

A TAILORED PATH THROUGH DYSCALCULIA: HARMONIZING DIFFERENTIATED AND TARGETED INDIVIDUAL INSTRUCTION

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Abstract

Dyscalculia, a persistent learning difficulty influencing basic arithmetic and numerical understanding, significantly affects students' academic paths and broader life opportunities. While differentiated instruction (DI) has garnered attention as a flexible, learner-centered approach to accommodate diverse student needs, questions remain about whether DI alone can fully address the complex and intensive requirements of learners with dyscalculia—particularly in large, heterogeneous classrooms. Emerging evidence indicates that some students with severe mathematical learning difficulties may benefit from more assessment-informed, individualized instruction, complementing or even surpassing DI's group-level differentiation strategies. This article synthesizes contemporary research on DI's efficacy, limitations, and potential enhancements for dyscalculic learners. By examining dyscalculia's multifaceted etiology, exploring teacher preparedness, considering contextual and cultural factors, integrating technology, and analyzing policy implications, we propose that blending DI principles with more targeted individualization can better ensure effective mathematics learning and sustained achievement for students facing the steep challenges of dyscalculia.

Keywords: Dyscalculia, Differentiated Instruction, Individualized Instruction, Mathematics Education, Inclusive Education, Teacher Development

1. Introduction

Mathematics forms a critical foundation for academic success, informed decision-making, and engagement in an increasingly complex, technologically driven world (Butterworth, 2005). Persistent difficulties in mathematics can have significant academic, vocational, and socio-emotional consequences, undermining both future opportunities and self-efficacy (Mutlu, 2019; Onyishi & Sefotho, 2021). Among these persistent difficulties, dyscalculia stands out as a specific learning disorder affecting the understanding, representation, and manipulation of numerical information (APA, 1995; Geary, 2004, 2010). Students with dyscalculia often struggle with number sense, arithmetic operations, and spatial relationships, relying on rudimentary counting strategies (Bender & Beller, 2012; Geary, 1990) long after their peers have mastered more advanced skills.

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Dyscalculia's roots are neurocognitive, linked to dysfunctions in numerical cognition (Butterworth & Laurillard, 2010; von Aster & Shalev, 2007; Piazza et al., 2010) and to deficits in working memory (Andersson & Östergren, 2012), resulting in challenges that transcend the simplistic notion of “not trying hard enough.” Although prevalence estimates vary (Lewis, Hitch, & Walker, 1994; Shalev, Auerbach, Manor, & Gross-Tsur, 2000), early and robust intervention is widely recommended (Wagner, 2017). Yet educators and policymakers continue to grapple with identifying the most effective instructional strategies—particularly in modern, diverse classrooms where the range of needs is vast (Deunk et al., 2018).

1.1. Differentiated Instruction: Strengths and Shortcomings for Dyscalculic Students

Differentiated instruction (DI) has gained considerable attention as an approach that acknowledges diversity in readiness, interests, and cognitive styles, adapting teaching methods and materials accordingly (Tomlinson, 2001; Gentry, Sallie, & Sanders, 2013). Grounded in frameworks such as Gardner's (1983) multiple intelligences and Vygotsky's (1978) Zone of Proximal Development, DI encourages teachers to see diversity as a resource, designing tiered assignments, using flexible grouping, and offering multiple representations of concepts. Research consistently demonstrates DI's potential for improving mathematics achievement and motivation (Bal, 2023; Chamberlin & Powers, 2010; Flaherty & Hackler, 2010; Meyad et al., 2014), increasing engagement (Heinle et al., 2022), and fostering more inclusive environments (Onyishi & Sefotho, 2021).

Yet, the very principles that make DI effective for a broad population may be insufficient for students with dyscalculia, whose difficulties often run deeper than simple skill gaps (Geary, 2010). While DI encourages responsiveness, it frequently operates at a group level, creating clusters of students with somewhat similar needs rather than addressing each learner's unique profile of misconceptions. Dyscalculia often presents entrenched conceptual challenges that require careful, sustained one-on-one attention (Mazzocco et al., 2013; Tennant & Tennant, 2010). Math anxiety can further impede learning (Mutlu, 2019), meaning that providing “lower-level” tasks or more practice within a DI framework may not directly tackle the underlying cognitive and affective barriers dyscalculic students face.

Given these complexities, even a thoughtfully implemented DI model might not fully “crack the code” for a dyscalculic learner's persistent misunderstandings and slow growth. In large, heterogeneous classrooms, limited teacher time compounds the problem (Dijkstra et al., 2017; Faber et al., 2018). Although DI is more flexible than traditional methods, it may still not enable teachers to focus intensively on an individual's evolving needs, evolving

misconceptions, and specific cognitive style preferences (Arnup et al., 2013). As a result, the dyscalculic student risks remaining at the margins—benefiting from general differentiation but never receiving the precise interventions essential for meaningful progress.

1.2. Integrating Individualization: Assessment-Informed Instruction for Dyscalculic Learners

Recent findings highlight that more assessment-informed, individualized instruction can yield substantial gains for at-risk learners, including those with severe mathematics difficulties (Connor et al., 2018). By using assessment data to finely tailor early mathematics instruction (ISI-Math), Connor et al. demonstrated significant improvements in students of varying initial skill levels, socio-economic backgrounds, and gender. These findings underscore the value of pinpointing each learner's specific strengths and deficits, rather than relying solely on group-level differentiations.

For dyscalculic students, this kind of granular individualization may be particularly crucial. Unlike DI, which might provide three levels of tasks or multiple group options, individualized instruction informed by continuous assessment can pinpoint exactly what underlying concept the dyscalculic learner fails to grasp—be it number magnitude processing (Butterworth & Laurillard, 2010), basic arithmetic fact retrieval (Geary, 2004; Mazzocco et al., 2013), or more nuanced spatial reasoning (Mazzocco et al., 2013). By identifying these deficits, teachers can offer step-by-step, carefully sequenced support, ensuring that learners master foundational concepts before moving on (Connor et al., 2018). Over time, this approach can break the cycle of repeated failure and frustration, gradually building the student's confidence and competence.

1.3. Teacher Preparedness and Professional Development

Implementing individualized instruction alongside DI poses a significant challenge for teachers. While DI demands flexibility and resourcefulness (Tomlinson, 2001), full individualization requires even more advanced data literacy, diagnostic skill, and adaptive pedagogy (Langelaan et al., 2024). Teachers must interpret frequent assessment results, modify lesson plans continually, and commit extra time to one-on-one instruction—an undertaking often complicated by large class sizes and limited resources (Zerai et al., 2023).

Furthermore, teachers may harbor doubts or negative beliefs about their ability to meet every learner's needs at an individual level (Dijkstra et al., 2017; Timmermans & Rubie-Davies, 2018; Bobis et al., 2021). Addressing these attitudes requires comprehensive training

that builds confidence, demonstrates the feasibility and benefits of individualized strategies, and offers supportive leadership structures. Through such professional development, educators can become skilled at layering individualized interventions atop a DI foundation, thereby meeting the intensive needs of dyscalculic students more effectively.

1.4. Leveraging Technology and Data-Driven Insights

Adaptive learning systems, dashboards, and computer-assisted arithmetic tools offer promising avenues for integrating DI with individualization (Berrett & Carter, 2018; Keuning & van Geel, 2021; Songer et al., 2020). These technologies can provide immediate, ongoing feedback on student performance, highlight persistent misconceptions, and deliver targeted practice aligned with a student's specific skill gaps. By automating some aspects of diagnosis and progress monitoring, technology can alleviate the teacher's workload, enabling more informed and strategic interventions.

In under-resourced environments, even partial incorporation of technology can help teachers approximate individualized supports (Zerai et al., 2023). For instance, a teacher struggling to provide daily one-on-one support might rely on an adaptive platform to deliver incremental skill-building exercises, then periodically review performance data to guide targeted instructional sessions. In wealthier school systems, greater resource availability can enable a smoother synergy between DI and individualized instruction, ensuring that dyscalculic learners receive exactly the kind of nuanced support they need.

1.5. Contextual and Cultural Dimensions of Implementation

Cultural norms, school policies, and socio-economic factors influence the feasibility of blending DI with individualized instruction. Some educational systems promote flexible groupings and encourage the use of adaptive technologies, while others remain committed to more uniform, whole-class methods (Deunk et al., 2018). Ensuring that dyscalculic learners receive the intensive support they need demands buy-in from administrators, evidence-informed policy decisions, and strategic resource allocation.

Policy frameworks can mandate that DI serve as a baseline for inclusivity while simultaneously requiring additional, assessment-informed measures for learners showing persistent arithmetic difficulties (Marishane et al., 2015). This combination acknowledges diversity while also recognizing that a subset of learners, including those with dyscalculia, need more than differentiation alone can provide.

1.6. Motivation, Engagement, and the Long-Term Benefits of Individualization

While DI can enhance interest through varied activities and representations (Galiç & Yıldız, 2023), dyscalculic learners who repeatedly encounter failure may need more than interest-driven enhancements. Individualized instruction ensures each step is aligned with the learner's cognitive readiness, making every success genuine and meaningful (Connor et al., 2018). Over time, this authenticity can shift a student's perception of mathematics from a domain of insurmountable obstacles to one of achievable challenges.

As learners experience success tailored to their specific gaps, math anxiety may diminish, replaced by greater self-efficacy, resilience, and willingness to engage (Mutlu, 2019; Onyishi & Sefotho, 2021). These positive transformations influence not only mathematics learning but also a learner's broader approach to educational challenges, ultimately contributing to a more adaptive, growth-oriented mindset.

1.7. Toward a More Nuanced Vision of Inclusive Mathematics Education

Differentiated instruction corrects the shortcomings of uniform teaching by acknowledging and responding to diversity (Tomlinson, 2001). Yet as the literature and classroom experience suggest, DI alone may not suffice for students with dyscalculia, whose learning difficulties are both deep and specific (Geary, 2010). The accumulating evidence that individualized, assessment-informed instruction can significantly boost the performance of students with pronounced mathematics challenges (Connor et al., 2018) underscores the need to enrich DI with more personalized strategies.

Building a hybrid model—where DI sets the stage for broad inclusivity and individualization provides the final layer of targeted support—requires teacher training, technological integration, supportive policies, and often a shift in educational culture (Dijkstra et al., 2017; Deunk et al., 2018; Langelaan et al., 2024). Despite these challenges, the potential payoff is substantial: a truly inclusive mathematics learning environment where even the most vulnerable learners experience meaningful progress, confidence, and competence.

As classrooms grow more diverse and educational standards shift toward personalization, the synergy between DI and individualized instruction will likely become a hallmark of best practice in mathematics education. Dyscalculic learners, representing some of the greatest instructional challenges, can be seen as catalysts inspiring more thoughtful, evidence-based models. By blending DI's flexibility with the pinpoint accuracy of individualized interventions, we can take a significant step toward ensuring that every student's mathematical potential is realized.

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