FOUNDATIONS OF INCLUSIVE MATHEMATICS EDUCATION: PRINCIPLES, LEARNER DIVERSITY, BARRIERS, AND PEDAGOGICAL PERSPECTIVES

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ABSTRACT

Inclusive mathematics education seeks to ensure equitable learning opportunities for all learners, including those with visual impairment, through responsive pedagogical practices and accessible learning environments. This paper presents a conceptual narrative review of the literature on inclusive mathematics education, synthesising theoretical perspectives, empirical evidence, and policy-related scholarship. Relevant literatures were identified through Web of Science, and Google Scholar using keywords such as inclusive mathematics education*,* visual impairment*,* inclusive pedagogy*,* Universal Design for Learning*, and* differentiated instruction*. Priority was given to peer-reviewed journal articles, books, and policy documents that addressed inclusive mathematics teaching and learning. The review examines the principles of inclusive mathematics education, learner diversity, barriers to effective implementation, and pedagogical foundations that support meaningful participation and achievement. It highlights equity, accessibility, active participation, high expectations, and collaboration as core principles underpinning effective mathematics instruction. The paper further emphasises the roles of Universal Design for Learning, differentiated instruction, formative assessment, and collaborative teaching in addressing learner variability. It concludes that effective inclusive mathematics education requires proactive instructional planning, accessible resources, and continuous teacher professional development to improve mathematics learning outcomes for all learners. It was recommended among others that government and employers of teachers should ensure that teachers are expose to inservice trainings to equipped them with emerging pedagogical mathematics instruction.*

Keywords: Inclusive mathematics education, visual impairment, learner diversity, Universal Design for Learning, differentiated instruction.

INTRODUCTION

Inclusive education has evolved from a placement-oriented approach to a broader pedagogical commitment that ensures learners with special needs are present, actively participate, experience a sense of belonging, and achieve meaningful academic outcomes. (United Nations, 2015). Rather than merely placing learners with disabilities in mainstream classrooms, inclusive education seeks to create learning environments where every learner has equitable opportunities to access, participate in, and benefit from quality education. The fundamental principle of inclusive education acknowledges that every learner possesses unique strengths, abilities, and learning needs, and therefore requires appropriate instructional support to maximize their educational potential (Baraily, 2024). Ainscow (2020) argues that inclusion requires educational

systems to identify and remove barriers that prevent learners from participating fully in educational opportunities. From this perspective, inclusion is achieved not simply through physical placement in regular classrooms but through the continuous transformation of school cultures, policies, curricula, and pedagogical practices to ensure that learner diversity becomes a source of educational enrichment rather than exclusion. Similarly, Florian (2014) emphasises that inclusive education should be judged by the quality of pedagogical practices that enable all learners to participate meaningfully in shared learning experiences rather than by physical placement alone.

Achieving these goals requires the effective implementation of evidence-based models of inclusive education. Adaka (2025) identifies several instructional models that promote successful inclusion in mainstream classrooms. The **Full Inclusion Model** involves assigning a special education teacher to collaborate with the general classroom teacher in supporting learners with disabilities through instructional adaptations and individualized assistance. The **Team Teaching Model** emphasizes collaborative planning, instruction, and assessment between general and special education teachers to meet the diverse learning needs of all learners. **Wang's Adaptive Learning Environment Model** advocates designing flexible learning environments that allow learners to progress at their individual pace while actively participating in classroom activities. The **Strategies Intervention Model** highlights the importance of guided social interaction and appropriate curriculum adaptations in promoting learners' cognitive and social development. Similarly, the **Circle of Inclusion Model** focuses on fostering learners' socio-emotional development by promoting active participation in both curricular and extracurricular activities alongside their peers. Furthermore, the **Systematic Approach for Accessing Learning Environment (SAALE) Model** emphasizes the need to modify the physical, instructional, and social learning environments to accommodate the diverse needs of learners. Collectively, these models underscore that effective inclusion extends beyond classroom placement to encompass collaborative teaching, differentiated instruction, accessible learning environments, and learner-centred pedagogical practices.

Mathematics occupies a central position in school curricula because it underpins scientific reasoning, technological innovation, financial literacy, and the problem-solving competencies required for lifelong learning (Adebiyi *et al* 2026). Consequently, equitable access to mathematics education is fundamental to achieving Sustainable Development Goal 4, which advocates inclusive, equitable, and quality education for all (United Nations, 2015). Despite its significance, mathematics remains one of the most cognitively demanding school subjects, particularly for learners with diverse educational needs, including those with visual impairment. Its reliance on abstract reasoning, symbolic representation, logical thinking, and the cumulative development of concepts often presents considerable learning challenges (Powell et al., 2021). These characteristics require teachers to employ flexible, learner-centred instructional approaches that accommodate learner variability while maintaining high academic expectations.

For learners with visual impairment, mathematics education presents additional challenges because many mathematical concepts are traditionally conveyed through visual representations such as diagrams, graphs, geometric figures, and spatial illustrations. Consequently, meaningful participation in mathematics learning requires accessible instructional materials, tactile representations, Braille mathematical notation, assistive technologies, and effective instructional adaptations. At the same time, mathematics provides opportunities for developing higher-order thinking skills, creativity, logical reasoning, metacognitive abilities, and problem-solving competence, all of which contribute significantly to learners' self-efficacy and

academic confidence. Gervasoni and Peter-Koop (2020) observe that although inclusive education has become an international educational priority, relatively few studies have adequately explained how genuine inclusion can be effectively realized within mathematics classrooms. Inclusive mathematics education may therefore be conceptualized as the deliberate organization of mathematics instruction, learning resources, assessment practices, classroom interactions, and support services to ensure that learners with diverse abilities and educational needs participate meaningfully and achieve common mathematical learning outcomes. (Fuchs, & Fuchs, 2017).

The goal of inclusive mathematics education is not to develop separate curricula for different groups of learners but to provide multiple, flexible pathways through which all learners can access the same mathematical concepts and demonstrate their understanding. This philosophy aligns closely with the principles of Universal Design for Learning (UDL), which encourages educators to anticipate learner variability during the planning stage by designing flexible goals, instructional methods, learning materials, assessments, and learning environments that minimize barriers to learning (CAST, 2024). The UDL Guidelines 3.0 further emphasize the importance of eliminating exclusionary practices and creating learning environments that recognise learner diversity as a valuable educational resource rather than a challenge to be managed.

Nevertheless, mathematics presents unique pedagogical demands within inclusive classrooms because mathematical learning involves interconnected concepts, specialised language, symbolic representations, abstract reasoning, and cumulative knowledge development. Learners who fail to acquire foundational mathematical concepts often experience increasing difficulties as instruction becomes progressively more complex. Consequently, effective inclusive mathematics instruction requires teachers to identify prerequisite knowledge, diagnose misconceptions, employ multiple forms of representation, provide differentiated instructional support, and continuously monitor learners' understanding through ongoing formative assessment. These pedagogical considerations provide the theoretical foundation for developing a comprehensive framework capable of supporting effective mathematics instruction in inclusive classrooms.

Principles of Inclusive Mathematics Education for Learners with Visual Impairment

Effective inclusive mathematics education is founded on several interrelated principles that guide instructional planning, classroom implementation, assessment, and learner support. These principles provide the theoretical and practical basis for designing mathematics instruction that accommodates learner diversity while ensuring equitable access to meaningful learning opportunities. For learners with visual impairment, these principles are particularly important because mathematics often relies heavily on visual representations, symbolic notation, and spatial reasoning. Consequently, effective instruction requires deliberate pedagogical adaptations that promote active participation, accessibility, and academic success.

- **Equity**: It is a fundamental principle of inclusive mathematics education. Unlike equality, which provides identical educational experiences for all learners, equity recognises that learners require different forms and levels of support to achieve comparable educational outcomes (OECD, 2018). Equitable mathematics instruction therefore involves adapting teaching strategies, instructional materials, assistive technologies, classroom activities, and assessment methods according to individual learning needs rather than treating all learners uniformly. For example, for learners with visual impairment, equity may involve providing

Braille mathematics textbooks, tactile graphics, embossed diagrams, accessible digital resources, screen-reading software, talking calculators, and orientation support. Similarly, learners with hearing impairment may require sign language interpretation or captioned instructional materials, while learners with specific learning disabilities may benefit from scaffolded instruction, explicit modelling, and additional guided practice. Equity ensures that all learners are afforded appropriate opportunities to achieve common mathematical learning outcomes irrespective of disability or learning differences.

- **Accessibility:** Accessibility is another essential principle underpinning inclusive mathematics education. According to CAST (2024), accessibility should be integrated into instructional planning from the outset rather than introduced as a reactive accommodation. Mathematics teachers should therefore design lessons that provide multiple means of accessing mathematical concepts through diverse representations and instructional resources. Such resources may include concrete manipulatives, tactile graphics, Braille mathematical notation, three-dimensional models, digital applications, audio descriptions, symbolic representations, and authentic real-life contexts. These varied instructional approaches enable learners with visual impairment to access mathematical knowledge through tactile and auditory channels while simultaneously benefiting other learners with diverse cognitive and sensory profiles. Embedding accessibility into lesson design minimises learning barriers and promotes meaningful participation for every learner.
- **Active Participation:** Meaningful participation is central to inclusive mathematics education. Effective classrooms provide opportunities for all learners to engage actively in mathematical reasoning, inquiry, discussion, exploration, and collaborative problem-solving. Hattie (2023) emphasizes that active learner engagement significantly improves academic achievement because it promotes deeper conceptual understanding, strengthens motivation, and enhances learners' confidence in applying mathematical knowledge. For learners with visual impairment, active participation requires accessible instructional materials, verbal explanations of visual information, opportunities to manipulate tactile learning resources, collaborative learning experiences, and sufficient time to complete mathematical tasks independently. Inclusive participation moves beyond physical presence in the classroom by ensuring that every learner contributes meaningfully to the learning process.
- **High Expectations**: Inclusive mathematics education is founded on the belief that disability does not define a learner's academic potential. Consequently, teachers should maintain high yet realistic expectations for all learners while providing appropriate accommodations and individualised instructional support (Florian, 2014). Research consistently demonstrates that teachers' expectations influence learners' motivation, persistence, self-efficacy, and academic achievement (Hattie, 2023). Learners with visual impairment should therefore be challenged to engage with rigorous mathematical concepts and higher-order problem-solving activities while receiving the instructional adaptations necessary to support their success. Maintaining high expectations fosters learner confidence, resilience, and independence while promoting equitable educational outcomes.
- **Collaboration:** Collaboration represents another cornerstone of effective inclusive mathematics education. Successful inclusion depends on coordinated partnerships among mathematics teachers, special educators, rehabilitation professionals, therapists, school administrators, families, and learners themselves (Friend *et al*., 2010). Collaborative planning enables educators to design differentiated instructional activities, develop appropriate accommodations, integrate assistive technologies, monitor learner progress, and provide

timely interventions when learning difficulties arise. For learners with visual impairment, collaboration also facilitates the preparation of accessible instructional materials, Braille transcription, tactile learning resources, and individualised support services. Such multidisciplinary collaboration strengthens instructional quality and enhances learners' participation and achievement in mathematics.

Learner Diversity in Inclusive Mathematics Classrooms

Learner diversity is an inherent characteristic of every inclusive mathematics classroom. Learners differ in their prior mathematical knowledge, cognitive abilities, learning pace, communication styles, language backgrounds, motivation, sensory functioning, cultural experiences, and social interactions. These differences require mathematics teachers to move beyond the assumption that all learners should receive identical instruction delivered in the same manner, at the same pace, and through the same instructional resources. Instead, effective inclusive mathematics instruction recognizes learner variability as a natural characteristic of classrooms and responds through flexible, learner-centered pedagogical practices.

Florian (2014) conceptualizes inclusive pedagogy as an approach that extends learning opportunities ordinarily available to all learners rather than developing separate instructional approaches for particular groups. This perspective is especially relevant in mathematics because many instructional adaptations designed for learners with disabilities simultaneously enhance learning for the entire class. For example, concrete manipulatives help learners who experience difficulties with abstract reasoning while enriching conceptual understanding for all learners. Likewise, tactile graphics, structured demonstrations, worked examples, collaborative problem-solving, digital simulations, and explicit mathematical language improve accessibility and conceptual understanding across diverse learner groups.

Supporting this perspective, Moura and Moreira (2024), in their systematic review of inclusive mathematics education, emphasize that effective mathematics instruction increasingly depends on teachers' ability to adapt pedagogical practices to accommodate learner diversity rather than relying on uniform instructional approaches. Their findings demonstrate that inclusive mathematics classrooms are characterised by flexible teaching methods, differentiated learning activities, accessible instructional resources, and continuous assessment practices that promote participation and achievement for all learners.

For learners with visual impairment, inclusive mathematics instruction requires specialized instructional adaptations that facilitate access to mathematical concepts traditionally presented visually. Such adaptations include tactile graphics, Braille mathematical notation, accessible digital mathematics software, audio feedback, tactile manipulatives, raised-line diagrams, and detailed verbal descriptions of mathematical procedures and visual representations. Learners with hearing impairment may require visual demonstrations, captioned instructional materials, written explanations, and sign language support, while learners with specific learning disabilities often benefit from explicit instruction, systematic scaffolding, repeated guided practice, and opportunities to connect concrete experiences with symbolic mathematical procedures. These examples demonstrate that inclusion is not synonymous with providing identical resources for every learner; rather, it involves ensuring that each learner has equitable access to the same essential mathematical concepts through appropriately adapted instructional pathways.

Learner variability also extends to academically advanced learners. Inclusive mathematics education should not focus exclusively on remediation or additional support for

struggling learners. Learners who demonstrate advanced mathematical understanding require opportunities for enrichment, mathematical investigation, modelling, creative reasoning, and higher-order problem-solving. Consequently, an effective inclusive mathematics framework should provide sufficient flexibility to accommodate learners requiring intensive instructional support while simultaneously challenging those capable of advanced mathematical thinking. Such responsiveness ensures that every learner is appropriately supported, challenged, and empowered to achieve their full mathematical potential.

Barriers to Effective Mathematics Learning in Inclusive Classrooms

Despite the expansion of inclusive education, several barriers continue to restrict effective mathematics learning. Gervasoni and Peter-Koop (2020) identify the realisation of inclusive mathematics education as an important challenge because general commitments to inclusion do not automatically translate into appropriate mathematics teaching practices.

One major barrier is the use of uniform instructional approaches in heterogeneous classrooms. When teachers present mathematical concepts through a single method, learners who require different forms of representation or additional scaffolding may experience unnecessary difficulties. UDL responds to this problem by encouraging teachers to design multiple pathways for engagement, representation, and action and expression (CAST, 2024).

A second barrier is the abstract nature of mathematical concepts. Learners may struggle when teachers move rapidly from concrete experiences to formal mathematical symbols without establishing conceptual meaning. Effective inclusive mathematics instruction should therefore make deliberate use of concrete materials, representations, models, examples, mathematical language, and real-world applications.

The third barrier concerns inaccessible learning materials. Conventional print textbooks, diagrams, graphs, worksheets, and digital mathematics platforms may not be usable by learners with visual, physical, or other disabilities. Accessibility must consequently be considered during instructional planning rather than treated as an afterthought.

The fourth barrier is insufficient teacher preparation. Inclusive mathematics requires teachers to possess both mathematical content knowledge and pedagogical knowledge concerning learner diversity. Recent systematic evidence suggests that professional development focused on inclusive mathematics practices can strengthen teaching methods and learner outcomes, while technology-enhanced approaches may improve accessibility and engagement for learners with additional needs.

The fifth barrier is weak formative assessment. If assessment is used primarily at the end of a unit, teachers may fail to identify misconceptions early enough to intervene. Black and Wiliam (2009) emphasise that formative assessment becomes pedagogically valuable when evidence of learner understanding is used to modify teaching and learning activities.

Pedagogical Foundations of Inclusive Mathematics Instruction

- **Universal Design for Learning:** UDL provides a proactive approach to instructional accessibility. Rather than waiting for learners to experience difficulty before making accommodations, teachers anticipate variability and design flexible learning experiences from the beginning (Meyer *et al,* 2014). CAST (2024) identifies multiple means of engagement, representation, and action and expression as central principles of UDL. In mathematics, this may involve combining concrete materials, tactile resources, diagrams, verbal explanations, symbolic representations, digital tools, and collaborative activities.

- **Differentiated Instruction:** Differentiated instruction provides a framework for responding to differences in learner readiness, interests, and learning needs. Tomlinson (2017) emphasises differentiation of content, process, product, and learning environment. Applied to mathematics, this allows teachers to maintain common curriculum objectives while varying the level of scaffolding, complexity, instructional representation, learning activity, and assessment method.
- **Social Constructivism:** Vygotsky's (1978) social constructivist perspective emphasises that learning develops through social interaction, language, guided participation, and collaboration. Mathematics learning can therefore be strengthened when learners explain mathematical reasoning, work collaboratively, engage in mathematical dialogue, and receive scaffolded support from teachers and peers.
- **Formative Assessment:** Formative assessment provides the mechanism through which teachers determine whether learners are progressing toward instructional objectives. Black and Wiliam (2009) explained that assessment becomes formative when evidence about learner understanding is used to make instructional decisions. This principle is central to the proposed framework because assessment should occur before, during, and after mathematics instruction rather than only at the conclusion of a unit.
- **Collaborative Teaching:** Collaborative and co-teaching approaches provide opportunities for general and special education teachers to combine their expertise. Friend et al. (2010) describe co-teaching as a collaborative instructional arrangement in which educators share responsibility for planning, instruction, and assessment. In inclusive mathematics classrooms, such collaboration can facilitate differentiation, small-group instruction, individualised support, and continuous monitoring.

CONCLUSION

Inclusive mathematics education is fundamental to ensuring that all learners, including those with visual impairment, have equitable opportunities to develop mathematical knowledge, skills, and confidence. Achieving this goal requires more than the physical placement of learners in mainstream classrooms; it demands intentional instructional planning, accessible learning resources, differentiated teaching strategies, and collaborative support systems that address learner diversity. The principles of equity, accessibility, active participation, high expectations, and collaboration provide a strong foundation for effective inclusive mathematics instruction, while pedagogical approaches such as Universal Design for Learning, differentiated instruction, formative assessment, and collaborative teaching enhance learner engagement and achievement. Therefore, creating inclusive mathematics classrooms requires sustained commitment from educators, school leaders, policymakers, and other stakeholders to ensure that every learner can meaningfully participate in and benefit from quality mathematics education.

RECOMMENDATIONS

1. Mathematics teachers should ensure that the plan their lesson with inclusiveness in view.
2. Government and all employers should make available the resources required for taching and learning.
3. It was recommended among others that government and employers should ensure that teachers are exposed to in-service training to equip them with emerging pedagogical mathematics instruction.

Conflict of Interest
The author declares that there is no conflict of interest regarding the publication of this paper.

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