make frequent errors in letter formation due to deficits in the fine motor skills required for pencil control. These difficulties are not limited to the motor aspect; they



also involve organizational and cognitive challenges , as the learner struggles to translate thoughts into clear, structured written text.

2-3- Mathematical Difficulties (Dyscalculia):

Children with this type of learning difficulty face significant challenges in understanding basic numerical concepts, such as grasping place value or comprehending quantitative relationships between symbols. They often struggle to perform simple arithmetic operations and to recall numerical facts quickly and accurately. This weakness is frequently linked to deficits in mental representations of numbers or impairments in logical sequencing skills, which in turn make it difficult for the learner to solve mathematical problems that require abstract reasoning or prior planning.

2-4- Multiple Learning Difficulties:

This category refers to cases in which more than one type of learning difficulty overlaps, causing the learner to experience deficits across several domains—such as reading, writing, and mathematics—simultaneously. This pattern is often attributed to a broader dysfunction in neurological processing mechanisms that disrupt the integration of perceptual and cognitive functions. It may also be accompanied by weaknesses in attention, working memory, or executive organization, making the learning process particularly demanding and requiring comprehensive, multidimensional educational support.

These classifications highlight that learning difficulties are not a single, uniform condition but rather a diverse group of disorders that require a precise understanding of their nature. Such understanding is essential for designing instructional strategies that align with the

specific characteristics of each category and support learners in reaching their fullest potential (Al-Rubaih, 2022).

This classification is practically valuable because it guides both assessment and intervention strategies; however, it should not be interpreted as representing entirely distinct or isolated categories. In reality, cognitive mechanisms —such as working memory and executive attention—often overlap across these classifications. Consequently, a child diagnosed with dyslexia may also exhibit difficulties in numerical reasoning, and vice versa.

The most effective approach, therefore, is one that combines domain-specific and integrative perspectives : employing specialized diagnostic tools while simultaneously conducting a comprehensive evaluation of shared cognitive processes, in order to construct a holistic understanding of the learner’s profile.

3- General Characteristics of Learning Difficulties:

Learning difficulties are distinguished by a set of core features that differentiate them from other developmental disorders or general academic delays. These characteristics provide insight into the complex nature of learning difficulties and inform both educational and diagnostic approaches. The most prominent characteristics include the following:

3-1- Relative Continuity Over Time:

Learning difficulties are characterized by their persistence; they do not disappear spontaneously or after brief periods of instruction but continue to manifest at varying levels despite consistent educational exposure. This persistence is largely attributed to neurological and functional factors that affect core cognitive processes such as memory, attention, and language processing. Consequently, learners require long-term educational interventions that emphasize the

development of compensatory strategies and higher-order thinking skills, rather than relying solely on repetitive traditional drills.

However, this continuity does not imply that the severity of the difficulty remains fixed. Its impact may fluctuate depending on the nature of the support provided and the degree of awareness and understanding surrounding the learner's condition.

3-2- Domain Specificity:

A defining feature of learning difficulties is their tendency to affect a specific cognitive domain rather than general intellectual ability. For example, a child may struggle with reading or mathematics while performing at an average or even superior level in other areas. This specificity indicates that the difficulty does not stem from an overall intellectual limitation but from impairments in particular neural processing mechanisms responsible for linguistic or numerical functions.

Hence, accurate diagnosis is crucial to precisely identify the area of weakness and to design targeted educational interventions that address the specific difficulty while recognizing and fostering the learner's strengths in other domains.

3-3- Individual Variability in Expression:

The manifestations of learning difficulties vary considerably from one student to another, even when the type of disorder is the same. The intensity and pattern of the difficulty are influenced by multiple factors, including heredity, neurological maturity, the quality of the educational environment, and the level of family support. Some learners may exhibit pronounced weaknesses in foundational skills such as symbol recognition or information retrieval, while others may

struggle primarily with slow processing speed or deficits in executive organization.

This variability underscores the importance of approaching each case individually , avoiding uniform instructional strategies, and instead tailoring interventions to meet the unique profile and needs of every learner with learning difficulties.

3-4- Gap Between Theoretical Understanding and Practical Application:

A common characteristic among learners with learning difficulties is their ability to demonstrate sound conceptual understanding during verbal discussions while struggling to translate that understanding into effective performance in classroom activities. For instance, a student may correctly explain a mathematical concept or a grammatical rule but fail to apply it when solving exercises or writing.

This discrepancy often stems from weaknesses in linking abstract understanding to practical execution , or from limitations in working memory , which hinder the retrieval of relevant information at the moment it is needed. The gap between theoretical comprehension and practical application thus serves as a clear indicator of processing dysfunctions , rather than a lack of effort or attention.

Taken together, these characteristics illustrate that learning difficulties represent a complex phenomenon shaped by the interaction of neurological, cognitive, and environmental factors. Addressing them effectively therefore requires a comprehensive educational approach that acknowledges individual differences and is grounded in a deep understanding of the nature and underlying mechanisms of each difficulty (Dweikat, 2019).

These characteristics require researchers and practitioners to adopt a long-term perspective , tracking the child's developmental trajectory

over the years rather than relying on brief or isolated assessments. They also call for the implementation of individualized and gradual intervention plans that account for variations in each learner's responsiveness to instruction.

Furthermore, the gap between theoretical understanding and practical performance highlights that the success of any educational strategy depends on how well teaching methods align with the learner's mode of information encoding. Learners who struggle to translate abstract understanding into practical action benefit most from instructional approaches that reconstruct representations or strengthen the sensory channels involved in learning.

➤ **General Diagnostic Mechanisms**

Accurate diagnosis of learning difficulties represents a critical step in identifying the nature of the problem and designing appropriate educational programs to address it. This process requires the integration of both quantitative and qualitative assessment methods to ensure a comprehensive understanding of the learner's condition. The key components of a scientific diagnostic approach to learning difficulties include the following:

4- Multi-Source Assessment:

Scientific diagnosis relies on collecting data from multiple sources to ensure both the accuracy and comprehensiveness of evaluation. This includes the administration of standardized tests that measure academic abilities—such as reading, writing, and mathematics—alongside cognitive assessments designed to evaluate intelligence and core mental processes.

In addition, classroom observations are conducted to document behavioral patterns and interaction styles during learning activities,

while reports from teachers and parents provide valuable context linking academic performance to everyday behavior. This diversity of information sources enables a holistic understanding of the learner's profile and helps differentiate between temporary academic difficulties and genuine developmental learning disorders.

4-1-Verification of Exclusion Criteria:

A fundamental principle in scientific diagnosis is ensuring that the learning difficulty is not caused by external factors that can be addressed through conventional means. Therefore, it is essential to rule out conditions such as uncorrected hearing or vision impairments , inadequate quality of basic instruction, or environmental and cultural deprivation. Additionally, psychotic or generalized neurological disorders that affect overall cognitive functioning must also be excluded.

This step aims to confirm that the learning difficulty stems from a specific deficit in cognitive processing mechanisms, rather than from limited learning opportunities or sensory or intellectual impairments.

4-2- Analysis of Cognitive Processing Mechanisms:

This component of diagnosis focuses on understanding how a child processes information rather than merely evaluating the outcomes of learning. It involves assessing the efficiency of working memory, processing speed, and phonological awareness, as well as the ability to use linguistic and numerical symbols effectively.

Such analysis helps identify the specific cognitive breakdowns that hinder learning—for example, difficulty retaining information while performing tasks, slow comprehension of instructions, or weak associations between sounds and letters. Understanding the nature of these processes provides the foundation for designing educational interventions tailored to each learner's strengths and weaknesses.



4-3- Classification of Severity and Impact:

After collecting and analyzing the relevant data, the degree of learning difficulty and its impact on both academic performance and daily functioning are determined. This classification allows educators to develop an intervention plan that corresponds to the level of need—whether the difficulty is mild and manageable within the regular classroom, moderate and requiring specialized support, or severe and necessitating an intensive remedial program.

Additionally, the evaluation considers the broader effects of the difficulty on areas such as communication, time management, and social participation, ensuring that the educational response remains comprehensive and balanced (Al-Rubaih, 2022).

Scientific diagnosis of learning difficulties is not merely a process of measurement; rather, it is an integrated diagnostic pathway grounded in both qualitative and quantitative analysis aimed at understanding the specific mechanisms of a learner's weaknesses. Its ultimate goal is to provide the appropriate educational and psychological support that enables effective learning and fosters both academic and social inclusion.

Diagnosis, in this context, is not merely the assignment of a label but rather an interpretive process aimed at uncovering the cognitive structure underlying the learner's difficulties. This requires trained professionals who can interpret test results in light of the child's educational and psychological context. Moreover, the diagnostic process must be dynamic, meaning that it should be revisited over time to adjust both assessment and intervention according to the child's response, as the stability of certain factors—such as working memory—may evolve with development or early intervention.

5- General Influential Factors (Biological, Environmental, and Psychological) :

Learning difficulties arise from the interaction of multiple factors, which can be categorized into several main domains:

5-1- Physiological Factors:

This category refers to a range of elements associated with the organic structure and physiological functions of children who experience learning difficulties. These factors include functional neurological disorders, imbalances in hemispheric or lateral dominance, as well as visual and auditory problems that may impair the child's ability to effectively receive and process information. (Al-Rahbia, 2012)

5-2- Lateralization Disorder:

Lateralization disorder is considered one of the neurological factors contributing to learning difficulties, as it results from incomplete functional specialization between the two cerebral hemispheres, leading to a disruption in neural coordination that affects the child's ability to process and organize information. This disorder is often manifested through inconsistency in the use of one side of the body for motor or perceptual tasks—such as the dominant hand or eye—which can result in weaknesses in reading, writing, and visual-spatial discrimination. Moreover, instability in lateral dominance may reduce the child's capacity for focus and attention, thereby making the acquisition of academic skills more challenging. (Deprasue, 2012)

5-3- Biological and Genetic Factors:

Recent neuroscientific research indicates that some children are born with structural variations in the brain regions responsible for linguistic and numerical processing, leading to reduced efficiency in information transmission between specialized cortical areas. Genetic

factors also play a significant role in predisposing individuals to specific learning difficulties within certain cognitive domains—such as weaknesses in verbal memory or numerical cognition. This hereditary influence is often evidenced by the recurrence of similar learning patterns and difficulties among members of the same family.

5-4- Neurocognitive Factors:

These factors involve functional deficits in key cognitive processes that underpin effective learning. For instance, limitations in working memory reduce a child's ability to retain and manipulate information during task performance, while slow processing speed hampers success in academic activities that demand rapid, sequential responses. Additionally, some children exhibit deficits in symbolic representation of quantities, which compromises their numerical reasoning and mathematical understanding, resulting in a restricted and often imprecise grasp of quantitative concepts.

5-5- Environmental and Educational Factors:

The educational environment plays a crucial role in shaping a child's cognitive and academic development. Low-quality early education or the use of inappropriate teaching methods can exacerbate existing learning difficulties. Likewise, insufficient parental support or the absence of a stimulating, resource-rich learning environment may restrict linguistic and cognitive growth. Conversely, the availability of diverse educational resources and instructional approaches that account for individual differences can significantly enhance a child's responsiveness to learning and mitigate the impact of learning challenges.

5-6- Psychological and Emotional Factors:

A child's psychological state exerts a direct influence on their ability to learn and adapt to educational contexts. High levels of anxiety or low self-esteem can lead to academic withdrawal and diminished confidence in one's abilities. Similarly, reduced motivation to learn often results in decreased effort when confronting academic challenges, thereby intensifying learning difficulties and undermining the effectiveness of educational interventions designed to enhance performance. (Dweikat, 2019)

It can be stated that the aforementioned factors—biological and genetic, neurocognitive, environmental and educational, as well as psychological and emotional—do not operate in isolation; rather, they interact in complex ways to form the overall structure of learning difficulties. Moreover, laterality disorders and physiological factors can be viewed as extensions of this neurofunctional interaction, representing additional manifestations of disrupted neurophysiological integration that directly affect a child's academic and cognitive performance.

Laterality disorders reflect an inconsistency in neural dominance between the two cerebral hemispheres, resulting in deficits in visuomotor coordination and difficulties in organizing spatial and linguistic information, which negatively affect reading and writing skills. In contrast, physiological factors—including visual, auditory, or neurological impairments—can limit the child's ability to accurately perceive educational stimuli, thereby increasing the difficulty of processing and comprehending information.

Accordingly, these factors can be viewed as an interconnected network of neurological, psychological, and environmental influences that collectively contribute—at varying degrees—to the emergence of learning difficulties. This interdependence underscores the necessity of adopting a comprehensive approach to diagnosis and intervention,

one that simultaneously considers the physical, neurological, cognitive, and emotional dimensions of the learner.

Learning difficulties thus represent a multidimensional phenomenon that demands a nuanced understanding of the underlying cognitive processing structures and their educational and psychological contexts. A clear recognition of their manifestations, an accurate classification of their types, and a careful differentiation of their causes form the first essential step toward designing effective educational and therapeutic responses that respect the unique profile of each learner.

Moving beyond merely describing learning difficulties toward understanding their underlying structure requires a rigorous research methodology and close collaboration among educational psychologists, neurologists, teachers, and families. Such a partnership enables the translation of diagnostic findings into practical educational and psychological strategies that target specific functional weaknesses while reinforcing areas of strength—rather than limiting the process to a superficial description of the problem.

6- The Concept of Mathematical Learning Difficulty (Dyscalculia)

Mathematical learning difficulty, or dyscalculia, is grounded in a complex cognitive and neurological framework that concerns how the human mind represents numbers and understands quantities. The ability to perceive numbers is not merely an academic skill but a fundamental cognitive function that begins to develop in early childhood through what is known as numerical intuition.

This innate sense enables children to differentiate between quantities approximately even before they learn numerical symbols or arithmetic

procedures. Over time, this intuitive capacity evolves into a more abstract and symbol-based representation of numbers. For example, a child comes to understand that the numeral (5) does not merely denote “a group of five objects,” but rather represents a stable numerical value that can be used in addition, subtraction, and comparison operations.

However, children with dyscalculia struggle to make a smooth transition between these developmental stages. They may possess an intuitive grasp of quantity , yet find it difficult to connect this understanding to numerical symbols —or, conversely, they may memorize symbols without comprehending their quantitative meaning.

Neurocognitive research indicates that this disorder is associated with a functional deficit in the posterior parietal region of the brain, an area responsible for processing numerical and spatial relationships . This deficit does not imply structural damage or injury, but rather a reduced efficiency in the neural communication pathways that support numerical processing and integration.

At the cognitive level, this weakness is associated with several internal processes, including:

- Quantity representation: establishing the connection between a number and the magnitude it signifies.
- Discrimination between close numerical values: for instance, distinguishing between 8 and 9 or 14 and 41.
- Understanding numerical relationships in mathematical operations: recognizing that addition and subtraction are inverse processes.
- Organizing logical steps in problem-solving: the ability to move sequentially from given data to conclusions.(Gari, 2023)

For the child, learning mathematics is not merely a complex task but an experience often marked by confusion and a recurring absence of meaning. Each step appears isolated from the next, and every result seems disconnected from what preceded it. Consequently, the child fails to develop a sense of mathematical logic and instead perceives numbers and symbols as detached entities, devoid of real-world relevance.

Understanding the conceptual foundation of dyscalculia is essential, as it reveals that the difficulty does not stem from “lack of effort” or “inattention,” but rather from the deep cognitive structure governing how the mind perceives numerical relationships.

This insight transforms how teachers and families approach the child: instead of emphasizing rote memorization of tables and procedures, the focus shifts toward rebuilding the concept of number itself through sensory exploration, visual representations, and graduated use of concrete tools that allow the child to see relationships before memorizing them.

Thus, the therapeutic path begins with meaning before symbol, and sensory experience before symbolic practice.

6-1- Definition of Dyscalculia (Mathematical Learning Disability)

Dyscalculia is defined as a developmental disorder that specifically affects an individual’s ability to comprehend basic numerical concepts, process number-related information, and perform both simple and complex mathematical operations. This impairment occurs independently of general intelligence, learning opportunities, or any evident sensory or neurological deficits.

The disorder manifests in the child's performance during tasks that involve numerical reasoning. Affected learners often display an unusual slowness in grasping mathematical relationships, commit frequent errors in simple calculations despite repeated practice, or struggle to estimate quantities approximately before performing detailed computations.

From an educational perspective, dyscalculia is classified as an academic learning difficulty, meaning that it is confined to a specific cognitive domain rather than reflecting a general impairment in intellectual ability or knowledge acquisition.

From a clinical standpoint, it is viewed as a dysfunction in the symbolic and quantitative representation mechanisms of numbers. In other words, a child may understand that a numeral represents "something," yet struggle to associate it with its actual value or to use it effectively in constructing coherent mathematical operations.

It is crucial to distinguish between dyscalculia and general academic underachievement in mathematics. Academic weakness may result from ineffective teaching, lack of practice, or insufficient family support. In contrast, dyscalculia represents a structural cognitive deficit that persists even when adequate instruction and repeated practice are provided.

Thus, a child with dyscalculia may show only limited progress despite increased time, explanation, and effort, because the difficulty does not lie in the quantity of learning but rather in the way the brain processes numerical information . (Wernicke, 2021)

Understanding the concept of dyscalculia serves as a fundamental starting point before discussing its causes or consequences. A precise definition of the term allows it to be clearly distinguished from other

issues that may appear similar—such as test anxiety or ineffective teaching methods.

Once it is recognized that the difficulty lies in the mental representation mechanisms of numbers , relying solely on repetition, memorization, or increased homework becomes ineffective, as these strategies fail to address the root of the problem.

Effective educational approaches should instead focus on strengthening working memory , developing the child’s ability to perceive quantities, and introducing numbers through sensory, visual, and concrete experiences—all of which help reconstruct the symbolic representation of number from its foundation.

6-2- Behavioral and Cognitive Characteristics of Dyscalculia

Dyscalculia manifests in learners through a range of behavioral patterns and cognitive features that can be observed in various learning situations—both during mathematical activities in the classroom and in everyday contexts involving the use of numbers, estimation of time, or measurement of distances.

These manifestations serve as key diagnostic indicators that help teachers and specialists identify the nature and severity of the difficulty. The following are the most prominent behavioral and cognitive characteristics of dyscalculia :

6-3- Weak Retrieval of Basic Numerical Facts:

One of the most distinctive features of dyscalculia is the child’s marked difficulty in recalling simple numerical results that are typically acquired through repetition and practice—such as multiplication table outcomes or basic addition and subtraction facts. Instead of retrieving answers automatically from memory, the child

often resorts to finger counting or to drawing symbols and visual aids, even at relatively advanced grade levels.

This persistent reliance on external supports reveals an absence of stable mental representations of numbers within working memory, making each calculation a new cognitive effort that requires reconstructing understanding every time. Such weakness is frequently accompanied by slow task performance and repeated errors arising from the loss of sequential order in mental operations.

6-4- Distorted Perception of Numerical Symbols and Orientation:

Children with dyscalculia often display confusion in reading and writing numbers. They may mix up visually similar digits such as (6) and (9), or reverse the order of numbers like (12) and (21). In some cases, they even write numbers upside down or in the wrong direction.

Moreover, these children tend to struggle with understanding place value—they may not grasp the distinction between ones, tens, and hundreds—leading to frequent errors in interpreting and writing numbers. This perceptual deficit directly affects their ability to perform complex calculations, as they lose track of each digit's function within an operation and have difficulty arranging numbers according to their numerical value.

6-5- Deficits in Understanding Numerical Concepts and Logical Relationships:

Children with dyscalculia often struggle to grasp basic quantitative concepts such as **“more than,” “less than,”** or **“equal to.”** They also find it difficult to represent logical relationships between numbers, which in turn weakens their ability to build higher mathematical concepts like addition, subtraction, and multiplication—

processes that depend on understanding the quantitative relationships among numbers.

Furthermore, these children often fail to connect a number with the actual quantity it represents, treating numbers merely as abstract symbols without real quantitative meaning. This lack of conceptual grounding leads to a mechanical and superficial approach to arithmetic learning, where operations are performed by rote rather than through genuine comprehension of numerical relationships.

6-6- Slowness in Problem Solving and Difficulty Organizing Steps:

Slow performance in arithmetic tasks is one of the most prominent indicators of dyscalculia. Affected children often pause repeatedly while solving problems to reread the information or reorder the numbers, showing hesitation and a lack of systematic progression from one step to the next. This confusion becomes more evident in word problems that require translating language into mathematical symbols, where the child struggles to identify the correct operation or extract relevant data from the text.

Such difficulties reflect weaknesses in executive organization and mental planning, leading the child to rely on guessing rather than following a logical, sequential thought process.

6-7- Emotional and Behavioral Manifestations:

Dyscalculia is not confined to cognitive difficulties; it also encompasses emotional and behavioral aspects that significantly influence motivation toward learning. Children who repeatedly experience failure in mathematics tasks often develop feelings of frustration and anxiety toward the subject, leading them to avoid numerical activities in the classroom.

Over time, these negative experiences contribute to the formation of a poor self-image and diminished self-esteem, accompanied by a loss of confidence in their academic abilities. Such emotional strain further exacerbates the difficulty, as it undermines concentration, reduces attention span, and weakens the motivation to engage or persist in learning activities (Wernicke, 2021).

These cognitive, behavioral, and emotional manifestations together form the diagnostic framework for dyscalculia, highlighting the disorder's multidimensional and complex nature. Consequently, effective intervention must integrate **targeted cognitive support , the development of fundamental numerical skills, and psychological reinforcement aimed at strengthening self-confidence and motivating the learner to engage positively in mathematics learning.

The importance of recognizing these manifestations lies in the fact that early detection can prevent mathematical difficulties from developing into a broader academic crisis. A child does not fail because of a lack of motivation to learn, but because their cognitive system requires a different approach—one grounded in experimentation, concreteness, and visual representation before moving on to abstraction and symbols. Ignoring these early indicators can trap the child in a cycle of reinforced failure , where mistakes accumulate and mathematics becomes a source of anxiety rather than a field for reasoning and discovery. Therefore, observing these behaviors at an early stage represents the first essential step toward effective educational and remedial intervention.

7- Causes of Dyscalculia:

Dyscalculia is a complex cognitive disorder that arises from the interaction of multiple neurological, cognitive, and emotional factors , and it cannot be attributed to a single cause. Rather, it is associated with dysfunction in several core mental processes that normally work

in concert to support mathematical activity. The following are the primary explanatory factors underlying this condition:

➤ **Weakness in Numerical Working Memory:**

Working memory is one of the key cognitive systems underpinning mathematical performance, as it allows the learner to temporarily store and manipulate information during problem solving. When tackling mathematical tasks, a child must recall numbers, compare intermediate results, and remember previous steps to complete the operation. If working memory capacity is limited or unstable, the child may lose track of elements of the problem while solving it, leading to frequent mistakes or longer completion times. This kind of deficit makes sequential operations—such as long multiplication or division—particularly demanding, as they require more cognitive effort than the child can sustain, resulting in slower performance and diminished confidence in their mathematical abilities.

➤ **Deficit in Perceptual Quantity Representation:**

Before a child can effectively engage with mathematical symbols, they must develop an accurate internal representation of number and quantity. The ability to perceive differences such as between “four” and “five” or “greater than” and “less than” forms the foundation of mathematical understanding. When this mental representation is vague or unstable, numbers become for the child mere visual shapes without meaning, making it difficult to connect symbols with the real quantities they signify. As a result, the transition from sensory understanding of numerical concepts to symbolic reasoning becomes impaired, and learning higher-level operations such as addition, subtraction, or multiplication turns into a process of rote memorization rather than conceptual understanding.

➤ **Difficulties with Mathematical Language:**

Language serves as a fundamental tool in mathematical thinking—it conveys concepts and clarifies relationships between numbers and operations. Many children with dyscalculia also struggle to understand mathematical vocabulary or to translate verbal problems into symbolic equations. For instance, a child may not realize that the phrase “less than” signifies subtraction, or that “twice the number” indicates multiplication. This linguistic weakness extends beyond vocabulary to the very structure of mathematical reasoning, making it difficult for the child to analyze word problems and grasp the logical relationships they contain. Such deficits become even more pronounced when solving multi-step problems that require an integrated understanding of both language and symbols.

➤ **Slow Perceptual and Cognitive Processing:**

Mathematical problem-solving requires rapid shifting between symbols and concepts, as well as the retrieval of appropriate rules at each stage. When a child has a reduced processing speed, moving from one step to the next becomes slow and fragmented. They need more time to encode numbers or compare results, which disrupts the fluidity of thought and increases the likelihood of errors. Moreover, slow processing limits the learner’s ability to follow complex instructions or multi-step problems, leading them to rely on trial and error rather than systematic, conceptual understanding.

➤ **Emotional and Psychological Factors:**

Emotional dimensions play a pivotal role in maintaining or aggravating mathematical learning difficulties. A child who repeatedly experiences failure or criticism from teachers or peers often develops a negative attitude toward mathematics. Over time, this frustration may evolve into a fear of failure, leading the child to avoid situations

that require numerical performance. Such math anxiety undermines concentration and disperses attention during problem-solving tasks, thereby intensifying the difficulty and perpetuating a cycle of avoidance and failure. Furthermore, diminished self-esteem weakens the child's motivation to learn, making them less willing to persist or exert effort when faced with mathematical challenges.

Dyscalculia is not merely a difficulty in learning mathematical operations; it is a multidimensional disorder that affects both the cognitive and emotional structures of the child. Understanding its causes requires viewing it as the result of an interaction among neurological, linguistic, and emotional factors. Therefore, effective intervention must adopt an integrated educational approach that combines cognitive training, the development of mathematical language, and the enhancement of motivation and self-confidence. (Gari, 2023)

Dyscalculia, therefore, can be understood as the result of an interaction between subtle cognitive processes and accumulated learning and emotional experiences. What distinguishes this disorder is that it is not linked to the child's general intelligence, nor does it reflect a lack of effort or willpower. Rather, it indicates a difference in the way the brain processes numerical concepts. Consequently, understanding its causes should not serve a merely diagnostic purpose, but rather guide educational intervention toward gradually building numerical representation, strengthening working memory, providing multiple problem-solving models, and addressing the emotional factors that may hinder learning.

8- Strategies for Identifying and Diagnosing Dyscalculia:

The process of identifying and diagnosing dyscalculia represents a crucial step in designing effective educational and psychological

interventions. It enables specialists to understand the nature of the disorder and accurately determine its dimensions before implementing any remedial or instructional plan. Relying solely on observable school performance or academic results is insufficient, as signs of mathematical weakness may be influenced by temporary factors such as anxiety, lack of experience, or limited practice. Therefore, scientific diagnosis depends on a multi-method and multi-source approach , combining classroom observation, standardized assessments, psychological evaluations, and qualitative analysis of the learner's performance.

➤ **Structured Classroom Observation:**

This represents the first step in the early identification of dyscalculia, where the teacher observes the learner's behavior in various instructional contexts. Observation involves tracking recurring performance patterns, such as slow execution of arithmetic operations, difficulty retaining numerical information during problem-solving, constant reliance on finger counting or tangible aids, and repeated simple errors despite ongoing practice. The purpose of this stage is not to make a definitive diagnosis, but rather to identify preliminary indicators that warrant a more precise assessment by psychological and educational specialists.

➤ **Comprehensive Psychological and Educational Assessment:**

Following classroom observation, a series of psychological and educational tests are administered to determine the nature and scope of the difficulty. These assessments typically include measures of numerical working memory, processing speed, quantitative representation, and understanding of basic numerical concepts. In some cases, an individual intelligence test is also used to rule out the possibility of a general intellectual delay. It is essential that the child's

performance be compared to peers of the same age group rather than solely to academic expectations, in order to discern whether the difficulty stems from a specific learning disorder or from a typical learning delay.

➤ **Error Analysis and Performance Pattern Study:**

Effective diagnosis goes beyond determining the degree of difficulty—it requires understanding the type and nature of the errors made. Some children may misplace digits within an arithmetic operation, while others may select the wrong operation or misread symbols. To assess this, the child is asked to solve a set of problems while verbalizing their thought process and reasoning aloud. This approach allows the examiner or specialist to analyze the child's cognitive pathway rather than focusing solely on the final answer. Through such analysis, it becomes possible to gauge the child's awareness of the operations used, their ability to move logically from one step to the next, and their capacity for self-correction and reflection. Moreover, this method reveals the problem-solving strategies the child relies on—whether random, systematic, or based on guesswork.

➤ **Neurological, Auditory, and Visual Assessments:**

Because dyscalculia may overlap with other neurological or sensory disorders, it is essential to ensure that the physical systems supporting learning processes are functioning properly. This stage includes assessments of visual and auditory abilities, as well as attention-related capacities, alongside examinations of hemispheric brain function and neural integration efficiency. Such evaluations help rule out physiological factors that might contribute to the manifestation or intensification of mathematical difficulties.

➤ **Assessment of Emotional Factors and Learning Motivation:**

Psychological and emotional aspects play a crucial role in understanding dyscalculia, as math-related anxiety or low self-confidence can intensify cognitive difficulties. Therefore, it is recommended to include measures of emotional state and motivation within the diagnostic process—such as personal interviews or behavioral questionnaires—to form a comprehensive picture of the child’s emotional profile and how it affects their mathematical performance.

➤ **Standardized Mathematical Achievement Tests:**

Standardized tests are used to measure a child’s performance across various mathematical domains, such as understanding numerical concepts, performing arithmetic operations, and solving applied problems. These assessments aim to compare the child’s abilities with peers of the same age or grade level. However, such tools primarily assess the observable outcomes of learning—what has been acquired—without revealing the underlying cognitive processes that produced that performance. Therefore, this stage serves as an initial entry point that must be complemented by other diagnostic methods capable of uncovering the internal thinking mechanisms behind mathematical behavior.

➤ **Assessment of Working Memory, Attention, and Visual Discrimination:**

A set of specialized cognitive tests is employed to measure numerical working memory, selective attention, processing speed, and the ability to visually discriminate and symbolically encode numbers. These assessments help elucidate the mental structures that underlie mathematical performance and clarify whether the difficulty stems

from a weakness in retaining numerical information during processing, from attentional lapses, or from deficits in perceiving visual relationships between symbols. For instance, children with impaired working memory often struggle to hold information while solving problems, whereas those with weak visual discrimination may confuse symbols or numerical orientations. The results of such evaluations provide a qualitative analysis that deepens the understanding of how the difficulty develops and manifests cognitively.

➤ **Preparation of a Comprehensive Diagnostic Report:**

At the conclusion of the diagnostic process, the results of all assessment tools are compiled into an integrated scientific report that outlines the type of difficulty, its level of severity, and the child's specific strengths and weaknesses. This report serves as the foundation for designing an Individualized Educational Plan (IEP) that addresses each learner's unique needs. Ideally, the teacher, school psychologist, and family should all participate in discussing the report to ensure collaborative implementation of the intervention plan in an effective and sustainable manner. (Garry, 2023)

Through these integrated steps, the identification of dyscalculia becomes a precise scientific process grounded in both quantitative and qualitative data, avoiding subjective judgments or superficial assessments. This comprehensive approach ensures early and targeted intervention that helps the child overcome numerical challenges and develop mathematical and cognitive abilities within a supportive and balanced educational environment.

9- Strategies for Supporting Learners with Dyscalculia:

Intervention strategies for addressing mathematical difficulties are based on reconstructing the child's foundational understanding of numerical concepts rather than merely reteaching conventional curricular content. The goal is to enable the child to grasp the quantitative meaning of numbers before progressing to symbolic or abstract representations. These strategies can be summarized in the following key approaches:

-Sensory concretization of numbers:

The intervention process begins by using tangible materials—such as cubes, beads, or counting blocks—to help the child perceive quantity in a concrete, hands-on manner. This sensory engagement enables the learner to associate numerical symbols with their real quantitative meaning, thereby forming stable mental images of numbers in long-term memory. This stage serves as the foundation for rebuilding the child's cognitive system in a way that allows for precise mental representations of numerical concepts.

-Visual representation of numerical relationships:

Following the sensory phase, visual tools such as number lines, charts, and operation maps are introduced. These representations help the child visualize numerical relationships and trace how numbers move within operations—such as increases, decreases, or transformations. The gradual shift from tangible materials to visual representations prepares the learner for higher levels of abstract mathematical reasoning.

-Enhancing numerical working memory:

Working memory plays a central role in processing numerical information. It can be strengthened through short, repetitive exercises such as ordering numbers, comparing quantities, or executing simple sequential steps. These tasks enable the child to retain information

while processing it, thereby improving their capacity for logical organization in mathematical problem-solving.

-Fostering a positive emotional climate:

A supportive learning environment—free from comparison and time pressure—is essential. Children should be encouraged to think aloud, explore, and make mistakes without fear of judgment. A sense of cognitive safety enhances motivation and nurtures creativity in mathematical reasoning.

-Gradual scaffolding and fostering independence in learning:

Teachers provide guided support as needed, then gradually withdraw assistance as the child demonstrates growing autonomy. This approach strengthens the learner's sense of self-efficacy and rebuilds confidence in their mathematical abilities. This principle represents a crucial step toward transitioning from dependence to independent mathematical thinking. (Belmouchi, 2016)

Educational evidence demonstrates that addressing dyscalculia is not a matter of speed or the intensity of practice, but rather a question of depth in constructing meaning . The child needs time to reorganize mental representations and rediscover the connection between numbers and the real world. When mathematics shifts from being a set of procedures performed out of fear of mistakes to an exploratory activity grounded in understanding, the child begins to regain balance in the learning process. Effective intervention is not measured by the number of problems solved, but by the child's level of comprehension, engagement, and confidence in their ability to learn.

4. CONCLUSION

Dyscalculia is not a temporary difficulty in learning mathematics, nor is it a sign of low intelligence or lack of effort. Rather, it reflects a distinctive way in which the mind processes numerical concepts. A child with dyscalculia does not lack ability, but instead requires a different path—one that emphasizes gradual construction of meaning rather than repetitive procedural practice.

Future research may focus on conducting longitudinal investigations to examine the developmental trajectories of executive functions among children with dyscalculia within Arab educational settings. Additional studies could explore the effectiveness of digital and technology-assisted intervention programs in improving mathematical skills and learning outcomes. Furthermore, greater attention should be given to understanding the association between working memory processes and mathematical learning difficulties across different stages of education. Pursuing these lines of inquiry would contribute to advancing the existing body of knowledge, strengthen the scholarly significance of the current study, and provide valuable directions for future research and evidence-based educational practices.

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