



Original Article

The Impact of Dyslexia in Understanding Mathematics and Career Prospects in Kenya. Review of Literature

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This article probed into the impact of dyslexia on the comprehension of mathematics and future career opportunities. It explored the characteristics, evaluation, origins, physiological aspects, hurdles, tactics for intervention, and suggestions regarding dyslexia. The article also revealed that the worldwide prevalence of dyslexia displayed variation due to differing definitions of dyslexia, varying diagnostic tests, diverse age groups, geographical settings, and languages spoken. Globally, dyslexia's prevalence ranged from 15% to 20%. Specifically, in a primary school in Nairobi, Kenya, the prevalence among 7 to 9-year-olds was 7.49%. The article emphasised the necessity for early identification to enable timely intervention and support, underscoring the significance of mathematics as a determinant of career prospects in Kenya. Dyslexia arises from environmental, hereditary, or cognitive factors, either individually or in combination. The study also highlighted that nearly 90% of the research was published in medical, neuropsychological, or psychological journals, whereas only 6% appeared in educational journals. Dyslexia affects individuals in various ways, mainly impacting their reading and writing skills. Learners with dyslexia struggle with grasping abstract concepts, leading to difficulties in recalling words. They might reverse letters and read words in a mirrored manner, exacerbating their challenges in comprehending texts and subsequently hindering academic progress. The article proposed several teaching approaches for individuals with dyslexia in the realm of mathematics, including task analysis, multisensory methods, and a field-dependent approach.

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INTRODUCTION

According to Wajuihan and Naidoo (2011) and Knight (2021), dyslexia is a word coined in the Greek language whereby 'dys' is defined as difficulty and 'lexia' is associated with words, usually the inability to interpret words. According to the American Psychiatric Association (APA) (2013), dyslexia is categorised as a specific learning disorder that is explained as having constant trouble in understanding and utilising learning skills, which is characterised by incorrect, slow and difficulty in reading words, spelling or both.

The World Health Organization (WHO) (2011) states that dyslexia is an unpredicted and enduring difficulty in gaining beneficial reading abilities even with sufficient cognition, social-cultural possibilities and education offered to the learner.

According to the National Joint Committee on Learning Disabilities (NJCLD) (2014) Lyon et al. (2003), dyslexia is a neural condition described in the 1930s that affects an individual's reading, writing, conversation, spelling, computation, and interpretation abilities. According to Wajuihan and Naidoo (2011): European Dyslexia Association (2022), dyslexia is the most common learning disorder with different prevalences in various countries. In Europe, the prevalence of dyslexia is 15% of the society, while it was reduced in countries that did not have English as their first language, like China and Japan, to as low as 1%. According to Snowling and Henderson (2012), based on the various studies that had been done on the gender discrepancies in the prevalence of dyslexia indicated that the male-to-female ratio was as high as 6:1. This was due to the fact that males with dyslexia have comorbid behaviour disabilities like

attention deficit disorder (ADHD) unlike females with dyslexia.

According to Ndori (2022) and Karau (2023), in Kenya, arithmetic has great value in the school syllabus as it affects daily living and employment opportunities. However, due to below-average performance and poor perceptions of mathematics, there is a hindrance among learners who are pursuing their coveted opportunities. The Kenya Universities and Colleges Central Placement Service (KUCCPS) utilises compulsory subjects like English, Kiswahili, and Mathematics as a criterion for admission to higher learning institutions. As a result, many students are prevented from undertaking their coveted programs even if they have attained the minimum requirements.

Richardson (2021) states that there are approximately thirty-five million Americans with a learning disorder with dyslexia having the highest number. This number cannot be fully confirmed as many individuals do not accept they have difficulties in learning.

According to Neurohealth (2022), there are various types of dyslexia that have been classified in terms of their treatment methods. Phonological dyslexia is based on challenges in associating sounds with images; rapid naming dyslexia is based on the inability to name colours, numerals and syllables; double deficit dyslexia is based on having difficulties in two areas of reading; surface dyslexia is based on the ability to pronounce novice words but not common words, and visual dyslexia is based on the inability of the individual to remember images that they had seen. Dyslexia can be classified as developmental dyslexia, which is

congenital or inherited and acquires dyslexia which may be a result of injury or an illness that affects brain function.

According to Cheruiyot (2015), the prevalence rate of dyslexia among learners aged 7 to 9 years old was about 7.49%. Literacy abilities like reading are important in order to succeed in school as reading abilities are used in various sectors of academic units. Individuals with dyslexia struggle with reading, which tends to overshadow their cognition level. Most of these individuals undergo emotional anguish and low self-confidence and may opt to perform disorderly behaviours so as to mask their learning disorders. Persons with dyslexia do not advance their reading abilities over time.

According to Kumar and Raja (2012), dyslexia affects each individual differently based on the severity of the condition and the efficiency of teaching. The major challenges are with word discerning, fluent reading, spelling, and writing. Other challenges include reception and expressive language abilities, phonetic abilities like phonetic recognition and difficulty naming letters and names.

According to Almahrag (2021), learners with dyslexia have particular writing and spelling difficulties and also particular difficulties in some fields of arithmetic, like numeracy. In the past, dyslexia focused on literacy, but some dyslexic challenges are also transmitted into the teaching of arithmetic. Previous research done on dyslexia concluded that about sixty per cent of individuals with dyslexia had some challenges with school arithmetic. Dyslexia is a lifelong condition, but its effect on an individual's potential is dependent on the educational intervention. Determining the origin of arithmetic problems in an individual is difficult. Individualised teaching methods are required in order to teach mathematics since people do not learn in the same manner, and mathematics being a sequential unit, every new concept is based on initial knowledge; thus, failure is cumulative. Arithmetic regulations are inconsistent, unlike in spelling; hence, the reason why individuals with

dyslexia get hindered in learning mathematics is that it challenges the security of understanding math.

According to Tiril and Okumuş (2022), learners with dyslexia often have challenges with math abilities; hence, they need assistance to adapt to the process with a variety of methods and practices to advance their math abilities. Individuals with dyslexia usually have attention difficulties and cannot focus on a unit or circumstance for a long duration, thus having challenges in understanding subjects. The tutors have to make adjustments to aid in the educating process, as some learners with dyslexia write letters and numerals backward. The tutor can write on the board more clearly and adjust their tone so as to capture the attention of these learners.

According to Witzel and Mize (2018), in order to recognise learners with learning disabilities, a multi-tiered system of support methods can be utilised. This method helps assess learners with particular needs, and the interventions are aimed directly at these needs. There are various strategies that can help learners with dyslexia learn arithmetic and reading, like task analysis, explicit instruction, multisensory instruction, and field-dependent approaches.

In comparison to studies done on learners without dyslexia, there are far minimal studies that have been done on learners with dyslexia with regards to how dyslexia impacts mathematics understanding and career prospects; thus, there is a need for research studies to be conducted. The article will, therefore, explore the characteristics, aetiology, pathophysiology, epidemiology, assessment, and intervention strategies and make recommendations on teaching strategies for students with dyslexia.

RESEARCH STUDIES DONE ON DYSLEXIA

According to Lopes, Gomes, Oliviera and Elliott (2020), there were challenges in the current research studies on dyslexia as most of the studies (90%)

were conducted by medical, neuropsychologists and psychologists unlike educationalists who conducted 6% of the research studies.

Studies conducted by Acheampong et al. (2019), Elias (2014), Washburn, Joshi, and Binks (2010), and Charan and Kaur (2017) found that the awareness of dyslexia was average with regard to the knowledge score. However, even if most of the participants had heard of the condition, they were not aware of its aetiology and its identification in the class setup. Minimal to average understanding was found among tutors in elementary or basic school, respectively. The deficiency in knowledge of dyslexia may be a result of the different methodologies utilised to elaborate on the disorder when training teachers. This tends to affect how learners are handled in the class and thus invariably determines their performance. The detection of dyslexia is vital as far as awareness of dyslexia is concerned. Awareness of the features of dyslexia will assist in providing appropriate interventions.

A study carried out by Muhamad, Walker, and Rosenblatt (2016) explored the difficulties tutors faced when teaching learners with dyslexia mathematics, and it was found that the teachers enjoyed teaching them arithmetic; however, inadequate training, minimal teaching experience, and minimal exposure to multiple teaching approaches was a hindrance.

Studies carried out by Richardson (2021) and Grifol-Freixenet et al. (2020) on dyslexia in higher education indicated that the higher educational surroundings should have the appropriate adaptations to cater for the diverse needs of these learners. Educational success in higher education for learners with dyslexia necessitates a universal design for learning. Learners with dyslexia should have an opportunity to utilise their internal strengths and not be coerced to fit into a mould of traditional, standardised educational development.

A study carried out by Almahrag (2021) and Humphrey (2002) on how dyslexia affects

arithmetic teaching and how cognition difficulties can affect the tutoring of arithmetic in students with dyslexia indicated that these learners needed extra assistance in arithmetic and self-esteem. Approaches that should be used when assisting individuals with dyslexia should be individualised to cater for the specific difficulties. Tutors and other individuals assisting individuals with dyslexia should have a thorough understanding of dyslexia, how it impacts learning, and how to support learners with dyslexia.

Studies were done by Rao et al. (2017), Shaywitz, Morris and Shaywitz (2008), Cai et al. (2020), Tidy and Huins (2015), Tiernan and Casserly (2018); Lyytinen et al. (2021) on the interventions of dyslexia showed that in India language processing abilities, academic frameworks, individualised educational program, and early intervention were a vital part of management of dyslexia. In China, intervention measures for dyslexia are delayed, unlike in other languages like English due to the complicated Chinese writing methods. In the United Kingdom, the most efficient intervention method for learners with dyslexia is phonics-related and multisensory methods, which include hearing, visual and kinaesthetic components. In Finland, a game-associated instruction, the Graphol Learn technology, was made for application in several alphabetical writing methodologies and, hence, both translucent and transparent orthographies. This instructional method can give some answers in regions like South Africa, where the language of education and tutoring is usually opaque English, while the national languages of the nation are transparent including Afrikaans and Sepedi.

A study carried out by Makgato et al. (2022) to determine the awareness and understanding of dyslexia among primary school tutors in Tswane County, South Africa, indicated that these tutors have minimal awareness and understanding of dyslexia. In developed nations, tremendous progress has been made in addressing matters associated with dyslexia, unlike in low- and middle-

income nations like South Africa, where it has not received appropriate attention. It was noted that early detection via testing, caregiver involvement, adequate education environment and tutor professional advancement were vital to assist learners with dyslexia.

Ooko, Aloka and Koweru (2023) carried out research on the Impact of Mathematical Dyslexia on Academic Achievement among Upper Primary Students in Public Schools in Changanwe Sub County, Mombasa County, Kenya. The research revealed a notable and statistically significant connection between academic performance and the field of mathematics. Consequently, the study proposed the creation of an educator training program focused on enhancing their abilities to support students with mathematical dyslexia.

Characteristics of Dyslexia

According to Tiril and Okumuş (2022), studies on dyslexia carried out in the 1920s by Samuel Orton, some common characteristic features were discovered, which included challenges learning and recalling words, challenges writing, skipping words while reading, inverse detection of the syllables b and q and numerals 6 and 9, combining sounds of syllables, inappropriate speech, challenge determining the most adequate worn when speaking, difficulties determining direction either up or down and time like before or after and challenges determining hand to arm coordination.

According to Philip (2019), students with dyslexia have difficulties with their self-esteem as it is a language-related condition that affects reading, writing, spelling and speech, which can create hindrances in participating in social interactions, thus causing low self-confidence.

Methods of Assessing Dyslexia

According to the International dyslexia association (2020), Lowell, Felton, and Hook (2014), and Moats and Dakin (2008), learners who keep undergoing challenges with literacy abilities even

after being provided with high-quality, specialist instruction using response to intervention then formal assessment is required to find out if one has dyslexia. Evaluation of dyslexia is based on individual testing and is offered by competent specialists. Academic testing determines if one has dyslexia and hence offers the needed diagnostic documentation to ensure specially created instruction and accommodations are given throughout the academic career. Clinical evaluation documents learners' progress in terms of an increase in standard scores but not with regard to aging or grade scores. Grownups with dyslexia may require accommodations at work, like extra time or electronic readers. Early accommodations should be offered from kindergarten when the difference among struggling readers can be reduced by taking advantage of brain plasticity for understanding language-related knowledge.

According to the University of Michigan (2023), Wiig, Semel and Secord (2013), and Wiig, Secord and Semel (2006), there are a variety of tests used by specialists to evaluate the various challenges faced by learners with dyslexia. To evaluate spoken and written language, a norm-referenced assessing linguistics behaviour communicative scale is used to evaluate a child's progress from birth up to two years old. It focuses on cognition, social, and linguistic progress. The clinical evaluation of Language Fundamentals Preschool Second Edition is also a norm-based test that consists of a four-stage evaluation system used to determine if language impairment is present in children aged three to six years old. Another norm-associated evaluation, known as a clinical evaluation of language fundamentals fifth edition, was created to detect, diagnose, and offer follow-up due to language and communication impairments among individuals aged five to twenty-one years old.

According to Roswell et al. (2005), Caldwell and Leslie (2011), and Woodcock (1998), in order to evaluate reading in individuals with dyslexia, there are several tests that are utilised. The diagnostic

assessment of reading with trial teach strategies test is designed for individuals aged five years old up to grownups to determine the learners' strengths and challenges in reading, including print understanding, phonological understanding, letters and sounds, quiet reading and reading understanding. The Qualitative Reading Inventory Fifth Edition is a criterion-based test that evaluates reading skills from emergent to secondary school stages. The Woodcock reading mastery test is utilised to evaluate basic abilities in reading and understanding among individuals from kindergarten to adulthood.

According to Kaufman and Kaufman (2004) and Wechsler (2001), to evaluate achievement in individuals with dyslexia, several tests are utilised. The Kaufman Test of Educational Achievement second edition comprehensive form offers grades for educational accomplishments in reading, arithmetic, and written and spoken language. It is utilised for individuals aged between four and twenty-five years old. The Wechsler Individual Achievement Test second edition is used to evaluate the accomplishment of people aged four years all through adulthood. It offers grades in four areas of academic accomplishments: reading, arithmetic, written and spoken language. It makes comparisons between accomplishments and skilful performance.

According to Roid (2005); Woodcock, McGrew, and Mather (2001), several tests are used to evaluate intelligence and cognition skills. The Stanford-Binet intelligence scales for early childhood are utilised for children aged two to seven years and usually detect developmental impairments and peculiarities while offering information to help come up with intervention strategies to alleviate intelligence skills. The Woodcock-Johnson III tests of cognitive abilities are created to measure cognition skills and function. It is utilised in individuals aged five to ninety-five years old. These tests evaluate information, reasoning, memory and recall, hearing process and speed.

According to Fudala (2000), Goldman, and Fristoe (2000), several tests are utilised to evaluate articulation in individuals with dyslexia. The Arizona Articulation Proficiency Scale third revision is a norm-based test of basic American English consonant and vowel pronunciation that is utilised in individuals aged one and a half years up to nineteen years. The Goldman –Fristoe test of Articulation second edition is a norm norm-based test that resonates around the pronunciation of sounds by alienating a consonant in every word location. It is utilised for individuals aged two to twenty-one years old.

According to Bricker et al. (1999), Sparrow, Cicchetti and Balla (2005), there are various tests used to evaluate social skills in learners with dyslexia. The second ages and stages questionnaire is filled in by caregivers. It evaluates children in their natural surroundings. It evaluates several factors like communication, gross and fine motor, problem-solving and personal social. It is utilised by children aged four months to sixty months. The Vineland Adaptive Behaviour Scales second edition is administered to the caregivers in the form of an interview. It evaluates people from birth to adulthood by measuring the personal and social abilities they utilise on a day-to-day basis.

According to Beery and Beery (2004) and Folio and Fewell (2000), several tests are utilised to evaluate the motor abilities of individuals with dyslexia. The Beery-Buktenica developmental test of visual motor Integration fifth edition, evaluates how far a child can incorporate their vision and motor abilities. This test exists in two versions: the short form is used on children aged two to seven years old, and the full form is used on children aged two to eighteen years old. The Peabody Developmental Motor Scales second edition is created to evaluate early childhood motor progression in children from birth to six years old. It is divided into gross, fine, and total motor scales. The scales assess grasping, use of hands, hand-eye coordination, and finger dexterity.

Aetiology of Dyslexia

According to Cheruiyot (2015), there are various causes of dyslexia like hereditary factors whereby dyslexia is passed on through families whereby one has a twenty-three to sixty-five per cent chance of being dyslexic if one's parents were dyslexic and a forty to eighty per cent chance of being dyslexic if one has a dyslexic sibling. Neuroscientific factors also predispose one to become dyslexic as the left hemisphere posterior part of the brain in individuals with dyslexia is not fully simulated during reading. Ecological factors, which include socioeconomic factors, poor teaching methods, delayed milestones, and inadequate stimulation, may contribute to dyslexia as they usually affect verbal memory, working memory, phonological prowess and verbal and visual processing. A study was done in a Romanian orphanage that initially tested the intelligence quotient of children while they were in the orphanage and after they were adopted, indicating there was an increase in intelligence quotient when they were in the foster homes, unlike when they were in the orphanage.

According to Zhou (2023), cognition factors also contribute to causing dyslexia with regards to the phonological concept, which describes a disorder in reading skills that is a result of cognition defect in the portrayal and processing of speech sounds, particularly the ability to correspond letters with the right words. Many scholars have found out that the phonological concept cannot fully explain dyslexia and have emphasised the impact of a hearing disorder together with phonological difficulties and visual difficulties in predisposing one to dyslexia, hence picturing dyslexia as a sensorimotor disorder. Cultural variations determine how dyslexia is described in various countries due to differences in language, rules, and diagnostic methods. The presentation of dyslexia is determined by variations in linguistic features, including syllables, pronunciations, and scripts; hence, the symptoms differ in a variety of cultures and languages. For instance, some languages like German and Italian

do not have a particular writing system; thus, they are easy to read and write and achieve fluency because of compatibility between sounds and syllables.

Pathophysiology of Dyslexia

According to Sulkes (2022), dyslexia is mostly associated with cortex dysfunction emanating from congenital neurodevelopmental anomalies. Dyslexia is associated with the left hemisphere and connected to dysfunctions in brain regions associated with language association and sound and speech development.

According to Marwaha and Remien (2023), the cerebellum takes part during the early stages of the learning process. There are structural and functional differences between the cerebellum of individuals with dyslexia and those without dyslexia. Persons with dyslexia have reduced grey matter in the right lobule of six. This lobule also presented with inappropriate activities when the individual with dyslexia was directed to name objects quickly. Using functional magnetic resonance, it was found that individuals with dyslexia had disrupted activations in the left temporoparietal areas and bilaterally in the frontal and occipital areas.

IMPACT OF DYSLEXIA ON UNDERSTANDING MATHEMATICS

According to Zhou (2023), dyslexia affects persons in a number of ways, commonly their skills in reading and writing. Learners with dyslexia have challenges in understanding abstract ideas and hence slow in remembering words. They may invert letters and read words in a reverse manner, thus increasing the challenges of understanding texts and, hence, poor educational advancement.

According to Conti-Ramsden et al. (2004) and Willcutt et al. (2007), language is vital in several educational abilities; hence, learners with dyslexia may undergo challenges across the curriculum. Previous research on learners with dyslexia has indicated struggles in several areas like English,

arithmetic, and science and the final average grade. However, it is worth noting that these investigations often failed to account for coexisting conditions.

According to Boets and De Smedt (2010), Moll et al. (2015), and Vukovic et al. (2010), past examinations of children with dyslexia have identified deficits in counting and mastery of number facts. Peng et al. (2012) state that those who suffer from combined reading and math disorders encounter specific challenges related to phonological storage that are absent in the group dealing solely with math-related issues.

According to Chin and Ashcroft (2017), learners with dyslexia have challenges with their short memory, unlike learners without dyslexia. Hence, learners with dyslexia tend to lose track if they are dealing with multistep cognitive mathematic challenges or may not understand the sequence of rules. Research done based on learners with dyslexia found that it took a fifty per cent longer duration to complete a group of mathematics queries than learners without dyslexia. Learners with dyslexia have challenges in focusing on complex numbers, which tends to slow their activities. It is, therefore, vital to choose adequate working methods with learners with dyslexia whereby being aware and making appropriate adjustments can assist them in their learning process.

According to Blalock (1987), Cordoni et al. (1981), Vogel and Walsh (1987), and Göbel and Snowling (2010), few research studies have explored questions of fundamental fact memorisation in grownups with dyslexia. Three researches conducted on individuals with dyslexia found that based on cognition evaluation using the Wechsler adult intelligence scale, the mathematics subset was the lowest or second lowest for individuals with dyslexia. The digit span subset was the lowest, which evaluates the functional memory. Grownups with dyslexia also have challenges in remembering addition and multiplication knowledge.

Intervention Strategies for Teaching Mathematics in Individuals with Dyslexia

According to Browder, Jimenez and Trela (2012), Witzel and Riccomini (2007) and Gersten et al. (2009), there are several approaches that can be utilised in the teaching of individuals with dyslexia mathematics. Task analysis entails dividing a given task into tiny steps and then consecutively prompting every step for learners. For arithmetic, task analysis can involve dividing long division into several steps. Learners should practice one step at a time instead of performing the whole process at once, which enables them to make fewer mistakes. Another approach used to teach learners with dyslexia mathematics is explicit instruction, that is, the eventual dissemination of knowledge from the tutor to the student, whereby the tutor starts by introducing the importance of the lesson followed by the tutor demonstrating clearly while interacting with the learners.

According to Birsh and Ghassemi (2010), and Witzel and Mize (2018), another approach that is used to teach learners with dyslexia mathematics is multisensory instruction, whereby one can teach new knowledge by using several methods. Multisensory structured language is utilised mostly for learners with dyslexia, and they usually comprise task analysis, explicit instruction, and auditory, visual, and tactile sensory output so as to ensure interaction and aid memory of several contents of literacy like letter recognition, phonetic memory, and processing. For mathematics, the concrete to representational to the abstract sequence of instruction method is utilised whereby learners are taught using several representations, starting with concrete manipulations and then figurative representations of the manipulations and then completing with abstract practice, which helps in increasing sensory input and interaction while aiding memory.

According to Browder, Jimenez, and Trela (2012), another approach that is utilised to teach mathematics to learners with dyslexia is the field-

dependent approach, whereby it is based on a progressive scaffold of completely solved illustrations to assist guide a learner through the course of learning. Field-dependent education is based on a tutor's task analysis and guided stepwise advancement to illustrate how to finish a challenge. In arithmetic, these steps can be illustrated using a graphic organiser.

CONCLUSION

In summary, the article examined the global, regional, and local impact of dyslexia on both mathematics comprehension and career prospects, with a specific focus on Kenya. The research revealed that the worldwide prevalence of dyslexia falls within the range of 15% to 20%. This prevalence tends to be higher in English-speaking nations compared to countries where English is not the primary language. The article strongly emphasised the critical significance of early identification and intervention for individuals with dyslexia. While information about dyslexia is spreading worldwide, it is predominantly concentrated in developed countries. Lower- and middle-income countries are lagging behind in this regard, as evidenced by students navigating their educational journey without their challenges in learning being identified.

An existing limitation in current dyslexia research pertains to its distribution, with nearly 90% of studies being published in medical, neuropsychological, or psychological journals and merely 6% appearing in educational journals. This presents a barrier to prompt diagnosis and early intervention. Within the context of Kenya, the majority of dyslexia studies have centred on primary schools, prompting the article to recommend expanding research to encompass secondary schools and institutions of higher education. Conducting more comprehensive studies on dyslexia is imperative, given its impact on mathematical comprehension—a pivotal factor influencing career choices in Kenya.

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