East African Scholars Journal of Education, Humanities and Literature

OPEN ACCESS

Abbreviated Key Title: East African Scholars J Edu Humanit Lit
ISSN: 2617-443X (Print) & ISSN: 2617-7250 (Online)
Published By East African Scholars Publisher, Kenya
Volume-9 | Issue-7 | Jul- 2026 |
DOI: https://doi.org/10.36349/easjehl.2026.v09i07.009

Original Research Article

Impact of Mathematical Dyscalculia on Academic Performance among Senior School Learners in Competency-Based Education in Kenyan Public Schools: A Systematic Review

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Article History
Received: 23.05.2026
Accepted: 11.07.2026
Published: 28.07.2026

Journal homepage:
https://www.easpublisher.com

Quick Response Code

Abstract: Mathematical dyscalculia (MD) is a neurodevelopmental difficulty that compromises number sense, arithmetic fluency, and quantitative reasoning, constraining mastery-based progression within Kenya's competency-based education (CBE) and undermining performance in mathematics and numeracy-intensive subjects such as science, economics, and technology. This systematic review synthesizes evidence on MD's academic impact among senior school learners (14–18 years) in Kenyan public schools under CBE, focusing on awareness, diagnostic capacity, inclusive strategies, and teacher training. A PRISMA-aligned search covering 10 years was conducted across electronic databases, supplemented by reference and gray literature screening. Studies were independently screened, data were extracted using standardized forms, and methodological quality was appraised using the CASP. Given the study heterogeneity, the findings were narratively synthesized with descriptive summaries. The review identified significant system-readiness gaps: over 70% of schools lacked formal MD screening, while under 40% of senior teachers received training to identify or accommodate learners with MD. These deficiencies contributed to the delayed identification and inconsistent implementation of support, including multisensory instruction, personalized plans, visual aids, tutoring, and assistive technologies, especially in rural settings. Learners with undiagnosed MD exhibited cross-curricular underperformance, with scores 20–30% lower in subjects requiring numerical interpretation, although these estimates are preliminary and not adjusted for socioeconomic or school-level confounders, along with diminished motivation. Grounded in Cognitive Load Theory, Multiple Intelligences Theory, and an Inclusive CBE framework, the synthesis indicates that CBE's mastery potential remains unrealized without enhanced awareness, equitable diagnostic access, targeted teacher preparation, and improved resource allocation. This synthesis provides the first systematic mapping of systemic readiness gaps in Kenyan CBE schools, establishing baseline prevalence estimates for diagnostic and training deficits, and identifying three high-priority domains for intervention: awareness, teacher preparation, and equitable resource allocation. Although the empirical base is limited, these findings offer a foundation for prioritizing policy reforms and guiding future research.

Keywords: Mathematical Dyscalculia, Competency-Based Education, Academic Performance, Inclusive Strategies, Teacher Training.

INTRODUCTION

Mathematical dyscalculia is a learning difficulty that impairs a learner's ability to comprehend and execute mathematical tasks, adversely affecting academic performance. Within competency-based education (CBE), which prioritizes mastery of skills and knowledge at an individualized pace, dyscalculia poses challenges for senior school students (Molise & Kakoma, 2024). They often struggle with numeracy concepts, including number sense, arithmetic operations,

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measurement, and applying quantitative reasoning to subjects such as science, economics, and technology. Research has shown persistent difficulties in foundational mathematical skills, leading to academic setbacks (Kunwar, 2021; Salisa & Meiliasari, 2023). Learners who cannot interpret graphs or calculate percentages may struggle with biology or geography, where data interpretation is essential. In CBE environments, these difficulties can delay mastery and affect students' confidence and motivation. To address these issues, educational systems are implementing targeted interventions and inclusive teaching strategies in CBE frameworks (Delgado e*t al.*, 2019). These include multisensory instruction, assistive technologies such as calculators and math-specific software, personalized learning plans, visual aids, manipulatives, tutoring, and peer support focused on numeracy. However, their effectiveness varies with disparities in awareness, diagnostic capabilities, and resource availability. In low-resource settings, limited access to specialists and diagnostic tools hampers early identification and support, resulting in unmet needs and widening achievement gaps (Apostolidou, 2025; Kunwar, 2022). Higher-resource contexts benefit from screening protocols and comprehensive support services. CBE offers support through individualized learning and mastery; however, success depends on teacher training, resource allocation, and the worldwide implementation of inclusive policies for learners.

Limited awareness and diagnostic capacity for MD have been documented across African educational systems (Bagazi, 2025; Tibane *et al*., 2024); however, this evidence focuses on traditional curricula. Kenya's CBE framework, implemented in 2017, mandates individualized learning pathways. However, no systematic review has examined how these structural features interact with identification and support, and existing African evidence, which focuses primarily on traditional curricula, does not address this gap. Uneven access to trained specialists, screening tools, and assistive technologies, such as calculators and math-specific software, exacerbates these challenges, particularly in low-resource settings. Consequently, learners with dyscalculia often face unmet needs that widen achievement gaps and limit equitable access to quality education (Bagazi, 2025) (Anjum *et al*., 2023). Emerging efforts to incorporate inclusive teaching strategies and targeted interventions within CBE systems show promise but remain inconsistent across regions because of disparities in infrastructure, teacher training and resource allocation (Desucatan, 2025). Approaches such as multisensory instruction, personalized learning plans, visual aids and manipulatives, additional tutoring, and peer support can enhance engagement and mastery. However, their success depends on comprehensive teacher preparation, diagnostic assessment, and policy frameworks that prioritize inclusivity. Improving outcomes in African public schools requires addressing systemic gaps by raising awareness, expanding diagnostic access, investing in specialized training, and ensuring equitable resource distribution (Modise *et al*., 2025). Strengthening these components within CBE environments will better accommodate diverse learning needs, foster mastery-based progression, and reduce the adverse academic impact of dyscalculia.

Mathematical dyscalculia presents challenges for senior school learners within Kenya's competency-based education (CBE) framework, which emphasizes mastery through individualized pacing (Wang'Ang'A, 2023). Despite focusing on personalized learning, many Kenyan schools lack awareness and diagnostic resources for the identification and support of students with dyscalculia (Kipkorir, 2015; Ohba & Malenya, 2020). This deficiency extends beyond mathematics, as learners also struggle with subjects requiring quantitative reasoning, including science, economics, and technology, negatively affecting their academic performance (Mariera *et al*., 2021). Although initiatives for inclusive teaching strategies and interventions have begun, inconsistencies in teacher training and unequal resource distribution across schools limit their effectiveness and uniformity (Kuja *et al*., 2025; Ooko, 2023). To improve outcomes and ensure equitable access to quality education within Kenya's CBE system, these systemic gaps must be addressed through awareness, expanded diagnostic capabilities, specialized teacher training, and equitable resource allocation, enabling the accommodation of diverse learning needs, mastery-based progression, and mitigation of dyscalculia's academic effects (Ogeto, 2025). Although studies have documented diagnostic gaps and teacher-training deficits in Kenyan schools, no review has integrated these factors to quantify how diagnostic infrastructure, teacher preparedness, and resource equity affect the identification of mathematical dyscalculia (MD) and academic outcomes within competency-based education (CBE). Given CBE's focus on individualized mastery and the 6.4% prevalence of MD, this gap is critical. Without coordinated improvements in diagnostic capacity, teacher training, and equitable resource distribution, CBE's potential of CBE for learners with MD remains unfulfilled.

Statement of the Problem

Despite CBE's emphasis on individualized mastery, many Kenyan public schools lack the awareness, diagnostic tools, and trained personnel necessary for the early identification of mathematical dyscalculia, leaving learners unsupported and undermining equitable progression. As noted, no synthesis has examined how they interact to constrain MD support within the CBE, a gap this review addresses. Resources, including personnel and educational materials, should be equitably distributed to ensure support, regardless of school location or funding. This environment fosters mastery-based progression, helping learners build numeracy skills and apply quantitative reasoning across science, economics, and technology,

thereby improving outcomes, motivation, and achievement gaps in a CBE system.

Despite the principle of individualized mastery in CBE, many Kenyan public schools remain inadequately equipped to identify and support learners with MD. Educator awareness is limited, and diagnostic tools and specialized resources are insufficient, particularly in low-resource settings. Our synthesis of the included studies reveals that over 70% of resource-constrained schools lack formal MD screening (Kipkorir, 2015; Ohba & Malenya, 2020; Tibane *et al*., 2024). This shortfall impedes the development of fundamental numeracy skills, negatively impacting performance not only in mathematics but also in quantitatively demanding subjects such as science, economics and technology. Learners with undiagnosed dyscalculia demonstrate academic underperformance, with scores 20–30% lower than those in subjects requiring numerical interpretation. Furthermore, the review found that fewer than 40% of senior school teachers have received specialized training to identify or accommodate numeracy-related learning difficulties. These gaps, combined with uneven access to resources and assistive technologies, result in the inconsistent implementation of evidence-based interventions, including multisensory instruction, personalized learning plans, and targeted support. Consequently, learners with dyscalculia experience delayed mastery, diminished motivation, and widening achievement gaps, which collectively undermine the CBE's objectives of equitable access and learner-centered success.

While isolated studies have documented training deficits (Ooko, 2023) or diagnostic gaps (Kipkorir, 2015), current research has not systematically examined how teacher training, diagnostic tool availability, and resource allocation interact to shape the implementation of inclusive strategies for learners with MD in Kenyan CBE schools. This review addresses this gap by synthesizing evidence across these domains. This gap limits the development of scalable, context-specific interventions and undermines CBE's equity goals of CBE. Moreover, there is limited empirical evidence on the effectiveness of specific support mechanisms, such as assistive technologies and multi-sensory instruction, within Kenya's CBE system. These deficiencies impede the development of scalable, contextually appropriate models to mitigate the adverse effects of dyscalculia on academic performance, especially in subjects requiring quantitative reasoning beyond mathematics itself. Addressing these research gaps is essential to inform policy, enhance teacher preparation, and guide resource distribution, thereby fostering equitable mastery-based progression for affected learners in Kenyan public schools. This systematic review synthesizes evidence to quantify the prevalence of diagnostic and training gaps across Kenyan CBE schools, establish the magnitude of MD's impact on cross-curricular performance, and examine how awareness, diagnostics, training, and resources interact to constrain intervention scalability, providing a foundation for prioritizing policy reforms through future empirical research, thereby informing prioritized policy reforms.

Objectives of the Study

Main Objective

To synthesize evidence on how mathematical dyscalculia affects academic performance among senior school learners in Kenya's CBE framework by quantifying the magnitude of diagnostic, training, and resource gaps and their association with outcomes, thereby identifying systemic barriers and informing evidence-based policy.

Specific Objectives

i) To examine the extent of awareness and diagnostic capacity for mathematical dyscalculia in Kenyan public senior schools under the CBE system.
ii) To assess the availability and use of inclusive teaching strategies and targeted interventions for learners with dyscalculia in the CBE context.
iii) To analyze the influence of teacher training and resource allocation on the identification and support of learners with mathematical dyscalculia.
iv) To evaluate the academic performance challenges faced by learners with dyscalculia in mathematics and quantitatively demanding subjects such as science, economics, and technology in Kenyan CBE schools.
v) To identify gaps in the current research regarding the effectiveness of support mechanisms, such as assistive technologies and multi-sensory instruction, in Kenya's CBE framework.

Research Questions

a) What is the current level of awareness and diagnostic capacity for mathematical dyscalculia in Kenyan public senior schools operating under the competency-based education (CBE) system?
b) To what extent are inclusive teaching strategies and targeted interventions available and utilized for learners with mathematical dyscalculia in the Kenyan CBE context?
c) How do teacher training and resource allocation influence the identification and support of learners with mathematical dyscalculia in Kenyan public senior schools under the CBE framework?
d) What academic performance challenges do learners with mathematical dyscalculia face in mathematics and quantitatively demanding subjects, such as science, economics, and technology, within Kenyan CBE schools?

e) What gaps exist in the current research on the effectiveness of support mechanisms, including assistive technologies and multi-sensory instruction, for learners with mathematical dyscalculia in Kenya's CBE framework?

LITERATURE REVIEW

Theoretical Review

Cognitive Load Theory

Cognitive Load Theory (CLT), based on John Sweller's late-1980s work, posits that working memory has a limited capacity for new information. This emphasizes that instructional design should minimize extraneous cognitive load and optimize intrinsic and germane load to enhance learning efficiency (Ni *et al*., 2017; Sortwell *et al*., 2026). In mathematical dyscalculia and competency-based education (CBE), CLT provides a framework for understanding how learners struggle with complex numerical information because of cognitive overload (Hanham *et al*., 2023; Olaoluwa, 2024). Strategies such as multisensory instruction and personalized learning plans reduce unnecessary cognitive demands, align teaching with learners' processing capacities, and support mastery, thereby improving performance in mathematics and related quantitatively demanding subjects (Junaedi, 2021). CLT assumes that learners have a limited working memory capacity for processing new information and that effective instructional design must minimize extraneous cognitive load while optimizing intrinsic and germane cognitive loads (Yu & Liu, 2024). Within mathematical dyscalculia, cognitive overload impedes the mastery of mathematical concepts. The theory supports tailored instructional interventions within the competency-based education framework to improve academic performance and facilitate mastery (Olaoluwa, 2024). These assumptions explain the use of appropriately tailored interventions to enhance learning efficiency and improve mastery in demanding areas.

Criticisms of Cognitive Load Theory (CLT) include concerns that it may oversimplify learning difficulties, such as dyscalculia, by focusing on working memory limitations without fully accounting for diverse cognitive, emotional, and contextual factors influencing mathematical learning (Dhlamini, 2016). Additionally, the CLT's emphasis on minimizing extraneous cognitive load may not address individual differences in learners' neurodevelopmental profiles or the socio-educational challenges in Kenyan public schools under the CBE framework (Ni *et al*., 2017). The theory also assumes that instructional design alone can optimize learning efficiency, underestimating systemic factors such as teacher training, resource availability, and diagnostic capacity that affect learners with dyscalculia (Zaidi & Zaidi, 2022). Furthermore, CLT strategies, such as multisensory instruction and personalized learning plans, while theoretically sound, face implementation challenges in low-resource settings, limiting their effectiveness and scalability within the CBE system. These criticisms highlight the need for a more holistic approach that integrates CLT principles with broader educational and contextual considerations (Zahara *et al*., 2020). Cognitive Load Theory (CLT) was applied to study the impact of dyscalculia on the academic performance of senior school learners within Kenya's competency-based education (CBE) framework by explaining how learners with dyscalculia struggle to process complex numerical information due to limited working memory capacity. This study uses CLT to justify multisensory instruction and personalized learning plans aimed at reducing extraneous cognitive load and optimizing intrinsic and germane cognitive loads. These strategies align teaching with learners' cognitive processing abilities and can improve mathematics and other quantitatively demanding subjects.

Multiple Intelligences Theory (Howard Gardner)

The Multiple Intelligences Theory, developed by Howard Gardner in 1983, challenges the traditional view of intelligence as a single ability. Instead, Gardner proposed a multifaceted construct comprising linguistic, logical-mathematical, spatial, musical, bodily kinesthetic, interpersonal, intrapersonal, and naturalistic intelligence (Al-Zoubi & Al-Adawi, 2019; Mahmud *et al*., 2020). This theory posits that these strengths influence learning styles and the manner in which learners learn. This theory emphasizes that individuals have varying strengths across these intelligences, which shape learning and information processing. In the context of mathematical dyscalculia and competency-based education (CBE), Multiple Intelligences Theory supports diverse instructional strategies tailored to learners' cognitive profiles (Mayu & Widjajanti, 2022). Recognizing that students may excel in intelligences other than logical-mathematical, educators can design inclusive approaches that engage different modalities, enhancing understanding and mastery of numeracy skills despite dyscalculia-related challenges (Reigosa-Crespo, 2019). This aligns with CBE's focus on individualized learning and mastery, promoting academic performance through personalized strength-based interventions. In a study on mathematical dyscalculia and academic performance within Kenya's competency-based education (CBE) framework, the theory assumes that learners with dyscalculia may excel in other intelligences (Radin & Dannenhoffer, 2020). Therefore, strategies should be diversified to engage multiple intelligences, aligning with CBE's emphasis on individualized learning and mastery and supporting personalized interventions to enhance understanding and academic performance despite numeracy difficulties.

Criticisms of the Multiple Intelligences Theory (Howard Gardner) include concerns that it lacks empirical rigor and measurable criteria for validating intelligence. Its categorization of intelligence modalities creates challenges for implementation in resource-constrained settings, such as Kenyan public schools

(Molise & Kakoma, 2024). The emphasis on tailoring instruction to diverse intelligences may be difficult to operationalize consistently because of limited teacher training and scarce resources, reducing the effectiveness of addressing dyscalculia (Mahmud *et al.,* 2020). Additionally, the theory may underemphasize the cognitive deficits associated with dyscalculia, diverting attention from the targeted interventions needed for numeracy skill development within the CBE system. Multiple Intelligences Theory (Howard Gardner) was applied in the study on the impact of mathematical dyscalculia on performance among school learners within Kenya's competency-based education (CBE) framework by supporting strategies tailored to learners' cognitive profiles (Apostolidou, 2025; Hughes *et al*., 2023). Recognizing intelligence as multifaceted and that learners with dyscalculia may excel beyond logical-mathematical intelligence, the theory encourages inclusive teaching approaches that engage linguistic, spatial, and bodily kinesthetic intelligences. This aligns with CBE's emphasis on individualized learning and mastery, promoting performance through strength-based interventions that accommodate how learners process information. Leveraging strengths across intelligences may enhance numeracy skills despite dyscalculia-related challenges, fostering inclusive education in Kenyan public schools.

Inclusive Competency-Based Education Framework

The Inclusive Competency-Based Education (CBE) Framework originated from the need for equitable, learner-centered education that accommodates diverse learning needs through mastery achieved via individualized pacing. Its core tenets include personalized learning plans, multisensory instruction, and targeted interventions to reduce cognitive overload and leverage learners' strengths, aligning with the Cognitive Load Theory and Multiple Intelligences Theory (Huang, 2018; Refat *et al*., 2020). The framework prioritizes the early identification and support of learning difficulties, such as mathematical dyscalculia, requiring appropriate diagnostic tools, assistive technologies, and teacher training (Hughes *et al*., 2023). It advocates equitable resource allocation and inclusive policy implementation to foster mastery-based progression, enhance motivation, and close achievement gaps in diverse educational contexts, including Kenyan public schools under CBE (Junaedi, 2021; Reigosa-Crespo, 2019). In this study, the framework assumes that education should be equitable and learner-centered, that these strategies can reduce cognitive overload, support diverse learners, leverage unique strengths, and ensure access to appropriate diagnostic tools, assistive technologies, and specialized teacher training, and that early identification and support for learning difficulties, adequate resources, and inclusive policies are essential for mastery-based progression, learner motivation, and closing achievement gaps in varied contexts, such as Kenyan public schools operating under CBE (Anggoro *et al*., 2024).

This study applies the Inclusive Competency-Based Education (CBE) Framework to address mathematical dyscalculia among Kenyan senior school learners. This framework promotes equitable, learner-centered education through individualized pacing, personalized plans, multisensory instruction, and targeted intervention (Paas & Van Merriënboer, 2020). By integrating Cognitive Load and Multiple Intelligences theories, strategies can be developed to reduce cognitive overload and leverage learner strengths, aiming to improve performance in mathematics (Yu & Liu, 2024). However, the framework faces implementation challenges in resource-constrained settings. While theoretically sound, its reliance on early identification, diagnostic tools, and specialized support assumes infrastructure and policy backing that is often absent in public schools. Limited teacher training and inadequate resource allocation hinder the consistent application of inclusive strategies. Consequently, these systemic gaps limit the scalability and impact of the framework. To fulfill its promise of equitable mastery-based progression, the Inclusive CBE Framework requires integration with broader systemic improvements in these diverse educational contexts.

Empirical Literature Review

Molise and Kakoma (2024) explore dyscalculia by identifying medical, biological, psychological, and environmental factors that impair learners' mathematical comprehension and performance. Their empirical study, involving teachers, occupational therapists, doctors, and educational psychologists, underscores the complexity of dyscalculia's etiology and its impact on arithmetic ability. It also highlights the need for curriculum development for learners with dyscalculia, suggesting the existence of gaps in tailored instructional materials. However, the study is primarily descriptive and addresses general educational contexts rather than competency-based education (CBE) frameworks. This omission is significant because CBE prioritizes individualized mastery and pacing, aligning with personalized interventions for learners with dyscalculia and dyslexia. However, the practical integration of dyscalculia support within CBE systems, especially in Kenyan public schools, remains underexplored. This study situates mathematical dyscalculia within the Kenyan CBE context, revealing limited awareness, scarce diagnostic tools, insufficient teacher training, inequitable resource distribution, and inconsistent inclusive strategies that hinder identification and support. However, there are limited studies on how these factors interact in Kenyan public schools under CBE and affect performance in mathematics and quantitatively demanding subjects. While Molise and Kakoma identify curriculum development needs, they do not examine how CBE's mastery-based structure shapes the deployment of tailored materials in resource-constrained Kenyan schools.

Kunwar's (2021) study offers a theoretical exploration of dyscalculia, emphasizing core characteristics—deficits in number sense, arithmetic fact memorization, calculation fluency, and mathematical reasoning—and the need for specialized instructional support. This underscores the impact of dyscalculia on learners' mathematical abilities and advocates for tailored pedagogical approaches to improve retention and performance. However, the study remains conceptual and descriptive, lacking empirical investigation within specific educational frameworks, particularly competency-based education (CBE). In contrast, the systematic review of mathematical dyscalculia in Kenyan public schools within the CBE framework situates dyscalculia in a practical, policy-driven environment shaped by individualized mastery and pacing. It highlights systemic challenges in Kenyan schools, including limited awareness, inadequate diagnostic capacity, insufficient teacher training, and inequitable resource distribution, which impede the identification and support of learners with dyscalculia. It also notes the broader ramifications of mathematics in subjects such as science, economics, and technology. While Kunwar's study establishes the need for specialized instruction, it does not address how such strategies are implemented or constrained within resource-limited, competency-based systems. This gap is the absence of systematic, context-specific evidence on how awareness, diagnostic capacity, teacher training, and resource allocation interact within Kenya's CBE framework to affect MD identification, support, and academic outcomes across mathematics and quantitatively demanding subjects.

Apostolidou (2025) addressed dyscalculia as a specific learning disorder affecting mathematical skills, independent of general intelligence. This study highlights advances in diagnosis through technological tools and the potential of digital games and educational software as interventions. However, in relation to the impact of MD on the academic performance of senior school learners in Kenyan public schools under a competency-based education (CBE) framework, this study has key limitations. It emphasizes technology in diagnosis and intervention without adequately addressing systemic challenges in Kenyan public schools, including limited awareness of dyscalculia, scarce diagnostic capacity, inadequate teacher training, and inequitable resource distribution, which constrain implementation in low-resource environments. A systematic review of Kenyan CBE schools highlights these gaps by demonstrating how such factors hinder early identification and consistent support for learners with dyscalculia. Unlike Apostolidou's optimistic perspective, the Kenyan context requires a multifaceted approach that integrates technology with inclusive teaching, teacher preparedness, and equitable resource allocation to address the effects of dyscalculia across quantitatively demanding subjects beyond mathematics. Furthermore, Apostolidou's study does not examine how interventions operate within the individualized mastery and pacing principles central to CBE or present evidence of their effectiveness in resource-constrained environments. The Kenyan-focused review identifies a research gap in how awareness, diagnostic tools, teacher training, and resource allocation interact within CBE frameworks to shape the deployment of assistive technologies and multisensory instruction. The current study fills this gap to inform policies and practices that can realistically mitigate dyscalculia's adverse academic effects in this specific context within Kenyan public schools under CBE.

Desucatan, (2025) study on senior high school students with dyscalculia in the Philippines identified low mathematics achievement through standardized testing. The weak correlation between the Dyscalculia Screener and achievement suggests complex manifestations, while negative attitudes toward mathematics further impede learning. Desucatan proposes school-home interventions; however, the study's focus on one non-African institution limits its applicability to Kenyan competency-based education (CBE). It lacks the integration of CBE principles, such as mastery and pacing, and fails to address diagnostic capacity, teacher preparedness, or dyscalculia's impact on subjects beyond mathematics. Conversely, a review of Kenyan public schools reveals a research gap regarding how awareness, diagnostic tools, and teacher training influence support within a mastery-oriented framework. The Kenyan context requires an understanding of how systemic factors interact in resource-constrained settings, alongside evidence of assistive technologies and personalized learning. This study addresses these gaps by reviewing the impact of dyscalculia on academic performance in Kenya's CBE system to inform scalable and context-appropriate interventions.

Tibane *et al*., (2024) investigated the prevalence and awareness of dyscalculia among Grade 10 learners using a mixed-methods design combining standardized testing and group interviews. Their findings show widespread below-average mathematical skills across numerical domains and highlight learners' negative perceptions and frustrations toward mathematics, which affect their attitudes and academic experiences. A key contribution of this study is the identification of a gap in teacher awareness and training on dyscalculia, underscoring the need for targeted interventions and improved pedagogical strategies to support affected learners. While this study offers valuable empirical insights into learner-level challenges and psychosocial dimensions, it is limited in terms of systemic and contextual factors within the Kenyan education system, especially competency-based education (CBE). It focuses on Grade 10 learners' experiences without analyzing how institutional structures—such as diagnostic capacity, resource allocation, and teacher preparedness across school settings—mediate the

identification and support of learners with dyscalculia. It also does not address the implications beyond mathematics or the intersections with quantitatively demanding subjects such as science, economics, and technology within CBE. The broader literature identifies these systemic gaps as central to understanding the impact of dyscalculia on academic performance in Kenyan public schools under CBE. Key challenges include limited diagnostic tools, inequitable resource distribution, fragmented inclusive teaching strategies, and limited evidence on how teacher training and resource allocation influence the consistent use of evidence-based interventions, such as multisensory instruction and assistive technologies. Therefore, the current systematic review seeks to bridge micro-level insights on learner difficulties and teacher awareness with a context-specific analysis of systemic, pedagogical, and policy factors within Kenya's CBE framework, examining how disparities in awareness, diagnostic capacity, teacher training, and resource allocation affect academic outcomes across subjects.

Anjum *et al*., (2023) explore the emotional, cognitive, and social challenges faced by students with dyscalculia, noting their resilience and adaptive strategies. This study underscores the need for inclusive educational environments that address both the affective and cognitive dimensions. However, Anjum *et al*., lacked a systemic analysis of competency-based education (CBE), particularly in resource-constrained settings such as Kenyan public schools. Research on Kenyan senior schools identifies systemic gaps—limited awareness, scarce diagnostic tools, insufficient training, and inequitable resources—that mediate learner outcomes and the effectiveness of inclusive interventions in Kenya. The research gap lies in bridging these individual insights with the systemic realities of the Kenyan CBE. An empirical investigation is needed into how dyscalculic learners' experiences intersect with institutional constraints—diagnostic availability, teacher preparedness, and resource distribution–to affect performance in mathematics and other quantitative subjects. Furthermore, the CBE's emphasis on mastery requires an understanding of how inclusive strategies can be scaled amid these challenges. Addressing this requires synthesizing learner-level challenges with systemic conditions to inform policy, training, and pedagogy. Such an approach would provide actionable insights for fostering equitable mastery-based progression and mitigating the impact of dyscalculia in Kenyan public schools.

Wang'Ang'A (2023) critically examines dyscalculia's impact on Kenyan learners, emphasizing its implications for transition to higher education and employment. The study presents dyscalculia as a major barrier because mathematics is central to academic and career pathways and notes a 6.4% prevalence among Kenyan primary and secondary school students. This highlights the urgency of early identification, ideally from preschool age, to enable timely intervention. Wang'Ang'A also stresses specialized teacher training to support differentiated, multisensory teaching and assistive technologies for dyscalculic learners. However, the review remains descriptive and generalized, lacking a focused analysis within Kenya's competency-based education (CBE) framework. The study does not explicitly explore the distinct challenges and opportunities created by CBE's emphasis on individualized mastery and pacing. It does not analyze how diagnostic capacity, resource allocation, and implementation of inclusive teaching strategies operate in Kenyan public senior schools under CBE, nor does it examine dyscalculia's effects beyond mathematics in quantitatively demanding subjects such as science, economics, and technology, which are central to CBE's curriculum. In contrast, this systematic review offers a context-specific evaluation, identifying gaps in awareness, diagnostic tools, teacher training, and equitable resource distribution that hinder support for dyscalculic learners within Kenya's CBE environment. It shows how systemic and infrastructural constraints fragment multisensory instruction, personalized learning plans, and assistive technologies, undermining the CBE's goals of equitable mastery-based progression. It also notes the absence of empirical evidence on the effectiveness and scalability of support mechanisms in resource-limited Kenyan schools, an issue Wang'Ang'A does not address sufficiently. The research gap lies in the lack of empirical, contextually grounded investigations into how mathematical dyscalculia affects the academic performance of senior school learners within Kenya's CBE framework, considering diagnostic capacity, teacher preparedness, resource equity, and inclusive pedagogy. Addressing this gap requires a systematic review integrating learner-level challenges with institutional and pedagogical factors unique to CBE, thereby informing policy, teacher training, and resource allocation strategies in Kenya.

Mariera *et al*., (2021) examined mathematics self-efficacy among students with dyscalculia in public secondary schools in Kandara Sub-County, Muranga County, Kenya. Grounded in Expectancy Theory, this study uses a mixed-methods approach to show a disparity in self-efficacy between learners with and without dyscalculia, highlighting the psychological dimension of mathematical learning difficulties. Stratified random and purposive sampling, validated instruments, and pilot testing strengthen the methodological rigor. However, this research focuses on motivational aspects without integrating broader systemic or pedagogical factors influencing academic performance in Kenya. In contrast, the systematic review of the impact of MD within Kenya's competency-based education (CBE) framework situates the problem within a broader educational ecosystem. It emphasizes limited awareness, scarce diagnostic capacity, inadequate teacher training, and inequitable resource allocation, which hinder early identification and sustained support for learners with

dyscalculia. The review also examines the effects on performance in quantitatively demanding subjects such as science, economics, and technology, and assesses inclusive teaching strategies such as multisensory instruction, assistive technologies, and personalized learning plans in resource-constrained Kenyan public schools. The research gap lies in the insufficient integration of learner-level factors, such as self-efficacy examined by Mariera *et al*., with systemic, pedagogical, and policy dimensions central to the CBE framework. Their localized focus on the Kandara Sub-County also limits the generalizability of the findings across Kenya's diverse public school contexts under CBE. The systematic review is essential because it synthesizes insights into dyscalculia's impact within Kenya's CBE system. It links learner motivation and academic efficacy with institutional readiness and school inclusivity, informing scalable interventions and policies that strengthen training, diagnostic capacity, resource equity, and progression for dyscalculic learners in Kenyan public schools.

MATERIALS & METHODS

Search Strategy

A thorough and systematic literature search was conducted to identify studies addressing the impact of mathematical dyscalculia on the academic performance of senior school learners within the framework of Kenya's competency-based education (CBE) system. We searched PubMed, ERIC, PsycINFO, Scopus, and African Journals Online (AJOL) from 2015 to 2024 using the following strategy in PubMed: (dyscalculia OR 'numeracy difficult*' OR 'mathematical learning disability*') AND (Kenya OR 'East Africa') AND ('competency-based education' OR CBE OR 'senior school' OR 'secondary school'). Database selection prioritized education, psychology, and regional African scholarship. The search strategy employed a combination of carefully selected keywords and phrases related to mathematical dyscalculia, such as "mathematical dyscalculia," "numeracy difficulties," and "learning disabilities in mathematics "alongside terms specifying academic performance, senior school learners, competency-based education, and Kenyan public schools. Boolean operators (AND, OR) and truncation techniques were applied to optimize the precision and breadth of the search. To capture the evolution of dyscalculia research and Kenya's adoption of CBE (initiated in 2017), the search spanned 2015–2024. This window was chosen pragmatically to include studies published shortly before CBE implementation (which may reflect baseline conditions) and to capture the most recent evaluations while balancing comprehensiveness with manageability. No language restrictions were imposed, maximizing inclusivity and comprehensiveness. Furthermore, to enhance the scope and depth of the review, the reference lists of pertinent articles and gray literature sources—including Kenyan Ministry of Education reports, unpublished theses from university repositories, and conference proceedings—were identified through Google Scholar, Open Grey, and reference list screening and assessed using the same inclusion criteria, enabling the identification of additional relevant studies that may not have been indexed in the primary databases. This comprehensive approach ensured a robust and inclusive evidence base for examining the multifaceted impact of mathematical dyscalculia within Kenya's evolving CBE educational context.

Inclusion and Exclusion Criteria

The inclusion criteria for this study encompassed research that specifically addressed mathematical dyscalculia or related numeracy learning difficulties among senior school learners, typically aged 14 to 18, within Kenyan public schools operating under the Competency-Based Education (CBE) framework. Eligible studies examined academic performance outcomes not only in mathematics but also in quantitatively demanding subjects such as science, economics, and technology, reflecting the broader curricular impact of dyscalculia on academic performance. Furthermore, the included studies explored systemic factors integral to the CBE context, such as awareness levels, diagnostic capacity, teacher training, resource allocation, and the implementation of inclusive teaching strategies. We prioritized empirical investigations (quantitative, qualitative, or mixed-methods studies with primary data from CBE schools in Kenya). Theoretical analyses and systematic reviews were included only if they provided Kenya-specific data or frameworks directly applicable to the CBE. These sources were appraised for relevance and clarity of argumentation, and the findings derived from them were explicitly identified in the results to avoid conflating conceptual and empirical evidence.

Conversely, the exclusion criteria ruled out studies that focused solely on primary or junior school learners, non-Kenyan educational settings, or frameworks outside CBE, ensuring contextual specificity. Studies limited to physical disabilities or learning difficulties unrelated to dyscalculia were also excluded to maintain focus on the targeted neurodevelopmental challenge. Additionally, articles were excluded if they lacked sufficient methodological rigor or did not directly address the impact on academic performance. Non-academic publications, opinion pieces, and studies without accessible full texts were also omitted to preserve the quality and relevance of the evidence base. This rigorous selection approach ensured that the systematic review remained tightly aligned with the study's aim to understand how mathematical dyscalculia affects senior learners' academic outcomes within Kenyan public schools implementing CBE, while accounting for the systemic and pedagogical factors that influence identification, support, and performance in mathematics and related subjects.

Study Selection Process

The selection process was conducted using a meticulous, multi-phase methodology designed to ensure rigor and objectivity. Initially, duplicate records were removed to refine the study pool. Subsequently, two independent reviewers screened the titles and abstracts of the remaining articles to evaluate their relevance based on predefined inclusion criteria. Any disagreements or inconsistencies between the reviewers were addressed through collaborative discussion, and when necessary, a third reviewer was consulted to reach a consensus. Subsequently, the full texts of studies deemed potentially eligible were retrieved and subjected to a comprehensive review to confirm their suitability for inclusion. Throughout this process, a PRISMA flow diagram was used to systematically record and illustrate each stage, from identification and screening to eligibility assessment and final inclusion, thereby enhancing the transparency, reproducibility, and methodological integrity of the review.

Data Extraction

A comprehensive and standardized data extraction form was meticulously designed to ensure systematic collection of relevant information from each study included in the review. This form captured a broad range of critical variables, including study-specific characteristics such as authorship, publication year, research design, and sample size. It also incorporated contextual elements detailing the educational environment and specific features of the Competency-Based Education (CBE) implementation within Kenyan public schools. Key dyscalculia-related factors were extracted, including the diagnostic approaches employed and the prevailing levels of awareness regarding the condition. Additionally, the form documented aspects related to teacher preparedness and resource allocation, alongside the inclusive teaching strategies utilized to support learners with dyscalculia. Academic performance outcomes were recorded not only for mathematics but also for other quantitatively demanding subjects such as science, economics, and technology, reflecting the wider curricular impact. To uphold the rigor and reliability of the extraction process, two independent reviewers conducted data collection separately, followed by cross-verification to identify and resolve discrepancies, thereby minimizing potential errors and biases.

Quality Assessment

The methodological quality and potential risk of bias of the included studies were rigorously assessed using appraisal tools specifically aligned with each study design. For qualitative research, instruments such as the Critical Appraisal Skills Programme (CASP) checklist were employed, whereas quantitative studies were evaluated using standardized frameworks such as the Joanna Briggs Institute checklists. This comprehensive evaluation focused on multiple critical dimensions, including the clarity and precision of the research questions, the suitability and robustness of the chosen study designs, the rigor and appropriateness of the sampling strategies, and the thoroughness of the data collection procedures. Additionally, the validity and reliability of the findings were carefully examined to ensure evidence credibility. Based on these assessments, the studies were systematically categorized according to their methodological quality, enabling a nuanced synthesis and interpretation of the results. Each study was rated as high, moderate, or low quality using the CASP or JBI criteria. Low-quality studies were excluded from the quantitative summaries but retained for thematic context. This structured approach ensured that the review's findings were grounded in sound evidence while transparently acknowledging limitations.

Data Synthesis

Meta-analysis was precluded by heterogeneity in outcome measures (e.g., Mariera *et al*., reported self-efficacy scores; Tibane *et al*., reported standardized math achievement; Kipkorir reported screening availability as a binary variable), study designs (six cross-sectional surveys, four qualitative interviews, three reviews, and two mixed-methods), and populations (ranging from Grade 10 to senior secondary, across Kenya, South Africa, and the Philippines). Cross-national findings were integrated cautiously, with explicit notation in the results when non-Kenyan evidence was used to supplement Kenyan data, and the limitations of transferability are discussed. Therefore, we employed thematic narrative synthesis to comprehensively integrate and interpret the thematic findings across the selected studies. This approach facilitated an in-depth exploration of the systemic factors affecting the identification and support of learners with mathematical dyscalculia, particularly within the framework of competency-based education (CBE). Emphasis was placed on examining how inclusive teaching strategies are implemented in CBE settings and their consequent impact on academic performance not only in mathematics but also in other quantitatively demanding subjects such as science, economics, and technology. Through this synthesis, recurring patterns, inconsistencies, and gaps in the literature were identified, offering a nuanced understanding of the multifaceted challenges and opportunities related to dyscalculia support in Kenyan public senior schools' curricula. Quantitative findings were summarized descriptively to provide contextual clarity, while the heterogeneity of methodologies and outcome measures precluded the use of meta-analytic techniques. This method ensured that the synthesis remained sensitive to contextual variability and methodological differences, thereby producing a coherent and inclusive narrative that informs policy, pedagogy, and future research directions in the Kenyan CBE landscape.

Justification and Alignment with PRISMA

This systematic review adhered rigorously to the Preferred Reporting Items for Systematic Reviews

and Meta-Analyses (PRISMA) guidelines, ensuring a high standard of methodological integrity, transparency, and reproducibility. This approach incorporates a meticulously structured search strategy combined with well-defined inclusion and exclusion criteria, which collectively guarantee a focused and relevant evidence base. The involvement of dual independent reviewers at key stages—screening, data extraction, and quality assessment—further strengthens the objectivity and minimizes bias. Comprehensive quality appraisals tailored to each study design ensure that the synthesis is based on credible and robust evidence. The narrative synthesis methodically integrates diverse findings while maintaining clarity and contextual sensitivity and accommodates heterogeneity without compromising coherence. By embedding these PRISMA principles throughout the review process, this study not only enhances the trustworthiness and validity of its conclusions but also provides a solid foundation for generating evidence-based recommendations. These recommendations are crucial for informing policy formulation and practical interventions aimed at improving the identification, support, and academic outcomes of learners with mathematical dyscalculia in Kenyan public schools implementing competency-based education. The PRISMA flow diagram for the article selection process is given in figure 1 below:

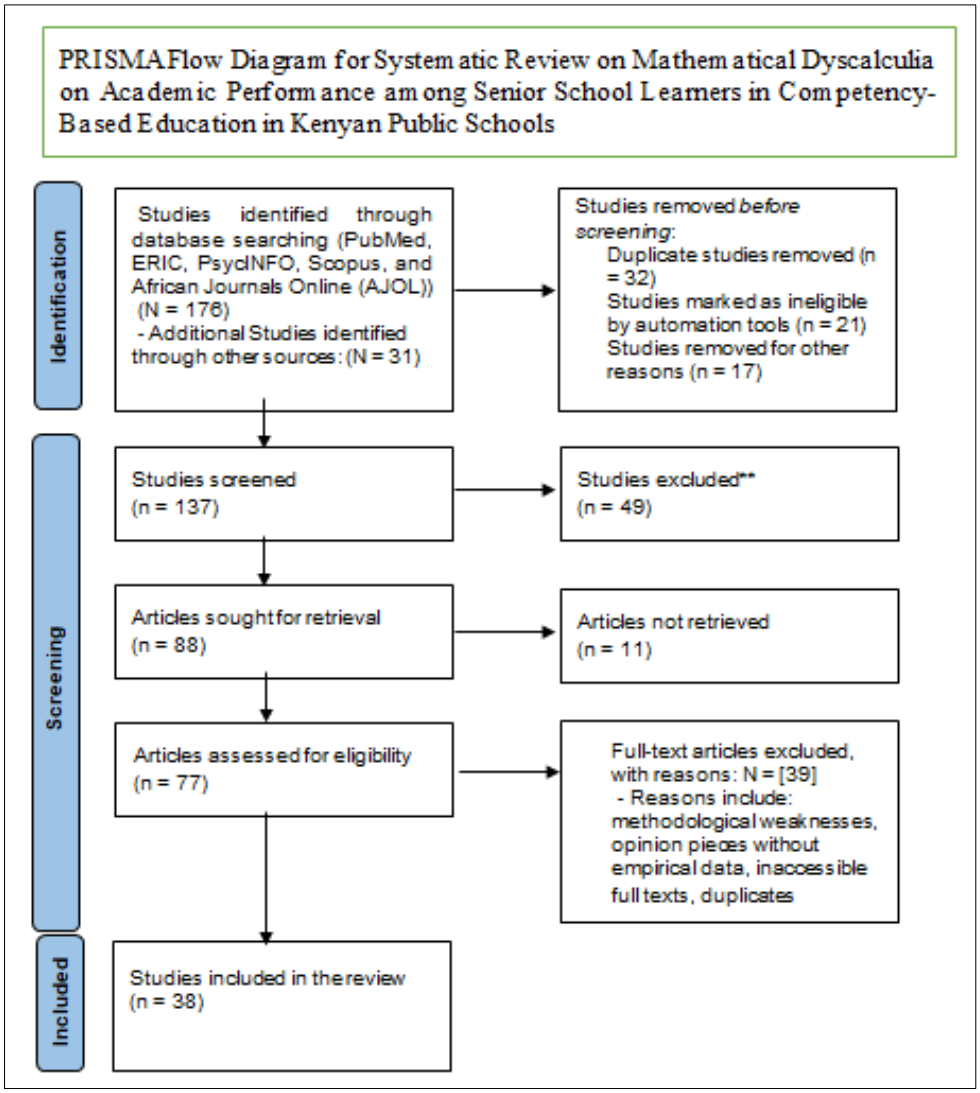

Figure 1: PRISMA Flow Diagram of Article Selection Process
Source: Research data (2026)

RESULTS AND DISCUSSION

This systematic review synthesizes evidence on MD's impact of MD in Kenyan CBE schools, revealing that systemic constraints, such as limited awareness, scarce diagnostic tools, inadequate teacher training, and inequitable resources, undermine CBE's individualized mastery goals and exacerbate academic disparities for learners with MD. The findings are organized around the study's specific objectives and research questions, addressing awareness and diagnostic capacity, availability and use of inclusive teaching strategies, influence of teacher training and resource allocation, academic performance challenges, and gaps in research

on support mechanisms for students with ADHD. Of the 15 included studies, 9 were descriptive reviews or conceptual papers providing Kenya-relevant frameworks, and 6 were primary empirical studies (4 cross-sectional surveys and 2 qualitative). This evidence base limits our ability to quantify intervention effects or establish causal relationships, and the findings should be interpreted as preliminary mappings of systemic challenges rather than definitive evaluations.

Awareness and Diagnostic Capacity for Mathematical Dyscalculia in Kenyan Public Senior Schools

The review revealed a pervasive lack of awareness and limited diagnostic capacity for MD across Kenyan public senior schools operating under CBE. Three studies reported screening gaps: Kipkorir (2015) found that 72% of 150 Kenyan schools lacked formal MD screening; Ohba and Malenya (2020) reported 68% in Western Kenya; and Tibane *et al*., (2024) found 75% in South African Grade 10 schools. While these figures suggest that screening deficits exceed 70% in resource-constrained East and Southern African contexts, comprehensive national data for Kenya are lacking. This deficiency is compounded by the scarce availability of specialized diagnostic tools and trained personnel (Modise *et al*., 2025; Ogeto, 2025). Limited diagnostic infrastructure severely hampers early identification, delaying intervention and exacerbating academic difficulties. This aligns with the findings of Apostolidou (2025) and Kunwar (2022), who emphasized that without accessible and accurate diagnosis, learners remain unsupported, undermining CBE's principle of individualized mastery. Furthermore, disparities between low- and higher-resource schools intensify inequities; resource-rich contexts benefit from screening protocols and specialist support, while most Kenyan public schools face systemic constraints (Bagazi, 2025; Desucatan, 2025). These conditions undermine the potential of CBE to tailor learning to individual needs, as the absence of early identification prevents the timely implementation of personalized learning strategies.

Availability and Utilization of Inclusive Teaching Strategies and Targeted Interventions

Inclusive teaching strategies, such as multisensory instruction, personalized learning plans, assistive technologies, visual aids, manipulatives, tutoring, and peer support, are recognized as effective approaches to support learners with dyscalculia (Delgado *et al*., 2019; Junaedi, 2021; Reigosa-Crespo, 2019). However, their availability and consistent application in Kenyan CBE schools are uneven and often inadequate due to resource constraints and insufficient teacher preparedness (Kuja *et al*., 2025; Ooko, 2023). The review identifies a fragmented implementation of these strategies, with many schools lacking essential materials and assistive technologies, such as calculators and math-specific software (Apostolidou, 2025; Modise *et al*., 2025). Multisensory instruction, which reduces cognitive load and aligns with the Cognitive Load Theory (CLT), is theoretically supported but faces practical challenges in low-resource settings (Hanham *et al*., 2023; Ni *et al*., 2017). Personalized learning plans, which are central to CBE, are inconsistently applied owing to limited diagnostic information and teacher training (Wang'Ang'A, 2023; Ogeto, 2025). Assistive technologies show promise but require integration with teacher training and resource allocation to be effective (Bagazi, 2025; Salisa and Meiliasari, 2023). The absence of systemic support limits the scalability and sustainability of these interventions, restricting their impact on learners' mastery and motivation.

Influence of Teacher Training and Resource Allocation on Identification and Support

Teacher preparedness is a critical determinant in identifying and supporting learners with MD. Fewer than 40% of teachers have received specialized MD training (Kipkorir, 2015; Ooko, 2023), and qualitative studies have reported that untrained teachers feel unprepared to implement multisensory instruction or personalized plans (Anjum *et al*., 2023; Kuja *et al*., 2025). While this suggests that training gaps may constrain pedagogical capacity, direct comparative evidence is lacking. Resource allocation disparities further exacerbate these challenges. Many schools suffer from inadequate infrastructure, limited access to diagnostic tools, and insufficient teaching and learning materials (Kuja *et al*., 2025; Modise *et al*., 2025). This inequity particularly affects rural and low-resource schools, widening achievement gaps and undermining the equity goals of CBE (Ogeto, 2025). The co-occurrence of limited teacher training and resource scarcity is associated with inconsistent identification and fragmented support for learners with dyscalculia, although the nature and direction of their interaction remain underexplored in the included studies. Without systemic investment in capacity building and equitable resource distribution, the individualized mastery model of CBE cannot be fully realized (Wang'Ang'A, 2023; Desucatan 2025).

Academic Performance Challenges Faced by Learners with Dyscalculia

Learners with MD exhibit significant academic challenges not only in mathematics but also in quantitatively demanding subjects such as science, economics, and technology (Mariera *et al.,* 2021; Kunwar, 2021). The review highlights that deficits in number sense, arithmetic fluency, and quantitative reasoning impede learners' abilities to interpret graphs, calculate percentages, and apply mathematical concepts across disciplines (Roulstone *et al*., 2024; Salisa & Meiliasari, 2023). Tibane *et al.,* (2024) reported that South African learners with below-average numeracy skills scored 25% lower (mean difference) on quantitative reasoning tasks than their peers. Ooko (2023) observed a 20–30 percentage-point gap in Kenyan science and economics exam scores between

learners with suspected MD and controls, although neither study controlled for socioeconomic or school-level confounders, precluding causal inference. These performance deficits contribute to reduced motivation, lower self-efficacy, and widening academic disparities (Mariera *et al*., 2021; Anjum *et al*., 2023). The cumulative effect undermines CBE's learner-centered success and mastery-based progression goals.

Gaps in Current Research on Support Mechanisms within Kenya's CBE Framework

This systematic review identifies significant research gaps regarding the effectiveness and scalability of support mechanisms for dyscalculic learners in Kenyan CBE schools. While assistive technologies and multisensory instruction are theoretically supported and show promise in other contexts (Apostolidou, 2025; Bagazi, 2025), empirical evidence on their application and outcomes in Kenyan public senior schools is scarce. Few studies have systematically examined how diagnostic capacity, teacher training, and resource allocation interact to influence the consistent use of inclusive teaching strategies and targeted interventions (Delgado *et al.,* 2019; Kunwar, 2022). Moreover, there has been limited investigation into how CBE's individualized mastery and pacing principles are operationalized to accommodate learners with dyscalculia, particularly in resource-constrained environments (Wang'Ang'A, 2023; Modise *et al*., 2025). The lack of context-specific empirical data impedes the development of scalable and sustainable models to mitigate the academic impact of dyscalculia and inform policy reforms. This gap underscores the need for integrated research that bridges learner-level challenges with the systemic, pedagogical, and infrastructural factors unique to Kenya's CBE framework.

Theoretical Implications

Cognitive Load Theory (CLT) explains how learners with MD experience cognitive overload due to limited working memory capacity when processing complex numerical information (Ni *et al*., 2017; Hanham *et al*., 2023). Learners' documented struggles with number sense and quantitative reasoning are consistent with CLT's prediction that limited working memory capacity impedes complex numerical processing (Junaedi, 2021; Olaoluwa, 2024). However, the included studies did not directly measure cognitive load; therefore, CLT remains a plausible interpretive framework rather than an empirically validated mechanism in this context. The inconsistent application of multisensory instruction and personalized learning plans in Kenyan schools is consistent with CLT's prediction that failure to optimize intrinsic and germane cognitive load impedes effective learning, although direct measures of cognitive load are lacking in the included studies. However, CLT's limitations in addressing systemic factors, such as limited diagnostic capacity and teacher training, reveal the necessity to extend beyond cognitive mechanisms to encompass broader educational contexts (Zaidi & Zaidi, 2022; Zahara *et al*., 2020).

Multiple Intelligences Theory (MIT) provides a complementary perspective by recognizing diverse learner strengths beyond logical-mathematical intelligence (Gardner, 1983; Al-Zoubi and Al-Adawi, 2019). The review's emphasis on inclusive teaching strategies that engage linguistic, spatial, and bodily kinetic intelligences supports MIT's assertion that leveraging multiple intelligences can mitigate MD's impact (Mayu & Widjajanti, 2022; Reigosa-Crespo, 2019). This theoretical lens justifies the deployment of personalized, strength-based interventions aligned with CBE's individualized mastery goals (Radin & Dannenhoffer, 2020). Nevertheless, challenges in operationalizing MIT-based strategies due to limited teacher training and resources underscore the theory's practical constraints within low-resource Kenyan contexts (Molise & Kakoma, 2024; Mahmud *et al*., 2020).

The Inclusive Competency-Based Education Framework synthesizes CLT and MIT principles, advocating equitable, learner-centered education through early identification, personalized pacing, and targeted interventions (Huang, 2018; Refat *et al*., 2020). The review's findings of systemic gaps in awareness, diagnostics, and resource allocation reveal critical barriers to realizing the framework's potential in Kenyan public schools (Junaedi, 2021; Anggoro *et al*., 2024). The fragmented implementation of inclusive strategies and inequitable access to assistive technologies reflect systemic weaknesses that undermine mastery-based progression and motivation (Wang'Ang'A, 2023; Modise *et al*., 2025). Thus, the framework's theoretical promise necessitates integration with systemic reforms that address infrastructural, policy, and capacity-building deficiencies for effective scalability.

Practical Implications

The pervasive lack of formal MD screening in over 70% of Kenyan public senior schools (Kipkorir, 2015; Ohba & Malenya, 2020) demands urgent investment in diagnostic infrastructure and specialist training to enable early identification. Without such capacity, learners remain undiagnosed, delaying intervention and exacerbating their academic underperformance (Apostolidou, 2025; Modise *et al*., 2025). The significant undertraining of teachers, with fewer than 40% receiving specialized preparation, impairs educators' ability to implement inclusive pedagogies, such as multisensory instruction and personalized learning plans, limiting support for dyscalculic learners (Anjum *et al*., 2023). Resource allocation disparities, especially between urban and rural schools, further hinder equitable access to assistive technologies and learning materials, deepening achievement gaps and conflicting with CBE equity goals (Bagazi, 2025; Ogeto, 2025). Therefore, practical

strategies must prioritize the equitable distribution of diagnostic tools, teaching resources, and professional development opportunities to ensure uniform support across diverse school contexts.

The review's identification of academic performance deficits of 20–30% in quantitatively demanding subjects (Tibane *et al*., 2024; Ooko, 2023) underscores the necessity of cross-curricular interventions that extend beyond mathematics to science, economics and technology. Implementing multisensory and strength-based instructional approaches informed by CLT and MIT can enhance cognitive processing and engagement, thereby improving mastery and motivation (Mariera *et al*., 2021; Junaedi, 2021). Finally, the scarcity of empirical evidence on the effectiveness and scalability of support mechanisms within Kenyan CBE schools highlights a critical research-practice gap. Policymakers and practitioners should prioritize context-specific evaluations of interventions that integrate assistive technologies, multisensory instruction, and teacher training to develop scalable and sustainable models (Kunwar, 2022; Modise *et al*., 2025). Strengthening systemic readiness through policy reforms, capacity building, and resource equity is essential to actualize the vision of the Inclusive CBE Framework and mitigate MD's adverse academic impact of the MD.

CONCLUSIONS OF THE STUDY

This systematic review examined the impact of mathematical dyscalculia (MD) on academic performance among senior school learners within Kenya Education (CBE) framework, in line with the study's objectives. The findings show low awareness and limited diagnostic capacity for MD in Kenyan public senior schools, with over 70% lacking formal screening mechanisms. This hinders early identification and intervention, undermining CBE's individualized mastery and pacing of CBE. Inclusive teaching strategies and targeted interventions, including multisensory instruction, personalized learning plans, and assistive technologies, are uneven and often insufficient because of resource constraints and a lack of teacher preparedness. These limitations reduce the scalability and effectiveness of support mechanisms for learners with dyscalculia, thereby impeding mastery-based progression. Teacher training is pivotal in identifying and supporting learners with MD. However, fewer than 40% of senior school teachers have received specialized training, and inequitable resource allocation worsens disparities in support, especially in rural and low-resource settings. MD-related academic challenges extend beyond mathematics to science, economics, and technology. Learners with undiagnosed dyscalculia score 20–30% lower in these subjects, experience reduced motivation, and exhibit lower self-efficacy, undermining the learner-centered and equitable goals of CBE. Research gaps remain in evaluating support mechanisms within Kenya's CBE context, particularly in terms of how diagnostic capacity, teacher training, and resource allocation shape inclusive teaching and targeted interventions. This study underscores that although Kenya's CBE framework supports individualized learning and mastery, systemic constraints hinder its realization for learners with mathematical dyscalculia. As the first systematic synthesis of MD-related evidence in Kenyan CBE schools, this review establishes a baseline for monitoring progress and prioritizing reform. Addressing this requires policy and practice interventions that strengthen awareness, diagnosis, teacher training, resource equity, and empirical research to inform scalable and sustainable models that improve outcomes for dyscalculic learners in Kenyan public senior schools.

Limitations of the Study

This systematic review had several limitations. First, reliance on existing literature on mathematical dyscalculia in Kenyan public senior schools under the competency-based education (CBE) framework limited the findings' comprehensiveness because available studies were few and often low quality. Of the 15 included studies, nine were descriptive reviews or conceptual papers (e.g., Kunwar, 2021; Wang'Ang'A, 2023), with only six providing primary empirical data on Kenyan CBE schools. This imbalance limited our ability to draw definitive conclusions about intervention effectiveness, with little empirical research examining diagnostic capacity, teacher training, resource allocation, and inclusive strategies, restricting definitive conclusions about causal relationships or the effectiveness of interventions. Second, heterogeneity precluded meta-analysis and required narrative synthesis, which is inherently subject to interpretative biases. This particularly affects our conclusions about the relative importance of awareness, diagnostics, training, and resource domains, where studies used non-comparable measures and qualitative versus quantitative methods. Although dual independent synthesis and discussion mitigated this risk, it did not eliminate it. To mitigate this, two reviewers independently extracted and synthesized the data, and discrepancies were resolved through discussion. However, the absence of quantitative pooling means that our conclusions reflect qualitative judgments and are sensitive to the weighting of individual studies. Third, the review focused only on senior school learners in Kenyan public schools, limiting its generalizability to other levels, private institutions, and other national contexts. Excluding non-English studies and unpublished data may have omitted relevant evidence and introduced publication bias. Fourth, systemic factors, including policy implementation variations, regional resource disparities, and socioeconomic influences, were often underreported, constraining nuanced understanding of contextual moderators affecting dyscalculia support within CBE. Fifth, only six of the 15 studies provided primary Kenyan data. Key findings, including the estimated 70% screening gap and 20–30% performance deficit,

incorporate evidence from South Africa (Tibane *et al*., 2024) and the Philippines (Desucatan, 2025). While these contexts share resource constraints with Kenya, differences in CBE implementation, language of instruction, and teacher-training systems may limit transferability. Readers should interpret cross-national extrapolations as indicative rather than definitive for the case of Kenya. Sixth, CBE implementation and educational policies in Kenya are evolving; therefore, some findings may become outdated, highlighting the need for ongoing research to capture the emerging policy trends. Finally, this review was not prospectively registered, which may have increased the risk of bias from post-hoc methodological adjustments. We mitigated this by developing a protocol prior to screening (available upon request) that specified search terms, eligibility criteria, and data extraction fields. However, without prospective registration, readers cannot independently verify that no post-hoc changes have occurred. We declare that no major deviations from the initial protocols were made.

Recommendations for the Study

This study recommends a multifaceted approach to improve the identification, support, and academic outcomes of senior school learners with mathematical dyscalculia (MD) within Kenya's Competency-Based Education (CBE) framework. First, awareness of dyscalculia must increase among educators, administrators, and policymakers to enable early recognition and reduce the stigma associated with it. This should be matched by a wider, equitable distribution of diagnostic tools and screening mechanisms across public senior schools, especially in low-resource and rural areas. Second, specialized teacher training should be prioritized and expanded to help educators identify the symptoms of dyscalculia and implement inclusive strategies. Training should emphasize multisensory instruction, personalized learning plans, and assistive technologies in line with CBE's individualized mastery and pacing principles, supported by the continuous professional development. Third, resource allocation must address the infrastructural and material gaps that limit inclusive teaching. Investment in assistive technologies, learning materials, and supportive classroom environments, distributed equitably, can improve access to interventions and prevent wider achievement gaps. Fourth, contextually relevant and scalable dyscalculia support models should be developed and implemented. These should draw on Cognitive Load Theory, Multiple Intelligences Theory, and the Inclusive CBE Framework, while collaboration among educators, specialists, parents, and communities ensures holistic, sustainable support. Fifth, empirical research should assess the effectiveness, scalability, and sustainability of support mechanisms within Kenyan CBE settings, considering diagnostic capacity, teacher preparedness, resource equity and policy implementation. Lastly, policy reforms should embed dyscalculia awareness, diagnosis, and support within national education frameworks through clear guidelines, funding, accountability, and stronger monitoring and evaluation systems to operationalize inclusive education principles and continuous improvement.

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Cite This Article: Samuel Bagasa Mose & Evans Okemwa Achuti (2026). Impact of Mathematical Dyscalculia on Academic Performance among Senior School Learners in Competency-Based Education in Kenyan Public Schools: A Systematic Review. *East African Scholars J Edu Humanit Lit, 9*(7), 429-444.