

# Teachers' perspectives on ADHD neurodevelopment and mathematical interventions supports in inclusive foundation phase classes

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*Abstract: Children with attention deficit hyperactivity disorder struggle to process mathematical concepts despite international conventions on inclusive education and quality education for all. Teachers' capabilities to differentiate pedagogical practices despite learners' diverse educational needs was the issue. Piaget's neuroplasticity theory, Hebb's neurophysiological theory, and Vygotsky's sociocultural theory grounded the qualitative study within the interpretive paradigm to explore the phenomenon among purposefully selected teachers. The researchers observed mathematics books of ADHD-identified learners and reviewed the teachers' pedagogical practices to support the learners. The analysed data revealed teachers' lack of ADHD neurodevelopment comprehension, used standardised interventions and required knowledge appraisal on inclusive practices.*

*Keywords: Attention Deficit Hyperactivity Disorder; mathematics; inclusive education; neurodevelopmental brain functioning; Foundation Phase.*

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## INTRODUCTION

Despite South Africa being part of the interlinked objectives of the United Nations' Sustainable Development Goals (SDGs) to end poverty and provide quality education by 2030. The education system is still struggling with ADHD neurodevelopment and mathematical interventions and support for foundation phase learners in inclusive classes. The global goals include citizenship, climate change, quality education, human rights, and the transformation of the lives of persons with disabilities. It was pointed out 17 times in the United Nations SDGs that it aims to improve the world of children with disabilities and those with learning difficulties as a priority by improving the current segregation and exclusion practices imposed on these children and the embedded requirement to offer them reasonable accommodations in schools. The framework further justifies the importance of the meaningful implementation of the goals to address the quality and equality of education for all children, including those with special educational needs, thus enhancing their inclusion, fundamental rights, social participation, and gender equality across all SDGs. Inclusive and mainstream schools in the South African education system are those without dedicated classes separated by learner ability. Parents can choose from private, public, international, alternative and home-schooling for their children's education.

Mathematics is a fundamental learning area in South African schools. It is taught from the Foundation Phase throughout the education system. The Curriculum and Assessment Policy Statement (CAPS) manages teaching and learning in schools and requires teachers in the Foundation Phase to teach all subjects, including mathematics, home languages, and life skills (Department of Education, 2011). The teaching and learning practices and teachers' under-preparedness have plunged the country into a mathematics crisis resulting in learner underperformance (Chirinda, 2021) and teachers' negative attitudes toward mathematics (Jacobs & Spangenberg, 2014). The disparities in the socioeconomic environment (Spaull, 2013) and the learners' varied abilities to process mathematical concepts has contributed negatively to mathematics learning in mainstream classes (Ndubuka & Rey-Marmonier,

2019). Furthermore, overall learning, and mathematics learning in particular, is exacerbated by the multilingual South African context, children coming from diverse home language backgrounds, and schools using English as a medium of instruction (which, in many instances, is the learners' second or third language) in inclusive schools (Dicker, 2015; Thuketana & Makgabo, 2022).

According to Trends in International Mathematics and Science Study (TIMSS), a framework for assessing learners' mathematical achievement, South Africa is one of the worst achieving countries in the world in terms of mathematics outcomes, while also noting that ability in mathematics foregrounds future jobs and provides career foundations for learners to access the information-based world (Mullis & Martin, 2017). The subject develops children's capacity for thinking and equips them with problem-solving skills and creativity (Khalid et al., 2020). Thus, it is evident that learners without a solid mathematics background might struggle to achieve the necessary life competencies.

Additionally, with the background of challenges that teachers experience when teaching the subject to typically developing children, the study assumes that it is distressing to teach learners in inclusive contexts with curriculum differentiation demands (McKenzie, 2021). The curriculum and inclusive policies expect teachers to cater to learners with varied abilities, including those with ADHD. ADHD constitutes a range on the spectrum of disabilities and learning difficulties, including dyscalculia, that is, a difficulty in processing mathematical concepts (Kanevski, et al., 2022). The aforementioned significant challenges justified our rationale to investigate teachers' conceptualisation of ADHD neurodevelopment and the mathematical intervention competencies they hold to enhance these children's access, application of the learning area, Mathematics, and likelihood to apply the principles in real life.

### **Research Question**

What are the teachers' perspectives on ADHD-identified learners' neurodevelopment and mathematical interventions in Foundation Phase inclusive classes?

## **THEORETICAL FRAMEWORK AND LITERATURE REVIEW**

This study merged three theoretical frameworks to form a conceptual framework, namely Piaget's neuroplasticity theory, Hebb's neurophysiological theory, and Vygotsky's sociocultural theory. Hergenbahn and Olson (2012) merged Piaget's and Vygotsky's theories to benefit their study by focusing on the cognitive development that takes place inside out (Piaget) and outside in (Vygotsky). According to the authors, the theories they used focused on the teachers providing scaffolding to ADHD-identified learners to assist them to acquire the requisite knowledge and skills about mathematics. The incorporation of the theories proved beneficial to the study as it exposed the holistic support needs of those ADHD learners. In this study, the researchers merged Hebb's theory with Piaget's and Vygotsky's theories to better understand how the teachers supported learners diagnosed with ADHD to enable their understanding of mathematical concepts in an inclusive context.

Piaget's theory helped teachers and researchers to focus and understand children's cognitive activity and how individuals reflectively use ideas to construct new knowledge (Adler-Tapia, 2012). Piaget's theory helped teachers to better understand the neurodevelopment of ADHD learners and how to exercise the brain to improve children's conceptualisation of mathematics. Krüger et al. (2016, p. 240) agree with Adler-Tapia (2012) that Vygotsky is well-known for the concept of the 'zone of proximal development' (ZPD), which helps to explain why the teacher is the main bridging force between the known and unknown for learners diagnosed with ADHD. Hebb's neuropsychological theory concentrates on the gradual build-up of cell assemblies sequences starting from early childhood development (Hergenbahn & Olson, 2012). During the observations and interviews, Hebb's theory helped the researchers to understand whether teachers use this theory during inclusive teaching when working with ADHD-identified learners. Neuropsychological theory accounts for cognitive flexibility, long- and short-term memory, and the improvement of problem-solving skills. Therefore, this paper investigated teachers' perspectives on ADHD learners' neurodevelopment and mathematical interventions in Foundation Phase inclusive classes to suggest contextual strategies to support learners with ADHD.

### **The Global Prevalence of ADHD**

Abedivzadeh et al. (2019) state that seven per cent of children of school-going age are diagnosed with ADHD. Furthermore, they state that ADHD is a neurodevelopmental disorder affecting 11.1 per cent of Foundation Phase learners globally. Anderson et al. (2020) agree, indicating that neuro-imaging work has shown that brain dysfunction in learners diagnosed with ADHD leads to learning disorders. Additionally, Harpin (2017) and Faber (2017) agree and note that 30 per cent of ADHD-identified learners present learning disorders related to mathematics because of their brain functioning. The above justifies the need to explore strategies to support intervention provisions for ADHD learners in public mainstream schools to enhance their access to the curriculum and mathematics processing.

### **Teachers' Conceptualisation of ADHD Neurodevelopment and Support Needs**

Thuketana (2023) and Deloche and Seron (2019) state that little research has been conducted on the neurodevelopment of ADHD in learners and mathematics teaching in the literature. Deloche and Seron (2019) believe that when teachers understand ADHD neurodevelopment in learners, they can help ADHD learners to acquire mathematical skills and achieve inclusive outcomes. Badenes et al. (2022) agree with Deloche and Seron (2019), claiming that if teachers know how to support learners diagnosed with ADHD and integrate successful inclusive education practices into their teaching, it could help to lessen the possibility of these learners dropping out of school or experiencing psychological distress and, instead, they could internalise and learn to solve issues related to their mathematics learning disorders. Abedivzadeh et al. (2019) agree with Deloche and Seron's (2019) claim that ADHD is a complex neurodevelopmental brain dysfunction that most teachers do not understand adequately.

Before teachers present mathematical concepts to the learners, they should be aware that ADHD-identified learners struggle with short-term memory, with their attention span, and with behavioural problems. Therefore, Deloche and Seron (2014) describe practical strategies to help teachers understand ADHD-identified learners and to help them improve their mathematics learning. Furthermore, ADHD-identified learners can process limited information when teachers disregard the above-mentioned embedded characteristics, and they may block the processing of relevant information, which leads to distractibility and behaviour problems.

Goldberg (2017) agrees with the above authors and gives a more in-depth explanation of the neurodevelopment of ADHD. According to Goldberg (2017), studies were undertaken to understand the struggles that humans have with language and mathematics. The studies found that these subjects are aligned with the functioning of the brain. ADHD influences the brain's prefrontal cortex, which controls the child's attention, memory, and decision-making processes (Goldberg, 2017). Ayaz and Dehais (2019) suggest ways of stimulating these brain areas to help ADHD-identified learners focus better when learning mathematics. According to these authors, transcranial direct current stimulation can help the brain's attention, memory, and behaviour, which have been influenced by certain disorders or dysfunctions, to function better. This study aimed to explore teachers' knowledge and skills regarding the neurodevelopment of learners diagnosed with ADHD and ways of supporting them in solving mathematics problems regardless of their atypical development.

### **Mathematical Concept Processing in ADHD Learners**

Dei et al. (2017) and Oswald and Swart (2011) state that mainstream schools in inclusive African contexts are at a crossroads. According to the authors, a transformative agenda with regard to inclusive education practices has led to significant challenges in African schools. To enhance access to all learners, these schools straddle the provision of quality and equal education, which are grounded in African theories. Furthermore, Ayehsabu (2020) asserts that African countries fail to plan for reasonable leadership practices and inclusivity within diverse schools and communities. Dei et al. (2017) agree with the above author, stating that pre-colonial educators in African countries need to be transformed for their countries' education vision. Educators should understand the education systems and explain mathematical concepts in Afrocentric ways that encompass their learners' needs and capabilities. In so doing, inclusive education practices will start to accept social and individual differences and align with Vygotsky's sociocultural theory to incorporate children's cultural beliefs, values, and norms into learning (Dei et al. 2017).

According to Pather and Slee (2018), most schools in African countries are rural and receive less funding than rural schools in other parts of the world. According to the authors, teachers on the continent are inadequately supported and underqualified to teach in inclusive schools. The above situation can lead to challenges for teachers in terms of how they understand the neurodevelopment of ADHD in learners and their support needs. Dei et al. (2017) and Pather and Slee (2018) concur that the main challenges that teachers in African countries experience are with regard to the implementation of inclusive education. Accordingly, the challenges that teachers face are the lack of resources and skills to make teaching mathematics easier, differentiation in the curriculum, and the lack of distinguished assessment strategies for learners with brain dysfunctions such as ADHD.

Pather and Slee (2018) mention Libya as one of the African countries that struggles to implement inclusive education within a human rights-violation crisis. In the process, the country struggles to meet the educational needs of ADHD-identified children. ADHD Foundation Phase learners struggle with mathematics owing to the lack of teacher training and curriculum differentiation strategies. Pather and Slee (2018) also cite Rwanda and Zanzibar as countries struggling to implement inclusive education. On the other hand, countries like South Africa experience challenges with English as the medium of instruction in schools, as well as the need for more training of in-service teachers. However, an additional issue in South Africa is the lack of capacity to implement, among other things, the Screening Identification Assessment Support (SIAS) policy which aims to screen and offer support to children with

learning difficulties.

The above authors paint a bleak picture of inclusive education and support strategies for learners diagnosed with ADHD and those experiencing mathematics challenges in African countries. Teachers face challenges such as low motivation, negative attitudes toward ADHD-identified learners, a rigid regular curriculum, and a lack of training and support to achieve inclusive education success (Pather & Slee, 2018). By contrast, Badenes et al. (2022) note that conflict in the learner–teacher relationship indicates low social competence and behavioural difficulties. Attaining high-quality education remains a challenge in African countries because of the economic and health statuses brought about by colonialism and loans from the International Monetary Fund (Pather & Slee, 2018). Furthermore, the literature provides evidence of a gap in professional teacher education and funding to support learners diagnosed with ADHD in public mainstream and private schools.

## METHOD

This paper adopted a qualitative interpretive research paradigm (Thanh & Thanh, 2015). The paradigm was based on the ontological stance that individuals construct multiple realities ascribed to their realism (Bryman, 2012). Creswell (2014) agrees and opines that truth is subjective and emanates from participants' experiences and understanding. The research purposefully selected Foundation Phase teachers to investigate their views on ADHD learners' neurodevelopment and mathematics learning support (Creswell, 2013). Additionally, Creswell (2013) suggests neurodevelopmental and mathematics intervention approaches to enhance curriculum access and concept processing.

### Design

A multiple-case study design underpinned the study (Creswell, 2014), with 10 teachers from two inclusive schools – one public mainstream and one private mainstream – constituting the main participants. The researchers sought parental consent for the learners as secondary participants in classes whose teacher–learner ratio was 25:1 without teacher assistants. The schools were located in Pretoria, Gauteng, and both schools had learners who had been diagnosed with ADHD. The teachers and learners came from different cultural backgrounds and spoke different languages. The schools, however, used English as the medium of instruction. The study used semi-structured interviews to understand teacher practices in their classes and examination of learners' mathematics books as data-gathering strategies.

### Data Analysis

The study used a thematic data analysis approach incorporating the steps proposed (Creswell, 2014). These included primary theme identification, assigning codes to the themes, classifying the responses, and integrating the themes and responses into the report text. The researchers managed the data sets to build the analysis. The analysis method enabled the researchers to locate literature and empirical evidence for the later description of the findings (Bazeley, 2013).

### Quality Control

One of the steps to enhance the study's trustworthiness was allowing the participants to review the transcriptions. Rodrigues (2018) states that asking participants to verify what was said or explained enhances the study's trustworthiness. Additionally, to control any form of bias (Creswell, 2014), the researchers gave a brief explanation of ADHD neurodevelopment to the participating teachers. They captured the participants' conceptualisation of the concept from their point of view and presented the responses verbatim.

## FINDINGS

The study used responses from interviews and observations to narrate the three themes summarised through the teachers' conceptualisation of ADHD neurodevelopment and their practices in inclusive classrooms. The verbatim responses from teachers' interviews were presented descriptively to enhance the trustworthiness of the study (Shenton, 2004). The themes explained the types of support that the teachers received, reflected the inclusive strategies used to help the learners identified with ADHD, and the curriculum differentiation practices used in the classes.

### Teachers' Interviews

#### *Teachers' Understanding of the Neurodevelopment of ADHD.*

It was evident during the interviews that most of the teachers needed a significantly greater understanding of ADHD neurodevelopment than they had. A recurring response from most of the participating teachers was that ADHD was only about hyperactivity and distractibility. Three teachers

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who agreed on this responded:

I believe ADHD is when a child struggles to concentrate.

ADHD is when learners struggle to concentrate, and they take longer to understand certain concepts.

ADHD is when a child is too busy or has trouble concentrating.

The researcher also noticed the teachers' lack of understanding of the concept of ADHD neurodevelopment by observing their uncomfortable body language. One participant said, 'I have never really heard of the term neurodevelopment; it sounds psychological to me.' Another stated, 'I have not really heard a lot about the term neurodevelopment, but I believe it is the way the brain thinks and more the psychological part of the brain.'

According to Getz (2013), teachers with little knowledge or interest in the neurodevelopment of ADHD learners expressed less emotional closeness, collaboration, and conflict with the learners. Sjöwall and Thorell (2022) state that teachers need to understand that the brain of the ADHD-identified learner takes more time to mature. The delays appear in the brain's frontal lobe, which controls the learner's cognition, attention, and planning. The participants did not have any knowledge about this information. Some of the responses were, 'I think neurodevelopment, is the brain capacity of a learner's brain' and 'It must be a chemical imbalance in the brain.'

Most of the participants' answers appeared unclear and confused.

### *Teachers' Perspectives on ADHD Neurodevelopment Aligned with Mathematical Interventions.*

Most of the teacher participants had similar perspectives in common. They wanted to be more knowledgeable regarding the neurodevelopment of ADHD learners to help improve their mathematics interventions and to be able to pitch their mathematics pedagogy at a level that ADHD learners could process. A participant from the private school mentioned, 'I would like to study further one day to educate myself more about ADHD-diagnosed learners.'

All the participants agreed on the lack of teaching and support materials at the schools. This restricted their ability to teach and differentiate mathematical concepts clearly to ADHD learners. A participant from the mainstream school emphasised her use of textured materials and how it enhanced internalisation of mathematical concepts for her ADHD learners. She stated that the use of fidgets, cushions, and elastic bands helped to reduce hyperactivity and enhance learning in those learners diagnosed with poor ADHD concentration spans and their processing of mathematical concepts. However, it was clear to the researcher that some of the participants had negative perspectives about ADHD and mathematical interventions because of the lack of materials and budgets to enhance interventions.

According to the teacher participants from the private school, the poor availability of materials hampered their ability to teach mathematical concepts clearly. The worksheets with explanations in the learners' mathematics books were unclear and not at the learners' level of understanding. Even though the teachers from the public mainstream school did not have the same financial challenges as the teachers from the private school, they complained about the lack of relevancy of the materials. The teachers claimed that they were not given the autonomy to suggest the types of resources they needed. The Department of Basic Education (DBE) brought resources to the schools without assessing the support that the children needed. The researchers realised that lack of collaboration among the education stakeholders demotivated most of the teachers and perpetuated their negative attitudes toward supporting learners diagnosed with ADHD to process mathematical concepts in class.

When the teachers were asked about the mathematics interventions used for learners diagnosed with ADHD, a participant from the private school mentioned that she thought that some of the mathematics work was too difficult for learners diagnosed with severe ADHD. However, the teacher participants from the mainstream school felt more positive about this question and had a broader perspective on intervention strategies. This could be because they had resources funding and support from the DBE and received regular training opportunities. A teacher participant from the mainstream school claimed that the interventions taught to teachers were only compatible with an average learner and depended on the learner's individual capabilities, which they adapted for ADHD learners.

The teacher participants also mentioned that depending on how the learners learnt and understood the mathematical concepts, they differentiated their pedagogies. There was, moreover, a participant from the mainstream school who appeared optimistic. She claimed that her best intervention strategy was to break the work down into smaller steps, although it was very time-consuming. With this in mind, it was evident that the teachers' perspectives depended on the support they received from the DBE and the overall collaboration with the education stakeholders. Additionally, their lack of knowledge of ADHD neurodevelopment deprived these learners of support opportunities and further disadvantaged their progression.

### **Challenges Teachers Faced in Implementing Mathematics Interventions**

When the participants were asked about the challenges they faced during the teaching of mathematics for ADHD learners, one participant stated:

I have one learner who struggles with mathematics even when I give intervention examples on the whiteboard over and over. It is difficult for them even though you use different teaching methods.

Furthermore, another participant from the mainstream school explained that it was important for teachers to adapt their teaching methods to accommodate the ADHD learner's needs. One participant revealed, 'The only best way of working with the learner is one-on-one and to make sure he/she [sic] keeps up with the work. It requires a lot of time, work, and difficulty.'

A few challenges that all the participants agreed on were anger, aggression, irritability, and unpredictable emotions of the learners diagnosed with ADHD. The learners with a combination of these emotions presented with challenging behaviours in class. This shows that the teachers did not create a conducive learning environment to cushion these children for better behaviour or offer the learners alternative ways to express their emotions. A couple of the participant's responses were, 'A negative attitude will definitely cause my ADHD learners to be more busy or emotional, and then I will struggle to get work out of them', and 'They act busy, difficult, or very emotional.'

### **Support Teachers Received When Teaching ADHD Learners**

On realising that there was a gap in knowledge and skills to support ADHD learners, the lead researcher asked the participants about the support they needed and received. The teachers reported a complicated support perspective that posed a great challenge in teaching learners with ADHD. During the interviews, it was clear that the participants from the private school received less support than those from the public mainstream school. One of the participants from the private school stated, 'We (teachers) have to buy our own concrete material because of the schools' lack of finances.'

On the other hand, a participant from the public mainstream school stated:

We (teachers) get a lot of support from our school. We are constantly asked what training we need; the only thing is the lack of time for the training sessions. Our principal of academics is assigned to support mathematics teachers, and we especially get a lot of support from her.

The participants from the private school seemed frustrated when asked about the support they received from the DBE or any other entity. The researcher observed an opposite reaction to the mainstream school participants, who expressed a positive attitude regarding DBE support. Contrary to mainstream schoolteachers' gratitude, another teacher mentioned that support from the DBE sometimes constituted a waste of time. This participant stated:

Okay, so from the DBE, I do not think there is any support because the curriculum is paced, and curriculum advisers come to school with those expectations. They also tell us to use teaching aids to assist in teaching difficult concepts. However, it does not always work because children with ADHD do not keep their attention for long and need curriculum differentiation, more time than the pacing allows as well as something more concrete. They have to do something physical with their bodies to learn mathematical concepts. Otherwise, they do not benefit from teaching and learning activities.

According to White Paper 6 (Department of Education, 2001), teachers must get further training regarding learners who experience learning challenges and their neurodevelopment in order to keep up with recent research-based support strategies (Department of Education, 2011). However, teacher and learner support were lacking in the schools investigated. During the study, the researcher observed that the participants from the private school struggled financially and needed help. By contrast, the public mainstream school participants appeared optimistic about the financial support that they received. This was evident when a participant from the public school stated, 'Yes, we do get support and guidance from the Department.'

It was clear that the participants from the private school had little support. Therefore, they had to purchase and supply most of their materials themselves. These participants also did not receive enough training to enhance their knowledge about ADHD-identified learners. By contrast, the participants from the public mainstream school appeared to be very optimistic about the support they received from the school and the DBE. The participants from the mainstream school did not mention any lack of finances, and they appeared to be content with their pedagogical knowledge of teaching difficult mathematical concepts and resource use.

### **Observations**

The curriculum can be very cumbersome and rigid for learners with learning difficulties when not differentiated (Manicka, 2018). Furthermore, making the mathematics curriculum accessible to learners with or without learning barriers involves modifying, changing, adapting, extending, and varying teaching methodologies, teaching strategies, assessment strategies, and curriculum content.

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The participants complained that they did not always have the time to adapt the curriculum to support the ADHD-identified learners on a level expected of them. The researchers observed through the participants' body language that they were uncomfortable responding to perspectives on ADHD neurodevelopment and mathematics interventions. The participants' lack of understanding of ADHD neurodevelopment could also be observed in the setup of the learners' worksheets. Most of the mathematics worksheets were not adapted for ADHD and appeared too complicated in relation to their developmental level.

The researchers did not observe any adaptations to difficult worksheets to align with the ADHD-identified learners' level of development, even though the curriculum gave examples of flow diagrams, tables, and multiplication strategies. The process or pedagogic adaptations used were not clear on the worksheets, nor were the indigenous examples and methods given in the lessons. This was despite the contention of Vygotsky's sociocultural theory that contextualisation of learning materials enhances its internalisation. The mathematics worksheets given to the researcher were not specifically designed nor adapted for learners identified with ADHD who were struggling with concentration and hyperactivity challenges. The multiplication mathematics did not include the correct number lines, tables, or grouping of numbers to a specific pattern. A participant from the private school mentioned that Grade 3 learners were not allowed to use any concrete materials whereas the curriculum clearly states that teachers are allowed to use concrete apparatus or draw pictures to mentally support struggling learners with challenging activities.

Furthermore, the curriculum states that teachers must use systematic, explicit instruction, and visual representations when explaining concepts such as manipulatives, pictures, graphs, and extra assistance (Department of Education, 2011). The researcher did not observe enough differentiations made to worksheets to reassure her that the participants made use of curriculum differentiation when working with ADHD-identified learners. The above justifies the disjuncture between the didactic methods used for teaching ADHD-identified learners' mathematical concepts and their capability to process them.

## DISCUSSION

### **Mathematics Interventions Aligned with the CAPS Curriculum**

During the interviews and observations, it was clear that the perspectives of the teacher participants from both the private and public mainstream schools differed on the issue of mathematics interventions being aligned with the prescribed curriculum. The researcher was concerned that the teachers' mathematics interventions were not being aligned with the CAPS curriculum. It was evident when a participant from the private school mentioned that Grade 3 learners were not allowed to use concrete materials. By contrast, the curriculum acknowledges the progression of learner development from concrete to semi-concrete to conceptual learning and aligns with Piaget's neuroplasticity theory to acclimate as a result of learning and understanding.

Using concrete materials would benefit learners diagnosed with ADHD to internalise content, process it, and apply mathematical concepts to real-life experiences. However, most of the participants were not trained nor reskilled to differentiate the curriculum content for easy access to ADHD learners. The teachers interviewed noted that they were not encouraged to use the SIAS policy source support from curriculum managers to enrich their knowledge about the teaching content and pedagogical differentiation to meet the needs of ADHD children (Department of Education, 2016). It was also evident that the participants mostly felt discouraged because of the lack of funding for teaching aids, pictures, patterns, and supporting materials they needed to support ADHD-identified learners. Above all, the teachers struggled as they did not have teacher assistants in their classes. With the above said, it is apparent that teachers needed training with respect to Piaget's neuroplasticity and Hebb's neurophysiological theoretical underpinning to support their ADHD learners when they needed mathematical support.

### **Mathematics Interventions for Learners Diagnosed with ADHD in the Foundation Phase**

Each teacher had their own perspective on the mathematics interventions they used in classrooms. Some participants had a positive and broad perspective; others appeared more damaging as they contributed to the exclusion of ADHD learners in inclusive classes. Most of the teacher participants used different types of interventions when the ADHD learners struggled with mathematics but tackled hyperactivity or distractibility. Mash and Wolfe (2010) noted that teachers should, among other things, allow learners to stand up and stretch their bodies when they are losing concentration. The teachers used brain gym activities to support the learners who struggled with distractibility or concentration (Sjöwall & Thorell, 2022). These interventions included cross crawl, brain buttons, drawing the lazy eight, hook-ups, and thinking caps. The authors realised that the participants from the private school had a more negative outlook when they explained their perspectives. The cause of this might have been their lack of finances, training, and support. However, overall, the teachers from the private school felt that not all of them used

scientifically proven mathematics interventions aligned to the ADHD learners' capacity for support.

### **Challenges Teachers Face when Implementing Mathematics Interventions**

The biggest challenge that teachers face when implementing mathematics interventions for learners with ADHD is when a learner's attention deficit and distractibility influences their performance (Naudé et al., 2014). Most ADHD-identified learners have these challenges because for them mathematics is too difficult, boring, or overwhelming. The participants mentioned that the learners especially struggled with the concept of long multiplication. They tended to forget the steps because of the short- and long-term memory challenges embedded in ADHD. Furthermore, the teachers stated that the learners who had been identified with ADHD demonstrated a lack of understanding of concepts such as patterns and mental mathematics.

The participants also mentioned that finding additional time to prepare differentiated lessons and materials was a big challenge as they were overwhelmed with work. The participants from the private school mentioned that they had to create new mathematics books themselves every term with worksheets, which was extremely time-consuming and overwhelming. The authors realised that the problem remained that the teachers received little support from the schools and the DBE.

### **Recommendations for further research and limitations**

Since the study was based on teachers' conceptualisation of ADHD, neurodevelopment, and mathematical interventions. The findings revealed teachers' varied views of ADHD and a limited understanding of learners' mathematical support needs in a South African inclusive context. However, the study provided a clear methodological description and a theoretical framework fitting for the unit of analysis. Therefore, the study suggests the following for further research;

- It would be interesting to research more deeply on teacher's conceptualisation and knowledge on how to differentiate the curriculum for ADHD learners.
- Researchers should replicate the study using the theoretical framework and adapt it to the South African context.
- The study was focused on teachers' knowledge of ADHD disorder in learners. It would be interesting to conduct further research on the "does" and "don'ts" of setting up a classroom to enhance information processing and also to examine the resources available in the classrooms of an ADHD learner.
- Furthermore, this study's limitation was that it was conducted in similar environments and the authors recommend that future studies be conducted using different approaches and broader investigations to provide contextual and comparative intervention strategies.

### **CONCLUSION**

This study explored mathematics teachers' perceptions of ADHD-learners learners' neurodevelopment and mathematical interventions in identified private and public mainstream Foundation Phase classes. The findings illustrate issues emanating from historical challenges in the resistance to transformation attempts in South Africa. White Paper 6 policy on SDG targets (Department of Education, 2001) to improve the lives of learners with special needs provides support and reskills teachers to be knowledgeable and capacitated to provide learner support. However, the lack of the DBE's mediation and budget allocation predisposes ADHD learners to exclusion and the continuous struggle for mathematics achievement.



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### **Competing Interests**

No competing interests motivated the authors to conceptualise and produce the article for publication.

### **Author Contributions**

The three authors contributed equally to the writing and process of the paper's publication. Stefnie Loots was responsible for collecting and analysing the data under the mentorship of the two co-authors.

### **Ethical Contribution**

Permission to conduct the research was sought and granted by the ethics committee of the DBE in the Pretoria South District with protocol number EDU163/21. The school principals granted permission to access the school and the teachers, who gave their consent to participate in the study. The ethical considerations observed included the participants' anonymity, vulnerability, and right to walk away without penalty if they were unwilling to continue with the research protocols. The participants signed informed consent forms before the commencement of the interview sessions.

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### **Data Availability**

The data for this study is not available for sharing as it constitutes the intellectual property of the University of Pretoria.

### **Disclaimer**

The article expresses the views of the authors and study participants and not those of the researchers' institutions and participants' places of employment.

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