An overview of the causes of dyscalculia and its impact on learners' arithmetic ability[1]

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ABSTRACT

Some children experience severe struggles in understanding mathematical concepts. A condition called 'dyscalculia' impairs learners' capacity and limits their ability to perform and comprehend a mathematical concept. This study identifies factors that contribute to the weak academic performance by learners in mathematics. An empirical approach was used to gather data from a mainstream school and a special school. Interviews were conducted with teachers, occupational therapists, and learners. Virtual interviews included doctors and educational psychologists. The study revealed that learners' ability to learn and comprehend mathematics is influenced by medical, biological, psychological, and environmental factors. The consociate of the factors responsible for mathematical learning could raise awareness and provision to tackle the difficulties of mathematics teaching and learning. The study proposes further research around the development of mathematics curriculum underpinned by teaching and learning materials that accommodate the learning capabilities of learners with dyscalculia.

Keywords: dyscalculia, mathematics comprehension, medical, psychological, environmental factors.

INTRODUCTION

In the South African education system, mathematics is a central learning course for learners from grades R-12. The bare minimum of arithmetic grading in grades 1-12 is a moderate achievement of 40%-49% (level 3) indicating arithmetic competence. However, some learners are unsuccessful in attaining the minimum requirement because they severely struggle with learning the basic components of math, for example, reading, and writing numbers correctly, using the 4-math operations (+, -, x, ÷). Learners encountering stumbling blocks in acquiring mathematics often achieve below the minimum requirement. The elementary achievement of 0-39% (levels 1-2) indicates that learners have no understanding of the basic element of mathematics, hence they attain lower in mathematics criteria.

Dowker (2004) explains how learners battling with mathematics would have almost certainly not comprehended one or more of the numeracy components. For example, counting, estimating, matching, script integers, and executing the four main math operations. The complexity of arithmetical learning has created challenges for the South African education system. Analyses of the cross-national assessments of

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educational achievement have indicated that the South African education system is the worst when compared to other countries (Spaull, 2013). South African schools have been challenged with learners' performance in mathematics in the foundation phase. Studies have reported that 5-8% of learners encounter obstacles that disturb their grasp of mathematical concepts or procedures (Fuchs et al., 2010).

Literature suggests a variety of factors that influence arithmetic ability such as the velocity of cognitive processing, poor working memory, and concentration span (Temple & Sherwood, 2002). This paper proposes that it is important to know the factors that impact the acquisition of arithmetic skills in young children. There are several factors that attribute to learners' inability to acquire mathematical concepts and among them is dyscalculia. The ability to learn mathematical concepts is impaired by a condition called 'dyscalculia'. Dyscalculia is a learning disability that limits learners from understanding the fundamental number concepts necessary to understand mathematics (Sudha & Shalini, 2014). Learners who have dyscalculia have difficulty developing the fundamental number concepts that are necessary to understand mathematics due to this learning challenge. This study aims to provide a documented account of the basic causes of dyscalculia among children in the foundation phase.

Malmer (2000) mentioned poor intellectual progression, lack of mathematical vocabulary, neuro complications such as minor brain injury, and attention disorder as elements that impact learners' math understanding. This study will explore factors that cause the acquisition of mathematics in young children and their effect on learners' mathematical performance. This study will further discuss possible intervention strategies and suggest some avenues for further research. This study believes that understanding the causes of dyscalculia will aid in assessing the mediation plan and launching diagnoses.

The difficulties of teaching and learning mathematics in the Foundation Phase.

Studies have revealed that early years of mathematics competency can have a robust anticipating ability for future educational attainment (Duncan et al., 2007; Sinay & Nahornick, 2016). The vast differences in opportunities children have in their homes, and their early childhood environment contribute more to the differences in numeracy skills they have in schools. The difficulty of learning mathematics is a moral universal concern (Kunwar, 2021). Luneta (2023) asserts that almost all classrooms in South Africa are multilingual and the language of instruction is often not suitable for majority of the learners. The dilemma of learning and teaching mathematics in the foundation stage is that while mathematics is a language in its own right, teachers are required to teach in multilanguage classrooms where the language of instruction is in most cases different from most children home Language (Dicker, 2015). This poses difficulties in the teaching and learning of mathematics at the foundation level. The difficulty of delivering mathematics content effectively comes from language and communication barriers, attitude problems (for both the teachers and the learners) and school environment factors such as deficiency of access to basic facilities, poverty at home (Machaba & Lenyai, 2014). The lack of provisions for teaching aids can also well attributed to the difficulties in teaching and learning mathematics in the foundation phase learners' classroom. Learners revealed that teaching aids have progressive consequences on teaching mathematics even in fewer than best environments that is, below-resourced, rural, second-language classrooms (Maduna, 2002).

Absence of parental gratitude and participation, disabilities, and deficiency of resources improvement policies (Machaba & Lenyai, 2014). Initial identification of learners who encounter learning difficulties is of importance not merely to support them in making improvement, but also develop contributing memberships of the society (Groark et al., 2006). Furthermore, it is essential to recognize learners who encounter learning difficulties very early so that the educators can lessen or eradicate the learning difficulties on time. But on the other hand, it is also imperative to shun engaging destructive labels on younger children that could lead them to have lower expectation for success.

If learners who experience difficulties to learning mathematics can be detected at an early phase of development, they will have a better opportunity to be successful provided the difficult will be activated (Machaba & Lenyai, 2014). However, among the issues which place learners at danger of failure are unsuitable and insufficient provision of support facility, deficiency of supporting and protective regulation and policy.

RESEARCH PROBLEM

There is sufficient research that documents the performance of most learners from elementary school to tertiary in mathematics is below the expected levels (Norath & Luneta, 2015; Bethel, 2016). Teachers of mathematics have always been concerned about learners' low performance in mathematics especially at the elementary level, most especially learners that grapple with basic mathematical operations, numbers, number names and counting (Carlson, 2005). Teachers assume that all learners in a classroom understand their traditional instructional approaches despite the diverse learning strategies and intellectual abilities learners bring to class (Catania, 2020). For successful content delivery, mathematics educators should have knowledge of the diversity of learners with regards to teaching and learning mathematics (Machaba & Lenyai, 2014). Reasons behind some learners' weak performance can be explained from several factors but are mainly due to a basic learning disability. This study explores the causes of dyscalculia as a learning disability that affects how learners learn mathematics. When learners have difficulty grasping math concepts, their behaviour is regarded as abnormal (Catania, 2020). This study further explores factors that make it difficult for teachers to deliver mathematics content effectively.

LITERATURE REVIEW

Causes of dyscalculia

For our contemporary, educated society, it is crucial to comprehend how mathematical and arithmetic skills develop and the factors that are responsible for dyscalculia. According to research, mathematical difficulties can be caused by a variety of circumstances. Literature presents the following causes of dyscalculia: genetic, cognitive deficits, and brain differences.

Dyscalculia is a genetic condition

Studies indicate that dyscalculia is a genetic condition, which is genetically inherited from one of the alleles from a parent who has dyscalculia. Using the pedigree analysis to learn the inheritance of genes in children shows that a child inherits two alleles, one from the mother and one from the father. The genetic factor of dyscalculia derives from pedigree analysis of Mendelian segregation. However, research shows a lack of pure appearance of dyscalculia from the Mendelian pedigree because they are uncommon (Von Aster & Shalev, 2007). The conclusion on dyscalculia as a genetic condition is based on the relationship between the brain and behaviour and how it influences the nervous system (Von Aster & Shalev, 2007). However, the genetic factor for the prevalence of dyscalculia is limited to the phenotype.

Research shows that phenotype is driven by internal factors (emotional & cognitive) and external factors like environmental influences (socioeconomic, ethnicity, and language). Then the pedigree analysis is irrelevant because the phenotype is moderately heritable. The genetic molecular study is regarded as relevant for assessing inherited disorders. A study conducted on family aggregation (clusters of diseases in a family) depicted the prevalence of dyscalculia. The trial included 39 dyscalculic children and the results reported a prevalence of dyscalculia of 66% from the mother and 40% from the father while siblings scored 53% and extended family members scored 44% (Von Aster & Shalev, 2007).

The molecular genetic study for dyscalculia is limited by the cognitive heterogeneity that is common in some phenotypes (Von Aster & Shalev, 2007). Heterogeneity suggests that people may have the same phenotype (dyscalculia behaviour) but different genetic architecture (how genetic factors and environment combine); for example, a learner who has dyscalculia due to chromosomal deletion and a learner who

has dyscalculia due to other environmental factors (Von Aster & Shalev, 2007). Research indicated that families with the phenotype (dyscalculia symptoms) were rare to identify as compared to the dyslexia gene because dyscalculia involves various endophenotypes (Von Aster & Shalev, 2007).

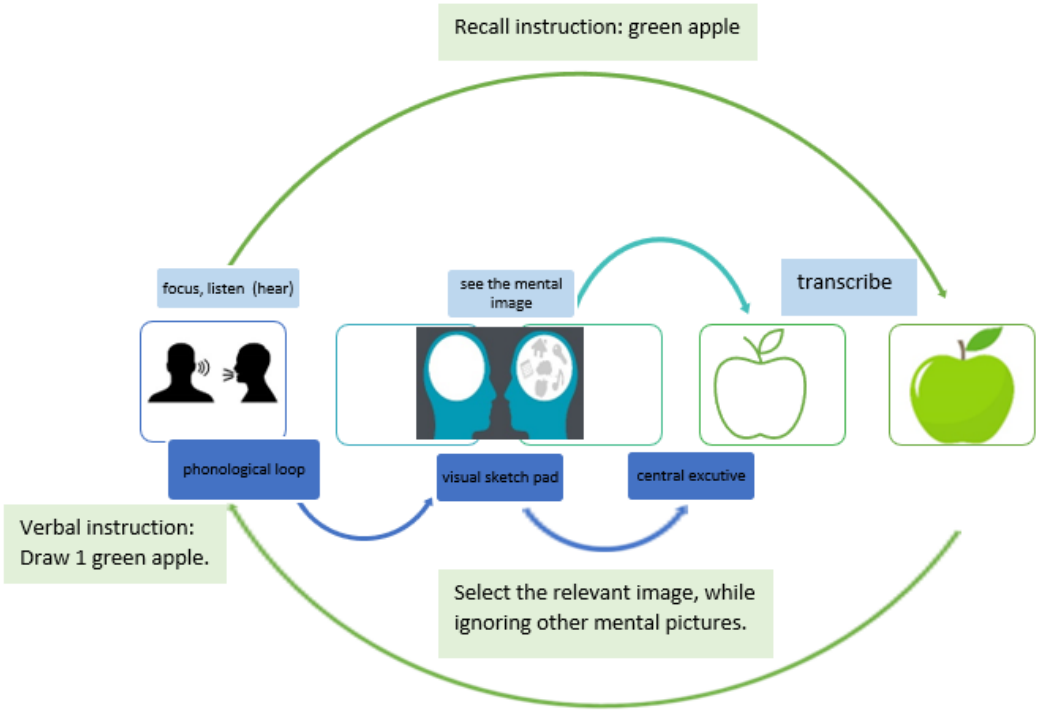
Lack of cognitive efficiency

A working memory cannot be classified as a separate structure, different components compose the working memory. The ultimate element of mathematics competence is the acquisition of basic arithmetic skills that entails the interaction of the three primary components of the working memory (phonological loop, visual sketch pad, and central executive). However, the functional component of the working memory is intricate when it comes to number processing (Szűcs & Goswami, 2013). Research indicates that learners with dyscalculia lack visual-spatial capability (Szucs et al., 2013). The ability of children's working memory is vital in the procurement of arithmetic skills.

The context signifies children's ability to execute control measures (central executive) to select the part to be executed and hold the action plan while processing the phonological loop (auditory) information and visual sketch pad (visuospatial) information (Chemerisova & Martynova, 2019). Lack of visuospatial, phonological ability and executive ability impact the cognitive ability to process numbers. Figure 1 below present illustrations of working memory components (Phonological loop, Visual sketch pad, Central executive) that respectively influence the capacity to solve math problems.

- **Phonological loop:** Verbal mathematics tasks were used to assess the capacity of the phonological loop (Chemerisova & Martynova, 2019). Learners with dyscalculia exhibit an inability to apply the phonological loop as a part of working memory through listening and understanding verbal instruction. The task of the phonological loop is to encode and store verbal information in temporary storage, however, there is a delay in the process of phonological analysis (Chemerisova & Martynova, 2019).
- **Visual sketch pad:** The spatial properties serve a central role in visuospatial working memory because it impacts the mathematic ability. The visuospatial sketchpad is an important foundation that grants temporary storage and rehearsal of visual and spatial information to the development of math skills that enable children to solve math problems (Liang et al., 2022). Children who have dyscalculia display a deficiency in spatial working memory tasks, in cooperation with visual spatial-simultaneous, and spatial-sequential working memory tasks (Mammarella et al., 2018). Spatial problems involve the reversal of numbers, struggle to comprehend before and after, cannot position objects, and rearranging things in order.
- **Central executive:** The central executive system directs the attention system that coordinates the other above-mentioned components. For successful execution of a task, there needs to be a good capacity of working memory to store transitional information. Thereafter, the application of long-term memory to execute the temporary stored information. Dyscalculia learners struggle to reject minimal disturbance while directing attention or focus to designated tasks; or example, they cannot do well when asked to choose a picture of a big animal in reality (Szucs et al., 2013).

Figure 1:
Interrelationship between working memory components (adopted from Szucs et al. 2013)



Brain alterations

Mathematical understanding requires various interactions of neurons which are key elements of the brain and nervous system to obtain stimuli. One of the key stimuli for mathematical competence is number sense which requires an efficient bilateral parietal lobe. Parietal lobe is responsible for the space or image information processing. Arithmetic processing uses the visuospatial working memory located at the (bilateral parietal and occipital lobes) and the left inferior frontal gyrus (speech system) (Xiang, Sun & Fu, 2016). Research indicates that dyscalculia is triggered by irregularities in the right parietal lobe (Kadosh et al., 2007). In a study conducted using neuro-navigated transcranial magnetic stimulation (TMS) to model the brain.

The study reported that TMS-induced neuronal action indicated disturbances in the right intraparietal sulcus which is responsible for number processing. (Kadosh et al., 2007). One study revealed that dyscalculia is linked with decreased grey matter and white matter volumes in areas of the brain connected to numbers (McCaskey et al., 2020).

METHODOLOGY

This paper responds to the research question: What are the factors that influence learners' mathematical learning? This study implemented a qualitative approach to collect data from the field. The information was collected through personal interviews. The interviews were conducted with people who have knowledge and experience on the topic. The responses were recorded and analyzed to draw conclusions (Kothari, 2004).

Sampling

Two schools were purposively selected to be part of the study, a mainstream school, and a special school that had learners with special needs to provide relevant information related to dyscalculia. We interacted with a modest number of foundation Phase teachers per grade from grades 1-3 at each school to obtain full perspectives of their pupils' mathematics learning difficulties and how environmental factors affect learners learning and what cognitive skills were needed to acquire and understand mathematics. From

the special school, we purposefully chose the participants because of their knowledge and experience in special education and teaching learners with learning disabilities.

Furthermore, we interviewed a doctor, specifically a pediatrician who deals with young children to get their intensive view on what could be the biological or medical reasons for the brain development of a child. We interviewed educational psychologists and occupational therapists who diagnose and assist learners with educational barriers. Data were collected from six teachers, 15 learners, one doctor, one educational psychologist, and one occupational therapist.

Table 1:
Summary of participants and their codes

School	Participants	Grade	Codes
Mainstream school	Educator 1	1	ME1
	Educator 2	2	ME2
	Educator 3	3	ME3
Special school	Educator 1	1	SE1
	Educator 2	2	SE2
	Educator 3	3	SE3
	Learners	Grade 1-3	L1-L9
	1 educational psychologist		PSY
	1 Occupational Therapist		OT
	1 Doctor		DR

Data analysis

The theme, development process, is the main data analytical process applied at the commencement of data interpretation and findings (Vaismoradi et al., 2016). It is an inductive approach to working with data that allows researchers to identify themes and categorize them. We began by attending to the teacher's audio-recorded interview, transliterating, and editing the information to prompt unwritten or unspoken movements such as nodding of heads and giggles. Inductive analysis demonstrates the method of thoroughly and thematically ordering teachers, psychologists, doctors, and learners' data from transcript by allocating codes to appealing data and then group the data into topics and themes. Coding refers to marking and classifying transcript to construct narrative and expand themes in the records.

During the analysis process were able to identify both similar and contrasting text. By analyzing the questions asked during the interviews and the responses received, we were able to identify patterns in the data. This helped us to determine which aspects were more relevant to the analysis of the learner's difficulties in acquiring arithmetic information. After conducting interviews, we analyzed the collected data by comparing it with the documents, literature, and the theoretical framework. This helped us to identify the themes that were relevant to the research question. Based on the analysis, we categorized the data and identified several key factors that contribute to the acquisition and retention of mathematical

knowledge by learners. To protect the participants' anonymity and confidentiality, assigned unique identifiers.

FINDINGS AND DISCUSSION

The following themes arose from participant's data analysis: (1) The brain developmental process of young children; (2) The key mechanisms of effective early childhood learning; (3) Learners' and teachers' psychological approach towards mathematics. The themes are encompassed by subthemes. The themes are inextricable as one depiction of a theme can correspond to another theme. These themes refer to the initial outcome or result of data analysis that generated actual outcomes of the research question. These themes are a result of the data collected from the interviews, classroom observations, and the questionnaire. Below is the table of the themes and subthemes.

Theme 1: The brain developmental process of young children

This study presents findings on learners' math acquisition based on their distinct capacity and incapacity from normal functional brains and brain irregularities. Mathematics learning requires a functional brain system to comprehend arithmetic information (Ren & Libertus, 2023). This study believes that teachers have minimal knowledge about disorders that impair the brain system. As a result, a doctor was included in the study to divulge her insight into the impact of the brain system and its influence to learning.

Pre & post-development of a child's brain

Data revealed that doctors, educators, educational psychologists, and occupational therapists understand the eccentric brain of learners and how it impacts learning. The doctor indicated that special learners are discretely unique like other learners, and, that some of their brain exhibits all symptoms in variable condition, while others may exhibit numerous of these symptoms, others may demonstrate only one symptom. The injury of the brain before, during and after birth has been associated with genetic or other developmental factors (Boardman et al., 2014).

Table 2:
Themes and Subthemes

Theme 1: The brain developmental process of young children	
Subthemes	1.1 The pre & post-development of a child's brain. 2. Cognitive differences of learners. 3. Diagnostic process of intellectual cognitive barriers.
Theme 2: The key mechanisms of effective early childhood learning	
Subthemes	1. The education setting. 2. The syllabus and instructional approach.
Theme 3: Learners' and teachers' psychological approach towards mathematics.	
Subthemes	3.1 Learners' emotional & behavioural attitude towards mathematics.

The doctor mentioned that some of the reasons children perform poorly are due to brain abnormalities.

Dr: There are conditions where for unknown reasons the children's brains are just not normal, a part of the brain is not functioning properly, or a different part of the brain that is missing like corpus callosum. Brain variances may be due to various things. For example, genetic disorders like downs syndrome. An infection that the mom had during pregnancy if a mom abuses alcohol or she's addicted to certain drugs or any medication, whether it's just the side effect of a medication that's supposed to be a good medication that can make the brain be affected and can develop

abnormally, so like children with fetal alcohol syndrome, they are also a small brain. Or complication during delivery takes long to get the baby out and the baby suffers from not having enough oxygen during birth. If it's bad the baby can start having fits and seizures. Or abnormal development of the brain during development while it's still an embryo those are the different things that can make a baby's brain to be abnormal.

The doctor's view about the complication during delivery that could result in the baby having fits and seizures concurs with the studies of Aldenkamp et al., (1990) and Gross-Tsur, Manor & Shalev (1993) that state epilepsy (brain-syndrome of regular seizures) as one neurological disease that increases the likelihood of development dyscalculia among children. Several studies assert that a number of children's poor academic performance is attributed to epilepsy (Aldenkamp et al., 1990; Scatolini, Zanni & Pfeifer, 2017).

The occupational therapist stated that some of the difficulties in learning may be linked to the formation of the brain.

OT: There could be a genetic problem like there could be a medical diagnosis. For instance, the child has hydrocephalus or some medical diagnosis. Some children have fetal alcohol syndromes. They have a smaller brain. Some children have an autistic brain, so the reason is their medical diagnosis.

The occupational therapist view corresponds with those of Landerl, Göbel and Moll, (2013), Shalev, Auerbach and Gross-Tsur, (1995) and Spencer, Stahl and Stefansson (2014) that is usual for dyscalculia to co-occur with autism spectrum disorder and language impairment. The occupational therapist and the doctor mentioned that prenatal alcohol exposure could be a reason some children are born with brain problems. Their statement concurs with Howel et al., (2006) that prenatal exposure to alcohol limits the intellectual ability of a child and impacts their ability to learn math.

This occupational therapist mentioned that some learning difficulties stem from genes. This indicates that some of the problems learners have been a result of genetic reasons while others are due to medical reasons. The doctor indicated that an abnormal brain could limit a child to learning, however, it depends on certain conditions.

Dr: … but not all learners. It depends on what the condition is that's affected the brain and how bad it is. But invariably it does limit them because the brain is the primary organ of learning. With any condition there is what we call a spectrum, meaning that we can grade it from 1- 10, 1 being very, very mild and 10 being severe and 10 being a child who can't speak, talk, or walk. then 1 is a child who might have minor learning disabilities or maybe a delay in achieving certain milestones, but then they still learn, OK. At school.

The doctor's reference shows that any effect on the brain may affect the child's capacity to learn but that depends on the seriousness of the condition. The doctor's comment agrees with Fouracre's (1958) study that when the brain is disturbed, some parts of the brain will not perform as normal, but the level of interruption may only be slight in some areas, and it varies with individuals.

Cognitive differences of learners

The children with dyscalculia show deficits in visual-spatial memory. Schuchardt, Maehler and Hasselhorn (2008) agree that spatial perception, memory, verbal ability, and intelligence are some of the factors that have been associated with understanding mathematics. Previous assumption on arithmetic disability regard perceptual skills as core skills to arithmetic learning (Eksteen, 2014; McLeod & Crump, 1978). Additionally, lack of visuospatial organization has been associated with difficulty learning mathematics (Barnes & Raghubar, 2014; Fouracre, 1958). One of the reasons that a child has poor numerical processing is because of their visuospatial skill and working memory. Children with abnormal brain have

perceptual disorders and struggle to see a whole, in its place, their mindset is only focused on one front-part that they see instead of a back and side part of a whole (Barnes & Raghubar, 2014; Fouracre, 1958). As a result, the perceptual ability of an abnormal brainchild is substandard and is prone to be affected. If the cognitive is malfunctioning the child will not connect perceptual experience and understand them in a natural way (Barnes & Raghubar, 2014; Fouracre, 1958).

Participants were asked what the reasons children have poor numerical processing. This inquiry presented participants with a chance to communicate their viewpoints on the subject matter. The occupational therapist and special educator mentioned that visual perceptual skill is an important component of learning.

OT: Poor visual perceptual skill and poor auditory perceptual skills are the basis why children can't do math because if they understand the spatial relations then they will be able to say, OK, the 5 goes like this and like that. And the 2 don't go like that. The two go that way. And if they know the 2 shapes, then they will know, OK 2 then it's permanent in their brain. They can then they can say, OK, 2 standing alone is a 2, but if you put a 1 in front then you have tens and units. Then it becomes 12. But if they don't have the basics of visual perception and auditory perception. They can't learn.

SE2: …it can be visual memory and visual discrimination. Like the 2, the 3, the 8 closure they don't see the 3 or they don't see the 8, they see half a number they think it's a 3. Or reversal that is also Visual discrimination reversal of 7 and 4, the 9 and the 6 swapping them top to bottom.

The occupational therapist and special educator 2 comments agree that dyscalculia learners exhibit a lack of direction/ orientation, difficulty understanding spatial orientation, and confusion over left and right leading to difficulties following direction. The occupational therapist supported the special educator 2 view's by saying.

OT: Some children have visual confusion when they see the letters reversed and not distorted and their spatial orientation of the letter isn't correct.

Special educator 2 (SE2) alluded to this by narrating a story of a boy by the name of Aden who has dyslexia, the boy struggles to remember the letter 'n' in his name when doing spelling, even when told that 'n' is at the end of his name, he will go letter by letter trying to trace the letter 'n'. Special educator 2 (SE2) further explained that the boy does the same with math.

SE2: The same with numbers whenever I ask him a number like when I say point to 7 at the number chart. I will first establish where I am on, then I go down to the bigger numbers. So, if I say to him point to 7, he goes like 1 2 3 4 5 6 7 if I say 27, he still counts 1 2 3 4 5 6 7, he just done 7. And I say 27 to get the point of referral he still does again the second time 1 2 3 4 5 6 7 and then he knows I go down to 10 20. Now while he remembers that maybe practice, I don't know. But then he would say 'Ma'am is that the number ma'am?' then I say yes, it's a 7 27 where is the 7? 1 2 3 4 5 6 7, he repeats it constantly. You would think if you have done it a 100x you should know it's a 7. For some reason he doesn't remember, each time he sums numbers his got to find the number each time again. I think it has to do with memory visual perception, something just doesn't click.

Special educator 2 (SE2) viewpoint corresponds to Landerl and Moll (2010) that children with dyscalculia also present signs of dyslexia. Dyslexia and dyscalculia are regarded specific learning disabilities because some children do not show early symptoms (Peters, de Beeck & De Smedt, 2020; Williams, 2013).

Literature indicates that the key element of learning is being focused and being an attentive listener. Lack of attention has been associated with dyscalculia. Gross-Tsur, Manor and Shalev (1996), Üstün et al.,

(2021) and Capano et al. (2008) revealed that individuals who have dyscalculia also have ADHD. The doctor indicated that some children struggle to concentrate because of nutritional reactions.

Dr: …if a child has vitamin B or iron deficiency that can also make it difficult for a child to concentrate or learn. If they're hungry like children who go to school without having eaten, they won't be able to concentrate.

One of the reasons children go to school without consuming any food is because of their social circumstances, therefore the doctor's comment is in support of (Shalev, Manor & Gross-Tsur, 2005) that socioeconomic status could be a factor linked with dyscalculia.

Teachers mentioned that children struggle to concentrate for a long period, they get distracted by internal and external things. Mainstream educator 2 states:

ME2: Noises from outside, interruptions when someone else comes into the class, Having too many children in the class. All the obstacles, things on the tables, the pencil cases, children around them, the tables, the chairs, there's a lot of things that can distract their attention, their concentration. They can be other things as well. If their mind they have like an emotional problem, things going on at home disturbing them, their mind is busy somewhere else. Playfulness, if they're too young, they struggle to concentrate because their mind is still thinking of playing. Where are my friends? I'm tired. I want to sleep. I want to play.

The special schoolteachers mentioned that learners perform better in the morning, they participate well especially if they are on medication (Risperidone or Ritalin). However, a doctor can only prescribe the medication.

Diagnostic process of intellectual cognitive barriers

It is firstly important for teachers to understand what dyscalculia is to effectively support the learners. When teachers understand what dyscalculia is and what causes it, it will be easy to diagnose or refer children to relevant people to get support. There is a lack of detection and diagnosis of dyscalculia, notwithstanding the information that the behavioral descriptions of dyscalculia are well outlined and known (Williams, 2013). A study revealed that lack of knowledge on dyscalculia leads to learners not being checked, evaluated and treated (Williams, 2013).

Appropriate intervention for learners with dyscalculia necessitates both teachers and parents to have a virtuous knowledge of the condition. The special schoolteacher mentioned that some parents lack knowledge of their child's learning disability and expect their child to perform normally like other children. The doctor noted that any concerns regarding children's academic issues are identified when the child starts formal school.

Dr: Usually learning concerns are picked up once the child is going to school. Unless at a young age where the child is at creche or home and they can't talk, crawl, or walk. There are special tests, Griffin tests and other special neurodevelopmental tests that doctors use to check a child's development if it is appropriate. If is a speech deficit or the hearing deficit isn't an autistic spectrum disorder. If they can hear or can see, they can speak but they have a sensory issue or whatever. I think those are sort of the things that we would do if we got a complaint that a child is not coping at school.

During the interview, teachers were asked what dyscalculia is and how they identify children with dyscalculia. Their response illustrated a lack of knowledge about this condition. Teachers mentioned that they use a screening form for early identification in grade 1 for learners at risk. Thereafter, they fill in an SNA form and refer the learner to a psychologist for diagnostic assessment.

The educational psychologist mentioned that she uses formative assessments or summative assessments and observations to diagnose children for learning disability but not dyscalculia. Educational psychologists play a major role in education by assessing how children learn and remember knowledge. The educational psychologist explained the screening process that she follows to assess learning barriers she said:

Psy: I use formative assessments or summative assessments and Observations. I will observe the students during tasks. When you give the student tasks, you will observe their understanding and if they're able to discuss the question using words and I will go through the student's work samples.

On the other hand, the occupational therapist mentioned that she knows about dyslexia but lacks knowledge about dyscalculia. She mentioned that dyscalculia needs specialists to diagnose it like the Red Apple dyslexia association or Star Griffin Dyslexia Association, and its usually people who have money who go for it as at the government school, they do not always even have the resources to diagnose.

OT: I use visual perception tests now and in your visual perceptual tests you can see that a lot of the children have problems with letter reversals or number reversals and spatial relations. However, with dyscalculia it needs specialists to diagnose it like Red Apple dyslexia association or Star Griffin Dyslexia Association, and its usually people who have money. You can do it, and it's usually for high functioning kids. Because we at the government school we don't always even have the resources to diagnose. Because an organization that does it, it is a private practice, and it costs a lot of money. problems with it and ultimately the psychologist in the GDF also are limited and the parents don't have the funds to go private and like I said that at government schools it's difficult to diagnose it because it isn't funded. You'll see that the child struggles with math's and you try all the learning, learning, teaching support material, but it doesn't work.

This signifies a lack of instruments to diagnose dyscalculia at schools, especially at public government schools. Teachers' lack of knowledge about this condition is in support with Williams (2013) that the underprivileged identification of dyscalculia drifts from government to educators, and the community (Williams, 2013). This lack of proper identification and diagnosis has resulted in a lack of support for learners with dyscalculia. Children are labeled for their incapacity to perform well and are not formally diagnosed to receive proper support and intervention.

Theme 2: The key mechanisms of effective early childhood learning

The education setting.

The learning environment is a major component of effective teaching and learning. However, teachers have indicated that the learning environment may impose a challenge to the productivity of mathematics instruction. Mainstream teachers indicated that the biggest problem they encounter is the large number of learners in the classroom and the curriculum that restricts them from delivering effective content.

ME3: I really think that is a barrier immediately if you have many children in the class, it's something impossible. I've had 47 learners at one stage. I just think that if the classes are a little bit smaller, they are more manageable. I would love my ideal class to be of 32 learners. I think the class of 32 is my ultimate goal a class of 32 makes, for instance, I can have eight children, eight children, eight children, eight children. And then I've got space. And I've got days where I can have things like a sandbox and shapes and models and a computer too.

ME2: Having too many kids in the classroom makes it difficult for the teacher to get to everyone to make sure they learn the basic skills of counting and number recognition. Having a lot of children means you have a lot more minds, and a lot more creativity going on. While you think you're learning one concept, someone else is doing something else, and then you need to attend to

that, and then even the teacher loses concentration because she must attend to another child. So having many children can be the challenge.

This indicates that the number of learners in the classroom plays a big role in how a teacher engages with learners. While on the other hand, a teacher from a special school expressed how convenient it is to have less learners in a class.

SE1: Because of the few learners that I have, it's easy to identify learners who are struggling because you are involved so you can quickly see.

SE2: Learners with learning disability constantly need help. I've got 15-16 while the other classes are like 8 or 9 and that's ideal. Because you can work one-on-one. But with 15 or 16 it's very difficult and also very exhausting because you've got to constantly think of each child, what they are thinking and family circumstances.

Mathematics is socially discovered by learners before formal education. A home is regarded as an informal education setting for the child. Teachers mentioned that some children lack early exposure to numbers. They were not exposed to numbers when they were young, they stayed at home and did not attend preschool or grade R where they get an opportunity to learn a bit of perceptual and number recognition before, they get to school formal work.

ME3: I think barriers start already when a child is a toddler and running around at home. When we were small, our mothers used to be at home. We didn't go to nursery schools. You needed to be well off to send your child to nursery school. You will work with your mother and your mother will say 'mommy is doing washing', and she will say quickly help me sort out the clothes put the red clothes together. So, that is already where number sense starts, because now mommy will say, how many socks do you have? pair up all the socks. All those things are used eventually for math's concepts.

The teacher mentioned another factor that contributes to the delay in the acquisition of math knowledge. Some children spend too much time on their phones, and they do not engage with their parents because the parents are too busy, and children miss the opportunity to learn accidental skills.

ME2: Children sit and watch TV, more tablets, phones, they play more games than they did. A few years back children were running outside climbing trees, and that's mathematical skills with life skills combined. I think even the parents are too busy to pay attention to them. A simple thing like how many white cars drive past us today. That's counting and color recognition. I think the parents are too busy, life is too rushed and too busy for children to learn any incidental skills.

Teachers suggest that education should not start when a child starts formal education, however, it should start at home when a child is still a baby. However, teachers suggest that their other reasons that restrict children to that opportunity such as not affording daycare or parents being too busy to engage in math through play with their children. This indicates the important role of a domestic and community setting in shaping youngsters' number knowledge; however, the occupational therapist believes that the economic status of the family also has an impact to the cognitive development of a child she said:

OT: Other kids have socio-economic problems. So, you'll find bright children. But their socio-economic background is so poor that these children are neglected. The parents are so poor, they move from school to school. They don't have stability, so these children are clever, but they have missed out on the basics of school and education and then they have a backlog because of that because they've never had a stable house and stable school every week, they are absent at least three days or two days, they miss four. I think social and economic background can be a factor.

Teachers mentioned that barriers start when children are still small at home and helping around to sort laundry and when parents teach children to show their age using fingers from the age of two growing up when they learn extra numbers automatically. However, the teachers noted that some children struggle to use fingers; eight years old battle to get to three and keep the two fingers down. Therefore, that could be a physical problem or muscle tone.

SE2: If it's not a physical disability, mental brain, cognitive problem. I think not being exposed to numbers, letters, and counting.

Teachers view support Gerstmann's (1930) finger agnosia that some children struggle to distinguish and separate their fingers to solve math problems.

The syllabus and instructional approach

Both the special school and the mainstream school follow the CAPS Curriculum (Curriculum Assessment Policy Statement) using ATP (Annual Teaching Plan) that determines which content should be taught, the timeframe for each content, and what should be assessed. Though at the special school, they try to adapt to the curriculum, they still encounter challenges. The teachers from both institutions expressed concerns regarding the curriculum as a key factor in weak teaching and learning of mathematics.

SE3: The curriculum is a rush. It's a total rush with teaching math. Math needs to be learned in steps. If you skip one step somewhere, somehow there will be a problem further.

SE2: I think the people that aren't knowledgeable with kids with learning disabilities don't know what's good for the child. Like child friendly they don't keep the child's disability in mind when planning the curriculum. Because, we must follow the CAPS curriculum and we have to keep up with the curriculum, sometimes I think they shoot a bit too high, normal kids can do it, but our kids can't, you've got to pressure them, and push them because although they've got a disability, they've got to keep up.

SE1: They couldn't cope with mainstream curriculum; however, we also do mainstream curriculum but the fact that we have smaller classes and the fact that we have different resource and therapist available it's easy for the learners to do mainstream curriculum. We adapt the curriculum, but we still look at the ATP and we do the assessment like the department wants us to do. We adapt and we use more visual and we do visual stuff, we do individual assessments, there is like a whole holistic approach. I think that's what makes us different.

Educator 2 from the special school emphasized how they should keep up and ensure that most curriculum content is covered. This shows that they face the same challenges of the curriculum when it comes to things they are expected to cover in the curriculum. While educator 1 from special school explained one of the reasons learners are referred to special schools and the benefits of being in the special schools.

This indicates that some learners struggle with the curriculum expectation from mainstream because of many learners in the classroom. Then they perform better when moved to special school considering that special school have less learners in the class. Contrary to that, ST2 believes that the curriculum needs to be adapted to cater for learners with disability she said:

SE2: Normal kids that got learning disability over the year I found you've got to try to do the basic of the curriculum so that they can at least learn it and understand it and make it their own, so that when they get older, they can be able to adapt and learn other methods, because to teach a grade 2 child 5 different methods it's just mixing them up because they don't understand it, it's too mixed up, they need structure. If they have dyscalculia or dyslexia, you can't follow the normal CAPS because they can't, it's a disability if something is not clicking somewhere it's not functioning.

SE2 views that the curriculum is structured in such a way that most of the content should be covered over a specific period and earners with dyscalculia or dyslexia grapple with different sets of content. Fouracre (1958) in this over 50 years old seminal article state that learners with brain disorder get confused if instruction and therefore learning is prepended not properly structured. Schollar, (2015) further asserts that over 80% of children with dyscalculia achieve lower grades when scored for mathematical understanding of the stream curriculum. Teacher 1 explained some of the challenges faced by mainstream teachers and said:

SE1: …at the mainstream if they teach the kids to add and subtract on the number line it will be like that throughout. While if our children struggle with that, we try to implement it, but we don't put the focus on that and we don't use that as the main method. We would rather use counters.

SE2: …inspectors should understand that we don't use that method because it's not applicable to our kids. Sometimes when you get an inspection, they would complain that you haven't covered the whole curriculum. I think the people that aren't knowledgeable with kids with learning disabilities don't know what's good for the child. Like child friendly they must keep the child's disability in mind. Again, we follow the curriculum, but we try and adapt it and make it child friendly for the learning disability. We want every child to succeed, it doesn't help the child being a failure or feeling as a failure one time we want them to succeed in something.

ME3: If you are out, you just give like the curriculum writers, they are outside and say they say this will work. But they don't understand why we spend time singing math songs or why we spend time playing. Because this kind of things you cannot capture in the books and it's this kind of thing that's developing the math's.

ME2: I think with the curriculum if they could make it a bit easier for learning disability teachers, to get the easy easiest method to stick to, so that the learners could use, instead of coming and say but you haven't used this and that method.

ME2: I feel like the people in the department is giving us work which won't really fit in the system because they don't know what's really going on in the classrooms. They want us to work according to a textbook, but in real life, that's not possible. Yes, it's easy for them to sit in their offices and do the ATP's and then expect us to comply. But it doesn't work like that. There are many challenges we have in the classrooms, weather, electricity, sick children. Admin staff. I think the people upstairs must come downstairs and come visit us so that they can see what's really happening in the classrooms and then they will get a better understanding of what they expect of us and that it can't work always the way they want.

ME3: There's no time because they want to see written work, they want the DBE books to be completed. They want to see evidence of written work in the books you are rushing through your work to get done so that you don't get in trouble when they come for inspection. They must come and come see how we teach in the class, come give advice They don't want to see what practical I am doing. Don't judge me on my written work. come and judge me on how I'm teaching, and if the ATP can just be like the DBE book and correlates with the ATP that we start from the front instead of jumping around the DBE book.

The teachers' viewpoints concur with Butterworth, Varma and Laurillard (2011) and Shalev, Manor and Gross-Tsur (2005) that these hitches appear to be a main barrier to succeeding in the math curriculum.

Theme 3: Learners' and teachers' psychological approach towards mathematics.

Learners' emotional & behavioral anxiety

Learners with incapacity in mathematical computation may exhibit impulsive and possibly antisocial behavior (Badian & Ghublikian, 1983). Teachers mentioned that some children do not enjoy learning math, they lose interest because they do not understand it. The teachers mentioned that the reasons could

be that they do not understand English, and they lack vocabulary, they did not grow up with math at home the parents did not engage with them, for example, to send them to get two cups. Therefore, they lack confidence in doing it. Teachers also mentioned that learners may have a fear of the teacher, because some teachers have limited patience and get agitated when learners do not understand. Then learners pick that up and become anxious to try, they are afraid to make mistakes.

ME1: Some children enjoy math more than others, especially the cleverer ones. While others lose interest because they don't understand either they don't understand English or the concept, or they just don't like it. I think there's always a positive and a negative, so there's always children enjoying learning math, willing to learn, willing to do more. The extra step, the next step, the next level, and there's others that don't care. They don't like it. They don't want it. They don't enjoy it. It's just more work.

This statement indicates that math anxiety is built is not something with which learners are born. Their lack of interest in learning math is due to their previous experiences with numbers. The teacher suggests that language is another factor to math anxiety, because if the child does not understand the symbolic language of math, it will be difficult to engage and solve math problem. If they had hardship before learning math, they psychologically build a negative attitude because they do not enjoy it.

ME2: Children have no interest in math. They didn't grow up with math. They don't know where it's coming from, or they have a Brain disorder. They're not confident in doing math. Some of them might only experience mathematics at school. No mathematics at home. Mommy doesn't ask questions like go get me two cups, one cup or give me three toys, then this is the only place that they get in contact with math. Maybe this is the only time they do and then they maybe get a fear because they don't know this, or the vocabulary will also be they don't understand.

The teacher suggests that lack of prior experience with math may be a factor to learners not having the interest and confidence to learn math: Because they never had math experiences before at home when they were toddlers, they only learn math at school, and then they develop fear because they lack understanding of the subject.

ME3: It's fear for the teacher because teachers only have a certain patience as well, and after the third, fourth time, we all don't always have the resources and time to reteach, and then the children also get anxious. There's always a few crying because they don't know what to do and the teacher is getting agitated. I think it's the teacher's attitude as well if the teacher makes it fun for them. If teachers change their attitude make it fun for them make it learner appropriate, learners will also change their attitude.

The statement made by the teacher also suggests that the teacher's attitude towards learners when they struggle with math is what leads learners to be afraid of making mistake. The teacher notes that some teachers lack patience to repeat when learners do not understand, therefore they get irritated when they get some answers wrong.

SE2: When children have learning disabilities at the mainstream schools and they come to us, those children have been through so much failure, ridicule, aggression frustration, peers not understanding and there are many factors other than being cool you know brain capacity or disturbance in the brain there's lots of diet textures smells they so much involved in a learning disability is not just oh he can't read, he can't write. There is so much burgage around them. This is a child people always laugh and the child doesn't only have a learning disability in class, the disability carries through at home and your friends at the shops in the mall on the beach at a restaurant at a holiday resort.

SE2: The first week of school leaners were counting dots and writing the number. This boy was soothing and crying and I said, what happened? Did you get hurt, the tears squirt. His tears were squirting. What's wrong? He said 'I think I've got this wrong. I think this is addition and I might be wrong' and I said, 'well, number one, it's not addition you're just counting the dots and let's check, you're not wrong. You're Right'. He said, 'thank you I thought I was wrong. mustn't make a mistake' and I said 'you can make a mistake; you've got an eraser to erase and fix it'. He was in such a physically noxious state.

It's important for a teacher to attend to the child's learning discomfort because when a child struggles with mathematics normally they develop anxiety which forces them to lose focus and not pay attention to the subject matter. The teacher explained the root of math anxiety she said:

SE2: Anxiety comes from adults from home into school. Adults would say 'if you don't have math's at high school, you not going to be able to have any future. You can't study anything. You can't have a career'. They make kids anxious and scared that they build up a mental block.

The teacher's comment points to community stereotype regarding mathematics as being a challenging subject. Those who are competent at mathematics are seen as being a genius. Teachers are then faced with a huge responsibility to reassure learners that math has different content and clarify that arithmetic is just a single piece of mathematics and some pieces do not involve arithmetic (Williams, 2013).

SE2: Parents and community hold a belief that you've got to perform. You've got to be a doctor. You've got to be something great to be a person. I tell my learners to just do your best and that's our motto: 'Be the best not first'. Do your best, don't be first to finish. Do it slowly if you're wrong, we erase it. We help each other, and that is why we don't move on if not all of us understand. I think it's pressure everybody around us and not even math, reading and writing you've got to perform performing.

The teacher reveals that math anxiety is so predominant in the community from both parents and teachers. Parents mostly instill their undesirable spirits or attitude to their children (Sparks, 2011). Therefore, a teacher should make less effort to make the learners feel intelligent and restrict themselves from asking questions when they do not understand. The classroom should stimulate learners to feel safe to make mistakes and learn to the best of their ability.

ST3: More of the behavior change from somebody that's sweet. You find that a child when it's math time there's stomach aches, there's headaches, there's whatever ache. After that, the child is fine. Or before that the child is fine. Also, behavior problems start when you get somebody that's fine when you notice that it's makes this person. And sometimes it's just because they don't want to do math, so they now want to distract you. There was one child he was in my class in Grade 3 after break. He ran, there was a teacher standing there. He ran from there. He just pulled the teacher's skirt down. When you talk and talk and talk, because this child is not like that, but now he wants us to waste more time here instead of going to class and do math.

Children who struggle in math tend to be disruptive and avoid participating during teaching and learning. They develop an undesirable attitude and react by displaying unsuitable behavior in the classroom (Williams, 2013). The teacher's comment concurs with William (2013) that learners with math learning disability exhibit undesirable attitude and act out of line.

Learners on the other hand expressed that math is a difficult and confusing subject because of its complexity with number patterns, which makes numbers not to be in order, the mathematics operation that involves multiplication, division, subtraction, and addition when solving bigger numbers and counting in patterns using a number chart.

Table 3:
Ns Learners' overall response on mathematics learning

Grade 1	**L1: got 6 + 7. He got 18, he says he used a number chart to get the answer. He said: '*it's difficult and math is the hardest difficult thing*'**
	L2: '*Dividing and plus. times Eight 8 x 8 x 8 is difficult for me it's difficult because it's long division.*'
	L3: '*Dividing and plus. 1000 x 1000 is difficult*'
Grade 2	L4: '*Because it's about numbers and it's difficult for me because sometimes I always get confused.*'
	L5: ;*Times and dividing. It's difficult* when there's a multiplication like 70. I mean 27 + 1 = 27 + 2 + 5. I don't know the answer, so I give the random number.'
	L6: '*I cannot. I'm not good at counting force 20 times.*'
Grade 3	L7: '*Because I'm struggling, and my fingers are not…. I cannot count properly.*'
	L8: '*It's when I see divide and multiplication, it's really hard to and sometimes I get confused which one is multiplication and which ones dividing. I think when we do times when it's like a test and we need to do times on our own, it's really difficult for me.*'
	L9: '*I can't count till two hundred. My fingers are not good I get confused, and I lose which number I'm at, so I go all the way the back and start all over.*'

Table 3 shows that learners experience mathematical difficulties at all levels of learning, but that those grappling with dyscalculia are in a more severe state of comprehending and tacking mathematical problems.

CONCLUSION

In conclusion, both the study and the literature has delineated that children with dyscalculia are mainly due to genes, brain abnormality, and cognitive deficit. Most of these children remain unidentified and undiagnosed due to lack of diagnostic tools even when referred to special schools. This study has further shown that mathematical difficulties can be caused by medical conditions such as brain abnormalities and certain disorders. Learners' perceptions of mathematics are influenced psychologically by their parents and teachers. The government's lack of recognition of this condition limits individuals from receiving the appropriate support. The privatization of dyscalculia associations or institutions disadvantages learners from poor backgrounds. The government should consider providing support to individuals who cannot afford to get private assistance due to socioeconomic status by de-privatization and providing funds to special schoolteachers, and educational psychologists to receive proper training and tools to diagnose children with dyscalculia.

There are both internal and external factors that impinge on impair learners' ability to acquire mathematics knowledge within the learning environment, such as large number of learners in the classrooms, teachers' attitude towards mathematics, the curriculum and multilingual classrooms and disenable learners from being taught in mother tongue. These factors worsen the condition and deprive learners with dyscalculic from opportunities to receive appropriate support. In the classroom, the curriculum has been found to be one of the major factors that contribute to poor mathematics instruction and learning, especially for learners with learning disabilities, since it has been designed for learners with less cognitive disabilities such as dyscalculia who can acquire mathematical skills as a given pace and level of difficulty. Children with dyscalculia need a differentiated curriculum that will be suitable for

them to learn basic mathematics. Teachers' methods of teaching that are mostly acquired at teachers training institutions are predominantly for learners without dyscalculia or any other cognitive impairment. Learners with dyscalculic require teachers who understand their condition and provide differentiated instruction for them, rather than expecting them to perform at the same level and pace as the rest of the children. The teachers' inappropriate instructional approaches, limited resources and the indifferent curricula means that learners with dyscalculia will always be left behind and uncatered for both in schools and communities.

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