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Investigating teachers' conceptualisation of ADHD neurodevelopment and mathematical interventions in Grade 3 Foundation Phase classes

by

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Submitted in accordance with the requirements for the degree

MAGISTER EDUCATIONIS

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March 2023

DECLARATION

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DECLARATION OF ORIGINALITY

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Declaration

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2. I understand that this DISSERTATION is my own original work. Where other people's work has been used (either from printed sources, internet, books, or any other sources), it has been properly acknowledged and referenced in accordance with departmental requirements.

3. I have not used work previously produced by another student or any other person to hand in as my own.

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Faculty of Education

Ethics Committee

19 July 2022

Dear Mrs S Loots

The application for ethical clearance for the research project described below served before this committee on 15 June 2022:

Ethics Protocol No:	**EDU163/21**
Principal investigator:	**Mrs S Loots**
Student/Staff No:	**12280047**
Degree:	**Masters**
Supervisor/Promoter:	**Dr NS Thuketana**
Department:	**Early Childhood Education**

The decision by the committee is reflected below:

Decision:	**Approved**
Comments:	
Period of approval:	**Two years**

The approval by the Ethics Committee is subject to the following conditions being met:

1. The research will be conducted as stipulated on the application form submitted to the Ethics Committee with the supporting documents.
2. Proof of how you adhered to the Department of Basic Education (DBE) policy for research must be submitted where relevant.
3. In the event that the research protocol changed for whatever reason the Ethics Committee must be notified thereof by submitting an amendment to the application, together with all the supporting documentation that will be used for data collection namely; questionnaires, interview schedules and observation schedules, for further approval before data can be collected. The changes may include the following but are not limited to:
    - Change of investigator,
    - Research methods any other aspect therefore and,
    - Participants.

The Ethics Committee of the Faculty of Education does not accept any liability for research misconduct, of whatsoever nature, committed by the researcher(s) in the implementation of the approved protocol.

Best wishes

Prof Funke Omidire
Chair: Ethics Committee
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ETHICS STATEMENT

Stefnie Loots has obtained for the research described in this work, the applicable research ethics approval. I declare that I have observed the ethical standards required in terms of the University of Pretoria's "*Code of ethics for researchers and the Policy guidelines for responsible research*".

Signature: 

Date: 2023-03-01

ABSTRACT

Teachers need to be made more knowledgeable and trained about ADHD to successfully present inclusive teaching in mathematics to ADHD-identified learners. The more knowledgeable teachers are about the neurodevelopment of ADHD, the more knowledge they will have in using the correct strategies, inclusive methods, and resources to support these learners. However, this objective will be challenging if teachers do not receive enough support from the school management and the Department of Basic Education. There is a clear lack of support for some teachers.

The research study was rooted in the three theories used by Piaget's neuroplasticity theory, Vygotsky's sociocultural theory, and Hebb's predominantly neurophysiological theory. The research study adopted a qualitative approach situated in the interpretive paradigm. A case study research design was used to investigate five Grade 3 Foundation Phase teachers from a mainstream and private school. All five teachers had completed a BEd degree; some had a BEd (Hons) in Learning Support. They all received their degrees from a South African university. Semi-structured interviews were conducted with each teacher, along with observations of mathematics books from ADHD-identified learners in their classrooms, together with a review of the methods and strategies they used to support these learners. The analysis of this study revealed that teachers lack knowledge about the neurodevelopment of ADHD. The observations also revealed that teachers do not present worksheets of mathematics correctly to their ADHD learners and therefore need to be more knowledgeable about inclusive teaching. The study also showed that the private school struggled more financially than the mainstream school because of the lack of support from their school management and DBST. In light of these findings, eleven sets of recommendations were made to ensure that teachers can build more understanding about the neurodevelopment of ADHD learners and how to present inclusive teaching more successfully.

Keywords: Attention Deficit Hyperactivity Disorder, ADHD-identified learner, mathematics, inclusive education, neurodevelopment/brain functioning, Foundation Phase, private school, mainstream school.

LANGUAGE EDITOR'S DISCLAIMER

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3 March 2023

TO WHOM IT MAY CONCERN

The dissertation "Investigating teachers' conceptualisation of ADHD neurodevelopment and mathematical interventions in Grade 3 Foundation Phase classes" by Stefnie Loots has been proofread and edited for language by me.

I verify that it is ready for publication or public viewing regarding language and style and has been formatted per the prescribed style.

Please note that no view is expressed regarding the document's subject-specific technical content or changes after this letter's date.

Kind regards

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DEDICATION

I would like to dedicate this research to my husband, Manie Loots. Thank you for all your love and motivation and for believing in me.

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- Lastly, I want to thank all my participating teachers, without whom this study would have been impossible.

LIST OF ABBREVIATIONS

ADHD	Attention Deficit Hyperactivity Disorder
BEd	Bachelor of Education
BEdHons	Baccalaureus Educationis Honoris
CAPS	Curriculum and Assessment Policy Statement
CWMT	Cogmed Working Memory Training
DBE	Department of Basic Education
DBST	District-Based support teams
DoE	Department of Education
FP	Foundation Phase
GDE	Gauteng Department of Education
mhGAP	Mental Health Gap Action Programme
P	Participant
SACE	South African Council of Educators
SENCO	Special Educational Needs Coordinator
WHO	World Health Organisation
WSE	WHOLE-SCHOOL EVALUATION: (WSE)

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1 CHAPTER ONE: INTRODUCTION AND ORIENTATION TO THE STUDY

1.1 INTRODUCTION

Neurodevelopment describes how learners diagnosed with attention deficit hyperactivity disorder (ADHD) perceive, learn, remember, and think (Sternberg & Sternberg, 2012). The neurodevelopment of attention deficit hyperactivity disorder (ADHD) identified learners could be defined as how the brainwave psychology of learners diagnosed with ADHD impacts their education. Research studies about ADHD and neurodevelopment have increased since the 1890s and continue to be conducted. However, only a few studies have been done on ADHD and neurodevelopment in mathematics intervention contexts. Given the increase in the number of children diagnosed with ADHD, it is likely that teachers will identify learners with ADHD in their classrooms (Maricle & Miller, 2019:1). In this regard, Faber (2017:5) states that learners diagnosed with ADHD experience difficulties with mathematics because of brain dysfunction. Studies show that 84% of learners identified with ADHD score poorly in mathematics (Kumar, 2014:25). The focus of the study was to investigate teachers' conceptualisation and knowledge of ADHD, neurodevelopment, and mathematical interventions in Grade 3 classrooms.

This research study aimed to compare the best practices teachers in mainstream and private schools use to support learners identified with ADHD, especially multiplication mathematical problems, times tables, figures, and diagrams about multiplication. Multiplication is identified as the most complex for learners diagnosed with ADHD and was therefore explored (Charlesworth & Lind, 2012). The study also focused on the teachers' knowledge about the neurodevelopment of ADHD-identified learners and the support teachers and learners receive in inclusive education contexts.

In inclusive education, much research shows a significant gap in teachers' understanding of neurodevelopment and mathematical interventions for learners struggling with ADHD (Deloche & Seron, 2018). Nazarboland, Abedivzadeh, and

Ghanbari (2019:1) state that ADHD is a neurodevelopmental disorder affecting 11,1% of Foundation Phase (FP) learners globally. Anderson *et al.* (2020) agree with the authors mentioned above and indicate that neuro-imaging work has shown brain dysfunctions in learners diagnosed with ADHD leading to learning disorders. Furthermore, Harpin (2017) and Faber (2017) agree and note that 30% of ADHD-identified learners present mathematical learning disorders because of their brain functioning.

The challenge in supporting ADHD-identified learners with mathematics difficulties depends on how knowledgeable the teachers are about the inclusive education principles and the ADHD-identified learners' neurodevelopment. Knowledgeable teachers can considerably impact these learners' lives by creating a love of mathematics. In general, the researcher believes that most FP teachers are not well equipped to support ADHD in learners and for inclusive education. This study compared Grade 3 teachers from private schools and mainstream schools' understanding of the neurodevelopment of ADHD-identified learners, as well as their abilities and the strategies they use to support those with mathematical challenges in inclusive contexts.

1.2 RATIONALE

According to Maree (2012:31), the rationale describes how the researcher became interested in researching the topic and why this phenomenon needs research. Kumar (2014:25) agrees with Maree (2012) and further states that the rationale is based on two beliefs. The first relates to how well a paradigm's methods can answer all the research questions accurately. The second relates to the belief that the methods used in the study will provide a better picture of the phenomenon. In this section, the researcher broadly spoke about her interest based on practical experience and confirmation of research in the specific field based on reading (Maree, 2012).

1.2.1 Personal rationale

The researcher has been engaged with learners in an inclusive classroom setting for the past five years. During this time, the researcher observed an increase in the number of learners diagnosed with ADHD and mathematical challenges in mainstream and private school classrooms. Moreover, she noted that teachers labelled learners identified with ADHD as 'no hope' learners. This led her to believe it is important for FP teachers to understand the neurodevelopment of learners diagnosed with ADHD and acquire information about mathematical inclusive teaching methods. Importantly, Young and Smith (2017) confirm the importance of inclusive education when they assert that for an ADHD-identified learner to understand mathematics, teachers must first understand their neurodevelopment.

As mentioned above, the researcher has five years of experience working with learners diagnosed with ADHD. She became interested in researching this topic when she realised that some teachers have little knowledge of the inclusive strategies that can help learners identified with ADHD with mathematics challenges to succeed. She remembered how a Grade 2 boy diagnosed with ADHD became so angry that he started screaming and throwing tantrums over his lack of understanding about a multiplication sum. There was also an incident where a learner threw his pencils at her and hid under his table, crying bitterly because of mathematics challenges. Harpin (2017) mentions how some factors, such as depression, anxiety, and aggression, can worsen co-existing challenges in learners diagnosed with ADHD. This gap is where the research could supplement the existing literature and contribute to the existing knowledge base.

1.2.2 Academic rationale

Studies show that 84% of South African ADHD learners score poorly in mathematics, and most FP teachers are not well equipped to identify learners with ADHD and provide them with the necessary support. The Department of Basic Education (DBE) explains that barriers to teaching mathematics become apparent concerning different aspects of the curriculum (DBE, 2001), such as the methods teachers use in teaching

mathematics, the availability of learning materials, and how teachers assess learning outcomes. The Education White Paper 6 policy document (DBE, 2001) encourages the education systems to support learners and teachers. Teachers who are not well educated about the inclusive education principles that support ADHD-identified learners struggling with mathematics can aggravate these mathematics challenges (Young & Smith, 2017). Bremner and Thompson (2016) argue that most teachers lack the requisite knowledge to improve the mathematical processing of learners struggling with ADHD. It is therefore assumed that teachers are not fully aware of the brain functioning of ADHD in learners. Undoubtedly, teachers' knowledge in this regard will make teaching mathematical concepts beneficial for learners diagnosed with ADHD. By pursuing the study, the effect thereof can emphasise the significance of research in neurodevelopment and mathematical interventions for the benefit of ADHD-identified learners.

1.3 PURPOSE OF THE STUDY

The proposed study aimed to explore Grade 3 FP teachers' knowledge of the neurodevelopment of learners identified with ADHD. As the researcher in this study, the following objectives were pursued:

- To find out how teachers in mainstream and private schools support learners diagnosed with ADHD with mathematical challenges.
- To determine to what extent teachers understand ADHD and neurodevelopment.
- To compare teachers in the mainstream as well as private schools' support strategies for learners identified with ADHD.

1.4 RESEARCH QUESTIONS

Researchers make use of research questions as a beacon to guide their studies. Research questions are used to get a better understanding and explanation of a topic under investigation. Hartell, Joubert, and Lombard (2016) claim that well-formulated questions can expose new research problems, resolve long-standing controversies, and challenge old beliefs. Research questions are valuable because they can reflect

on, examine, and promote intellectual activity. Maree (2012) supports the above claim and explains that a research question specifies what the researcher focuses on and reiterates that the right research questions direct the researcher to relevant literary resources and inform the data collection process. In this study, the following primary and secondary research questions were used:

1.4.1 Primary research question

How do Grade 3 FP teachers in mainstream and private schools conceptualise ADHD and mathematics access?

1.4.2 Secondary research questions

- What are teachers' perspectives on ADHD, neurodevelopment, and mathematics interventions in the Grade 3 Foundation Phase?
- What kind of support do teachers in mainstream and private schools receive to enhance mathematics access for learners diagnosed with ADHD?
- Which inclusive strategies do teachers in mainstream and private schools use to influence learners identified with ADHD with mathematical challenges?

1.5 CONCEPT CLARIFICATION

ADHD

According to Abedivzadeh *et al*. (2019:1) ADHD is a compound neurodevelopmental condition characterised by impulsivity and hyperactivity. Harpin (2017:1) similarly describes ADHD as a developmentally inappropriate level of inattention and hyperactivity-impulsivity that causes impairment. Smith and Young (2017:1) state that ADHD is a neurodevelopmental disorder caused by the dopamine and serotonin systems in the brain. In this study, ADHD refers to a dysfunction in a learner's brain that affects attention span, impulse control, emotions, and activity levels.

ADHD-identified learner

Sternberg and Sternberg (2012:163) state that an ADHD-identified learner is a child in school that is diagnosed with the disorder ADHD. Furthermore, they state that learners with ADHD show several distinctive symptoms, such as distraction by irrelevant sights and sounds. They often fail to pay attention, they are susceptible to

making careless mistakes in their work, they can fail to read instructions completely, they are susceptible to forgetting or losing things, and they tend to jump from one incomplete task to another task (Bakker, 2015). Greenblatt (2017:3) agrees with Sternberg and Sternberg (2012) and adds that an ADHD-identified learner is not a learner with a disease, but instead is a learner with a disorder or syndrome. Learners diagnosed with ADHD also have behavioural symptoms such as anxiety, aggression, and depression. These behaviours can lead to challenges at home or school. In this study, the researcher focused on ADHD-identified learners taking into account the many symptoms mentioned above.

Foundation Phase (FP)

Harpin (2017:15) states that the FP refers to Grade 1 to Grade 3 learners in mainstream and private schools. Meier and Naude (2014:133) further explain that in the FP, the most important concepts are laid. Learners in the FP use mathematics as a fundamental way of understanding and describing the world around them. Deloche and Seron (2019:18) agree with the authors mentioned above and state that FP is the substructure for young learners between five and eight years of age. Furthermore, Deloche and Seron (2018:18-19) state that “mathematics entails understanding as the learner’s number sense develops in the FP”. This study focused on Grade 3 FP learners from the ages of eight and nine years, as the researcher believes that this is where a strong sense of numbers starts developing. This belief will explain the importance of teaching mathematics (multiplication) in the FP.

Inclusive education

Nel *et al.* (2013:7) describe inclusion as the “right to educate all learners” even if modifications, adaptions, and support are needed. Harpin (2017:15) similarly regards inclusive education as the “recognition between differences and uniqueness among children”. In turn, Forlin and Loreman (2014:4) define inclusion as the ongoing process of providing quality education for “all learners”. This study focused on inclusion as education for all and investigated the strategies to ensure ADHD-identified learners with mathematics difficulties access the learning area.

Mainstream schools (within the inclusive context)

According to Buchanan and Buchanan (2016), mainstream schools are for all children (with or without disabilities). These schools are controlled by the government and follow a specific learning programme. Harpin (2017) agrees that mainstream schools accept all children but mentions a few disadvantages. According to Harpin (2017:17-19) “special need children in mainstream schools may not get all the assistance they need from the teachers”. Mainstream schools allow about 30-40 learners in a classroom setting. Learners with special needs can, therefore, easily be neglected. Therefore, these types of learners can drop out or be seen as "in the way" by most teachers (Harpin, 2017:17).

Mathematics

Krüger, Landsberg, and Swart (2016:241) define mathematics as being a collection of “rules”: arithmetic computations, mysterious algebraic equations or geometric proofs that need to be learnt in order to pass an examination. According to the Cambridge English Dictionary, mathematics is the science of numbers, forms, amounts, and relationships. Similarly, Deloche and Seron (2018:18-19) define mathematics as “symbols and notations for demonstrating numerical, geometric, and graphical relationships”. Meier and Naude (2014:2) agree with Krüger *et al.* (2016) and state that mathematics is “symbols, numbers, and images that explain and communicate our thoughts”. This study focused on mathematics as the science of numbers, forms, and relationships and the importance of supporting ADHD-identified learners in inclusive ways to understand mathematics better.

Neurodevelopment

The research study used the concepts of neurodevelopment and brain functioning interchangeably. In specific discussions using the term brain functioning will make it easier for the reader to understand what the researcher is referring to and how the brain works when the ADHD-identified learner thinks or learns. In this study, the term neurodevelopment refers to the brain psychology and development area when ADHD-identified learners are educated. In turn, Swingle (2015:21) explains that neurodevelopment is the “assessment of brainwave activities”. Similarly, Allen and Gramlich (2019:1) explain that neurodevelopment entails “examining the relationships

between the brain's functioning and behaviours". Kaufman, Maricle, and Miller (2019:392) agree with the above authors and state that neurodevelopment "studies associate the nervous system's biological organisation and function with cognitive processing and a way of behaving". Furthermore, Bakker (2015) describes neurodevelopment as the functions and activities of particular parts of the brain.

Private schools (within the inclusive context)

According to Buchanan and Buchanan (2016:7), private schools were first established by religious missionaries. Buchanan and Buchanan (2016:7-8) describe private schools as "organized, in order", and only a small number of children in one classroom (about 11 learners and not more). Parents enrol their children in a private school to access a comprehensive programme of learning and living that they find most suitable to the needs of their children. This allows teachers to approach and give more individual attention to each learner, especially learners with special needs. Private schools are "neither operated nor funded by an agency of government" (Buchanan & Buchanan, 2016:96). Harpin (2017:17) agrees with the above-mentioned authors but also state that "many private schools are more and more out of most parents' financial reach" because private schools become more expensive each year.

1.6 WORKING ASSUMPTIONS

Maree (2012) postulates that a working assumption is a researcher's belief without certain proof or knowledge. Researchers must revisit their assumptions at the end of their research study to ascertain whether the research is reliable and represents participants' responses. Accordingly, a qualitative study was undertaken, and a suitable hypothesis was formulated that guided the research. Table 1.1 below presents the working assumptions, and these beliefs were addressed in the study.

According to Haenssgen (2019), assumptions are statements contemplated as true based on logic but without proof. The researcher named and addressed some assumptions regarding this study in this table. The literature contained substantial scientific evidence regarding the neurodevelopment of the disorder ADHD (Smith & Young, 2017). Therefore, the researcher stayed vigilant of what teachers know in

comparison to the evidence in the literature. Table 1.1 reflects the study's working assumptions.

Table 1.1: Working assumptions

Assumptions	Addressing these assumptions
Most teachers have the wrong perspective about ADHD-identified learners and inclusive education.	Teachers have developed a finer understanding over the years of ADHD-identified learners and inclusive education to support these learners (Smith & Young, 2017).
Teachers have a lack of understanding of the neurodevelopment of ADHD-identified learners.	The literature contains substantial scientific evidence regarding the neurodevelopment of the disorder ADHD (Smith & Young, 2017).
Teachers lack inclusive knowledge principles to support learners diagnosed with ADHD and with mathematics difficulties.	Some teachers give learners diagnosed with ADHD the right support through inclusive education, and these learners usually succeed in many things in life (Harpin, 2017).

1.7 LITERATURE REVIEW

According to Kumar (2014), two broad functions of a literature review are to provide a theoretical background to your study and to enable you to contextualise your findings in relation to the existing body of knowledge and refine your methodology. Furthermore, Maree (2012) states that a literature review is usually an overview and summation of varied research relevant to the study under investigation. The researcher identified the gap between written work and the possible literature flaws during the literature review (Maree, 2012). After identifying these aspects, the researcher methodologically addressed the identified gaps and shortcomings (Maree,

2012). In the section below, a literature overview was provided of research appropriate to the research topic and salient facets of this study. Despite the inclusive principles suggested in the literature, none of the literature sources has provided comparative and conclusive evidence of how teachers support learners diagnosed with ADHD in mathematics learning.

1.7.1 Characteristics of ADHD

The literature describes ADHD as a brain dysfunction in learners encompassing inattention, hyperactivity, and impulsivity. Harpin (2017:186) describes ADHD as a "neurodevelopmental disorder that can manifest the same ADHD symptoms in all the learners diagnosed with ADHD". The above author mentions persistent inattention and impulsivity, increased motor restlessness, and difficulty starting tasks and sustaining them. Mash and Wolfe (2019:120) confirm the above assertions and state that "ADHD is identifiable by the characteristic behaviours manifested uniquely in different learners". According to Sjöwall and Thorell (2022), ADHD is related to multiple neurodevelopmental deficits such as delay-related behaviours and emotional dysregulations.

Abedivzadeh *et al.* (2019:3) agree with Sjöwall and Thorell (2022) and further explain that with ADHD, there are "co-existing difficulties". These difficulties can be characterised by anxiety, depression, conduct disorders, oppositional disorders, affective disorders, and Tourette syndrome disorders. Honkasilta, Jahnukainen, and Sandberg (2014:313) agree with the above-mentioned authors and state that certain characteristics of ADHD, such as, excitability, aggressiveness, uncontrolled emotionality, hyperactivity, and impulsivity, originate from a "brain dysfunction". Therefore, one can assume that the cognitive and intellectual deficits of ADHD-identified learners may lead to learning and mathematical problems. In turn, Kaufman *et al*. (2019:1) discuss the characteristics that learners diagnosed with ADHD present in classrooms. The authors mention "reading, language, handwriting, coordination problems, and mathematical problems". According to Sternberg and Sternberg (2012:164), studies have shown that learners identified with ADHD present more

"variable and slower reaction times" when completing challenging tasks or activities. The authors' assertions support the researcher's viewpoint regarding the importance of teachers' understanding ADHD as well as embedded neurodevelopment. In the section below, the focus falls on teachers' knowledge of ADHD in inclusive contexts.

1.7.2 ADHD in inclusive contexts

Inclusive education requires that children with disabilities are included in regular classrooms (Dei, Mahlo, & Phasha, 2017). Harpin (2017:150) mentions three important words a teacher should remember when teaching mathematics in inclusive contexts. These words are "structure, flexibility, and relationships". *Nel et al.* (2013) differ somewhat from the above authors and state that inclusive education only requires respect for and accommodation of all learners in a school environment. Bornman and Rose (2010:6) express the opinion that the education of ADHD-identified learners in inclusive contexts is the best when it encompasses "addressing barriers successfully" to make learning easier for learners diagnosed with ADHD.

Abedivzadeh *et al.* (2019:3-5) state that 7% of school-aged children are diagnosed with ADHD. In this regard, Anderson *et al.* (2020) emphasise the importance of inclusive education when they state that more than 50% of young learners diagnosed with ADHD present problems in mathematics. According to the Department of Basic Education (2016), mathematics pedagogy in an inclusive context aims to enhance learners' confidence to approach mathematical situations without bewilderment and fear and with a critical awareness of how to use mathematical relationships in environmental, social, cultural, and economic relations.

Anderson *et al.* (2020) mention that FP learners diagnosed with ADHD present specific problems in mathematics. The authors assert that ADHD-identified learners struggle to recognise certain mathematical concepts, turn written questions into mathematical symbols and identify and understand symbols. Abedivzadeh *et al.* (2019:5) agree with the above authors and mention that ADHD can also challenge learners with sorting a numeral series and their potential to perform the four fundamental operations of mathematics, and execute correctly, as well as duplicating

figures and observing operating symbols correctly. According to Badenes *et al.* (2022), ADHD in an inclusive mathematical context consists of social engagement and positive interpersonal relationships between the teachers and the ADHD-identified learner. Harpin (2017:153) reiterates the importance of teachers' knowledge about the varying capabilities of ADHD-identified learners in inclusive contexts. Forlin and Loreman (2014:8) agree with Harpin (2017:153) but confirm that teachers have "inadequate training, resources, and learning materials" to support learners diagnosed with ADHD.

Following the above perspective, the study explored teachers' perceptions regarding mathematics learning for ADHD-identified learners. Teachers in inclusive classes must understand developmental milestones and learners' support needs in regular classes to differentiate content and pedagogy for easy access.

1.7.3 Teaching mathematics to children diagnosed with ADHD in developed countries

McGinn and Schiefelbein (2017:1) state that developed countries are most likely to conduct studies about neurodevelopment and other learning disorders. Forlin and Loreman (2014:10) agree with this and state that developed countries act proactively to remove mathematical barriers to enable the full participation of all learners in inclusive classes. According to the authors, these are the critical aspects of making inclusive education successful for learners diagnosed with ADHD.

However, they indicate that North America, the United Kingdom, and Australia are more developed regarding inclusive education implementation. The authors mention that the countries studied mathematical neurodevelopment and ADHD learning disorders. McGinn and Schiefelbein (2017:357) disagree with the principal issues raised by Forlin and Loreman (2014:10) by mentioning that the "Asia-Pacific region has become interested in learning disorders and has focused on ADHD and neurodevelopment". Collie, Frydenberg, and Martin (2017:190) express a contradictory opinion to those mentioned above and state that the focus of the success of inclusive education in developed countries is the "three main classroom-level

processes". It starts with "positive relationships between the teachers and the ADHD-identified learners, effective ways of promoting social and emotional development, and understanding the neurodevelopment of typically developed and ADHD-identified learners" (Collie *et al.* 2017:191). Badenes *et al.* (2022) agree with Collie *et al.* (2017:190) and claim that "closeness between the teacher and learner identified with ADHD demonstrates a higher level of emotional and behavioural engagement" in these learners.

Honkasilta *et al*. (2014:12-13) mention that ADHD is regarded as a "basis for remedial education practices" in developed countries. The authors further explain how these countries use therapeutic and psychometrical approaches to protect learners diagnosed with ADHD against judgments and labels when teaching mathematics. Meier and Naude (2014:39) debate against the above authors' statements and state that "developed countries are more successful because of their advantages in supporting teachers in inclusive education". These authors mention advantages such as financial support, better resources, and environments. Honkasilta *et al.* (2014:13) argue that the material benefits of developed countries are not the key to their success in inclusive education, but rather their focus on "treating and adapting ADHD-identified learners' educational environments". Clearly, developed countries are more aware that a one-size-fits-all approach to mathematics instruction cannot work. The section below discusses how third-world countries use inclusive education to support learners identified with ADHD and mathematics difficulties.

1.7.4 Teaching mathematics to children diagnosed with ADHD in African countries

Dei *et al.* (2017:2) state that Inclusive education in African schools is at a crossroads. According to the authors, a neo-liberal agenda has led to significant challenges in African schools' inclusive education. Furthermore, Ayehsabu (2020:3) asserts that African countries "failed" to plan for reasonable leadership practices and inclusivity in diverse schools and communities. Dei *et al.* (2017:5) agree with the above author and mention that African countries' pre-colonial educators are no longer needed. Those educators could understand education and explain mathematical concepts in better

ways. Therefore, inclusive education in African countries would have to start accepting, among other things, the “social differences” in communities (Dei *et al.* 2017:5).

Pather and Slee (2018) agree with the above authors adding that most schools in African countries are in rural areas and receive less funding than in some parts of the world. According to the authors, teachers in these areas are inadequately qualified to teach in inclusive contexts. The above situation can lead to challenges in supporting and understanding the neurodevelopment of ADHD in learners. Dei *et al*. (2017) and Pather and Slee (2018) concur concerning the main challenges teachers in African countries experience regarding inclusive education. Accordingly, the challenges teachers face are a lack of resources and materials to make teaching mathematics easier, an inflexible curriculum and the lack of assessment of learners with brain dysfunctions, such as ADHD.

According to Pather and Slee (2018:5), “Libya is one of the African countries that struggles to implement inclusive education” and is further struggling with human rights violation crises. In the process, the educational needs of ADHD-identified children in Libya are unmet. In the foundation phase, ADHD-identified learners struggle with mathematics due to the lack of training of teachers, especially in inclusive education. Pather and Slee (2018:31) also cite “Rwanda and Zanzibar” as countries struggling to implement inclusive education. Furthermore, these countries have additional challenges with English as the medium of instruction as well as the lack of training of teachers.

The above authors paint a bleak picture of inclusive education and support strategies for learners diagnosed with ADHD and with mathematics challenges in African countries. Teachers face challenges such as “low motivation, negative attitude towards ADHD-identified learners, a rigid curriculum, and lack of training and support” for inclusive education success (Pather & Slee, 2018:87). Badenes *et al.* (2022) mention that conflict between the ADHD learner and teacher can lead to behavioural

difficulties such as aggression, anxiety, and depression in the learner. Therefore, 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 2018:3). Furthermore, the literature provides evidence of a gap in professional teacher education to support learners diagnosed with ADHD in mainstream and private schools. In the section below, the teaching of mathematics to learners diagnosed with ADHD in South African contexts is discussed.

1.7.5 Teaching mathematics to children diagnosed with ADHD in South African contexts

Krüger *et al.* (2016:52) state that "58% of young learners in South Africa grow up in a situation characterised by poverty and neglect". Children born and raised in such circumstances are at risk of developing learning difficulties. Nel *et al.* (2013:6-7) argue that South Africa "ratified the Salamanca protocol" to transform education into an inclusive education system in 1994. Furthermore, Nel *et al.* (2013:7) mention that the "Education White Paper 6 made education possible" for ADHD-identified learners and enables them to be seen as equal members of society. Apart from the DBE (2011), government departments generated reports, policies, laws, and programmes to support inclusive early childhood development in South Africa (Krüger *et al.* 2016). Donald *et al*. (2014:311) disagree with the above authors and state: "little is known about the needs of ADHD-identified learners in South Africa". Meier and Naude (2014) concur with Donald *et al.* (2014) and state that South African teachers need to know about the different learning disabilities. It is imperative to note that teachers' knowledge could influence compatibility in mathematics pedagogy for ADHD-identified learners and the conceptualisation of disabilities.

According to Henning (2013:61), mathematical concepts can "develop evenly" if teachers in South Africa instruct mathematics carefully and systematically. This view

supports Donald *et al.'s* (2014) argument about teachers lacking knowledge of mathematical interventions. Furthermore, Donald *et al.* (2014:311-312) mention that learners diagnosed with ADHD fall behind in mathematics because of "teachers not receiving enough support from the District Based Support Teams" (DBST). District Based Support Teams refer to professional support services at the district level, with their key function being to assist educational institutions. These support services should provide specialised learner and educator support when identifying barriers (DBE, 2001). Furthermore, according to Henning (2013), teachers do not have all the necessary learning materials and resources to support learners diagnosed with ADHD more concretely with mathematics. The research therefore aimed to provide empirical data regarding teachers' perspectives on the neurodevelopment of ADHD-identified learners in inclusive classes and thereby contribute to the South African knowledge base.

1.7.6 Teachers' knowledge about the neurodevelopment of ADHD in learners

Deloche and Seron (2019:14) state that "little research" has been done on the neurodevelopment of ADHD in learners and mathematics teaching in the literature. Furthermore, Deloche and Seron (2018) believe that when teachers understand the neurodevelopment of ADHD in learners, many countries can achieve inclusive outcomes. Badenes *et al.* (2022) agree with Deloche and Seron (2018:15) and claims that if teachers know how to support learners diagnosed with ADHD and successfully apply inclusive principles, it can help lessen the possibilities for these learners to "drop out of school, psychological distress, and internalizing and externalizing their disorders during further education".

Abedivzadeh *et al.* (2019) agree with Deloche and Seron (2018:14) that ADHD is a "complex neurodevelopmental brain disorder" that most teachers do not understand adequately. Before teachers' present mathematics lessons, they must know that ADHD-identified learners struggle with short-term memory, as well as with paying attention, and also with behavioural problems. Therefore, Deloche and Seron (2018) give practical advice when describing strategies to help teachers understand learners diagnosed with ADHD with mathematical learning. Additionally, ADHD-identified

learners can process limited information, while disregarding the embedded characteristics mentioned above may block the learners' processing of relevant information and lead 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), specific studies were undertaken to understand humans' struggles with language and mathematics about the functioning of their brains. Goldberg (2017:8) further explains that ADHD influences the "prefrontal cortex area of the brain that controls the child's attention, memory, and decision-making processes". These are also the three functions that influence ADHD disorder. Ayaz and Dehais (2019) suggest ways of stimulating these brain areas to help ADHD-identified learners focus better when doing mathematics. According to these authors, "transcranial direct current stimulation can help the brain's attention, memory, and behaviour areas that are influenced by certain disorders or dysfunctions to function better" (Ayaz & Dehais, 2019:143). This study aimed to explore teachers' knowledge of the neurodevelopment of learners diagnosed with ADHD. In addition, this study also observed whether teachers use the correct inclusive education methods to support ADHD learners in mathematics.

1.8 CONCEPTUAL FRAMEWORK

Maree (2012:42) describes a conceptual framework as a "researcher's map" that describes a specific situation and clarifies what is happening. Furthermore, a conceptual framework can be seen as a researcher's thinking tool and guide. Maree (2012) also elucidates that the conceptual framework forms a possible link between ideas and data, observations and an explanation, or a theory and logical proof. This study merged three theoretical frameworks to develop a conceptual framework as a lens to understand the phenomena under investigation. This conceptual framework consists of the following theories: Piaget's (1896-1980) neuroplasticity theory, Donald Olding Hebb's (1904-1980), predominantly neurophysiological theory and Vygotsky's (1896-1934) sociocultural theory (Donald *et al.* 2010:49). These theories underpinned the study. In this regard, Louw and Louw (2007) merged Piaget's and Vygotsky's theories. According to the above authors, the two theories focus on teachers

scaffolding ADHD-identified learners to acquire mathematics knowledge and skills. The researcher merged Hebb's theory with Piaget's and Vygotsky's theories to better understand how an ADHD-identified learner's brain works and where the teacher can adjust mathematics-inclusive teaching. Furthermore, the researcher believes a conceptual framework will provide broad insights to support learners diagnosed with ADHD's access to mathematics.

1.8.1 Piaget's neuroplasticity theory

The neuroplasticity theory has diverse implications for understanding children's cognitive development and educational methodologies. According to Piaget's theory, brain functions affected in specific areas can be corrected with the "appropriate form of intervention and training" (Donald *et al.* 2010:49). Therefore, this study used Piaget's theory to understand the neurodevelopment of ADHD learners. This theory also explains how the brain can be trained and exercised to support ADHD-identified learners with mathematical problems.

1.8.2 Vygotsky's sociocultural theory

Louw and Louw (2007) state that the zone of proximal development proposed by Vygotsky refers to the improvement of the performance of a child when working independently or under the guidance of skilled adults, such as teachers. Vygotsky's sociocultural theory mentions that FP learners learn new skills from adults or teachers who model and structure the learning experience. Learners diagnosed with ADHD cannot learn mathematical principles and develop executive functions independently or in the same way as learners developing typically (Donald *et al.* 2010). Therefore, the zone of proximal development was used to explain why the teacher is the bridging force between the known and unknown.

1.8.3 Donald Olding Hebb's predominantly neurophysiological theory

According to Hergenhahn and Olson (2012:372-373), Hebb's theory focused on "education and two kinds of learning". The first is the gradual build-up of cell assemblies and the phase sequence during infancy and childhood. The second kind of learning occurs once the phase sequence has been developed; subsequent

learning typically involves rearrangement. This study also used Hebb's theory (1980) to focus on the learning and memory of the brain. The neurophysiological theory helped the researcher to observe whether teachers used the theory in inclusive teaching to scaffold ADHD-identified learners' mathematics challenges. Figure 1.1 below illustrates how the three theories were merged into one figure and applied in this study.

Figure 1.1 on the following page illustrates how the researcher merged the three theories in one model and used them in her study. Figure 1.1 presents a picture of a neuron. Neurons are information messengers. They transmit information between different brain areas (Donald *et al.,* 2019). However, learners diagnosed with ADHD have low levels of neurotransmitters. This is the main feature of ADHD, therefore, this study focused on the teacher's knowledge of the neurodevelopment of learners diagnosed with ADHD. The green blocks represent Piaget's theory (1896-1980); the yellow block and circles, in turn, represent Vygotsky's theory (1896-1934), while the purple blocks represent Hebb's theory.

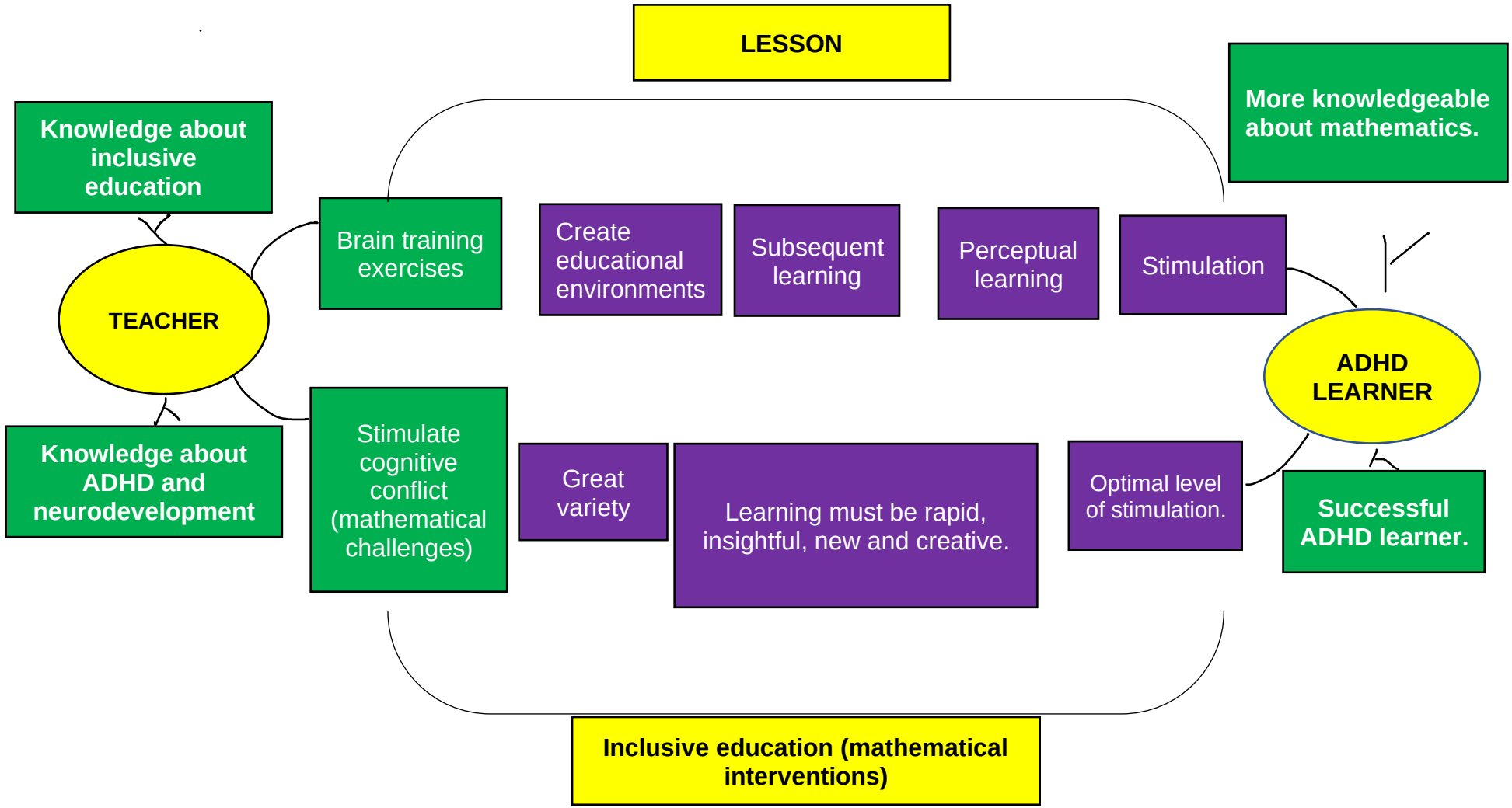


Figure 1.1: Merged frameworks from Vygotsky, Hebb, and Piaget, as adapted in this study.

1.9 EPISTEMOLOGY AND METHODOLOGICAL PARADIGM

This section introduced the epistemological and methodological approaches to the study.

1.9.1 Epistemology

Epistemology is an approach within the positivist paradigm or a positivist approach to the known reality (Hartell, Joubert & Lombard, 2016). Iannini, Nazir and Pedretti (2018) explain that a paradigm is a frame that represents the view of one's belief that pertains to how people assemble the understanding of their realities. Reality must be verified and tested to make predictions. According to Hartell *et al.* (2016), reality is known and reported according to observable facts and objectively approached. In this study, the interpretivist paradigm was used. It is also a fact that reality cannot be determined objectively. Therefore, this paradigm enabled the researcher to be aware of reality socially and subjectively (Hartell *et al.* 2016). Thus, the interpretivist paradigm is mostly concerned with how individuals explain the world around them. The interpretivist paradigm assumes that social reality is not singular or objective but shaped by context experiences. Interpretivists understand that they cannot separate values and facts nor view the social context in isolation from objective truths.

The potential advantage of this paradigm was that it was good for exploring hidden reasons behind difficult social processes. It determined whether teachers know enough about ADHD, neurodevelopment, and mathematics-inclusive education. Secondly, this paradigm helped the researcher better understand the phenomenon. Thirdly, this paradigm helped uncover interesting research questions for more research in the future. Lastly, the research was conducted in case studies that provided the researcher with more genuine information related to the object of research (Iannini *et al.* 2018). However, a challenge could have been that the teacher interviews may not necessarily be equally knowledgeable about the phenomenon, which may affect the study's trustworthiness. However, the challenge was overcome by gathering knowledge from a subjective angle and testing teachers' knowledge or lack thereof. This type of research could be time-consuming. The researcher made sure to use her time more effectively by arranging her interviews on specific dates and sticking to those dates accordingly (Maree, 2012).

1.9.2 Methodological approach

A qualitative approach was adopted that is described by Maree (2012:59) as an "interpretive research approach." Qualitative research focuses on understanding how people interpret their experiences, how they conceptualise their world, and the meaning they attribute to their

experiences (Maree, 2012). Hartell *et al.* (2016) mention that qualitative approaches investigate and understand a phenomenon. This study investigated how teachers present mathematics through inclusive education principles to ADHD-identified learners and how they understand the neurodevelopment of these learners.

Following this approach may enable the researcher to explore teachers' subjective perceptions in detail within the specific context of this study to develop a deeper understanding of the teachers' perceived needs and expectations (Maree, 2012). Accordingly, this implies a potential to provide data that are in-depth and rich in meaning, which may provide the insight required to provide a satisfactory reason for this research. The advantages of using qualitative research are that the participating teachers gave the researcher a broader and richer collection of information about the phenomenon under study. The teachers' real emotions were determined during the interviews. Accordingly, teachers' facial expressions and attitudes were evaluated when they answered the questions. The evaluation exposed how teachers present mathematics in an inclusive context. It enabled the researcher to understand teachers' precise situations better and led to more in-depth data that answered the research question (Leavy, 2017).

Two potential challenges were encountered using qualitative research. Firstly, timing could lead to a problem. Teachers can be in a hurry, frustrated, or not in the mood to answer questions. However, this challenge was overcome by dates and times negotiated with the teachers in advance. The teachers were then informed about a specific day on which they could spare an hour for the interview. Preplanning allowed the teachers to prepare mentally and not feel frustrated. Secondly, the five teachers interviewed did not necessarily answer all the questions truthfully. This omission might have led to answers being regarded as untrustworthy. However, this challenge was overcome by asking participants early in the interview to answer all questions truthfully and making confirmatory observations. The researcher did not provide the interview questions beforehand to make it even more trustworthy. The teachers were also asked to sign an undertaking and to be honest in all respects.

1.9.3 Research design

Maree (2012) and Leavy (2017) define a research design as a plan providing the structure on which a study's theories, methods, and instruments could be based. Furthermore, Maree (2012) explains that it is a plan for selecting participants, research and data collection

procedures to answer research questions. It is important to note that a research design consists of a research paradigm, approach, and type. The research paradigm and approach were discussed briefly before elaborating on the research type used in this study to explain this research design better.

1.9.4 Research paradigm

According to Hartell *et al*. (2016), a paradigm helps the researcher to look at research from a particular perspective. Maree (2012) agrees with Hartell *et al.* (2016) and mentions that a paradigm provides a lens through which the study can be interpreted. This study used an interpretive paradigm that provided a lens through which the study could be viewed, interpreted, and explained concurrently, considering the research's social and personal nature.

1.9.5 Research approach

There are three approaches to research, namely, the qualitative, quantitative, and mixed methods approach, respectively (Leavy, 2017). Maree (2007) describes the research approach to change as broad assumptions about detailed methods concerning data collection, analysis, and interpretation. In this case, the study followed a qualitative approach. During the study, an investigation was conducted on teachers' understanding of how to present mathematics through inclusive education principles to learners diagnosed with ADHD and how they understand their neurodevelopment. This approach enabled the researcher to gain broader insights and more information about the phenomenon under study.

1.9.6 Research type

Maree (2012) explains that a research design comprises six research types: conceptual studies, historical research, action research, case study research, ethnography, and grounded theory. Research types help to investigate and gain information about the phenomenon studied. Hartell *et al.* (2016:131-133) describe case studies as "the study of cases by gathering available and necessary information." It needs to be explained that a case study investigates a problem. Maree (2012:75) agrees with the abovementioned authors and describes a case study as a "systematic inquiry into an event or a set of related events which aim to describe and explain the phenomenon of interest."

The study used a multiple case study, enabling the researcher to obtain a more extensive description to explicate the phenomenon. Accordingly, using case studies helped the researcher to observe multiple teachers' conceptualisation of ADHD, neurodevelopment, and

how mathematics teaching unfolds in a natural mainstream schooling research setting (Haenssgen, 2019). Furthermore, this investigation included comparing private and mainstream teachers' conceptualisations of inclusive education principles, mathematics teaching, and brain neurodevelopment for learners diagnosed with ADHD. A holistic understanding of participants' responses to the situation and how they understood it and interacted with others could be obtained. In addition, this study provided insights into teachers' knowledge about incorporating inclusivity in the classroom, learners mathematics books, worksheets, and responding to the neurodevelopmental needs of learners diagnosed with ADHD in their classroom. During the investigation, the researcher used multiple techniques and sources to collect the relevant data (Hartell *et al.* 2016). Furthermore, it created space for the researcher to investigate and explore the realities of the case in specific contexts. Importantly, the multiple case study provided an opportunity to explore the uniqueness and complexity of teachers' understanding of ADHD, neurodevelopment, and inclusive education (Hartell *et al.* 2016). However, case studies can be extremely time-consuming and, in some cases, costly (Haenssgen, 2019). The researcher noted her research decisions and timetable (Hartell *et al.* 2016) to address these challenges. Similarly, the researcher only interviewed in-depth two teachers from the private school and three teachers from the mainstream school.

1.10 RESEARCH METHODS

According to Haenssgen (2019:25), research methods are the strategies used to "gather the data used in the data analysis to better understand the phenomenon under study and to discover new information". Hartell *et al.* (2016) agree with Haenssgen (2019) and add that research methods entail the steps regarding how and where data will be collected. This study used a qualitative approach, and, therefore, the participants were interviewed in their natural settings (the classroom). According to Leavy (2017), the researcher can develop the means to initiate her study and develop an understanding of the topic. This study collected data through semi-structured interviews, observations of mathematics books, worksheets, and field notes. These research methods were explained further under the heading, data collection.

1.11 PARTICIPANTS AND RESEARCH SITES

Creswell (2016) explains that a research question can only be addressed if a sampling procedure is involved. Maree (2012) agrees with Creswell (2016) and mentions that sampling involves the participants and research sites. A research site is a place where participants in

the study can be found (Haenssgen, 2019). Maree (2012) explains that a sample is a subset of the population when the researcher can't include the whole population in the study.

The study comprised social research; therefore, the researcher used non-probability sampling. Non-probability sampling uses non-random criteria, meaning samples are based on factors other than random chance. The researcher's study aimed to comprehensively describe teachers' knowledge and perspectives regarding ADHD, neurodevelopment, and mathematical interventions. Non-probability sampling consists of various forms such as "convenience sampling, voluntary response sampling, purposive sampling, snowball sampling, and quota sampling" (Haenssgen, 2019:55). The study used purposive sampling that entails the researcher choosing participants (teachers) who are holders of specific data (worked with ADHD-identified learners before) and can assist with the research problem (Creswell, 2016). Purposive sampling provided potentially information-rich cases for this study. Flexibility and adaptiveness also helped save time and money while collecting data. Furthermore, the purposive sampling methods helped obtain data from the various extremes of population groups. In addition, it helped the researcher to look at the averages and identify each teacher's perspectives. However, there can be a few disadvantages, one of which is that purposive sampling can be prone to researcher bias. A grounded theoretical framework helped the researcher to minimise biases by prioritising the important data and answering the research questions.

This study used a small sample size to acquire in-depth data in context, while enough time was spent with the participants to exhaust the data on the teachers' understanding of ADHD and the neurodevelopment thereof. Furthermore, the study investigated teachers' inclusive education strategies to support learners with mathematics challenges in mainstream schools. Maree (2012) states that the sample size is determined by the questions and the information to be gathered. Consequently, participants' selection criteria constituted the following characteristics:

- Grade 3 teachers with a Bachelor of Education degree, teaching ADHD-identified learners in mainstream or private schools in the Gauteng Province in Pretoria.
- Teachers with three or more years of experience working with learners diagnosed with ADHD. Three consecutive years were a fundamental consideration of teachers' experience and knowledge for working with learners diagnosed with ADHD (Gawe, Jacobs & Vakalisa 2011). Thus, three teachers were selected from the mainstream school and

two teachers from the private school. Only two teachers were selected from the private school because of the lack of teachers.

1.12 DATA COLLECTION METHODS AND INSTRUMENTS

Data collection and documentation are the approaches, designs, and instruments used to collect information for a researcher's study (Creswell, 2016:153). The data collection methods and documentation in this study included semi-structured interviews and reviewing mathematics books and worksheets.

1.12.1 Semi-structured interviews

Creswell (2016) defines an interview as a method to collect data and investigate, among other things, participants' perceptions about the world in which they live and to explain what their lifeworld is like from their viewpoint. Maree (2012:89) agrees with Creswell (2016:127) and identifies three types of interviews, namely "structured interviews, semi-structured interviews, and unstructured interviews". In this study, semi-structured interviews were used. According to Hartell *et al.* (2016) and Maree (2012), a semi-structured interview is usually viewed as flexible, during which a researcher uses a defined question plan that is more informal when interviewing the participants. The interviews are adaptable when some changes occur, such as unpredictable conditions (for example, when a teacher has insufficient knowledge about the phenomenon). The researcher used semi-structured interviews as a data-collection method to ask specific questions about teachers' perspectives on ADHD, neurodevelopment, and mathematics interventions in FP classrooms. Semi-structured interviews allowed the teachers to explain their perspectives and knowledge regarding ADHD, neurodevelopment, and mathematics intervention strategies.

Similarly, the approach gave the researcher a follow-up questioning opportunity if the participants did not answer completely and to the researcher's satisfaction. Before the interviews, a pre-informative session was beneficial to clarify their understanding of ADHD neurodevelopment. Furthermore, the interviews mainly consisted of eleven questions interviewing five teachers, two from a private school and three from a mainstream school. If there had been issues relating to the COVID-19 pandemic, the researcher would have used recorded zoom interviews. The interviews were held between the researcher and the teachers participating in the study. In this regard, the identified school principal's permission was sought before the research commenced. Furthermore, the teachers' consent was also sought,

and a request for permission to use a voice recorder to ensure no misunderstandings and missed information and notes were taken during the interviews. The teachers' body language was also observed during the interviews.

1.12.2 Observations

Hartell *et al.* (2016:115) define observations as "gathering open-ended, first-hand information through the observation of people or documents at a particular research site". It is believed that this data collection method is necessary to enable the researcher to observe the learners diagnosed with ADHD's mathematics books and the methods and worksheets the teacher used to support the learners struggling with mathematics. This approach enabled the researcher to note how teachers support learners identified with ADHD with mathematics challenges and what inclusive methods they use.

Should the pandemic have restricted the researcher from going to schools to observe the mathematics books and worksheets, the teachers would have been asked to email the essential documents as needed to the researcher. The researcher would then have observed and analysed these documents to get a better insight into the teachers' understanding of ADHD, neurodevelopment, and how they incorporated mathematics-inclusive principles in their pedagogy. The researcher believed that observing the mathematics books of the learners diagnosed with ADHD and the worksheets the teacher used to support these learners would enable her to explore and compare teachers' different strategies in both the mainstream and private schools to support ADHD-identified learners with mathematics challenges. The observations also enabled the researcher to observe how ADHD-identified learners respond to teachers' teaching pedagogy. The researcher observed the mathematics books and worksheets after the semi-structured interviews. Field notes were made to assist the researcher with describing and reflecting on events and ensure no misunderstandings or missed information. According to Creswell (2016:118-122), field notes are useful "tools" that help the researcher to remain focused when observing, reflecting, and identifying the required data.

1.13 DATA ANALYSIS AND INTERPRETATION

Maree (2007:183) describes data analysis and interpretation as the following process after the information has been captured. Hartell *et al.* (2016:109) agree and add that it is the "process of allocating meaning, conclusion and significance to the data" that were collected. Data analysis can only be conducted after the data have been obtained. Hartell *et al.*

(2016:117-120) note that there are different stages of data analysis consisting of "defining the terminology, categorising them under the relevant codes, and then interpreting their meaning".

The themes that emerged after transcribing the data elicited from the recordings and field notes were classified and categorised. Categories were created by ordering data into different categories (for example, necessary to less important), where the researcher saved this information as different records on her computer. The researcher aimed to answer the study's research questions with the data gathered from her participants. Content analysis was the primary data analysis technique used in this study as it helped to identify the frequency with which comments were made about an idea. Hartell *et al*. (2016:118-119) describe content analysis as an "approach" rather than as a method.

Furthermore, Hartell *et al*. (2016) state that identifying code units best describes the data. The advantages of using qualitative content analysis are that it helps the researcher to organise the data, break it up into controllable units, synthesise it by discovering patterns, and finally decide what is important. Using content analysis can be highly time-consuming. This challenge was addressed by working consistently and using highlighters to identify keywords and the data similarities and differences.

1.14 ETHICAL CONSIDERATIONS

Maree (2007: 41, 2012:24) state that a researcher first must "apply a proposal" to the ethics committee, where it will be decided whether the study upholds the ethical considerations in research. Maree (2012:41-42) further explain that ethical considerations pertain to whether the study will ensure the "confidentiality" of the results, findings and the "protection" of the participants. Hartell *et al.* (2016:40) agree with the authors and allude to ethical considerations, including providing consent letters and asking permission.

Firstly, the researcher sought approval from the university ethics committee to conduct the study. The university has ethics committees that "evaluate all research applications and research proposals per specific ethical guidelines" before students can begin their fieldwork (Hartell *et al.* 2016:41). Secondly, the researcher requested permission from the Gauteng Department of Education (GDE) and the District Office. Thirdly, after the researcher received permission from the University of Pretoria's ethics committee, the Department of Education, and the district office. She then approached the school principals to help point her to the classes with learners diagnosed with ADHD. Fourthly, the researcher sought consent from

the parents before approaching the teachers. Finally, after obtaining the parents' permission, the researcher approached the class teachers for the interviews and asked for the learner's mathematics books and worksheets for observation. The researcher did not mention whose documents she observed. Only the class teachers and the researcher's supervisors were informed of the selection criteria. Furthermore, pseudonyms were used to identify the learners diagnosed with ADHD. The other learners were informed about the research, but the researcher did not observe their mathematics books. They also did not know why the researcher observed some of the books. Lastly, although the learners were not physically part of the study, each Grade 3 learner was given a consent form to inform them about the study. The researcher also asked for permission from the parents whose children were diagnosed with ADHD to observe their children's mathematics books and worksheets. The consent letter included the study's purpose, what is expected from the teachers, and assurance of their anonymity and confidentiality. The researcher's contact details were also provided so the participants could contact her with any queries. An informed consent form was included with the participants' information sheet. The participating teachers were informed that they had the right to decline participation and could withdraw from the study at any time without any consequences. Ethical issues were considered in accordance with ethical and legal guidelines (Maree, 2012). A statement was also included that ensured the data would be code-protected and stored at the department of early childhood education for fifteen years. The participating teachers' permission was obtained to use the data for teaching, learning, and further research at the University of Pretoria.

1.15 TRUSTWORTHINESS

According to Maree (2007:86) and Hartell *et al.* (2016:41), trustworthiness consists of describing the "strategies a researcher will follow to ensure and verify the quality of the study". Marshall and Rossman (2016:44) and Maree (2012:140) agree with the authors as mentioned earlier and describe trustworthiness as "the way in which data are collected, sorted and classified." This section mentioned the four aspects that form part of trustworthiness and explains how they were applied in this study. The following elements of trustworthiness were discussed: credibility, transferability, dependability, and confirmability.

1.15.1 Credibility

Credibility refers to the significance of the results and their trust value for both participants and readers (Hartell *et al*. 2016). Corbin and Strauss (2015) agree with Hartell *et al*. (2016)

and state that credibility seeks truthful information. Various methods, such as interviews and observations, were used in the study, which ensured in-depth information was obtained/ According to the authors mentioned above, this would guarantee reliable information. The researcher believed the data collection complied with the requirements set by the authors for credibility, as various perspectives were included. A researcher who did not participate in the research was asked to assess the contents analysis of the study. This included clarifying the basic theoretical orientation, describing the process of exploring the phenomenon, and reporting the aspects that affected the study. Member checking was carried out. This allowed the researcher to explain to the participants how the data analysis was conducted (Maree, 2012 & Hartell *et al*., 2016). This also allowed the participating teachers to explain their meanings, correct mistakes, and add more information. Member checking was done by conducting follow-up interviews, asking participants to comment on the results or discussions in casual settings (Maree, 2012).

1.15.2 Transferability

The second component of trustworthiness is transferability. This refers to how far the results of qualitative research can be stretched, exported, and generalised to other contexts (Maree, 2012). Mertens (2014) agrees with Maree (2012) by explaining transferability as the extent to which the study's research can be generalised to other situations. Creswell (2016:190-191) states that transferability “mirrors external validity”. The researcher provided descriptions of the participants (teachers). The description included the sampling of participants, research sites, and why the researcher believed these participants were suited for her study. It must be noted that the study results cannot be transferred to contexts with different characteristics, and it was not the study's purpose. However, the results contributed to the research and formed mathematical baseline interventions for learners diagnosed with ADHD in FP classes with similar characteristics.

1.15.3 Dependability

The dependability aspect ensured that the results were consistent and did not vary (Corbin & Strauss, 2015). The researcher used various participants from different schools. This selection entailed three Grade 3 teachers from a mainstream school and two teachers from a private school. This selection enabled her to assess how different teachers respond to different settings. In addition, an external person was consulted to audit the research process.

1.15.4 Confirmability

The final component was conformability. This necessitated appropriate documentation of the data and ensuring that no bias was present in this study (Marshall & Rossman, 2016). Furthermore, confirmability was ensured by detailing the exact information of each participant when recordings were made during the interviews. Use was made of observations together with detailed field notes.

1.16 CONCLUDING REMARKS

For this research study, the introduction was outlined, followed by a discussion of a personal statement, the rationale, the purpose of the study, the research questions, concept clarifications, and working assumptions. In addition, a brief literature review was provided regarding the characteristics of ADHD, ADHD in an inclusive context, and how mathematics was taught to ADHD-identified learners in developed and third-world countries. Furthermore, in this chapter, a conceptual framework was coined from three theories to explain how ADHD-inclusive education can be taught better if teachers focus on the neurodevelopment of ADHD-identified learners. After this, the research methodology of this study was described. In this regard, the research paradigm, as well as the research approach and type, was described briefly. Lastly, the sampling methods, ethical considerations, and trustworthiness were discussed and explicated.

2 CHAPTER TWO: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

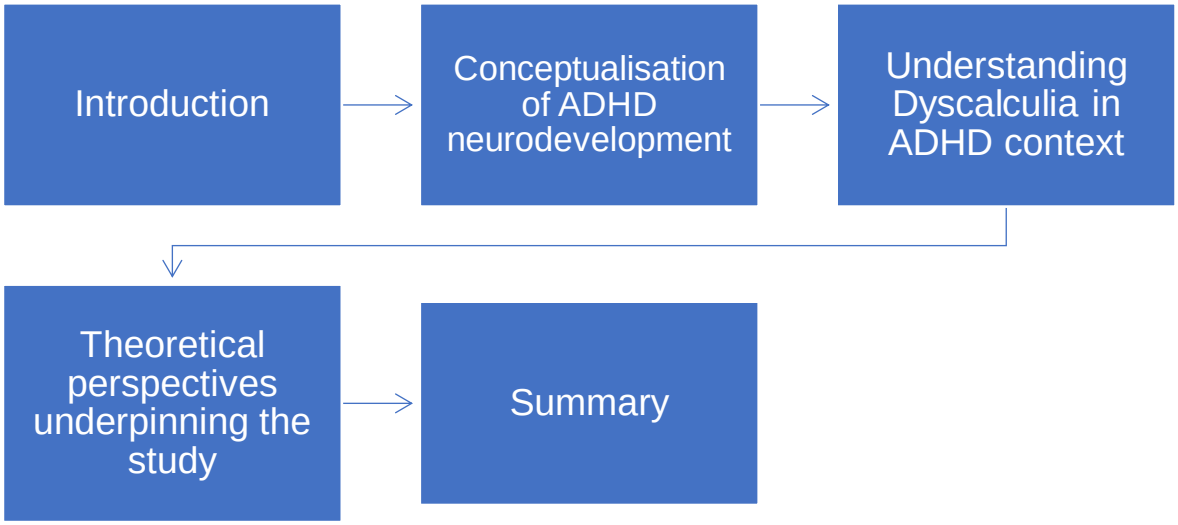


Figure 2.1: Overview of Chapter 2

2.1 INTRODUCTION

Chapter 1 provided the background of the study. To briefly reflect on Chapter 1, the researcher discussed the study's rationale, problem statement, research questions, and conceptual clarification. Chapter 2 provides an in-depth discussion of the conceptualisation of ADHD, neurodevelopment, and understanding dyscalculia in an ADHD context. The chapter also discusses the theoretical perspectives, namely Piaget's neuroplasticity theory, Vygotsky's sociocultural theory, and Donald Olding Hebb's neuropsychological theory underpinning the study. Lastly, a summary of the chapter is provided.

2.2 CONCEPTUALISATION OF ADHD NEURODEVELOPMENT

According to Mollon (2015), ADHD is not a single discrete syndrome. Mollon (2015) clarifies the phenomenon by stating that there are several forms and spectra of the ADHD disorder with overlap and comorbidity with other conditions. The neurodevelopment of the diagnosis of ADHD exists in a range of atypical features in the circuitry affecting the brain's frontal lobes. According to Faber (2017), if students are diagnosed with ADHD, it may include mathematics learning disabilities or mathematics disorders. The study suggests that ADHD-identified learners will learn mathematics better if teachers understand the disorder of ADHD, neurodevelopment, and mathematical interventions better. Krüger *et al.* (2016:454) define

ADHD neurodevelopment as a "persistent pattern of inattention and/or hyperactivity-impulsivity that interfere with learners' learning". Mollon (2015) agrees with Krüger *et al*. (2016) and further states that ADHD appears to be a hidden core within other mental health presentations. For example, there is a strong connection between ADHD and mood instability (Mollon, 2015). According to the researcher the, mood instabilities, innatention, and hyperactivity can affect mathematics learning.

Greenblatt (2017:7) explains that learners diagnosed with ADHD have "different genes" and lines of thinking than those not diagnosed with ADHD. Greenblatt (2017) clarifies this by stating that the areas in an ADHD brain that control attention, impulsivity, executive functioning, organizing, and focusing are smaller than a non-ADHD learner's brain. Mollon (2015) agrees with Greenblatt (2017), adding that the development of ADHD learners lags two to three years behind compared to typically developing learners. The cause for this is that ADHD brains receive less oxygen-rich blood flow and are less able to utilise blood sugar fuel (Greenblatt, 2017). The researcher believes the factors mentioned above cause ADHD-identified learners to struggle with mathematics and have a challenging time processing information for optimal functioning.

Greenblatt (2017) and Krüger *et al.* (2016) claim that the brain of learners diagnosed with ADHD has different wave activities from the other learners. Leaf (2013) agrees with the authors above and gives a remarkable explanation of an ADHD brain and neurodevelopment. According to Leaf (2013:19), the brain of learners diagnosed with ADHD is like "a big bulb with a mysterious light show inside, a pulsing parade of electrical waves named: Alpha, Beta, Delta, and Theta". These brain waves send communication from one mass of neurons to another, bringing together the regions of the brain to produce experience (Leaf, 2013).

Figure 2.2 below provides an example of the brain wave activities of most children diagnosed with ADHD. Swingle (2015) explains beta as the brain wave that controls a human's consciousness, awake state, and alert state. The beta brain wave of learners identified with ADHD is very active, as seen in Figure 2.2. Furthermore, the alpha brain wave controls how relaxed the learner is, whereas learners diagnosed with ADHD's alpha brainwave are very active, meaning that most of the time they are not relaxed. Swingle (2015) further states that the theta and delta brain waves control the deep relaxation and deep sleep state of humans. As seen in Figure 2.2, the theta and delta brain waves of ADHD-identified learners are very active and distracted. The researcher of this study attempts to give a clear understanding of

why learners diagnosed with ADHD struggle with attention and hyperactivity. According to Leaf (2013), teachers should also focus on their classroom setups because it can positively or negatively affect the brain waves and attention of ADHD learners.

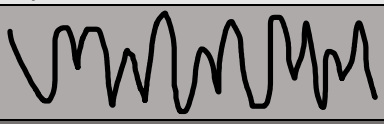
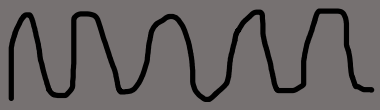
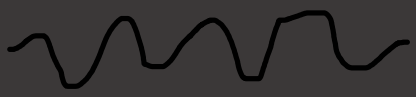
	**Beta** (awake, normal alert, consciousness)
	**Alpha** (relaxed, calm, lucid, not thinking)
	**Theta** (deep relaxation and mental imagery)
	**Delta** (deep, dreamless sleep)

Figure 2.2: Example of most brain waves of learners diagnosed with ADHD.

Swingle (2015:21) explains neurodevelopment as the assessment of brainwave activities. Allen and Gramlich (2019), and Kaufman, Maricle and Miller (2019) maintain that neurodevelopment entails examining the relationships between the brain's functioning and behaviours. Furthermore, neurodevelopment studies associate the nervous system's biological organisation and function with cognitive processing and a way of behaving.

McGough (2014:24) agrees with Swingle (2015:21) and maintains that one popular neuropsychological assessment has shown that ADHD arises from primary deficits in executive functions defined as cognitive processes. The process helps support problem-solving in learners. Learners identified with ADHD have a shortage in these cognitive processes, which further influence their working memory, response inhabitation, and weakness in executive control of the brain. McGough (2014) further mentions that the cognitive process is a significant function of the brain's prefrontal lobes. These prefrontal lobes are implicated further with behavioural hyperactivity, impulsivity, and inattention. The shortage of the cognitive process of the ADHD brain can negatively influence the learning of mathematics. From the perspective above, Bernstein and Lysniak (2018) state that teachers must engage these learners at their level of understanding to teach mathematics more effectively. The fundamental core of mathematics teaching to ADHD learners combines understanding how the ADHD brain learns and how to promote learning through problem-

solving. In this regard, Greenblatt (2017) states that a well-nourished brain is a well-balanced brain; hence, teachers can help improve the mathematics skills of ADHD-identified learners if they understand the neurodevelopment of an ADHD brain. A recent study has shown if teachers use “mindfulness meditation”, it can help train the ADHD brain to focus better (Greenblatt, 2017:176). Greenblatt (2017) further explains that teachers must instruct learners diagnosed with ADHD to use this skill in mathematics lessons. This skill can help with self-regulation, can control inattentiveness, and decrease hyperactivity and impulsivity. Leaf (2013:63) maintains that the conceptualisation of ADHD neurodevelopment can help improve mathematics skills through “positive words and physical touch”, such as a simple high five after each successful task.

Figure 2.3 below explains the brain structure and the frontal lobe's location. According to the researcher, if teachers understand the brain structure of learners diagnosed with ADHD, it will help them to understand their neurodevelopment and the support need of these learners. Teachers can use this knowledge to realise that the frontal lobe controls higher levels of executive functions. Executive functions refer to the brain's cognitive skills, such as planning, organising, and controlling responses. Most learners identified with ADHD have brain dysfunctions starting in the frontal lobe of the brain. If teachers can stimulate and focus more on this area of the brain, it can improve the mathematics learning of ADHD learners (Swingle, 2015). McGough (2014) states that cognitive training approaches to ADHD attempt to strengthen neuropsychological processes such as attention and working memory. Swingle (2015) agrees with McGough (2014), asserting that several commercially available, computer-based, proprietary programs are designed to ameliorate the cognitive functioning of ADHD-identified learners. Cogmed working memory training (CWMT) is the most popular cognitive training approach. This programme provides training in verbal and spatial working memory (McGough, 2014). Furthermore, this programme also supports attention training, cognitive remediation, executive function training, and enhanced cognitive control.

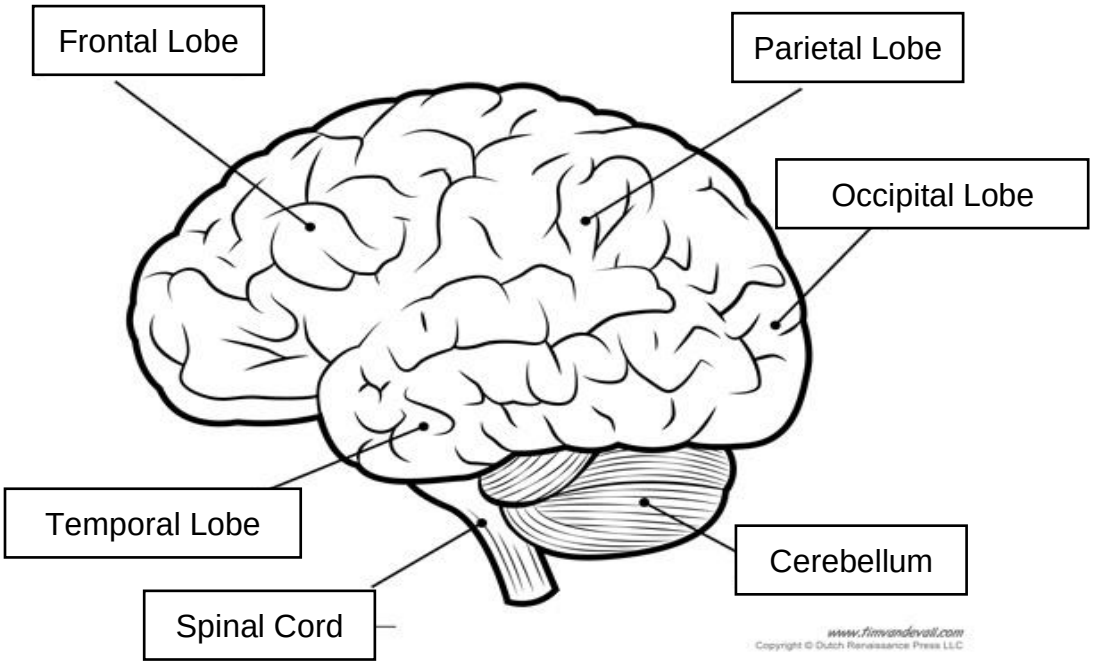


Figure 2.3: Illustration of the different brain structures

(Used from McGough, 2014:23)

2.2.1 ADHD conceptualisation from an international perspective

As mentioned in Chapter 1, some international countries are more developed and have more resources to help doctors and teachers understand the diagnosis of ADHD and the meaning of neurodevelopment and mathematics interventions. James (2007:89) conceptualises ADHD neurodevelopment as the “brain failing to maintain attention, hyperactivity, organizing, and impulsivity”. According to McGough (2014:3), ADHD is a “biologically driven, brain-based disorder”. McGough (2014) somehow agrees with James (2007) and speculates that ADHD behaviours are due to the dysregulation of cerebral fibres resulting from overstimulation. McGough (2014) further believes that ADHD symptoms result from dysregulated sensibility of the nervous system. Both James (2007) and McGough (2014) define ADHD as exceptional impulsivity, restlessness, and emotional reactivity, part of the neurodevelopment disorder. Sir George Frederick, regarded as the "father of British pediatrics", described ADHD as an

"abnormal defect of moral control", and he also believed it to reflect some levels of physical brain damage and dysfunction (McGough, 2014:5). McGough (2014) and Greenblatt (2017) opine that most doctors from England, Scotland, and America conceptualise ADHD and neurodevelopment disorder as inattention and overactive behaviour resulting from brain pathology. These authors further explained it as a complex brain-based, neurodevelopmental disorder arising from social, developmental, environmental, and genetic risk factors.

According to Greenblatt (2017), Krüger *et al*. (2016), and McGough (2014), environmental factors, psychosocial risks, and genetics can influence the neurodevelopment of learners diagnosed with ADHD. McGough (2014) states that environmental factors can include food, alcohol, and cigarette exposure. The researcher believes that if teachers can understand the risk factors of the neurodevelopment of ADHD, mathematics interventions will be easier to mitigate. McGough (2014:22) maintains that brain imaging has shown brain abnormalities such as “smaller brain and white matter volumes with particular decreases in the frontal cortex, cerebellum, and subcortical structures”. Most international doctors and paediatricians believe that therapy, nutrients, healthy foods, medication, deep sleep, and regular exercise can help support the neurodevelopment of learners identified with ADHD, which will benefit their mathematics skills (Greenblatt, 2017). Consolidating the different international submissions about ADHD, most international countries agree on conceptualising ADHD as a diagnosis causing overactivity, restlessness, distractibility, and short attention span. A panel of experts from America in childhood psychopathology proposed some symptoms of ADHD that were based on their own clinical and research experience. According to these experts, a child can only be fully diagnosed with ADHD when impaired behaviour for a minimum of six months take place and six to nine inattentive and hyperactive-impulse symptoms are clear (McGough, 2014).

2.2.2 ADHD conceptualisation from a South African and African perspective

Sheppard (2022) explains ADHD neurodevelopment as a learning impairment originating from the brain. Krüger *et al.* (2016) agree with Sheppard (2022) and further explain that ADHD can negatively influence the neurodevelopment of the brain. According to Kriegler (2015), the South African conceptualisation of ADHD neurodevelopment appears very similar to the international one. South Africa and African countries are primarily impoverished countries compared to some developed countries. This can negatively influence teachers' support systems in these poor countries. Kriegler (2015) further states that certain areas in South Africa and African countries have unvalidated diagnostic instruments leading to inaccurate

estimations of learners diagnosed with ADHD. Therefore, it can lead to learners struggling with mathematics without relating the cause to brain dysfunction, such as ADHD. According to McGough (2014:10), ADHD occurs in "all racial, ethnic, and socioeconomic groups and is not a function of intellectual ability". McGough (2014) further explains that reported rates are higher in poorer families and those raised by single mothers. Kriegler (2015) concurs with McGough's (2014) assertion, clarifying that most paediatricians, doctors, and mental health professionals are located in affluent urban centres, leaving poor urban settlements and rural regions deprived of services. However, Greenblatt (2017) disagrees with McGough (20104) and opines that prosperous cities in South Africa could have just as many learners diagnosed with ADHD because of reasons such as air pollution. According to Makoelle (2016:36), teachers must respond to the "needs" of learners diagnosed with ADHD in all circumstances.

Makoelle (2016) further states that teachers must have the skills to develop an inclusive curriculum and mathematics interventions. Most South African and African teachers differ greatly from teachers in developed countries regarding their skills, classroom set-up, and knowledge. Nel *et al.* (2013:7) state that the "White Paper 6 policy was designed to guide and support teachers in South Africa to educate learners with learning disabilities such as ADHD". Donald *et al*. (2014:311) agree with Nel *et al.* (2013:7) and state that "most of society in South Africa does not know much about ADHD and ways of making teaching and learning more accessible for these learners". Makoelle (2016) agrees with Donald *et al.* (2014) and opines that implementing inclusive education in South Africa and African countries is beset with problems as school managers and governors lack the needed skills to establish effective inclusive education systems in schools. Furthermore, Makoelle (2016) mentions that the school evaluation system created by the Department of Basic Education in South Africa does little to centralise the importance of inclusion in school management and leadership. According to the study, this can be why teachers do not have enough knowledge about learners diagnosed with ADHD, the neurodevelopment of these learners, and the correct mathematics interventions to support learners identified with ADHD. Hence, Makoelle (2016:133-134) states that "the whole-school evaluation (WSE) is a program designed in collaboration with the district-based support team (DBST) to help schools improve and to reflect the needs of schools and those of the teachers, as well as the available resources". Donald *et al.* (2014: 311-312) disagree with Makoelle (2016) and states that "ADHD learners fall behind because teachers lack essential knowledge, resources, and materials to help these learners learn". Donald *et al.* (2014) also mention that not all schools in South Africa and African countries give enough training for teachers to understand the diagnosis of ADHD, the

neurodevelopment of learners diagnosed with ADHD, and possible mathematics interventions.

Makoelle (2016) states that several studies on improving inclusive education and mathematics interventions show that most research has been conducted in developed countries in the northern hemisphere. McGinn and Schiefelbein (2017) agree with Makoelle (2016) and mention that inclusive practices in mathematics emanate from the United Kingdom and the United States. These countries use the inclusion index to guide schools and teachers in developing a better inclusive system. Akyeampong, Hill, and Kleinman (2015) mention that the World Health Organisation (WHO) in South Africa makes use of a mental health Gap Action Programme (mhGAP), which is WHO's action plan to scale up the support for mental, neurological (such as ADHD), and substance use disorders. The action plan also provides practical clinical guidelines for delivering mental health care by doctors. The most relevant treatment package for ADHD learners in low- and middle-income countries consists of high-risk screening groups, educational interventions, and behavioural interventions (Akyeampong *et al.,* 2015). The mhGAP also provides guidelines for care and indicates that each country must adapt and adopt the interventions to their contexts. Resources such as the World Health Organisation (WHO) and Mental Health Gap Action Programme (mhGAP) can help South African and African teachers to be more knowledgeable about ADHD, neurodevelopment, and mathematics interventions. This programme helps with any wide gaps between available resources and urgently needed resources to address any neurological mental burdens.

The researcher believes there is a clear contrast between the developed countries and the South African conceptualisation of ADHD. According to these countries, children diagnosed with ADHD have a frequently occurring, brain-based, neurodevelopmental disorder. The lifelong impact of ADHD extends beyond the disorder's defining features of developmentally inappropriate inattention, hyperactivity, and impulsivity levels. ADHD can also cause other mental health disorders, such as anxiety and depression (McGough, 2014). Some African countries, on the other hand, assert that ADHD is not real, and that teachers and parents fail to maintain appropriate discipline.

2.3 UNDERSTANDING DYSCALCULIA FROM AN ADHD CONTEXT

Bos, Schumm, and Vaughn (2007:69) describe dyscalculia as a "severe disability in learning mathematical concepts and computation". Hudson (2016:53) supports Bos *et al.* 's (2007) findings and defines dyscalculia as "the condition that affects acquiring mathematical skills".

Chinn (2018) concurs with Hudson's (2016) definition and adds that dyscalculia learners struggle with numbers and, thus, the quantities represented by the many symbols used in mathematics. The Department for Education and Skills (2001) states that dyscalculia is a condition that affects the ability to obtain mathematical skills, and it cannot be cured. The DBE (2001) further states that learners can master some numeracy skills and devise effective coping strategies to succeed in life with the right teaching methods. Hudson (2016) explains that dyscalculia can coexist in an ADHD context. Learners diagnosed with ADHD and dyscalculia will lack an intuitive grasp of numbers. The learners cannot recognise “number patterns, difficulty estimating answers, confusion of numbers, reverses of numbers, and extreme difficulty in learning times tables” (Hudson, 2016:55-56). Dyscalculia originates in those parts of the brain that are responsible for mathematical abilities. Many other problems come along with dyscalculia. Children diagnosed with dyscalculia may also struggle to read time and the passage of time, have difficulty keeping up with directions, be confused left and right, and have a poor memory of numbers that can lead to forgetting phone numbers or street addresses.

As mentioned above, the three main characteristics of ADHD are hyperactivity, impulsivity, and attention deficit. Hudson (2016:112) and Krüger *et al.* (2016:245) both define ADHD as a "neurobiological disorder" that cannot be cured but can be controlled using “medicine, behavioural therapy, and lifestyle changes”. The World Health Organisation has accepted ADHD as a genuine medical condition and not just a result of bad parenting (Hudson, 2016).

As mentioned above, authors like Hudson (2016) and Greenblatt (2017) argue that the brain chemistry of learners identified with ADHD is different from that of non-ADHD learners. The authors above further explain that the brain's frontal lobe is designed to control rational and logical behaviour. The human brain's frontal lobe also controls the site of personality, goal setting, planning, and organising. The frontal lobes make use of brain cells that use neurotransmitters to communicate. Furthermore, Bos *et al.* (2007) and Hudson (2016) agree with Greenblatt (2017) and mention that learners diagnosed with ADHD and dyscalculia have less neurotransmitter activity in the frontal lobe region. This shortfall can explain their lack of concentration and other related issues. Hudson (2016) and Krüger *et al.* (2016) state that teachers must be aware of learners diagnosed with ADHD and dyscalculia. Chinn (2018) agrees with Hudson's (2016) and Krüger *et al.’s* (2016:244) findings mentioned above and motivates that the vital life-skill area of mathematics must be taught in an empathetic way that matches the learner's cognitive style.

Chinn (2018) and Hudson (2016) both mention that the special educational needs coordinator (SENCO) should support teachers and advise them on how to teach learners diagnosed with ADHD and dyscalculia. Teachers must create a safe and relaxed environment for learners diagnosed with ADHD and dyscalculia. Hudson (2016) asserts that giving short instructions, repeating key points in mathematics, working slowly through examples, giving enough time for learners to answer questions, choosing easy mathematics language, and being consistent with supporting these learners can help with improvement in some areas. Chinn (2018) asserts teachers should keep several essential elements for communication in mind when working with learners diagnosed with ADHD and dyscalculia. If teachers convey content and instructions about mathematics at a level that exceeds the memory capacity of the learner, the learner will not be able to retrieve the information from memory. Learners make use of their working memory to do calculations. If the steps they use exceed their working memory capacity, they will fail at the task. Consistency is reassuring; if the teacher uses consistency, it will create a feeling of security for the learner. Chinn (2018) further states that teacher training about the theoretical bases of learning difficulties such as dyscalculia and ADHD can be an excellent strategy to help teachers educate these learners. It can also improve the knowledge teachers have about inclusive mathematics strategies. Figure 2.4 below gives a clear description of ADHD and dyscalculia characteristics and their similarities and differences, and the effect it has on mathematics.

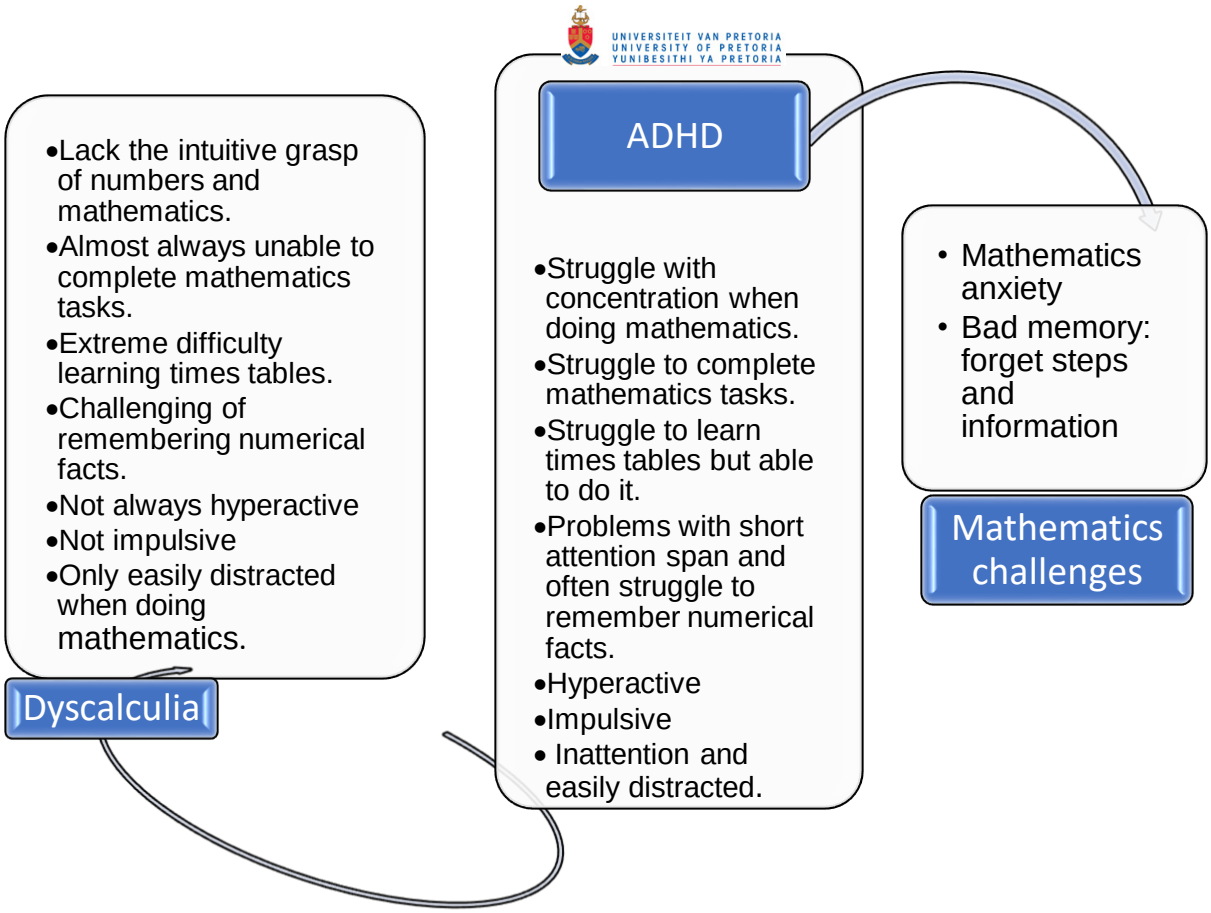


Figure 2.4: The relationship between ADHD and dyscalculia together with the mathematics challenges.

2.4 THEORETICAL PERSPECTIVES UNDERPINNING THE STUDY

Kumar (2014) defines a conceptual framework as an overview of perspectives and research results regarding the study under investigation. Maree (2012) agrees with Kumar (2014) and adds that a conceptual framework is a provisional explanation of events. These events link key concepts and principles recognised in the literature overview. In this research study, the researcher used a conceptual framework. This framework provided the researcher with the necessary platform to plan the study based on existing ideas in education. According to Kumar (2014), a conceptual framework provides a paradigm in which the researcher can study and interpret the results when positioning the results within the broader existing body of knowledge. Maree (2012) also elucidates that the conceptual framework forms a possible link between ideas and data, observations and explanations of a theory and logical proof.

This study merged three theoretical frameworks to form a conceptual framework. The conceptual framework consists of a merger of the following theories: Piaget's neuroplasticity

theory, Donald Olding Hebb's neurophysiological theory, and Vygotsky's sociocultural theory. Creswell (2016) and Hergenhahn and Olson (2012) merged Piaget's and Vygotsky's theories to benefit the study by focusing on the “cognitive development that takes place from the inside out (Piaget) and the outside in (Vygotsky)”. According to these authors, the two theories focused on teachers providing scaffolding to the ADHD-identified learner to acquire the requisite knowledge and skills about mathematics. In this study, the researcher merged Hebb's theory with Piaget's and Vygotsky's theories to gain a greater understanding of how teachers can support learners diagnosed with ADHD’s understanding of mathematics concepts. The conceptual framework provides a broad spectrum of insights to support ADHD learners' access to mathematical concepts.

Piaget's theory helped focus and understand children's cognitive activity and how an individual reflectively uses an idea to construct new knowledge (Tapia, 2012). Piaget's theory will help teachers better understand the neurodevelopment of ADHD learners and how to exercise the brain to improve in mathematics conceptualisation. Krüger *et al.* (2016:240) agree with Tapia (2012) and mention that Vygotsky is well-known for the concept of the "zone of proximal development" (ZPD). The zone of proximal development helped explain why the teacher is the main bridging force between the known and unknown for learners diagnosed with ADHD. Donald Olding Hebb's neuropsychological theory focused on the “gradual build-up of cell assemblies and the phase sequence during infancy and childhood” (Hergenhahn & Olson, 2012:372-373). Hebb’s theory helped the researcher during the observations and interviews to observe whether teachers make use of this theory during inclusive teaching when working with ADHD-identified learners. Figure 2.5 below lists the three theories the study used.

Figure 2.5: Summary of the three theorists' names.

2.4.1 Piaget's neuroplasticity theory and its integration into the research study

According to Hergenhahn and Olson (2012:281), Jean Piaget was born on “August 9, 1896, in Neuchantel, Switzerland”. Piaget showed an early interest in biology and received his PhD

in biology at twenty-one years of age. Piaget soon became an internationally known authority in child psychology. He continued his work studying his own three children. Piaget's theory about intellectual development in children was complicated and extensive. According to Piaget, educational experiences must be built around the learner's cognitive structure. Piaget's optimal education involves mildly challenging experiences for learners so that the processes of “assimilation and accommodation can provide intellectual growth” (Hergenhahn & Olson, 2012:270-281). Piaget, therefore, mentioned that teachers must know the level of functioning of each learner's cognitive structure and create an educational environment that generates opportunities for discoveries.

Piaget's neuroplasticity theory explains how a learner interacts with an experience. According to Krüger *et al.* (2016), Piaget mentions two things that could happen during an experience, assimilation and accommodation. Hergenhahn and Olson (2012) state the number of schemata available to an organism at any given time constitutes that organism's cognitive structure according to Piaget, meaning that the way an organism reacts towards its environment was important to Piaget. This is where the process of assimilation and accommodation starts. According to Piaget, assimilation refers to a kind of matching between the cognitive structures and the physical environment (Hergenhahn & Olson, 2012; Piaget, 1980). The cognitive structure existing at any given time sets the bounds on what the organism can assimilate. Piaget used an example by explaining that if reaching and grasping are available to a child, everything the child experiences will be assimilated into those schemata. Furthermore, Piaget mentioned a second important process, accommodation, that provides a mechanism for intellectual growth. Accommodation is the process of modifying the cognitive structure (Krüger *et al.* 2016*)*.

Suppose a Grade 1 learner struggles with times tables, and the teacher presents the learner with counting blocks he has never had the opportunity to play or work with before, then, these blocks present an opportunity for the learner to use them as a mathematics resource. This behaviour reveals the tendencies of assimilation and accommodation. The Grade 1 learner tries to grasp the counting blocks. To do this successfully, he must accommodate content in more ways than are immediately apparent. The learner must accommodate his visual activities to perceive the counting blocks correctly, for example, stacking the blocks on top of each other or grouping the blocks. In sum, the grasping and stacking of the blocks involve a series of acts of accommodation of the Grade 1 learner's behavioural structures to suit the demands of the environment. At the same time, working with the counting blocks also involves

assimilation. Therefore, the learner assimilates the counting blocks into his framework and assigns the counting blocks a "meaning". According to Hergenhahn and Olson (2012), assimilation and accommodation are functional invariants because they transpire at all intellectual levels, including mathematical development.

Krüger *et al.* (2016) agree with Hergenhahn and Olson (2012) and state that educational experiences must be built around the learner's cognitive structure. Therefore, learners diagnosed with ADHD of the same age and from the same culture tend to have similar cognitive structures, but require different kinds of learning material compared to a typically developing learner. Integrating the neuroplasticity theory in the study indicates that mathematics learning begins with the teacher's knowledge of how to construct new knowledge about challenging mathematics to support learners identified with ADHD. If learners struggle with a specific concept, such as multiplication (times tables), the teachers must use existing knowledge and give meaning to the new concept (Krüger *et al.* 2016). Tapia (2012) agrees with the authors above and asserts that teachers can reflectively use ideas to construct new knowledge and understanding. Learners diagnosed with ADHD must identify similarities in mathematical concepts and match new ideas to those already taught. Piaget's theory can help teachers understand how to reflect thoughts and results in changing and modifying mathematics teaching for ADHD learners to understand the material.

Piaget assumed all organisms tend to create a relationship between themselves and their environment. Piaget believed that the driving force behind intellectual growth is equilibration. Equilibration tends to organise one's experience to ensure adaption (Hergenhahn & Olson, 2012). As discussed earlier in the study, assimilation permits the organism to respond to a present situation by building on previous knowledge. For example, the teacher teaches times tables for the first-time using counting blocks. The learners already have previous knowledge about the mathematical concept ‘plus’. The learners master the new concepts building on their previous knowledge, but there is still a slight cognitive imbalance between their previous knowledge and the new knowledge taught. Because there is a need for harmony (equilibrium), the child's mental structure changes to incorporate these unique aspects of the new concept being taught, thus, causing the sought-after cognitive balance. According to Piaget, the accommodation causes a change in mental structures so that if the previous aspects of the environment were again encountered, they would not cause a cognitive imbalance. The above means that the new cognitive arrangement forms the basis for new accommodations because accommodation always results from a disbalance. Figure 2.6 illustrates the mechanisms of

assimilation and accommodation and the driving force of equilibration that provides steady intellectual growth.

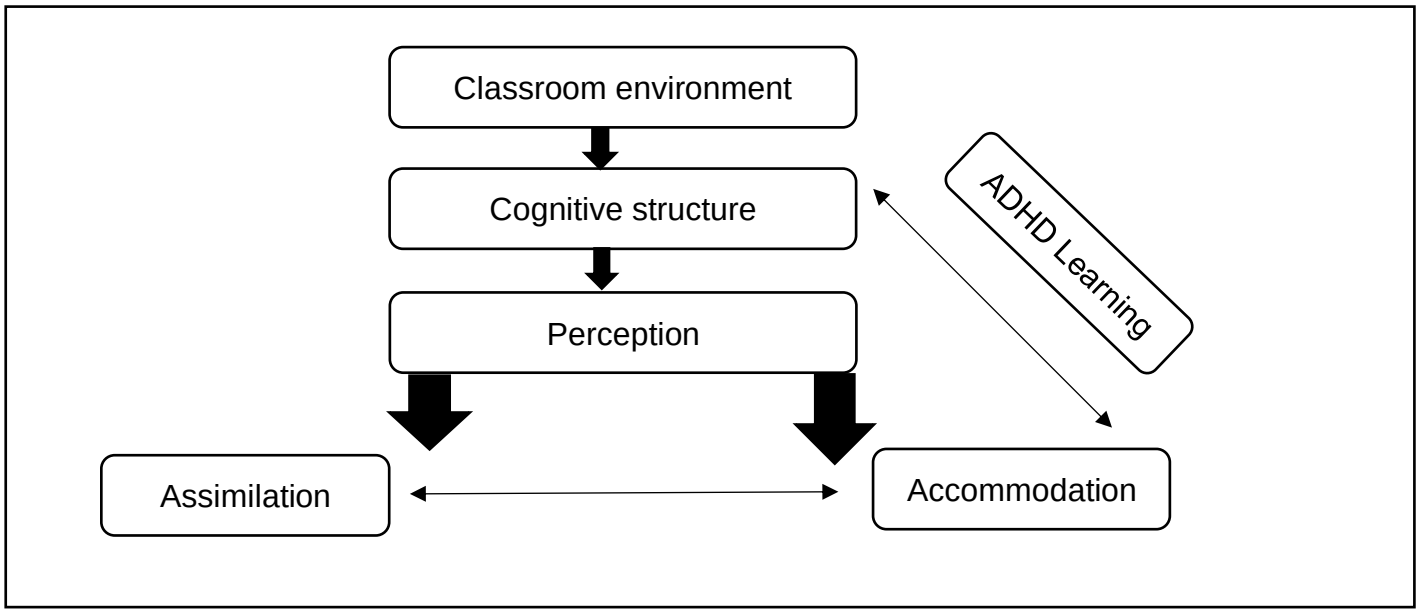


Figure 2.6: Representation of Piaget's equilibration

(used from Hergenhahn & Olson, 2012).

Figure 2.6 is a short representation of Piaget's equilibration. According to Donald *et al.* (2014), assimilation occurs when new information is taught that can fit into a child's existing map. For example, a Grade 3 learner may have a map about the concept of multiplication tables from the numbers one up to twenty. If the teacher adds new numbers, such as twenty up to a hundred, the child absorbs and assimilates the experience and extends their map to include the new numbers when doing multiplication, and not only work with the number one up to twenty.

Accommodation occurs when new information arises but contradicts the child's map. For example, the Grade 3 learner may learn about multiplication tables in a different pattern from those taught before. If the learner is used to the pattern 7 x 2=14 but now has to work with a different pattern, such as 7 x 2 = 14 (but written underneath each other), they have to adjust or reshape their map so that new information can be accommodated.

2.4.2 Vygotsky's sociocultural theory and its integration into the research study

According to Donald *et al.* (2014), Vygotsky was born in 1896 and lived and worked in Russia. Vygotsky was a Russian psychologist who provided important insights into cognitive development. Donald *et al.* (2014) state that Vygotsky developed a theory about how cognitive

development occurs through social interaction. Vygotsky worked with Luria, a brilliant neuropsychologist, and dealt with three critical aspects: the role of social context, language, and mediation. The section below briefly discusses the aspects and explains how they fit into the study.

Hergenhahn and Olson (2012) assert that Vygotsky's theory from a social context is that cognitive development takes place through social interaction. According to Vygotsky, children construct shared meanings through social interaction with teachers, parents, and others. Krüger *et al.* (2016) state children progressively develop meaning and understanding and adapt old meanings to bridge the gap between what they currently understand and what confronts them in social interactions. Donald *et al.* (2014) maintain that Vygotsky's focus on social interaction changes how we understand "meaning". Meanings are social constructions, sets of meanings, practices, information, and ways of understanding, built up and passed on between people, each with a past and culture of their own (Donald *et al.* 2014). Vygotsky spoke about distal and proximal meanings, where distal meanings are filtered down from the wider society or cultural communities, and proximal meanings are directly transferred through immediate interpersonal interactions. Hergenhahn and Olson (2012) agree with Donald *et al.* (2014) and state that these instantaneous social interactions occur at levels such as families, schools, classrooms, and local communities. Hergenhahn and Olson (2012) argue that proximal interactions can powerfully shape and develop an individual child.

Donald *et al.* (2014) and Krüger *et al*. (2016) agree that one of Vygotsky's contributions was showing language's important role in a child's cognitive development. The language includes spoken and mathematical language. Tapia (2012) states that language is a potent carrier of values, information, and world views. It is also the primary way people communicate in their social interactions. Hergenhahn and Olson (2012) agree with the abovementioned authors and assert that language is a key factor in cognitive development. Vygotsky maintains that children begin talking aloud to organise their actions and experiences. Vygotsky further explains that this talking aloud becomes silent, converting into an inner conversation and thought. In this way, the child becomes capable of thinking through language.

Mediation through social interaction is the engine that drives development (Donald *et al.* 2014). According to Vygotsky, mediation is how the child takes possession of the cognitive tools that make the construction of knowledge possible. Vygotsky further states that the child cannot do this on his own. This is where Vygotsky's theory plays an important role in the

researcher's study. The teachers play a significant role because they have already acquired those tools and, therefore, can mediate the construction of knowledge. Tapia (2012) agrees with Donald *et al.'s* (2014) statement about Vygotsky's Zone of Proximal Development (ZPD), which can be used to understand mediation better. According to Donald *et al.* (2014), the ZPD is the space where a child cannot understand a specific concept on his own but has the potential to do so through proximal interaction with another person (the teacher). For example, if a learner does not understand multiplication tables in mathematics, the teacher has already acquired the tools and knowledge and can help the learner through proximal interaction. Thus, the teacher can support the gap where the learner does not understand the connections between the familiar and the unfamiliar in terms of higher cognitive functions (Donald *et al.,* 2014). According to the researcher, it is crucial for teachers to be more aware when something they present is too far beyond learners diagnosed with ADHD's understanding or if they present something too familiar, which may cause them to lose the learners' attention. Hergenhahn and Olson (2012) agree with Donald *et al.'s* (2014) statement about Vygotsky's mediation process and further state that how the meditation process happens is very important. According to Hergenhahn and Olson (2012), the process must take place in the critical space of the zone of proximal development to be effective. Otherwise, interaction may not connect meaningfully with the learner's potential. If mediation is deliberate, the teacher is at least trying to connect with the learner's understanding and potential in the zone of proximal development (Donald *et al.,* 2014). Vygotsky's mediation process further states that if mediation challenges the learner to develop a new way of thinking, it can lift the learner to a higher level of understanding. Hergenhahn and Olson (2012) assert that learning is not only about the teacher giving information, but the process must also challenge the learner to organise and understand the information in progressively effective ways. Figure 2.7 below illustrates the critical space where a child cannot understand something on their own but has the potential to do so through the proximal interaction with a teacher.

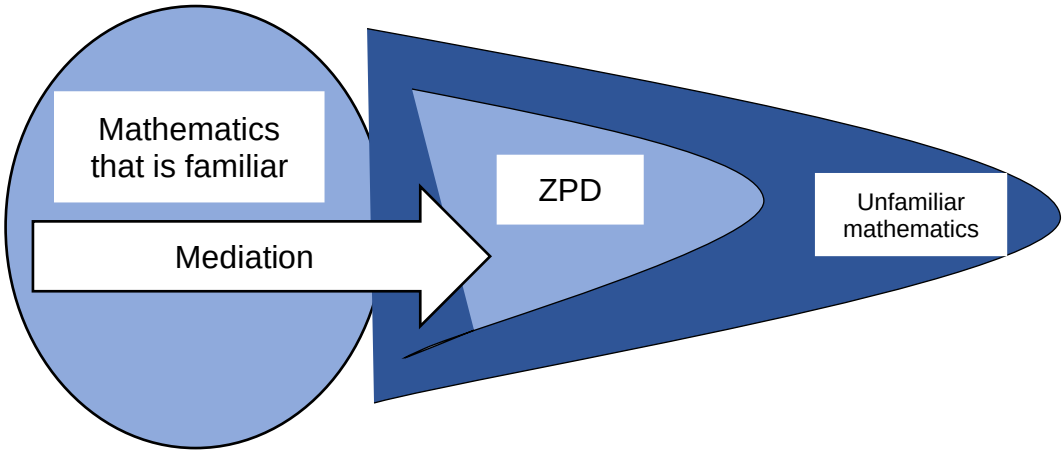


Figure 2.7: Illustration of the zone of proximal development (ZPD)

(used from Donald *et al.* 2014).

2.4.3 Donald Olding Hebb's neurophysiological theory and its integration into the research study

The researcher has chosen Donald O. Hebb's theoretical work for this research study because it is insightful and has an important link between brain science and mathematics learning. Donald O. Hebb was born in Nova Scotia on July 22, 1904. Both his parents were medical doctors. In 1925, Hebb received his B.A. from Dalhousie University (Hergenhahn & Olson, 2012). Hebb was one of psychology's most creative researchers and theorists. In 1937, Hebb went to the Montreal Neurological Institute to work with a well-known brain surgeon, Wilder Penfield. Hebb's job was to study the psychological status of Penfield's patients after brain surgery. After studying these patients, Hebb made conclusions about intelligence. According to Hergenhahn and Olson (2012:346), Hebb made “three observations about the brain: the brain does not work like a switchboard, intelligence comes from experiences, and childhood experiences are more important than adult experiences”. Hebb (1980) later realised in his theories that the best way for the human brain to learn is through observing different experiences in the human’s life, especially earlier in a child’s life. The more experience a child has, the more knowledge is built up in that child's brain.

According to Hebb, there must be an optimal level of arousal to learn better. When the arousal level in the classroom is too low, such as when the learner is drowsy, the child cannot use the sensory information transmitted to the brain. In addition, when arousal is too high, too much information is relayed to the cortex, resulting in confusion or irrelevant behaviour (anxiety,

anger, upset). Thus, teachers must understand that a level of arousal that is neither too high nor too low is necessary for the optimal cortical functioning and performance of ADHD learners. Figure 2.8 below shows the proposed relationship between optimal task performance and arousal level performance. Hebb explained that if arousal is too high, it is likely that the learner will operate in the environment to reduce the arousal level. For example, suppose the learner is trying to do mathematics while children are talking in the classroom next door. In that case, the learner may modify the environment (close the door) or find a less arousing environment more compatible with mathematics learning by sitting under their table. Suppose arousal is too quiet, and there is not enough sensory input to maintain an optimal level of arousal. In that case, the learner may increase arousal by talking with friends or the teacher.

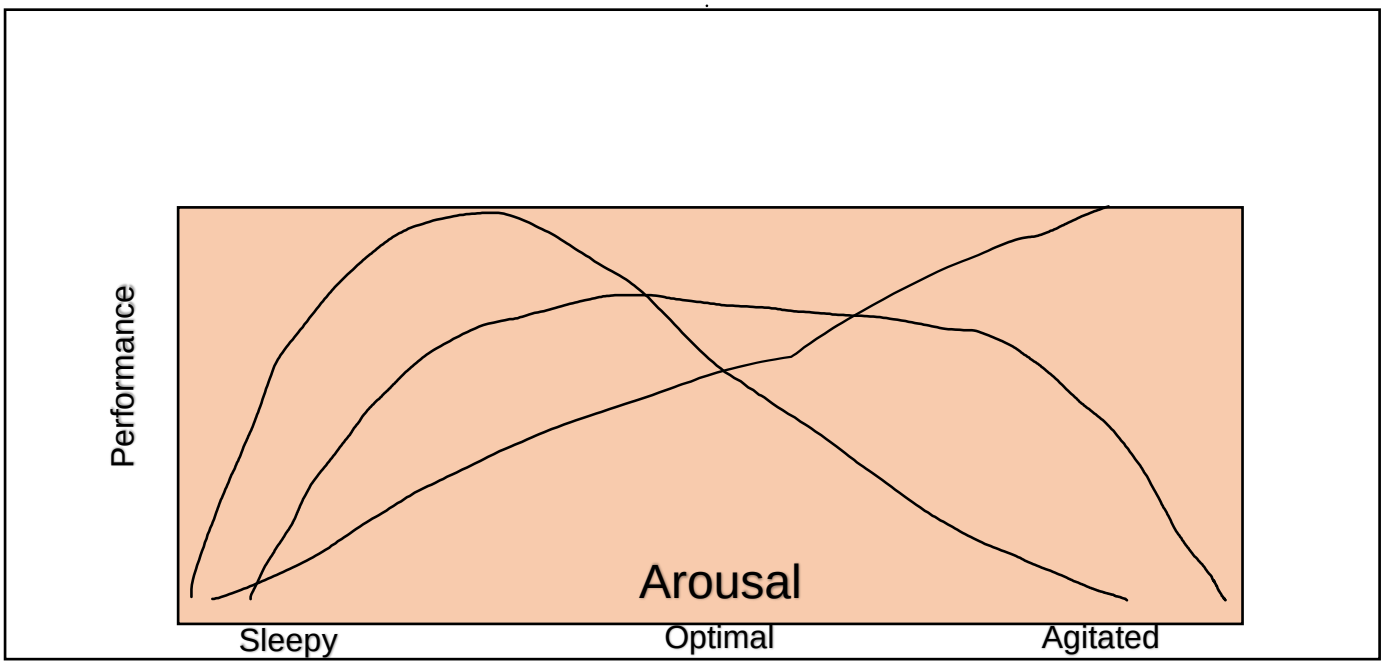


Figure 2.8: The proposed relationships between optimal performance on various tasks and arousal levels

(Used from Hergenhahn & Olson, 2012:346).

Hebb's neurophysiological theory justifies the importance of teachers' knowledge about ADHD and neurodevelopment in the study. According to Hebb (1980) and Greenblatt (2017), learners diagnosed with ADHD have brain dysfunction. Hergenhahn and Olson (2012:346) assert that mathematics intelligence comes from “experience and not necessarily genetics”. Greenblatt (2017:6) and Hudson (2016:112) argue with this statement and state that “intelligence comes from experience and has genetic components”. Both Hergenhahn and Olson (2012) and Greenblatt (2017) agree that ADHD can be caused by a neurological factor

that can have a major impact on learners diagnosed with ADHD's mathematics education. Therefore, the researcher believes Hebb's theory can help with information on how teachers can help learners identified with ADHD train their brains to focus and learn. Greenblatt (2017) states that most ADHD learners struggle with short-term and long-term memory and with certain mathematics concepts such as steps, patterns, and multiplication tables. The researcher believes that Hebb's neurophysiological theory would help observe whether teachers used the theory in inclusive teaching to scaffold ADHD learners' mathematics challenges. The researcher also believes this theory can help support learners with ADHD with memory challenges. Greenblatt (2017) mentions that ADHD learners have smaller brain areas that control attention, impulsivity, executive function, planning, focus, and memory. According to Hebb (1980), and Hergenhahn and Olson (2012:352), the brain has two types of memory: short-term and long-term. Hebb (1980) made a distinction between short-term memory and long-term memory. The author mentions during the creation of a child's long-term memory; there are "physical-structural changes between neurons". Also, during short-term memory storage, there is an ongoing activity in cell assemblies and phase sequences. Additionally, Hebb (1980) also believed that sensory experience helps set up neural activity, which Hebb referred to as reverberating neural activity. Hergenhahn and Olson (2012) agree with Hebb's assertion and state that if teachers use more sensory experiences, such as building blocks or music, it can help set up neural activity in the ADHD brain.

Hergenhahn and Olson (2012) believed that short-term memory is converted into long-term memory, of which Hebb was a major proponent. Greenblatt (2017) asserts that long-term memory depends on short-term memory, and ADHD learners' memories can easily be disrupted. According to Krüger *et al.* (2016), disruptions can be caused by overstimulated classrooms, too much noise, mathematics with challenging steps, impulsivity, hyperactivity, and inattention. Greenblatt (2017) agrees with Krüger *et al.* (2016) and further states that mathematics disruptions can also be caused by the learner overlooking steps when doing mathematics, finding it difficult to follow mathematics instructions, and having trouble focusing, and frequently losing track of the solution when doing mathematics. According to Hebb's theory (1980), the hippocampus is the learning part of the brain that consists of two types of learning. The first is the gradual build-up of cell assemblies, and the second is the phase sequence and rearrangement during early childhood. According to Hergenhahn and Olson (2012), short-term memory is converted into long-term memory through a theory named consolidation. Some changes occur in the brain during short-term memory conversion to long-term memory. The brain protects the 'thought' from interference from competing stimuli or

disruption. This process whereby experiences achieve a permanent record in our memory is named consolidation.

Hebb suggested that learning and memory occur at a cell-to-cell connection change. Krüger *et al.* (2016) define cell assemblies as an interrelated neurological package fired by external stimulation, internal stimulation, or a combination of both. Hebb explained cell assemblies as the neurological basis of an idea or thought being presented to us. Hebb's theory states that each environmental object we experience stimulates a complex pattern of neurons in the human brain called cell assemblies. For example, as a learner looks at a particular mathematics task, the learner's attention shifts from looking at the sum to getting the answer. As the learner's attention shifts, different neurons are stimulated. When all neurons are stimulated by different aspects, such as completing the sum and using concrete materials to help complete the sum, the result will be the perception and identification of the answer (Hergenhahn & Olson, 2012). Hebb's theory also suggests how the independent neurons become linked into stable cell assemblies. This theory is relevant to the study as it can explain why ADHD-identified learners struggle with mathematics that consists of extended steps because of their feeble concentration and memory.

According to Hebb, a phase sequence is a temporally integrated series of assembly activities with internal or external stimulation or both. Children/human beings experience a stream of thoughts when the phase sequence fires. For example, children experience a stream of thoughts in which a series of ideas are arranged logically. According to Hebb, the cell assemblies that are active simultaneously become interconnected. For example, when a baby hears footsteps, a cell assembly can become excited, and at the same time, the baby sees his mother's face and feels her hands picking him up, which excites other cell assemblies. So, the footsteps assembly becomes connected with the face assembly together with the pick-up assembly. This means that every time the baby hears footsteps, all three of the cell assemblies are excited and fired up. The researcher believes that teachers can use both cell assemblies and phase sequences to help learners diagnosed with ADHD with the learning and teaching of mathematics.

Greenblatt (2017) agrees with Hebb's theory above and asserts that learning can also occur through creativity. Greenblatt (2017) further states that ADHD learners are introduced to mathematics in Grade 1, and how they are taught provides an important framework for later learning in school. Hergenhahn and Olson (2012) assert that mathematics learning is a slow

process that involves the building up of millions of cell assemblies and phase sequences. However, once certain mathematics concepts have been learnt, an individual can rearrange them in any number of creative ways, perhaps in the form of a picture or a game. Hebb's theory agrees with Hergenhahn and Olson's (2012) statement, but according to Hebb, building the blocks comes first, and insight and creativity can be focused on after that.

Figure 2.9 below illustrates Hebb's two types of learning and how the researcher thinks it can be integrated into the teachers' classroom to help make mathematics teaching easier. Hebb (1980) believed in two types of learning, the gradual build-up of cell assemblies and phase sequences and rearrangement. If teachers understand these two types of learning, it could help improve learning for learners diagnosed with ADHD. The gradual build-up of cell assemblies can help with the neurodevelopment of ADHD. During phase sequence and rearrangement, teachers can learn how to use more creative ideas to make learning and teaching more accessible for ADHD-identified learners.

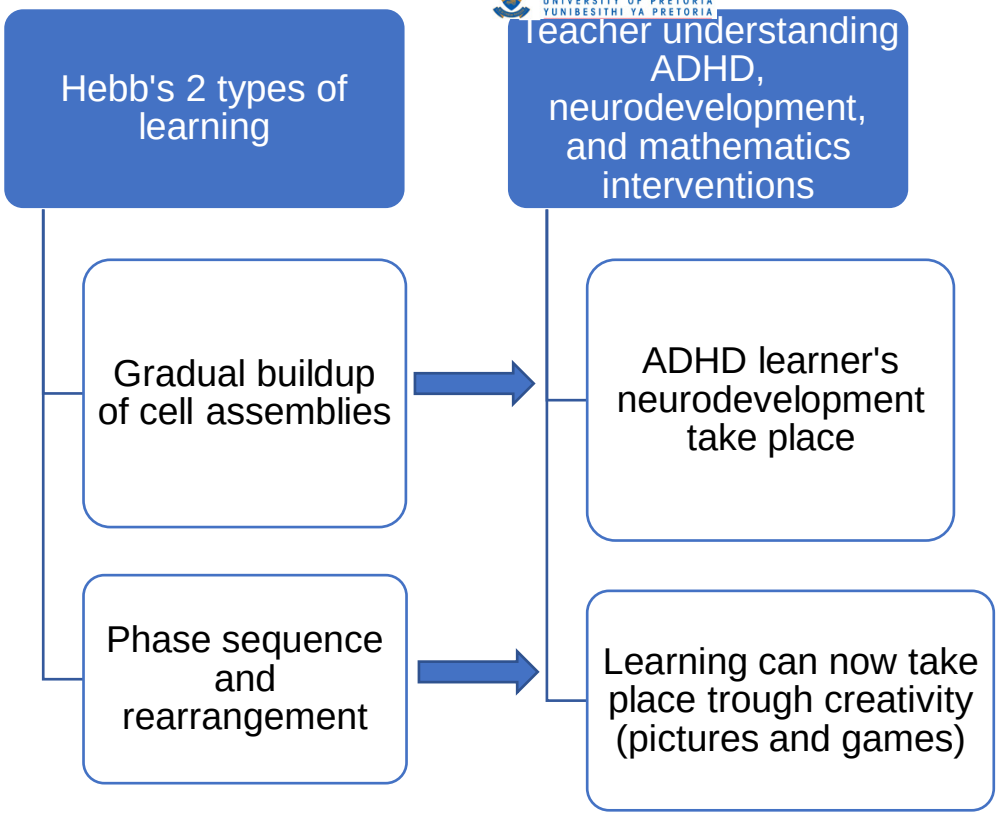


Figure 2.9: Two types of learning integrated with the teachers' understanding from Hebb's theory.

Getz (2013:32) mentions that during any learning and teaching in early childhood, the learner needs to have a wide variety of "sights, sounds, textures, and shapes to help set up neural activity and memory". Furthermore, Getz (2013) states the more complex the mathematics gets for ADHD-identified learners, the more there is to represent at the neurological level. Thus, teachers must understand the neurodevelopment of learners diagnosed with ADHD to create an educational environment with great variety. Building on Hergenhahn and Olson's (2012:373) study, Getz (2013) states that "contiguity and consistency are important in all forms of mathematics learning". Furthermore, Hergenhahn and Olson (2012) mention that the teacher must help learners identified with ADHD see what they have already learnt in new and creative ways. Getz (2013:33) agrees with Hergenhahn and Olson (2012) and opine that when the building blocks have been established, they can be "rearranged in an infinite number of configurations, such as creativity, so that learning can take place". Greenblatt (2017) agree with Hebb's theory (1980), stating that the physical characteristics of the teacher's classroom and the ADHD learner's learning environment are significant for any task. This understanding can support more effective learning. Hergenhahn and Olson (2012:373) state that when a child finally understands their mathematics tasks, "neurodevelopment takes place". When neurodevelopment in the learner's brain has taken place, it will become easier for the child to

understand and think deeply about how to complete mathematics tasks without it being physically presented with building blocks or pictures.

2.5 RELATION BETWEEN THE THEORIES

The researcher believes that Piaget's, Vygotsky's, and Hebb's three theories are considered the best fit for the research study. Piaget's theory about neuroplasticity and the active nature of cognitive development matches one of the basic neuroplasticity principles of the study. The development and growth of specific areas of a child's brain can be stimulated through intensively exercising the cognitive functions relevant to that area, thus improving mathematics learning. The researcher believes that if teachers are more educated in this area, it can help support ADHD learners with mathematics. Further, the researcher has confidence that the process of cognitive maps from Piaget (schemata and operations), as mentioned above, can be developed through active and progressive assimilation and accommodation and that new neural mapping occurs through the active usage of cognitive functions. Piaget's theory can also help with the stimulation of cognitive conflict. For example, if the teachers stimulate cognitive conflict in the learners, it can help challenge them to solve conflict (in this case, difficult mathematics problems) through active exploration and discovery. In the opinion of the researcher, this will help the ADHD-identified learners build up new neural and cognitive maps as stated by Piaget's theory. Teachers will help the learners progressively develop more effective ways of organising and adapting to new and complex mathematical challenges. Vygotsky's theory fits in with Piaget's by further focusing on the zone of proximal development by mediation in assisting the learners in reaching new levels of understanding. In terms of teaching, the teacher can use this theory to actively stimulate and guide the learner to use familiar (familiar mathematics) in grappling with unfamiliar (new mathematics) in their zone of proximal development. Hebb's theory can support the teacher's teaching by focusing on the level of arousal in the classroom. The researcher also believes that this theory can be used to give teachers a clear understanding of how to support ADHD-identified learners with memory challenges and help them conceptualise brain functioning.

2.6 SUMMARY

In Chapter 2, the conceptualisation of ADHD neurodevelopment and the understanding of dyscalculia in an ADHD context were explained, allowing for a broader understanding of the topic under investigation. The conceptualisation of ADHD and neurodevelopment was explained from an international, South African, and African perspective. Detail was provided about how teachers could enhance mathematics education for children with learning

disabilities. There was also an elaboration on how dyscalculia can affect ADHD learners. Finally, the theories on which the study was constructed were explained and linked to the research study's objectives. The following chapter, Chapter 3, will elaborate more on the study's research methods and procedures.

3 CHAPTER THREE: RESEARCH METHODS AND PROCEDURES FOLLOWED

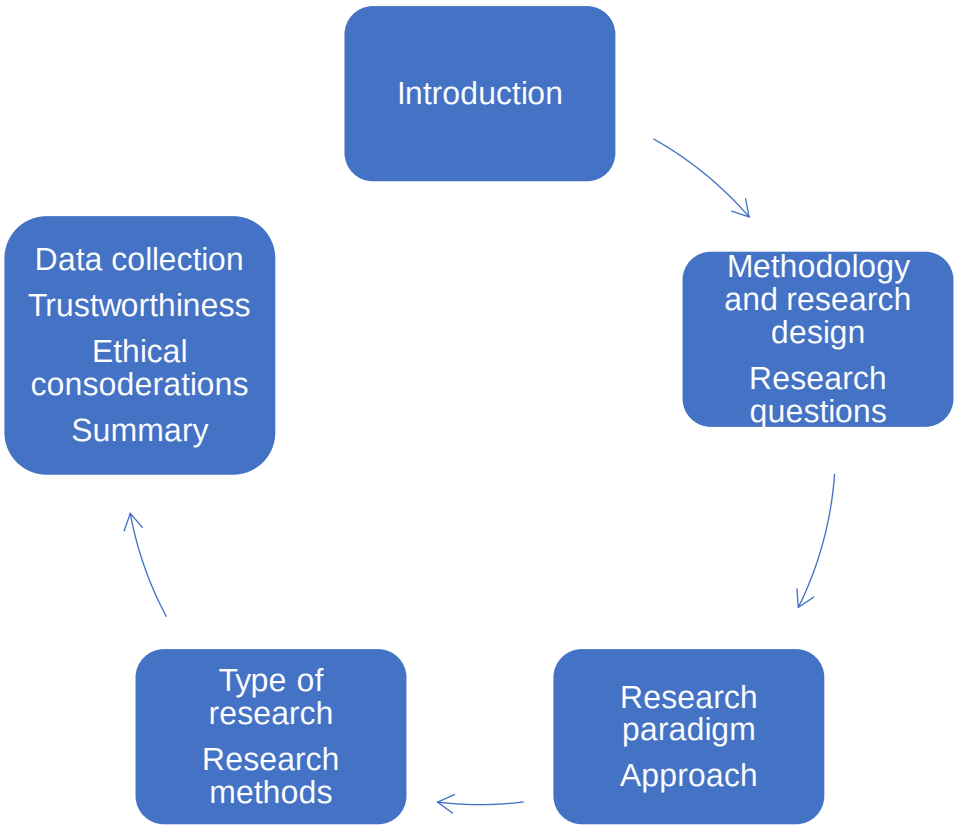


Figure 3.1: Outline of Chapter 3

3.1 INTRODUCTION

Chapter 2 described the study's theoretical framework and the literature review based on teachers' conceptualisation of ADHD, neurodevelopment, and mathematical interventions in Grade 3 Foundation Phase classes. In Chapter 3, the researcher discusses the research methods, approach, and procedures followed in conducting this study. This chapter explains the research methods with sampling, data collection, and data analysis. Furthermore, an explanation of how the data were collected and analysed within the interpretive paradigm is given. Lastly, the trustworthiness and ethical considerations of the research study were discussed. In terms of the literature reviewed, it was noted that learners diagnosed with ADHD experience difficulties with mathematics because of brain dysfunction in connection with ADHD (Faber, 2017). Therefore, this study investigated teachers' knowledge of ADHD, neurodevelopment, and mathematics interventions. The merged theoretical frameworks of

Vygotsky's, Hebb's, and Piaget's theories adapted in the study, as depicted in Figure 1.1, were already described in Chapter 1 and Chapter 2. Figure 3.2 below graphically illustrates a summary of the three theories adopted in the study.

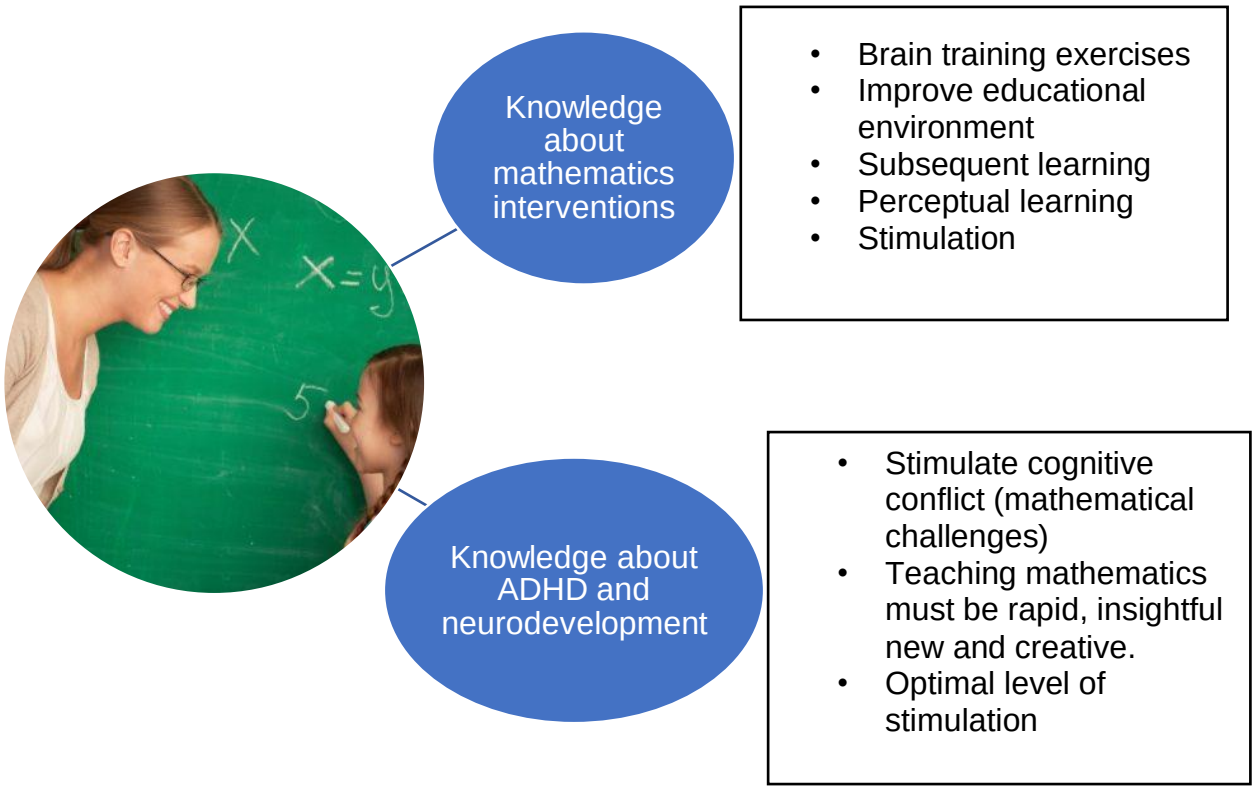


Figure 3.2: Merged frameworks of Vygotsky, Hebb, and Piaget as adapted in the study.

3.2 METHODOLOGY AND RESEARCH DESIGN

The term methodology is described as doing things in an orderly or systematic way (Creswell, 2016). Maree (2012) defines it as techniques and strategies used to order research that is collected. Kumar (2014) agrees with the authors above and states that methodology is a study or investigation to discover facts or information. According to Kumar (2014), research has multiple meanings, and its precise meaning varies from discipline to expert. Furthermore, Kumar (2014) explains research as a set of skills, a way of thinking, and finding answers to the research questions. A research methodology is a strategy and process that researchers use to help them identify, choose, process, and analyse a study's collected data. It, therefore, supports the researcher in deciding what research methods to use (Kumar, 2014).

As mentioned above, research is an investigation to discover facts for a study, whereas the term design refers to a plan for a special purpose. A research design is a particular plan for

examining the research problem (Maree, 2012). The research design clarifies the type of study the researcher will undertake (Kumar, 2014). Furthermore, Kumar (2014) explains research design as a road map that the researcher follows during her research journey to find answers to her research questions as objectively as possible. Kumar (2014) adds that, and states that a research design is a plan through which the researcher decides for herself and communicate to others the decisions she made regarding the type of study design she propose to use, how information will be gathered from the research participants, how the researcher will choose her participants, how the collected information will be analysed, and how the information gathered will be communicated. Research design can therefore be seen as a plan to answer the research questions, whereas a research method is a strategy used to implement that design (Hartell *et al.* 2016).

In this study, the researcher followed a qualitative research design comprising semi-structured interviews with five participants (Grade 3 teachers) to form multiple case studies within the two participating schools (a private school and a mainstream school). This chapter, therefore, examines the research design and the processes of how data related to this study were collected, accumulated, and analysed. The research questions, related to the focal point of this study, guided the researcher's investigation. Herewith follows a complete clarification of the study's research methodology. Figure 3.3 illustrates a summarised depiction of the research methodology.

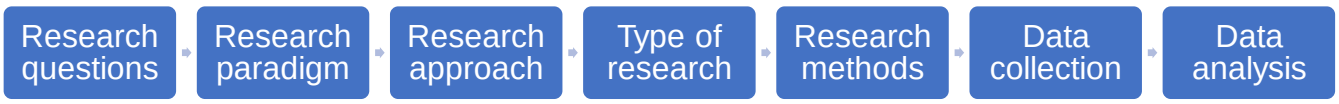


Figure 3.3: Summary of the research methodology

3.2.1 Research questions

The main research question and sub-question provided the focus for the methodology used in this study.

3.2.2 Primary research question

The main research question was:
How do Grade 3 Foundation Phase teachers in mainstream and private schools conceptualise ADHD and mathematics access?

3.2.3 Secondary research questions

- What are teachers' perspectives on ADHD, neurodevelopment, and mathematics interventions in the Grade 3 Foundation Phase?
- What kind of support do teachers in mainstream and private schools receive to enhance mathematics access for learners diagnosed with ADHD?
- Which inclusive strategies do teachers in mainstream and private schools use that influence learners identified with ADHD with mathematical challenges?

A semi-structured interview was conducted with five teacher participants individually to prompt responses to answer the primary research question. At the same time, the researcher observed the body language of each teacher as they were being interviewed, for example, whether they appeared comfortable or uncomfortable when answering specific questions. The researcher also observed mathematics books from the learners diagnosed with ADHD to generate data as guided by the secondary research questions. From the emergent findings, the researcher was able to answer the three secondary research questions and the primary research question.

3.3 RESEARCH PARADIGM

Iannini *et al*. (2018:98) explain that a research paradigm is a frame that represents the view of one's belief which pertains to how people assemble the understanding of their realities. A research paradigm may be viewed as a "set of conceptual frameworks that describes a particular theoretical approach to research" (Maree, 2012:70). Maree (2012) further states that a research paradigm envelop aspects of ontology, epistemology, teleology, and methodology. According to Kumar (2014), there are two main research paradigms, the quantitative and qualitative paradigms, whereas the mixed methods paradigm has emerged as a third approach. The quantitative paradigm is mainly rooted in the physical science or positivist approach to social enquiry. The opposite paradigm is named the qualitative paradigm or naturalistic approach. However, as stated by Kumar (2014), since the mid-1960s, there has been a recognition that both the quantitative and qualitative paradigms have their place, leading to the mixed methods approach.

The perspective of this study was a qualitative research approach with an interpretive paradigm. An interpretive paradigm assumes that social reality is not singular or objective but is shaped by experiences in contexts. Interpretivists understand that they cannot separate "values and facts nor view the social context in isolation from objective truths" (Hartell *et al.*

2016:9). Mack (2010) adds that interpretivism can be viewed and elucidated by numerous people in different approaches creating many perspectives of reality.

Using the multiple case study method in this research proposal enabled the researcher to gather different views and opinions of the participating teachers regarding their conceptualisation of ADHD, neurodevelopment, and mathematics interventions for Grade 3 learners. According to Kumar (2014), a case study is characterised by a very flexible and open-ended technique of data collection and analysis. The interpretive paradigm provided a satisfactory lens through which the research could be seen through an exciting field of vision. This information could also be interpreted and explained when bearing in mind the personal and social nature of the research performed as part of this study. According to Kumar (2014), this lens can give more clarity on the questions asked and the process of data being collected and analysed. Hartell *et al*. (2016) add that interpretivist paradigms assume that social reality is not singular or objective but shaped by experiences in contexts. Interpretivists understand that they cannot separate values and facts nor view the social context in isolation from objective truths. According to Brundrett and Rhodes (2013), the collected data of an interpretive paradigm provides rich and illustrative information on the research environment with a specific context. Therefore, a researcher with an interpretivist paradigm should explain the social reality as experienced by the participants.

3.4 APPROACH

A qualitative approach, according to Maxwell (2013:14), is described as a “do-it-yourself” approach rather than an “off-the-shelf” process. Furthermore, Maxwell (2013) states that this approach involves taking back and forth between the different components of the design and assessing their implications for one another. Creswell (2016) agrees with Maxwell (2013) and states that qualitative methods gain in-depth information, leading to a better understanding of the social phenomena being studied. Qualitative research enables the researcher to describe the experiences and perspectives of the participants and understand the phenomena in a specific context (Kumar, 2014).

This study followed a qualitative approach involving multiple case studies within an interpretive paradigm to investigate and explore teachers’ conceptualisation of ADHD, neurodevelopment, and mathematics interventions in the foundation phase. According to Hartell *et al*. (2016:65), qualitative approaches investigate and understand a phenomenon. Creswell (2016) resonates with Hartell *et al*. (2016), adding that qualitative research

approaches give substance, better understanding, and meaning to problems by investigating individuals who experience these problems. According to Maree (2012:72), a qualitative approach "is interested in understanding how people interpret their experiences, construct their world, and what explanation they attribute to their understanding and experiences". Kumar (2014:14) agrees with Maree (2012) and asserts that "a qualitative approach is embedded in the philosophy of empiricism; follows an open, flexible and unstructured approach to enquiry; aims to explore diversity rather than to quantify; emphasises the description and narration of feelings, perceptions and experiences rather than their measurement" (Kumar, 2014:14).

Table 3.1 below explains Kumar's (2014) research process, correlated with its orientation to this research proposal. The process of Kumar (2014) consists of emerging questions, data collected, and data analysis. According to Kumar's (2014) process and its position in the study, the study's emerging questions consist of primary and secondary research questions. The data collected in the study are composed from interviews with the participating teachers and observations of the mathematics books and strategies the teachers use. The researcher also used Kumar's (2014) inductive data analysis method by summarising all the raw data and then creating a link between the data collected and the research objectives.

Table 3.1: Example of how Kumar's (2014) process of research is correlated with its orientation to the researcher's study.

Kumar's research process	Orientation to this study
Emerging questions	Primary research question Secondary research question (Chapter 1)
Data collected: Participants surroundings	**Data collected:** Participants' (teachers') classrooms
Data analysis: Inductive	**Data analysis:** Summary of raw data than establishing links between data and the research objectives. **Inductive process:** Meaning was made from all collected by the researcher. These data were received from the participating teachers.

3.5 TYPE OF RESEARCH

According to Maree (2012:70), research types "help to investigate information about the phenomenon being studied". During this study, multiple case study research methods were used to collect and analyse the data of the participating teachers' conceptualisation of ADHD, neurodevelopment, and mathematics interventions in the foundation phase. In a case study design, the cases selected become the basis of a "thorough, holistic, and in-depth exploration of the aspects that the researcher wants to find out about" (Kumar, 2014:155). Creswell (2016) characterises a case study as a case being bounded, meaning there is a comprehensible definition of what is included and excluded as part of the case. The research study used a case study about teachers' conceptualisation about ADHD neurodevelopment. The information is bound by content area (e.g., mathematics), age level (e.g., Grade 3 learners), and disability (e.g., diagnosed with ADHD). In this study, observations of the mathematics books, methods, and worksheets from learners diagnosed with ADHD and the interviews with the teachers all contributed to a comprehensive understanding of the case (Creswell, 2016).

Hartell *et al.* (2016:131-133) reflect that case studies are "the study of cases by gathering all available information." Kumar (2014) agrees with the authors mentioned above, describing a case study as a systematic inquiry into an event or a set of related events which aim to describe and explain the phenomenon of interest. Maree (2012:75) emphasises that it needs to be explained that a case study investigates a problem. Maree (2012) and Kumar (2014) further assert that the case study design is based upon the assumption that the case being studied is typical of cases of a certain type and, therefore, a single case can give better perception and insight into the situations prevalent in a group from where the case was made. This design allowed the researcher to observe the social practice of teachers' conceptualisation and perception of ADHD, neurodevelopment, and mathematics interventions through the eyes of five teachers who enforce it within their Grade 3 classrooms. The multiple case study explored and investigated real life experiences of Grade 3 teachers in both private and mainstream schools within the Gauteng East Province in South Africa and can therefore only be interpreted in this context. However, according to Kumar (2014:155), multiple case studies provide "in-depth exploration and intensive study of certain aspects".

Maree (2012:83) reports that a case study is a "decision regarding what is to be studied, it also guides how an inquiry is to be conducted from any theoretical approaches". Kumar (2014) advises that multiple case studies can be used in pursuing an explanatory purpose for multiple perspectives of complex and unique systems in real life contexts, while Maree (2012) states that qualitative case studies anticipate to hear and see the unique and sincere experience of the participants. Multiple case studies can therefore be applied to gather and interpret the unique experience of Grade 3 teachers' regarding their knowledge about ADHD brain functioning and inclusive education in mathematics. Hartell *et al.* (2016) advise that the qualitative researcher should obstruct the probability of 'yes' and 'no' questions by leading the interview with issue-oriented questions prompting explanations from the participant in their response. Maree (2012:89) further asserts that interviews enable the researcher to "acquire rich and descriptive information" that will enable the researcher to understand the social reality of the participants.

3.6 RESEARCH METHODS

3.6.1 The role of the researcher

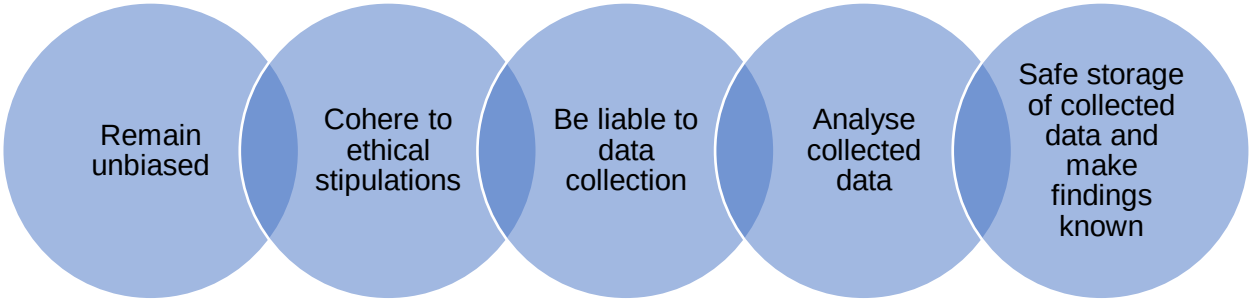


Figure 3.4: Summary of the role of the researcher during the research process

The researcher was in a 'collaborative partnership' with the participating teachers to collect data about each teacher's conceptualisation of ADHD, neurodevelopment, and mathematics interventions. According to Figure 3.4, the role of the researcher was to remain unbiased and objective during data collection. Ethical stipulations had to be adhered to, as stipulated by the institutions and committees.

During the data collection process, the researcher first audio-recorded the semi-structured interviews. Secondly, the researcher observed the teachers' body language and facial expressions as they were answering the questions. The observation protocol was used to write down this information. Thirdly, after the interviews, the researcher observed the mathematics books from ADHD-identified learners. Fourthly, photos were taken from pages in the mathematics books that the researcher found relevant to her study. During the observations of the mathematics books, the researcher especially observed mathematics methods, such as pictures, diagrams, tables, rhymes, patterns, and figures, that the teachers used, and worksheets (with examples and explanations). Lastly, the researcher observed the learners' marks and ability to understand the mathematics concepts.

The recorded data were transcribed. Each teacher had to be informed of the arrangements for anonymity and safety. During the study, the researcher aimed to:

- Be unbiased during the interviews and observations (documents).
- Be obedient to the ethical stipulations.
- Be apt to the data collection process and administrative factors, which included:
    - Assemble all information gathered during the semi-structured interviews, observations, and field notes.
    - Conduct and audio-record five interviews, observing the mathematics books of a learner diagnosed with ADHD and the mathematics methods and strategies the teacher used to help learners diagnosed with ADHD struggling with mathematics.
    - Transcribe data being recorded.
    - Ensure participants' anonymity and informed consent.
    - Analyse collected data and the different themes that emerged after transcription from the recordings and field notes was classified and categorised.
    - Make use of content analysis.
- The researcher's aim was to answer the study's research questions with the data gathered from the participating teachers (Kumar, 2014).

3.6.2 Participants and research site

Kumar (2014) mentions that in qualitative research, several considerations may impact the selection of a sample, such as the ease of accessing the potential participants and your judgment that the participant had enough knowledge about the situation of interest. Kumar (2014) also advises that when choosing a particular sample, it should include participants with enough knowledge about the studied topic. The study comprised social research, and therefore, use is made of non-probability sampling. According to (Haenssgen, 2019:55), non-probability sampling uses "non-random criteria, meaning samples are based on factors other than random chance". Haenssgen (2019) further explains that non-probability sampling consists of various forms. This study made use of the purposive sample form. Purposive sampling occurs when the participants are chosen according to pre-determined criteria relevant to the research questions (Maree, 2012).

Considering the current study's primary and secondary questions centring on teachers' conceptualisation about ADHD, neurodevelopment, and mathematics interventions, it is evident that teachers are the main focal point, and, therefore, can answer the questions the best. According to this study Grade 3 teachers can be considered as the participants with the superior knowledge about the research topic and seen as most appropriate. Therefore, the

study comprised five Grade 3 teachers (two private school teachers and 3 mainstream school teachers) currently employed by the participating school. The participants were included based on the following criteria:

- They are qualified teachers holding a Bachelor of Education degree.
- They are registered with the South African Council of Educators (SACE).
- Teachers with three or more years of experience teaching ADHD-identified learners in mainstream or private schools in the Gauteng Province in Pretoria.

The researcher has decided on the abovementioned criteria according to the following research assumptions:

- It is obligatory to include qualified, registered teachers from private and mainstream schools in South Africa, in this study to ensure that the data collected within this study is context specific.
- This study focuses on Grade 3 teachers.
- Grade 3 is considered the final and most important grade in the foundation phase that prepares learners for the next intermediate phase.

3.7 DATA COLLECTION

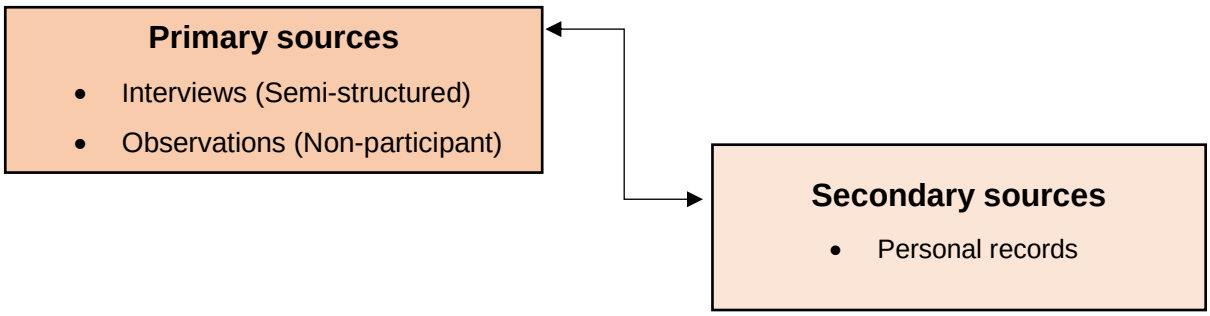


Figure 3.5: Summary of the methods of data collection that are used in the study.

Maree (2012:88) defines data collection as “bits and pieces of information found in the environment”. Kumar (2014) agrees with Maree (2012) and further states that information is gathered through two major approaches: primary sources and secondary sources. In this study, the data-collection process started with the ethics committee's approval and a permission letter from the Department of Education.

Data were gathered through primary sources such as semi-structured interviews and observations. The semi-structured interview questions were put together to bring out responses to the primary research question, which gave reliance to the true situation of the phenomenon being investigated, while the observations allowed the researcher to note how teachers support ADHD learners with mathematics challenges and what inclusive methods they use. In addition, field notes and voice recordings were considered crucial during the data collection process. Lastly, secondary sources, such as personal records were used. The researcher observed teachers' documentations as well as the mathematics books of learners diagnosed with ADHD.

3.7.1 DATA COLLECTION TOOLS

Kumar (2014) asserts that the choice of data collection tools depends upon the purpose of the research, the availability of resources, and the skills of the researcher. If the researcher chooses a data collection method, the socioeconomic-demographic characteristics of the research and study population play an important role. According to Creswell (2016), the researcher should know as much as possible about certain characteristics such as educational level, age, and ethnic background. Maree (2012) agrees with Creswell (2016) and further states that when choosing data collection tools, it is still important to ensure that the participants clearly understand the purpose and relevance of the study. This is exceptionally important when using questionnaires. In the following paragraphs, the study discusses each method of data collection that the researcher decided is most suitable and applicable.

(a) Semi-structured interviews

Kumar (2014) states that when using semi-structured interviews, the researcher asks a predetermined set of questions, using the same wording and order of questions as specified in the interview schedule. Bernstein and Lysniak (2018) discovered through semi-structured interviews how teachers' beliefs and perspectives guided their practice in education. Mostly, interviews were focused on obtaining responses from participants regarding their comprehension of the phenomenon being studied (Bernstein & Lysniak, 2018). Maree (2012) laid the groundwork for Bernstein and Lysniak (2018) by explaining that interviews acquire rich and descriptive information that will enable the researcher to understand the participant's reality and saturate data. According to Brinkmann (2013), qualitative interviews allow the participant's voice to be heard. Creswell (2016) asserts that with semi-structured interviews, general topics and questions were identified beforehand. The researcher was prepared to ask

follow-up questions depending on the participants' answers. Brinkmann (2013) further states that during a semi-structured interview, the researcher (interviewer) often audio-records the interviews and transcribes them for data analysis.

During the research, the researcher was goal-orientated in the semi-structured interview process. Each teacher was individually interviewed and audio-recorded to ensure no missed information or misunderstandings. The insinuation was that the researcher shaped the questions to address the research phenomenon under investigation. In addition, the participating teachers were informed about the study's purpose, and title before the researcher started the interview. It was then mentioned to the participating teachers that the interview was being audio-recorded for use in data analysis after approval had been obtained from each participant that audio recordings could be acquired. The researcher also explained difficult terms such as ADHD and neurodevelopment before she started with the interview questions. This explanation helped the participants to understand and provide relevant data. The interviews and observation of mathematics books, methods, and strategies lasted 45 minutes. The interviews were conducted by reflective listening to make each participating teacher feel comfortable. The semi-structured interview, which formed the baseline assessment, was done once. After that, the researcher reviewed the Grade 3 learners diagnosed with ADHD's mathematics books and the methods the teacher used to support these learners struggling with mathematics. The researcher also observed the concrete material the teachers used, which included counters, blocks, pictures, wall posters with diagrams of tables that explain multiplication sums and other resources teachers use to accommodate their learners. The interviews and observations were done within the interval of three (3) weeks for four (4) months. The research involved six different stages during the facilitation of the semi-structured interviews with the participants. The stages are reflected in Figure 3.6 below, followed by a discussion of each stage.

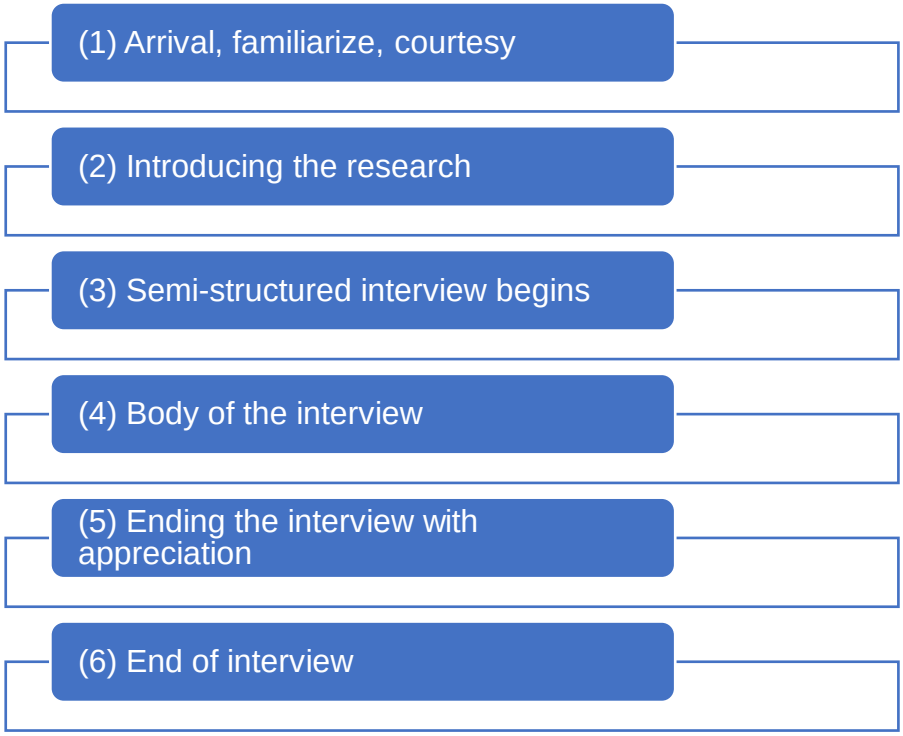


Figure 3.6: Six different stages during the facilitation of the semi-structured interviews with the participants.

Stage 1: Arrival, familiarisation, and courtesies

The first stage was about arrival, familiarisation, and courtesies. The participating teacher and researcher arrived at the research site (classroom or wherever the teacher felt most comfortable) where the semi-structured interviews took place. During these interviews, the first correspondence was familiarisation between the participating teacher and the researcher and a few random discussions. These actions helped the researcher to lay a foundation for the intended research. It was done in an affable way; the researcher assured and informed each participant that their time and information were highly appreciated. The researcher avoided giving any impression that may have implied participants facing cross-questioning by a critical panel. The first stage determined the tone of the participating teachers and therefore was very important in the research process.

Stage 2: Introducing the research

The researcher introduced the research topic to the participating teachers during this stage. The purpose of the research topic was made clear, and the teachers were given the opportunity to ask questions if they wanted to. The researcher also used the opportunity to briefly discuss her interpretation and understanding of the word “neurodevelopment” and

ADHD disorder. This information assured the teachers' understanding of the questions and ruled out any uncertainty. Lastly, the researcher reaffirmed the ethical procedures as stated in the letters they had received and signed earlier.

Stage 3: Semi-structured interviews begin

Participants settled down in their seats at this stage while the researcher handed out the semi-structured interview questions. The semi-structured interview questions were passed through different processes to assure quality control and no misinterpretations. However, there was an opportunity for further clarification of questions which some teachers found difficult to understand. There were no personal questions that might have hindered participants' responses or caused them any emotional or psychological discomfort. Each participating teacher was allowed to take as much time as required to respond to the questions.

Stage 4: Body of the interview

During this stage, further guidance and questions were addressed in responses to questions the participating teachers did not understand. The participants faced no barriers or challenges during the interview process; therefore, the semi-structured interviews were successful. Also, after each interview, the researcher collected the completed answers to the interview questions as written by the researcher and the recorded data.

Stage 5: Ending the interview with appreciation

After collecting the interview material, the researcher warmly thanked each participating teacher for their time and responding to the questions. The researcher also expressed gratitude for the participants' support. In doing this, the researcher helped them move away from the interview mode.

Stage 6: End of interview

During this final stage of the semi-structured interview questions, the researcher thanked the participants and ended the interview. The semi-structured interview questions were examined and formed the baseline for the research proposal.

(a) Observations

Maree (2012) defines observations as a systematic process of collecting data that depends on a researcher's ability to gather data through senses such as hearing and seeing without communication. According to Creswell (2016), there are two common approaches to

conducting observations during a research study: participant observation and non-participant observation. Brinkmann (2013) agrees with Creswell (2016) and states that during participant observation, the researcher can discover information that may be unknown to an outside observer. Furthermore, a non-participant or direct observation occurs when the researcher observes without interacting with the participants.

The observer was a non-participant during the research process. The researcher did not get involved in any activities but remained a passive observer. In this approach, the researcher observed the mathematics books and worksheets of the learners diagnosed with ADHD and each teacher's body language during the interviews. She primarily focused on which strategies and methods the teacher used to support ADHD learners with multiplication tables. As mentioned earlier in Chapter 3 (3.6.1), throughout the observations, the researcher used audio recordings to help provide a deeper insight into the interactions and ensure that no information was missed or misinterpreted (Kumar, 2014). The audio recordings also helped the researcher to listen to it a few times before interpreting an interaction or drawing conclusions. Field notes and an observation protocol were also used to write down important information the researcher saw and explored during the interviews and observations. According to Creswell (2016), field notes are unstructured written accounts and descriptions of what is occurring and of the participants. The field notes taken during the research consist of accurate accounts of what was observed during the semi-structured interviews (teacher's body language) and what was observed in the mathematics books, the methods that the teachers use, and the strategies of the teacher to support learners diagnosed with ADHD, struggling with mathematics. The observation protocol helped the researcher to specify elements.

3.8 DATA ANALYSIS

According to Bazeley (2013), qualitative analysis is like qualitative data with which the researcher works intensely; the data are engaging, challenging, contextualised, and highly variable. Data analysis in qualitative research is potentially productive of fresh insights and deep understanding (Bazeley, 2013; Maree, 2012). Both Bazeley (2013) and Kumar (2014) explain the importance of planning to gather data before collecting the actual data collection process. Bazeley (2013) further states that the foundation for data analysis is laid in the philosophical, methodological, and theoretical perspectives that the researcher adopts. Kumar (2014) agrees with Bazeley (2013) and adds that the analysis design is important before the researcher starts to gather the data. The data gathered through fieldwork must be

managed effectively and efficiently so that emerging ideas are not lost (Bazeley, 2013). How the researcher analyses and processes the data in a qualitative study depends on how the researcher plans to communicate the findings. According to Creswell (2016) and Kumar (2014), there are three ways in which the researcher can write about their findings: developing a narrative to describe a situation: identifying the main themes from your field notes, interviews, and observations, and writing about them. The researcher quantifies the frequency of occurrence to determine the main themes in order to provide their prevalence. The collected data in the research was done by first identifying the main themes that emerged from the researcher's interviews, field notes, and observation protocols.

3.8.1 Data analysis procedure

Kumar (2014) states that data analysis in a qualitative study involves four steps: Identifying the main themes, assigning codes to the main themes, classifying responses under the main themes, and integrating themes and responses into the text of your report. The data analysis was carried out following the four steps proposed by Kumar (2014). Following these four steps, the voice recordings obtained from the semi-structured interviews were encoded and transferred to the researcher's computer. After the voice recordings were transferred to the researcher's computer, the researcher first identified the main themes emerging from the observation protocols, field notes, and interviews. Secondly, codes were assigned to the main themes. Thirdly, the researcher went through the transcripts of all the interviews and notes and classified the responses in the notes under the different themes. Lastly, having identified responses that fall within different themes were integrated into the text of the researcher's report.

During the research, all interviews were semi-structured and authorised for in-depth discussions of open-ended questions. The interview questions centred on teachers' perspectives and conceptualisation of ADHD, neurodevelopment, and mathematical interventions in Grade 3 classes. All the interviews from both the mainstream and private school were voice-recorded, transcribed, and analysed using the following strategies:

1. Each voice recording was carefully listened to while the researcher made draft notes of recurring themes and topics.
2. A few of the interviews here and there were in Afrikaans. Therefore, there was no need to find an external translator, but it was something the researcher could manage as she is an Afrikaans home language speaker. The researcher back-translated the

English text to Afrikaans and compared those to the original Afrikaans transcription. The researcher referred the responses to the participants to ensure no ambiguity and to ascertain an accurate representation of the original data.

3. All the transcribed data from the interviews were intensely studied to form a holistic understanding of the gathered data.
4. Theme clusters were formed by coding text segments with phrases and words.
5. The researcher noted recurring themes and compared them to earlier draft notes.
6. Coded clusters were organised into emerging themes forming the critical data to be rigorously studied and discussed alongside the relevant literature.

The researcher managed data generated through fieldwork to build the analysis and track the progress of the analysis. This approach enabled the researcher to locate the evidence required to test and support the results the researcher put forward (Bazeley, 2013).

3.9 TRUSTWORTHINESS

Maree (2012) defines trustworthiness as how data are collected and sorted, especially if the formats are verbal and textual. According to Maree (2012) and Kumar (2014), the researcher can follow specific steps to enhance the study's trustworthiness. Rodrigues (2018) agrees with the authors mentioned above and states that the measures of the reliability and validity of any research proposal are replaced by the concept of trustworthiness in terms of establishing confidence in qualitative research findings. During the study, the researcher validated interpretations by triangulating viewpoints using field notes and observations. Rodrigues (2018) states that the researcher must ensure some form of reliability in qualitative research to prepare for people's examination and questions about the trustworthiness of what the researcher presents. Therefore, the researcher followed the following steps mentioned in Table 3.2 below, that ensured trustworthiness and reliability.

Table 2.2: Four steps to enhance a study's trustworthiness

Steps (Maree 2012 and Kumar 2013)	Achieved in the study
1. Verifying the raw data	Participants were allowed to review field notes and transcriptions. The participating teachers also completed a post-confidentiality interview form. Rodrigues (2018) states that another way to validate data is to ask the participants if the data

Steps (Maree 2012 and Kumar 2013)	Achieved in the study
	collected ring true to ensure that there can be no misunderstandings about what was said or explained.
2. Controlling bias	According to Kumar (2014), it is unethical to introduce bias into a research activity. Therefore, to control any form of bias, the researcher provided a brief explanation of her understanding about ADHD and neurodevelopment. This provided a platform on which the participating teachers could share their understanding and conceptualisation about ADHD neurodevelopment without any form of bias.
3. Avoiding generalisation	The researcher discussed context-specific data before each interview in strict relation to the case study only to avoid generalisation and distractions.
4. Maintaining confidentiality and anonymity	No names or identifying characteristics of schools or teachers were mentioned in the study. It is the researcher's responsibility always to protect the identity of all participants. The researcher, therefore, takes great care when discussing the data and referring to participants.

During the research, the researcher complied with the steps mentioned above. The participants were ensured that they could withdraw at any time should they wish to do so as stated in the assent letter form. The researcher controlled any form of bias by strictly adhering to the interview schedule and not participating in any teachers' discussions unrelated to the topic of the study. The researcher was aware of limiting qualitative research concerning generalisation and undertook not to generalise the data of this study to a broader context than

the one investigated. The researcher considered and respected the confidentiality and anonymity of each participating teacher. The researcher maintained this by not mentioning the participating schools' and teachers' names or personal identifiers. To evaluate the trustworthiness, the researcher used the following four aspects in her study: credibility, transferability, dependability, and confirmability.

Credibility was achieved by providing rich, in-depth data and direct quotes from each participating teacher. The researcher also made use of external verification (audit) of the data that were collected. This verification was achieved by submitting the documentation to a supervisor who did not participate in the research but asking them to assess how the conceptual analysis was carried out. This verification procedure enabled the researcher to assess the credibility of the results. Additionally, member checking was also used to ensure the accuracy of all the data collected. The participants were thus able to examine the data analysis and make comments. Transferability was achieved by providing an extensive and in-depth discussion about the underlying theoretical model, research methodology, data collection and data analysis strategies. Therefore, the researcher also explained the study's objectives, context, and background. This information will enable other researchers to assess whether the qualitative results are transferable to their different contexts (Maree, 2012).

According to Maree (2012), to strengthen the credibility of the research procedure, the researcher should monitor the quality of the recording and transcription of the data, the documentation, methods of observation and interviews. Additionally, the comprehensive method of collection and analysis of the data provides future researchers with adequate information to repeat the study as part of new research attempts, enhancing the dependability and consistency of this research.

Lastly, confirmability was achieved by the correlation between the data collected and the research findings. The researcher clearly described the process of data collection and analysis. The conclusion is also reported in detail and linked to the data analysis. Proof is provided that the researcher was self-aware throughout the research process and stated her own beliefs, values, biases, and affective state, as well as the impact of these on the research process in general and data collected and analysed (Maree, 2012). To assure confirmability the data collected will be retained for a period and made available for analysis by other researchers.

The researcher strived to enhance the present study's trustworthiness by adhering to the abovementioned procedures, also considering the four steps of trustworthiness as described in Table 3.2 (Four steps to enhance a study's trustworthiness).

3.10 ETHICAL CONSIDERATIONS

Kumar (2014) states that research ethics set guidelines to protect human participants in any form of research. Maree (2012) agrees with Kumar (2014) and defines ethics considerations as a way of providing exemplary guidance to research and practices. According to Rodrigues (2018) and Maree (2012), there are three ethical principles as guidance for all research participants: beneficence, respect, and justice for people (autonomy). These principles are implemented in three primary actions involved in planning and carrying out research. This help to provide true informed consent, determine and articulate risks and benefits, and enhances choosing participants equitably (Maree, 2012). Kumar (2014) states that the most important ethical issues to consider concerning the research participants are: collecting the information, seeking informed consent, providing incentives, seeking sensitive information, the possibility of causing any harm to participants, and maintaining confidentiality. Kumar (2014) further states the following ethical issues to consider relating to the researcher: avoiding bias, provision, or deprivation of treatment, using inappropriate research methodology, incorrect reporting, and inappropriate use of information.

Considering that this study was a qualitative study involving human participants and encouraged them to share their personal views and conceptualisation about ADHD neurodevelopment, made it compulsory for the researcher to keep several ethical considerations in mind. It is required to mention that numerous ethical considerations were adhered to before the commencement of the research. Ensuring ethical conduct, the researcher applied for ethical clearance and approval before data collection. The following ethical considerations were observed in this research study.

3.10.1 Ethical issues considered concerning the research participants and the researcher:

a) Collecting information

The researcher considered the relevance and usefulness of her research before collecting any information to avoid wasting the participants' time and to ensure the research are not unethical.

b) Seeking informed consent and voluntary participation

According to Kumar (2014), the participants must be informed about the research objectives, data analysis strategies, and to whom the results would be made known. The researcher ensured that each participating teacher knew what was expected from them, why the information was being sought, the purpose of the study, how they were expected to participate, and how it would, directly and indirectly, affect them. The consent during the research is voluntary and without any kind of pressure (Kumar, 2014). The researcher addressed the participants after receiving ethical approval from the University of Pretoria, the Gauteng Department of Basic Education and the participating school's principals from the mainstream and private school. The researcher gave each participant (teacher) a thorough letter explaining the research objectives and asking them to participate in this study voluntarily. The participants were also provided with a consent form by which the researcher acquired written informed consent from the participants prior to the starting point of the data collection (see Appendix E). The researcher assured each participating teacher that they could withdraw from the study at any time and that their participation was voluntary. Each participant was assured of having a clear understanding of the research project, what was expected from them, the challenges and benefits the research could hold, and how the data would be collected, analysed, and stored.

c) The possibility of causing harm to participants

The researcher ensured that each question asked during the semi-structured interviews caused no harm or discomfort. The researcher approached each teacher with kindness and professionalism to avoid anxiety or harassment. The identity and personal information of each participant and school were protected and never mentioned. Maree (2012) and Kumar (2014) state that the researcher must abide by an ethical code to protect participants involved in the study. The researcher must be responsible for not harming anyone during the data collection and analysis. This study did not hold the possibility to cause any form of harm to any participant. The researcher abided to the ethical code by protecting participants from any form of physical, emotional, and mental harm. The participants were encouraged to share information that they were comfortable sharing. The demeanour of this study did not cause any risks to the participants, and each participant knew that they could withdraw from the study any time they felt like it. There were no risk-related activities during the sample procedures, data collection and data analysis strategies. According to Kumar (2014) and Rodrigues (2018), the researcher should keep certain safety measures in mind to avoid any

harm and protect the participants' rights. Below is a description of all safety measures and how they were met in the study by the researcher.

- The research objectives must be communicated verbally and in writing to avoid any misunderstandings about the research project. During the study, the researcher ensured that each participating teacher received a detailed letter explaining the research methods, data collection, data analysis, what was expected from each participant, and how the data were to be used. At the beginning of each semi-structured interview, participants were thanked for their willingness to participate in the study. The researcher also explained the research objectives again before starting the interviews.
- Written permission must be required from each participant (teacher). Each participant was provided with a consent form. The researcher obtained the participants' consent to participate in the study.
- Documents and required forms must be filed with the respective research and ethics boards. The signed documents were held and protected by the researcher, the researcher's supervisors, and the research institution in strict confidentiality.
- The researcher communicated the data collection methods and activities to the participants in writing at the beginning of the research and verbally during the research.
- Detailed transcripts and written field notes must be made available to the participants for viewing. The researcher made the transcripts available to the participating teachers for viewing and allowed them to make changes if they did not agree to any statements (in the form of post-interview confidentiality forms).
- The rights of each participant were kept in mind before making any choices about reporting the data.
- As previously mentioned, no names or characteristics of the teachers or schools were mentioned, and they were kept anonymous. This procedure is for the protection of each participant.

The researcher protected the participants' anonymity and privacy by following the measurements as mentioned above. This also helped the researcher to avoid any form of harm during the research study.

d) Maintaining confidentiality

The participants were assured that all information they gave would be made anonymous. The researcher did not identify any individual or school during the study. The researcher also

assured that the research collected, written field notes, informed consent letters, and any other documents were treated with the utmost respect and confidentiality. The participating teachers were allowed to make any changes if they did not agree with any form of information or felt it could compromise their anonymity. All safety measurements were abided to by the researcher, ensuring each participant's safe, anonymous, and confidential participation.

3.11 SUMMARY

In this chapter, the research methodology was described concerning the selected research approach, sampling procedure, data collection, data analysis strategies, and the study's ethical considerations. The research methodology was justified in line with the research questions and objectives. The following chapter, Chapter 4, will report on the study's findings, data analysis, and interpretation.

4 CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

The purpose of Chapter 3 was to present the research design and methodology used in the study. The study focused on exploring Grade 3 teachers' conceptualisation of the diagnoses of ADHD, the possible mathematical interventions, and the data collection instruments. The interviews with the participating teachers were audio-recorded. The document observations (mathematics books and worksheets) were documented in an observation checklist (protocol) and a journal after the data were analysed. The emerging themes and categories were used as a direction for the interpretation of the data. Firstly, in Chapter 4, the researcher outlines the analysis of the research settings, participants, and data collected. The researcher discusses the research settings in table format and the participating teachers' profiles, such as gender, codes, work profile, qualifications, and amount of teaching years. Secondly, the researcher explains how the data were collected, coded, grouped into themes and categories, then analysed, and finally interpreted. Thirdly, the research findings are described. Lastly, the researcher briefly summarises the discussions on the analysed data and the chapter's conclusions. Furthermore, the researcher outlines the information further in Chapter 5. Figure 4.1 below illustrates the outline of Chapter 4.

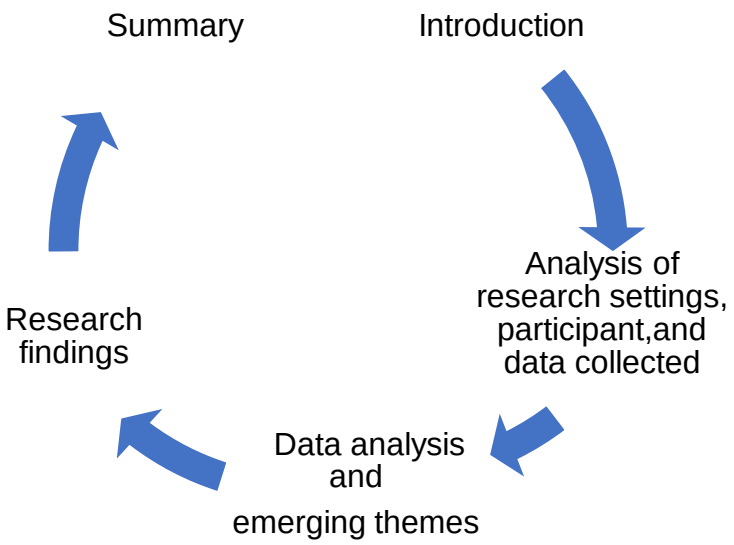


Figure 4.1: Outline of Chapter 4

4.2 ANALYSIS OF RESEARCH SETTINGS, PARTICIPANTS, AND DATA COLLECTED

The selected schools were located in Gauteng province in Pretoria. The study used one mainstream school and one private school. Both schools had learners with learning barriers, especially those diagnosed with ADHD. The teachers and learners came from different cultural backgrounds and spoke English and Afrikaans.

Names were not used to ensure the anonymity and safety of each participating teacher and the school's personal information. The private school was the first school interviewed. This school was referred to as Group 1. The private school did not have more than two Grade 3 teachers. Therefore, only two teachers were interviewed. These two participating teachers were identified as Teachers A and B. The second school interviewed was the mainstream school. This school was referred to as Group 2. Group 2 had enough Grade 3 teachers. Therefore, three Grade 3 teachers were interviewed. The teachers were identified as Teachers C to E. All five participating teachers from both schools identified had more than three years of experience working with ADHD-diagnosed learners.

4.2.1 Profile of participating teachers

Table 4.1 below presents the profile and codes of the participating teachers as part of the data collection process. All the participating teachers were females with more than three years of experience working with ADHD-diagnosed learners. The teachers' names were coded to ensure compliance with the ethical practices while conducting the research.

Table 4.1: Profiles of participating teachers: codes, gender, qualifications, work profiles, and years of teaching experience

CODE	GENDER	QUALIFICATION	WORK PROFILE	YEARS OF TEACHING EXPERIENCE
TA (Group 1)	Female	BEd Honours degree in learning support	• Grade R teacher for three years • Grade 3 teachers for 2 years	Five years

CODE	GENDER	QUALIFICATION	WORK PROFILE	YEARS OF TEACHING EXPERIENCE
TB (Group 1)	Female	Bachelor of Education degree	• Grade 1 teacher for 3 years • Grade 3 teacher for 2 years	Five years
TC (Group 2)	Female	Bachelor of Education degree	• Remedial education for 4 years • Grade 3 teacher for 3 years	Seven years
TD (Group 2)	Female	BEd Honours degree in learning support	Grade 3 teacher for 5 years	Five years
TE (Group 2)	Female	Bachelor of Education degree	• Nail technician for 6 years • Grade 3 teacher for 3 years	Three years

Teacher A (TA)

The first participant was teacher A, who had more than five years of experience working with learners diagnosed with ADHD. She had also completed her BEd Honours degree in learning support at the University of Pretoria. Teacher A had encountered several learners diagnosed with ADHD in her classroom during her five years of experience. She only had two years of experience working with Grade 3 learners and three years of experience working with Grade R learners. Teacher A is available daily after school to support her learners with homework or any challenges.

Teacher B (TB)

Teacher B has a Bachelor of Education degree. She is also a Grade 3 teacher with more than five years of experience working with learners diagnosed with ADHD. Teacher B worked with Grade 1 learners for three years and worked with Grade 3 learners for two years. She is also available after working hours to help learners with homework and any challenges they face.

Teacher C (TC)

Teacher C is a Grade 3 teacher with a Bachelor of Education degree, with seven years of teaching experience, including four years of remedial education experience. She also provides extra lessons to help learners after school hours with mathematics.

Teacher D (TD)

Teacher D is a Grade 3 teacher with a BEd Honours degree in learning support. She has been a teacher for five years. Teacher D is also a creative teacher who loves working with ADHD-diagnosed learners. She enjoys creating a safe and happy classroom environment for her learners. Her classroom consists of many resources to support her learners physically and emotionally.

Teacher E (TE)

Teacher E has been a Grade 3 teacher for five years with a Bachelor of Education degree. She was a nail technician for six years and only started teaching in 2019. She first did ‘relay’ work for the school in 2018 until she was hired for a permanent teaching position in 2019. Teacher E has a great passion for children and is very interested in learners diagnosed with learning barriers. She would like to study further one day to educate herself more about ADHD-diagnosed learners.

4.2.2 Data collection process

The researcher met with all the participants in their classrooms after school working hours, at a time and place the teachers found more comfortable. Before the semi-structured interviews and observations started, the researcher first explained the research topic and the purpose of the topic and lastly explained difficult concepts such as neurodevelopment and the diagnosis of ADHD from her personal point of view. The researcher reminded the participating teachers that they were at liberty to continue participating in the study. She also informed the participants they could withdraw from the study without providing any reason. The participants were also reminded that no names would be used during the study, only pseudonyms. As

mentioned in Chapter 3, the researcher used the six stages mentioned in Figure 4.2 below during the data collection process.

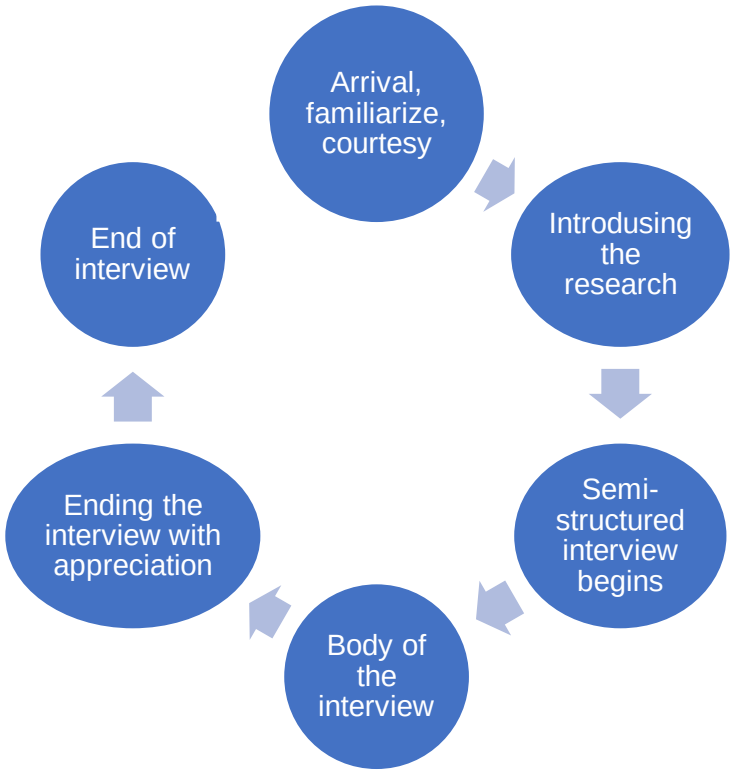


Figure 4.2: Illustration of the data collection stages

4.2.2.1 Arrival, familiarisation and courtesies

The first stage was about arrival, familiarisation, and courtesy. Most of the participants felt comfortable doing the interviews in the classrooms. From Group 1 (private school), TA and TB both did the interviews in their own classrooms after school hours. However, the principal from the mainstream school (Group 2) arranged with the researcher to meet the three participating teachers at the principal's office early in the morning. According to the principal, this was the most appropriate place for interviews at the time because the school was busy with rehearsals for the school concert. As the researcher finished interviewing one teacher, the next teacher waited outside for her turn. The first correspondence was familiarisation between the participating teacher and the researcher and a few random discussions and laughs. The process helped the researcher to lay a foundation for the intended research. It was done in a friendly way; the researcher assured and informed each participant from Group 1 and Group 2 that their time and information were highly appreciated. As mentioned earlier, the researcher assured each participating teacher to avoid any impression that might have made the participants feel that she was cross-examining them critically.

4.2.2.2 Introducing the research

During this stage, the researcher introduced the research topic to the participating teachers and explained certain concepts that the teachers found difficult such as neurodevelopment and the diagnosis of ADHD. This approach assured the teachers' understanding of the questions and ruled out any uncertainty. The participants were informed and reassured about the ethical procedures stated in the letters they received and signed.

4.2.2.3 The beginning of the semi-structured interviews

The participants settled down in their seats while the researcher started with the questions. The participants seemed to understand most of the questions responding with different emotions to the questions. The researcher audio-recorded the participant's answers and closely watched their body postures and every emotion as they answered the questions. The researcher recorded the information on the observation protocol. Each participating teacher could take as much time as required to respond to the questions.

4.2.2.4 Body of the interview

During this stage, further guidance and responses were dealt with in response to questions the participating teachers did not understand. The participating teachers faced no barriers or challenges during the interview questions, which made the interviews successful. After the interviews, the researcher collected all the information she had written down and stopped the audio recordings.

4.2.2.5 Ending the interview with appreciation

After each interview, the researcher collected the materials and thanked each participating teacher for their time and responses to the questions. The participants seemed to enjoy the interviews, and as mentioned by TE, this motivated her to want to study further. The researcher also expressed gratitude for the participants' support. In doing this, the researcher helped them move away from the interview mode and asked them if they could now observe the mathematics books and materials.

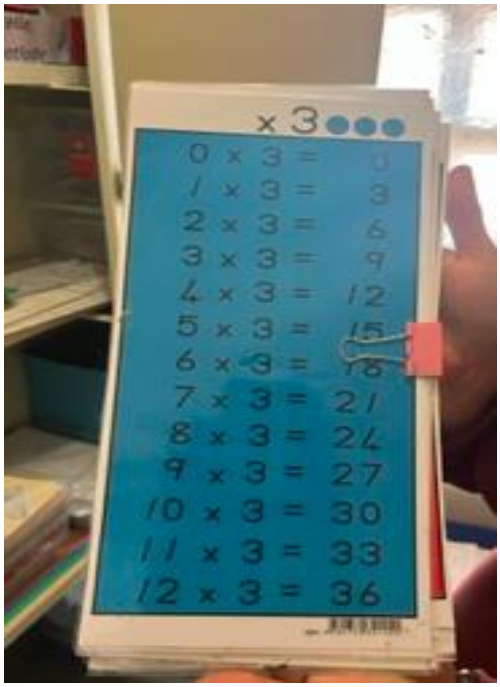
4.2.2.6 End of interview

As the interviews were done, the researcher examined the interview questions and started reviewing the participants' mathematics books, worksheets, and methods.

4.2.3 Observations

Before the researcher started with the observations, each teacher was asked to bring their ADHD-identified learners' workbooks, mathematics activities, and worksheets used

throughout the year. This was also arranged before the interviews started. Teachers TA and TB from Group 1 were kind enough to take the researcher through their classrooms and showed her the storeroom with all the concrete materials they used and shared. These materials were blocks, games, activities and unfix blocks. The participating teachers from the mainstream school (Group 2) only brought a few materials to the interviews and spoke about the rest of the material they used. The materials they spoke about were ADHD resources such as textured teddies, pillows, and fidgets. While observing the mathematical books, the researcher could view some worksheets and activities the teachers used during multiplication lessons. Figure 4.3 and Figure 4.4 below illustrate examples of concrete materials that the teachers used with the multiplication worksheets and activities in the learners' mathematics books.



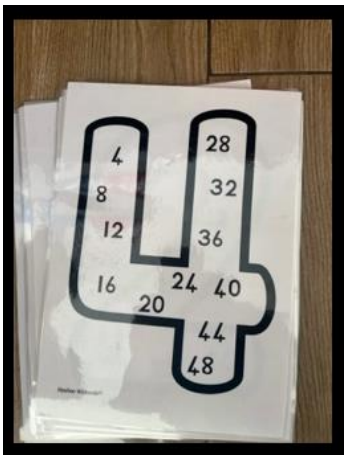
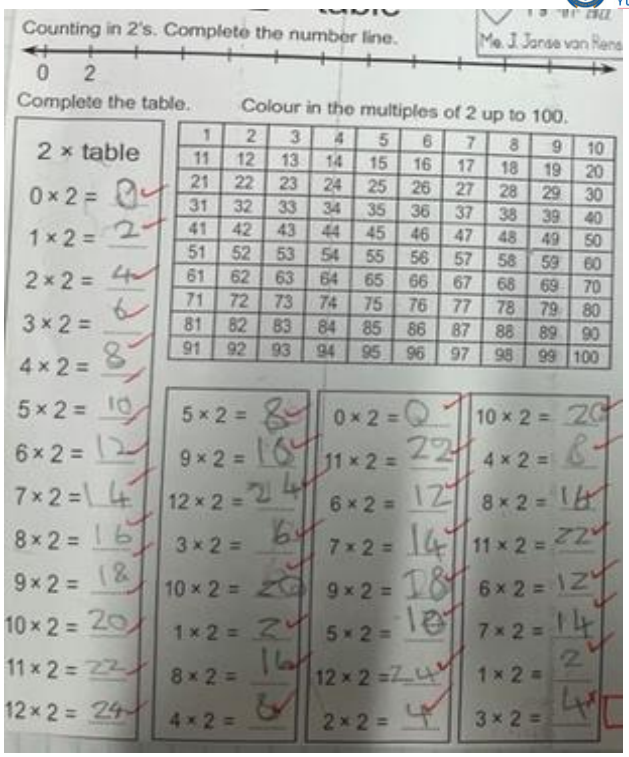


Figure 4.3: Photographs taken of some of the concrete materials participants used for multiplication and multiplication tables


Counting in 2's. Complete the number line.

0 2

Me. J. Janse van Rens

Complete the table. Colour in the multiples of 2 up to 100.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

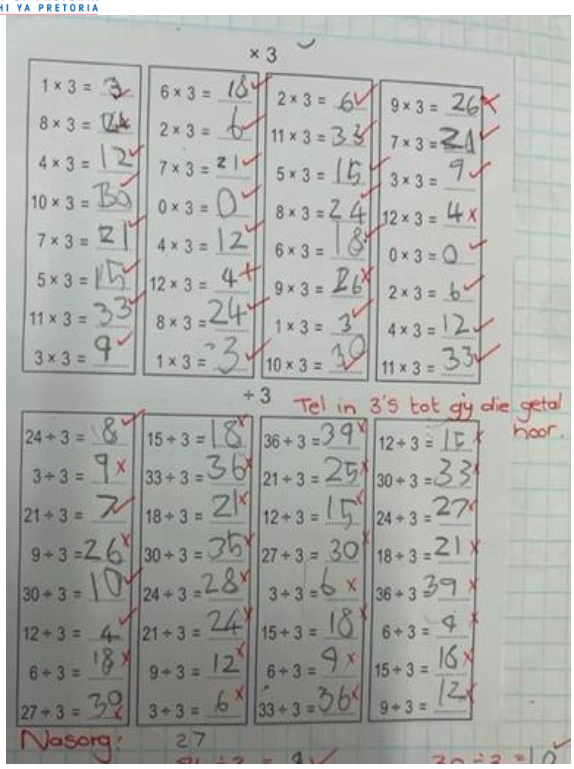
2 × table

0 × 2 = 0
1 × 2 = 2
2 × 2 = 4
3 × 2 = 6
4 × 2 = 8
5 × 2 = 10
6 × 2 = 12
7 × 2 = 14
8 × 2 = 16
9 × 2 = 18
10 × 2 = 20
11 × 2 = 22
12 × 2 = 24

5 × 2 = 8
9 × 2 = 16
12 × 2 = 24
3 × 2 = 6
10 × 2 = 20
1 × 2 = 2
8 × 2 = 16
4 × 2 = 8

0 × 2 = 0
11 × 2 = 22
6 × 2 = 12
7 × 2 = 14
9 × 2 = 18
5 × 2 = 10
12 × 2 = 24
2 × 2 = 4

10 × 2 = 20
4 × 2 = 8
8 × 2 = 16
11 × 2 = 22
6 × 2 = 12
7 × 2 = 14
1 × 2 = 2
3 × 2 = 6


× 3

1 × 3 = 3
8 × 3 = 24
4 × 3 = 12
10 × 3 = 30
7 × 3 = 21
5 × 3 = 15
11 × 3 = 33
3 × 3 = 9

6 × 3 = 18
2 × 3 = 6
7 × 3 = 21
0 × 3 = 0
4 × 3 = 12
12 × 3 = 4
8 × 3 = 24
1 × 3 = 3

2 × 3 = 6
11 × 3 = 33
5 × 3 = 15
8 × 3 = 24
6 × 3 = 18
9 × 3 = 26
1 × 3 = 3
10 × 3 = 30

9 × 3 = 26
7 × 3 = 21
3 × 3 = 9
12 × 3 = 4
0 × 3 = 0
2 × 3 = 6
4 × 3 = 12
11 × 3 = 33

÷ 3 Tel in 3's tot jy die getal hoor.

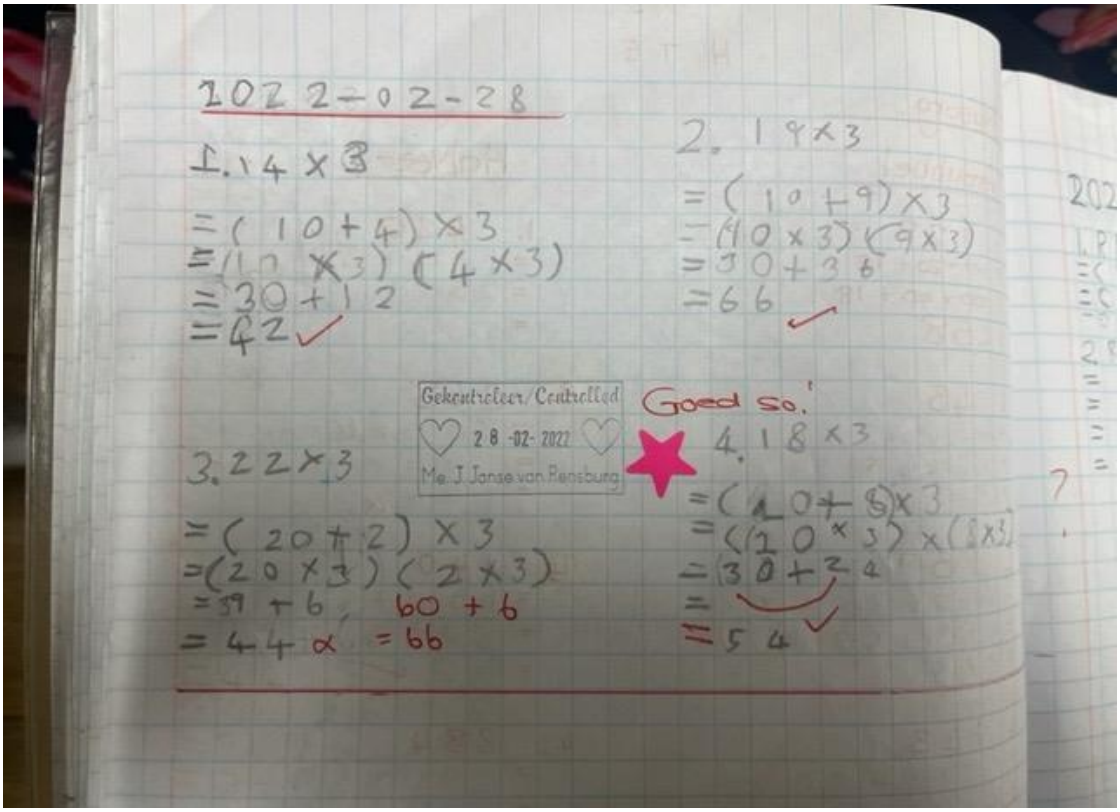
24 ÷ 3 = 8
3 ÷ 3 = 9
21 ÷ 3 = 7
9 ÷ 3 = 26
30 ÷ 3 = 10
12 ÷ 3 = 4
6 ÷ 3 = 18
27 ÷ 3 = 30

15 ÷ 3 = 18
33 ÷ 3 = 36
18 ÷ 3 = 21
30 ÷ 3 = 35
24 ÷ 3 = 28
21 ÷ 3 = 24
9 ÷ 3 = 12
3 ÷ 3 = 6

36 ÷ 3 = 39
21 ÷ 3 = 25
12 ÷ 3 = 15
27 ÷ 3 = 30
3 ÷ 3 = 6
15 ÷ 3 = 18
6 ÷ 3 = 9
33 ÷ 3 = 36

12 ÷ 3 = 15
30 ÷ 3 = 33
24 ÷ 3 = 27
18 ÷ 3 = 21
36 ÷ 3 = 39
6 ÷ 3 = 4
15 ÷ 3 = 18
9 ÷ 3 = 12

Nasorg: 27


2022-02-28

1. 14 × 3
= (10 + 4) × 3
= (10 × 3) (4 × 3)
= 30 + 12
= 42 ✓

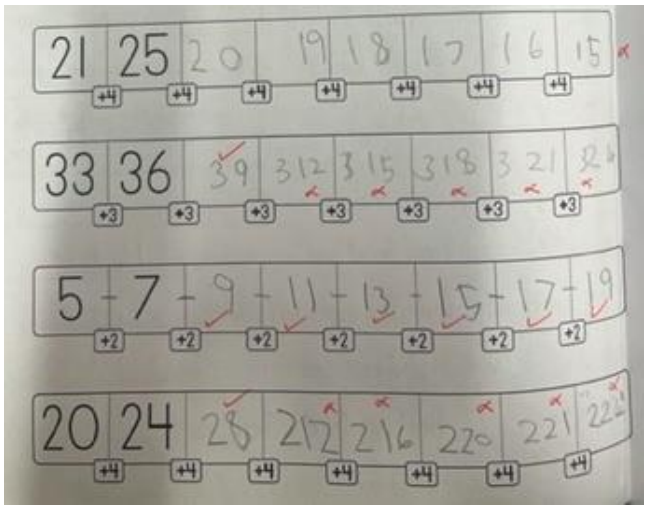
2. 19 × 3
= (10 + 9) × 3
= (10 × 3) (9 × 3)
= 30 + 36
= 66 ✓

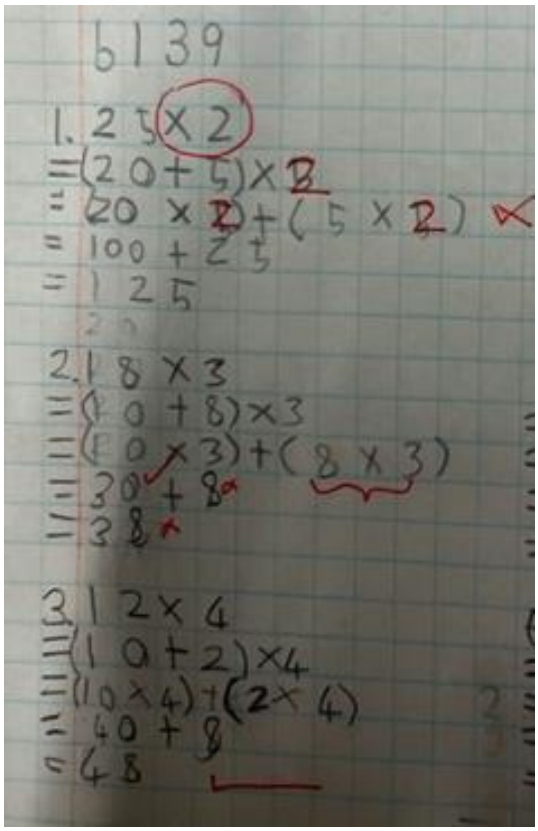
Gekontroleer/Controlled
28-02-2022
Me. J. Janse van Rensburg

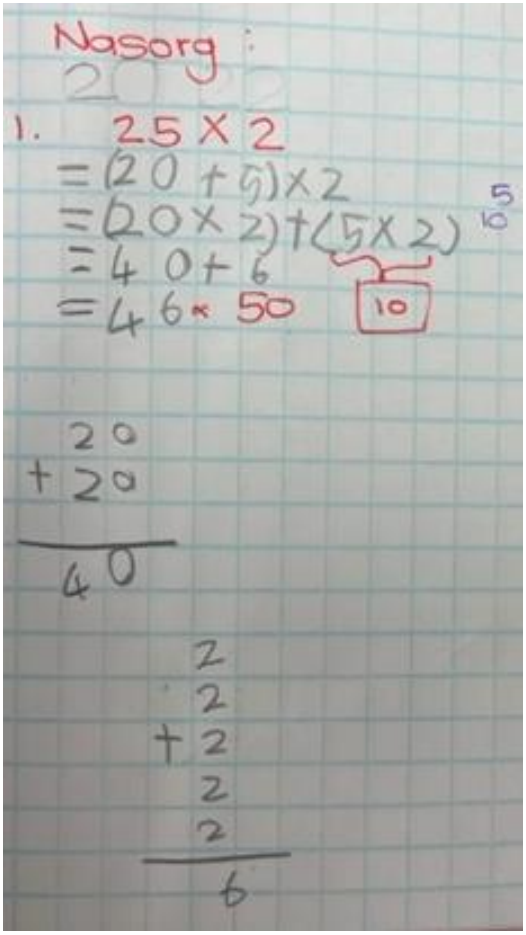
Goed so.

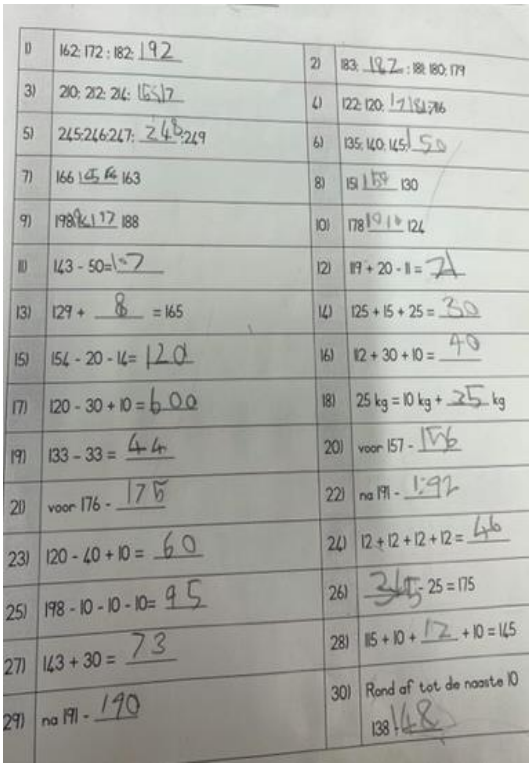
3. 22 × 3
= (20 + 2) × 3
= (20 × 3) (2 × 3)
= 59 + 6, 60 + 6
= 44 ∝ = 66

4. 18 × 3
= (10 + 8) × 3
= (10 × 3) × (3 × 3)
= 30 + 24
= 54 ✓









Maal somme - lang metode.

Kyk mooi na die voorbeeld en voltooi die somme:

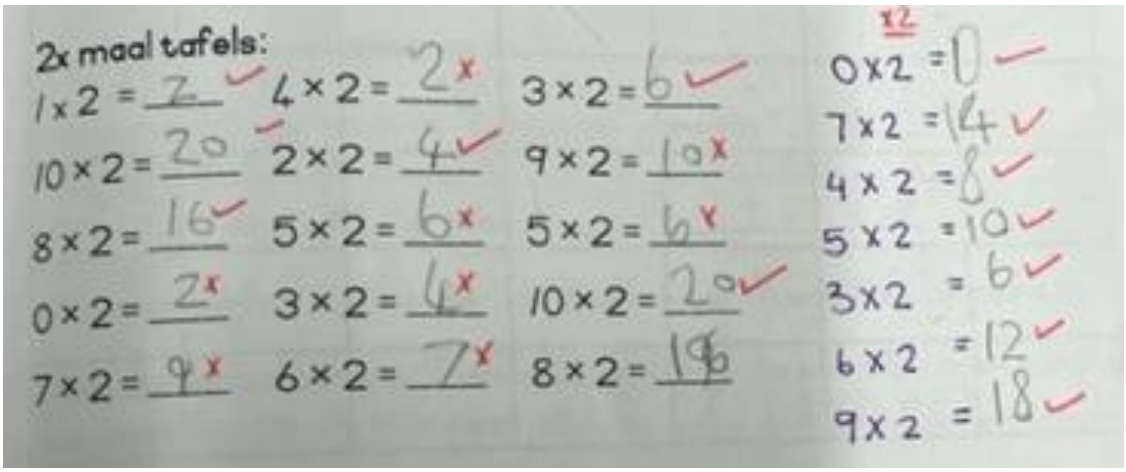
Voorbeeld: Som: 22×5.

Metode:

Stap 1:	Breek op	$= (20 + 2) \times 5$
Stap 2:	Maal elke getal	$= (20 \times 5) + (2 \times 5)$
Stap 3:	Tel saam	$= 100 + 10$
Stap 4:	Finale antwoord	$= 110$

Voltooi die somme in jou werkboek:

1. 25×2	2. 18×3	3. 12×4
4. 17×4	5. 23×3	6. 32×2

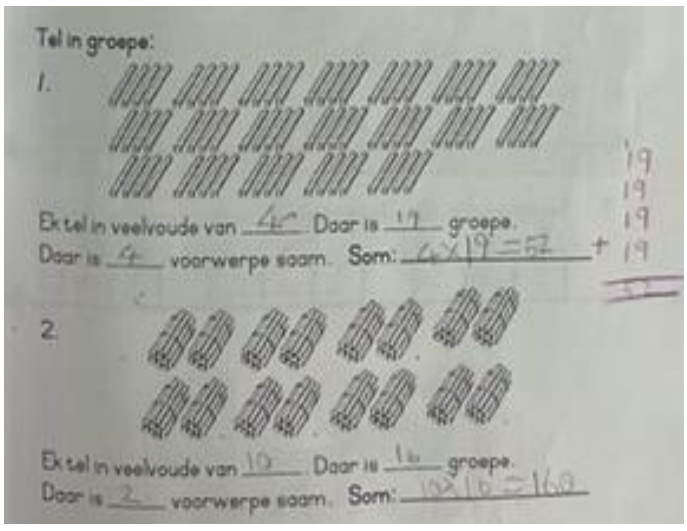


2x maal tafels:

$1 \times 2 = 2$ ✓	$4 \times 2 = 2$ ✗	$3 \times 2 = 6$ ✓
$10 \times 2 = 20$ ✓	$2 \times 2 = 4$ ✓	$9 \times 2 = 10$ ✗
$8 \times 2 = 16$ ✓	$5 \times 2 = 6$ ✗	$5 \times 2 = 6$ ✗
$0 \times 2 = 2$ ✗	$3 \times 2 = 4$ ✗	$10 \times 2 = 20$ ✓
$7 \times 2 = 9$ ✗	$6 \times 2 = 7$ ✗	$8 \times 2 = 16$

x2

$0 \times 2 = 0$ ✓
$7 \times 2 = 14$ ✓
$4 \times 2 = 8$ ✓
$5 \times 2 = 10$ ✓
$3 \times 2 = 6$ ✓
$6 \times 2 = 12$ ✓
$9 \times 2 = 18$ ✓



Tel in groepe:

1.

Ek tel in veelvoude van 4 Daar is 19 groepe.
Daar is 4 voorwerpe saam. Som: $4 \times 19 = 57$

19
19
19
19
+
57

2.

Ek tel in veelvoude van 10 Daar is 16 groepe.
Daar is 2 voorwerpe saam. Som: $10 \times 16 = 160$

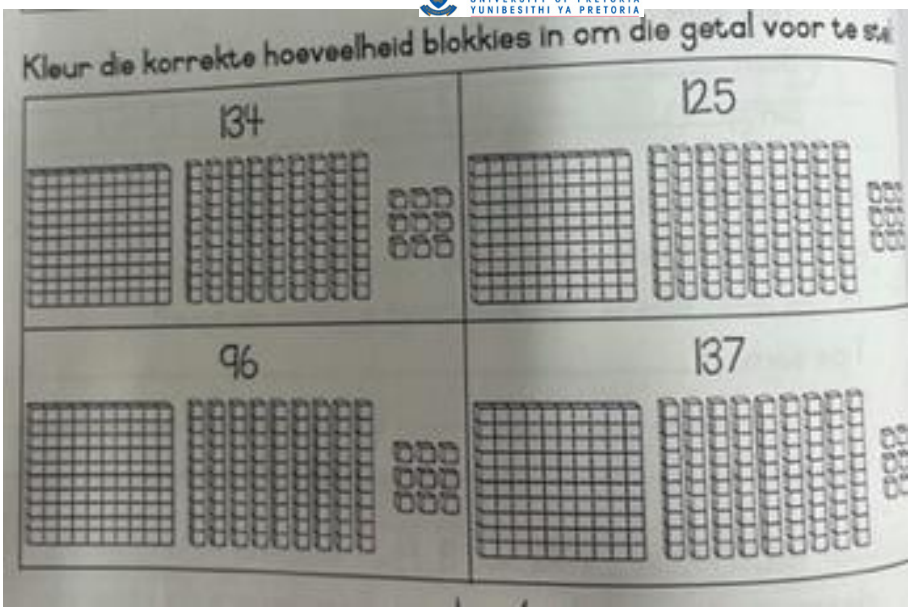


Figure 4.4: Examples of the teachers' worksheets

4.3 DATA ANALYSIS AND EMERGING THEMES

The data analysis procedure led to the emergence of repeated themes and discussion topics in each participating teacher's responses. The data were analysed according to four steps (see Chapter 3). Firstly, the researcher identified the primary and recurring themes in the response of each participating teacher. She studied and identified the main themes and subthemes that became visible from her field notes, interviews, and observation protocols. Secondly, she assigned codes to the main themes. Thirdly, she classified responses under the main themes, and lastly, she integrated the themes and responses into the text of her report. The emerging themes with subthemes are presented in the following table:

Table 4.2: Emerging themes

Themes	Sub-themes
Theme 1: Teachers' conceptualisation of neurodevelopment and ADHD	**Sub-theme 1.1:** Teachers understanding of the term neurodevelopment and ADHD **Sub-theme 1.2:** The importance of neurodevelopment compared to ADHD. **Sub-theme 1.3** Impact of ADHD on learners' cognitive development and learning.
Theme 2: Teachers' perspectives about ADHD neurodevelopment and the mathematical interventions in the Foundation Phase.	**Sub-theme 2.1**: Mathematics interventions aligned with the curriculum. **Sub-theme 2.2:** Grade 3 teachers' perspectives about mathematics interventions for learners diagnosed with ADHD in the Foundation Phase. **Sub-theme 2.3:**

Themes	Sub-themes
	Challenges teachers face in implementing mathematics interventions.
Theme 3: The support teachers receive	**Sub-theme 3.1**: Types of support teachers receive from the school. **Sub-theme 3.2:** Types of support teachers receive from the DBE
Theme 4: Inclusive strategies used to help learners diagnosed with ADHD	**Sub-theme 4.1:** Strategies and methods participating teachers used to make challenging mathematics easier for learners diagnosed with ADHD. **Sub-theme 4.2:** The benefits of the strategies teachers use for the neurodevelopment of learners diagnosed with ADHD.
Theme 5: Curriculum differentiation	**Sub-theme 5.1:** Caps mathematics assessment policies for Grade 3 learners. **Sub-theme 5.2** The teachers' views on the effectiveness of the Curriculum for ADHD diagnosed learners and what to add or remove. **Sub-theme 5.3:** Teachers' views about assessing children with learning disorders compared to typically developing children.

Table 4.3 depicts the codes used for referencing in the presentation of the research findings.

Table 4.3: Codes used for referencing in the presentation of the research findings

Semi-structured interviews	Participating teachers	Coding the transcribed notes	Codes used for the themes
Group 1 Private School	Teacher A Teacher B	A B	PA PB
Group 2 Mainstream School	Teacher C Teacher D Teacher E	C D E	PC PD PE

Furthermore, certain expressions, quotes, phrases, and participant responses were coded. For example, when the researcher directly quotes one of the participants' sentences, it was designated as ‘Quote 1’ (or ‘Q1’), ‘Quote 2’ (or ‘Q2’) and so forth. The researcher would first write the participant's words in quotation marks with the quote phrases afterwards. This helped authorise uncomplicated access to raw data.

4.4 RESEARCH FINDINGS

4.4.1 Teachers’ conceptualisation of neurodevelopment and the disorder ADHD

Teachers’ understanding of neurodevelopment is vital to understand the brain function of ADHD-identified learners. According to Muñoz-Silva, Lago-Urbano, Sanchez-Garcia (2022), if teachers do not understand how ADHD learners think, function, and behave, it can cause poor teacher-learner relationships. Teachers with little knowledge or interest in the neurodevelopment of ADHD learners can lead to less emotional closeness, less collaboration, and more conflict between the teacher and the learner (Munoz *et al*., 2022). It is important to understand that learners with learning disabilities such as ADHD are learners who have been and still form part of the population (Nel *et al.,* 2013). Therefore, teachers need to understand how the neurodevelopment of ADHD can influence the learning and daily functioning of ADHD-identified learners. Teachers that work with ADHD-identified learners should be cautious about believing that they do not need to understand the neurodevelopment of ADHD, especially because children mature into adults. According to Getz (2013), ADHD is not just a childhood disorder but a developing disorder, which does not stop as learners grow into adolescence and adulthood (Getz, 2013).

4.4.1.1 Teachers' understanding of the term neurodevelopment and ADHD

Shortly after conception, the central nervous system begins to develop. According to Getz (2013) all through the stages of mitosis, embryogenesis, cell migration, and myelination synaptic pruning, the brain becomes a highly specialised organ that allows us to perform,

speak, understand, and learn. Greenblatt (2017) agrees with Getz (2013) and further mentions that any disruptions of these processes can result in functional difficulty. When the brain develops, it undergoes mitosis. During mitosis, when brain cells multiply and divide in the neural tube in the ventricular surface part of the brain. Over time neuroblasts are laid out. As a person grows, synaptic pruning occurs. Synaptic pruning is where new nerve cells are removed from the ventricular part of the brain. The pruning helps to increase the process of the use of neuropathways and connections. Any disruptions in the synaptic pruning process have been linked with ADHD (Getz, 2013). This can also be because of a constant over production of the dopamine hormone in the brain of an ADHD-identified learner. This overproduction causes them to be hyperactive and distracted. According to Getz (2013), studies have shown a reduction in the frontal lobe of ADHD learners' brains. This reduction causes poor decision-making, lack of planning, and distraction.

According to Teacher A from (Group 1), neurodevelopment and ADHD are:

> *"The study of the brain and behaviours that have a connection with each other, and I believe ADHD is when a child struggles to concentrate" (Q1).*

Teacher B (Group 1) explained neurodevelopment and ADHD as follows (reading the answers from her computer):

> *"I think neurodevelopment is the effect of a brain injury on an individual's cognitive ability. Like how they behave and how they function. Not necessarily a brain injury but something that creates a reaction in the brain, causing a learner with learning disabilities to react the way they do. ADHD is learners that struggle to concentrate, and they take longer to understand certain concepts. ADHD learners are also learners that learn the fastest through practical examples, working in smaller groups, and they are mostly very social" (Q2).*

Teacher C (Group 2) stated that she has never heard of the term "neurodevelopment", but she thinks:

> *"It has to do with the way the brain functions and how it affects education. It is something psychological for me" (Q3).*

She further mentioned that ADHD is:

> *"I would say it is when a child does not necessarily understand concepts but there are certain factors that cause the child to not be able to understand something in class. Like for example he is too busy, or has trouble*

concentrating, or paste worksheets upside down and has trouble sitting still" (Q4).

Teacher D (Group 2) stated that neurodevelopment is:

"I think when based on children's neurodevelopment, it is the brain capacity of a learner's brain" (Q5).

She further explains ADHD as:

"a deviation in the brain and it is also a part of the brain that does not work, it is a neurological thing" (Q6).

Teacher E (Group 2) indicated, just as Teacher C, that she had never heard of the term neurodevelopment. She explains it as:

"I believe it is the way the brain thinks and more the psychological part of the brain." (Q7)

She further explains ADHD as:

"A chemical imbalance in the brain. It is some kind of a dysfunction in the brain" (Q8).

It was clear that most participants did not understand the term neurodevelopment. During the interviews, teacher B searched for the definition of neurodevelopment and ADHD. She read the answers from her computer, clearly showing that she does not know the answer. The participants did, however, have some comprehension that ADHD is caused by an injury in the brain but could not elaborate on that. According to a study conducted by Daniel Sheppard (2022), a better understanding of the neurodevelopment of learners diagnosed with ADHD would help to understand the difficulties the learners experience when doing mathematics or any other subject better. This understanding will also help to elucidate the impact of cognitive difficulties on their daily life and inform effective strategies at school and home.

4.4.1.2 The importance of neurodevelopment in respect of ADHD

According to Sjöwall and Thorell (2022), previous research has emphasised the importance of viewing ADHD as a disorder related to neurodevelopmental deficits such as executive deficits, delay related behaviours, and emotional dysregulation. Bakker (2015) laid the groundwork for Sjöwall and Thorell (2022), stating that neurodevelopment plays an important role in the diagnoses, learning, and behaviour of learners identified with ADHD. The teacher needs to understand that the brain of an ADHD learner takes more time to mature. The most

noticeable growth delays in an ADHD brain are at the frontal lobe of the brain. The frontal lobe of the brain controls cognition, attention, and planning. This can cause challenges with the learner's attention because of the disorder ADHD causing a dysfunction in the brain. Teachers can help improve this challenge by focusing on the correct classroom setup and planning worksheets and activities according to the learners' challenges.

According to Teacher A (Group 1):

> *"Neurodevelopment is the study of the brain that have a connection with each other" (Q9).*

Teacher D (Group 2) added:

> "*I see ADHD as a deviation in the brain"* (Q10).

Moreover, Teacher C and Teacher E from Group 2 mentioned that they realised, neurodevelopment can be connected to ADHD. In the opinion of Teacher C, teachers should be made aware of the understanding of young ADHD-identified learners' development. Sjöwall and Thorell (2022) mention that it has been shown that the overlap between working memory, inhibition, and speed of processing information is more significant in children diagnosed with ADHD. Teacher D (Group 2) had some understanding that the learning capacity of the brain of ADHD learners is more complex. Bakker (2015) states that the brain is an important determinant of an ADHD learner's mental functioning, development, and health.

According to Teacher E (Group 2):

> "*ADHD is a chemical imbalance in the brain."* She added: *"a dysfunction in the brain"* (Q11).

Underdevelopment and malfunctioning of certain parts of the brain have become an accepted explanation for children diagnosed with ADHD. At the same time, however, most teachers are not knowledgeable enough to understand the neuroscience of the disorder ADHD (Bakker, 2015). Furthermore, based on the experience of Teacher A and Teacher B from Group 1 they felt they were not taught well enough about the brain, emotions, and understanding of ADHD learners. Sjöwall and Thorell (2022) agree with Teacher A and Teacher B and state that there are not enough studies to examine the extent to which emotion dysregulation overlaps with other neurodevelopmental deficits concerning children diagnosed with ADHD.

Teacher B (Group 1) and Teacher C (Group 2) stated that they think ADHD is “hereditary”. Genetic factors have been described as playing a major role in the development of ADHD (Getz, 2013). Carter (2019) agrees with Getz (2013) and states that faulty genes or developmental problems during gestation or infancy can cause some disorders. The neurodevelopment of a learner with ADHD is important to understand because it can help make learning and teaching for these learners easier.

4.4.1.3 Impact of ADHD on learners’ cognitive development and learning

Executive deficits are significant in the cognitive development and learning of ADHD learners. These deficits can cause hyperactivity, impulsivity, inattention, emotion regulation, and long- and short-term memory challenges in the cognitive development of young learners diagnosed with ADHD (Sjöwall & Thorell, 2022). According to Bakker (2015), ADHD disorder was a childhood mental disease-causing overactivity, restlessness, distractibility, and a short attention span in the cognitive development of learners, and it was diagnosed by psychiatrists and school physicians. Sheppard (2022) further states that ADHD can make daily tasks, such as remembering homework, bringing the correct equipment to school, difficulty understanding the teacher's instructions, or struggling to complete tasks difficult for learners. In the 1950s, ADHD was labelled as a brain injury/brain dysfunction causing hyperactivity in learners and adults and called “hyperkinesis” at the time (Bakker, 2015:354). Bakker (2015:355) further states that ADHD can also cause learners to be “easily distracted” and is a form of “restlessness”. According to Muñoz-Silva *et al*. (2022), ADHD can cause or form part of other learning disabilities and disorders in learners' cognitive development, such as dyslexia, dyscalculia, dyspraxia, and autism.

Teacher C (Group 2) gave a brief explanation of one of her learners that corresponded with the information of the resources mentioned above, stating:

> *“I would say it is when a child does not necessarily understand concepts but there are certain factors that cause the child to not be able to understand something in class. Like for example he is too busy, or has trouble concentrating, or paste worksheets upside down and has trouble sitting still” (Q12).*

Furthermore, Teacher A (Group 1) mentioned:

"I have to use different types of teaching aids in order to help teach them because they do not always keep attention if you just talk about the concept you need to get something to get their attention" (Q13).

According to both Sjöwall and Thorell (2022) and Bakker (2015), the three neuropsychological deficits of ADHD, hyperactivity, impulsivity, and inattention can play an important role on learners' cognitive development and make the learning of difficult tasks in mathematics much more challenging. Furthermore, ADHD can also cause other dysfunctions in emotions, such as anxiety, aggressiveness, depression, and feeling overwhelmed.

Teacher B (Group 1) stated:

"They feel very uncertain about themselves even though they have the ability to get the correct answer" (Q14).

Furthermore, Teacher C (Group 2) stated:

"If you start your morning with a busy or moody attitude the learners will definitely pick it up and also act busy, difficult, or very emotional" (Q15).

Teacher D by the same token mentioned:

"They are very emotional sensitive. I cannot afford to walk in my classroom with a negative attitude. Negativity is like throwing petrol on fire for them. If they get emotional it is not a good thing. Children diagnosed with ADHD act different than learners who are not diagnosed with ADHD if they get emotional. The learners will withdraw and not want to work" (Q16).

Furthermore, Sjöwall and Thorell (2022) state that studies have measured emotional lability/impulsivity in learners diagnosed with ADHD such as being easily frustrated and losing their temper.

4.4.2 Teachers' perspectives about ADHD neurodevelopment and mathematical interventions in the Foundation Phase.

According to David (2020), further studies are necessary to develop training programmes that would prepare teachers better for the education of gifted children and children with learning disabilities such as ADHD, especially in mainstream schools.

In supporting the literature, a perspective that Teacher A (Group 1), Teacher D (Group 2), and Teacher E (Group 2) had in common was that they wanted to learn more about the

neurodevelopment of learners diagnosed with ADHD to help improve the mathematics interventions they use.

Teacher E (Group 2) stated:

> *"I would like to study further one day to educate myself more about ADHD-diagnosed learners" (Q17).*

She claimed that there are some concepts that she does not always know how to convey more clearly to her ADHD-identified learners.

As the researcher observed Teacher A and Teacher B (Group 1), they appeared to have a more concerned perspective about how they should learn and transfer mathematics interventions to ADHD-identified learners in their classrooms. According to the participating teachers from Group 1, they felt that some challenges affect their ability to incorporate good mathematics interventions. They further explained that this includes the lack of materials they have which can cause them to be unable to convey a concept clearly, and the worksheets with explanations in the learner's mathematics books are not always understandable or on the learners' level of education.

Teacher C (Group 2) mentioned that she believes the curriculum's mathematics interventions only work best with sufficient repetition and hard work.

Teacher D (Group 2) stated:

> *"I actually have a broad perspective on the mathematical interventions for learners diagnosed with ADHD. The reason is because I have a learner who does well in mathematics and then I have a learner who does badly in mathematics. I can experience both sides and experience that some of the mathematics interventions help learners but others not so much. I have to for example use a stretch band for one learner that I put around her legs to help her with hyperactivity and distractibility while some of my other learners sit on special cushions to help them with concentration while they do mathematics, where other learners just need a picture or blocks to help them" (Q18).*

According to Teacher D, her perspective is that mathematics interventions work best for her ADHD-identified learners when she uses ADHD resources such as textured materials, bands, cushions, and fidgets.

During the interviews, it seemed that Group 2 was more equipped with concrete materials than the teachers from Group 1. According to the White Paper 6 policy, educational structures, systems, and methodologies must meet the needs of learners with learning barriers.

Teachers A and B from Group 1 also mentioned that the mathematics curriculum is too difficult and overwhelming for them. They claimed that certain mathematical concepts needed more explaining and one-on-one intervention, making teaching difficult. Furthermore, the Education White Paper 6 policy also mentions that learning needs may arise because of an inflexible curriculum, and inappropriate and inadequate support. The teachers from Group 1 mentioned that they did not receive enough support and therefore struggled to implement mathematics interventions for learners with ADHD.

Some of the participating teachers' perspectives appeared negative, because, according to them, they do not always have enough materials to apply the mathematics interventions when they do complicated mathematics. Teacher B from Group 1 mentioned that she and Teacher A must share concrete materials when they work with concepts such as multiplication, halves, and patterns. However, they are not always equipped enough for that. There was a clear difference in the teachers' perspectives in Group 1 and Group 2, mainly depending on their circumstances.

4.4.2.1 Mathematics interventions aligned with the curriculum.

Mathematics interventions are methods and ways to make the learning and teaching of mathematics easier for children who are behind or with any neurodevelopmental challenges (Nel *et al*., 2013). According to Maringe and Prew (2015), the curriculum is more than just a plan for teaching and learning in schools. It encompasses a variety of activities, processes, inputs, outputs, and outcomes that explain and form decisions about the teaching and learning of mathematics in schools. Furthermore, the Curriculum and Assessment Policy Statement has been designed as a framework to guide the teachers on different ways to assess learners throughout the year. However, CAPS was also subjected to critique. Mathematics has been seen as ‘content-dense’ in some grades, compromising the quality of teaching and the opportunity for the learners to attain expected competencies (Maringe & Prew, 2015).

According to Nel *et al.* (2013), the curriculum can be seen as inflexible and not responding to the needs of a wide variety of learners diagnosed with learning difficulties. This shortcoming leads to complications such as inappropriate teaching and learning and the belief that all the learners have to "fit into" the same system. In supporting the literature above, the perspectives of each teacher were mentioned and aligned with the curriculum to determine if the curriculum's mathematics interventions work and, if not, what the reason could be.

Teacher E (Group 2) mentioned that she would find it very helpful to study further one day to educate herself more on the neurodevelopment of ADHD-identified learners. White paper 6 notes that teachers must get enough training to broaden their knowledge of complex mathematics concepts that must be taught to learners with learning barriers. The researcher concluded that the participating teachers in Group 1 did not receive much training, and the training received by Group 2 was not always helpful. This could make teaching difficult mathematics concepts mentioned in the curriculum more challenging for the teachers.

Teacher B (Group 1) mentioned that some mathematics concepts are too difficult for learners diagnosed with severe ADHD or ADD. According to Manicka (2018), a study found the curriculum very burdensome and rigid for learners with disorders. 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 (Nel *et al*., 2013). Teacher A (Group 1) stated that they do not always have enough time to support the learners on a level expected from them.

Teacher C (Group 2) stated:

> *"I believe that the mathematics interventions that we use works, but it is still hard sometimes. You really have to try to keep the attention and repeat the work numerous times for the ADHD learners while also working with learners that have no learning impairments" (Q19).*

According to the curriculum, repetition is very important, especially when the learners have to do mental mathematics related to multiplication.

Teacher D (Group 2) mentioned that she uses ADHD resources such as textural materials,

cushions, and fidgets. The curriculum mentions that teachers can use materials that can help support the learners with mathematics interventions. Furthermore, she observes the learners' work often and uses real-life examples. This method is also aligned with the curriculum.

Furthermore, Teacher E (Group 2) mentioned:

> *"Some of the mathematics interventions from the curriculum work. Although I have realized that when my ADHD-diagnosed learners do not drink their medication, they will struggle regardless of the mathematics interventions" (Q20).*

Teacher E adds that a few interventions mentioned in the curriculum can be described as successful. These include breaking steps down into smaller pieces to help ADHD-identified learners with their memory. She also claimed that giving clear directions and explanations for the learners' work is mentioned in the curriculum.

According to Greenblatt (2017), repeating work is one of the golden nuggets to help learners diagnosed with ADHD to remember difficult steps. Learners with ADHD usually lack iron, and iron-deficient children score poorly in mathematics (Greenblatt, 2017). Therefore, if necessary, medication for concentration and to boost the brain is very important regardless of the interventions given to teachers. Manicka (2018) agrees with the importance of the correct medicine and adds that inclusive education and mathematics interventions can only be possible if the curriculum considers all children.

During the observations, the researcher realised that the teachers' worksheets are not always set up correctly as mentioned in the curriculum. The curriculum states that teachers must use physical helping aids, pictures, patterns, and supporting materials to help teach learners with ADHD. These include number lines, images used to describe multiplication, multiplication tables, diagrams to record multiplication facts, concrete apparatus, worksheets with pictures (for work sums about multiplication), and row patterns (for repeated addition leading to mathematics). The figures below illustrate examples from the curriculum which explain the above information.

Figure 4.5: Examples of flow diagrams from the curriculum

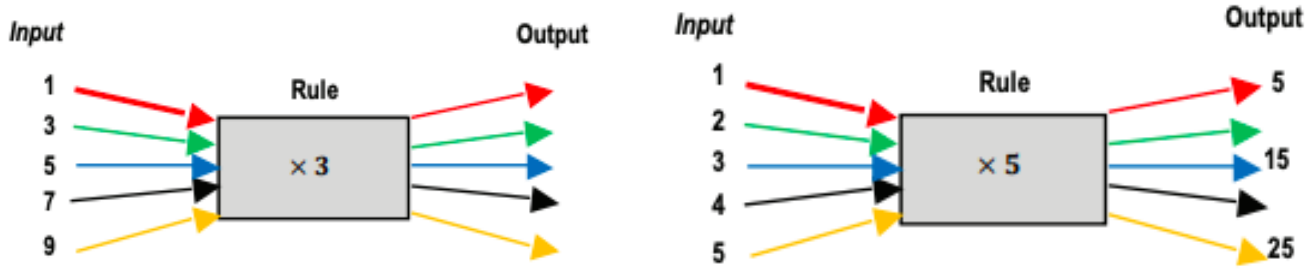


Figure 4.6: Examples of multiplication tables from the curriculum

×	2	3	4	5	6	7	8	9	10
1									
2									
3									
4									
5									

Figure 4.7: Examples of useful multiplication strategies using "doubling" from the curriculum

Fill in the times five row. What patterns do you see?

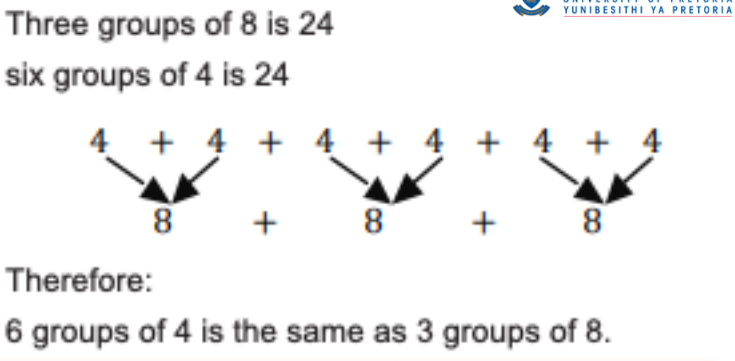
	1	2	3	4	5	6	7	8	9	10
× 5										
× 10										

Double the numbers in the times five row to get the numbers in the times 10 row. What patterns do you see?

Fill in the times two row.

	1	2	3	4	5	6	7	8	9	10
× 2										
× 4										

Double the numbers in the times two row to get the numbers in the times four row. What patterns do you see?



Figures used from the CAPS policy Statement document (DBE, 2011:340).

The figures above are examples from the curriculum about methods teachers can use to teach mathematics (multiplication) using semi-concrete objects for ADHD-identified learners. It also illustrated how teachers should design the tables, number lines, or grouping of numbers according to a specific pattern. The curriculum also mentions that teachers are allowed to tell learners with learning disorders or any neurodevelopmental challenges to use concrete apparatus or draw pictures to support them with challenging activities. Furthermore, the curriculum states that teachers must use systematic and explicit instruction when explaining concepts, visual representations such as manipulatives, pictures, graphs, and extra assistance.

4.4.2.2 Grade 3 teachers' perspectives about mathematics interventions for learners diagnosed with ADHD in the Foundation Phase.

According to Pratt (2002), teachers' perspectives are broader than mere teaching methods. Nel *et al.* (2017) explain teaching perspectives as beliefs that direct teaching actions and methods. During the interviews, it was clear that each teacher had their own perspective on the mathematics interventions they used in classrooms. Some participants had a positive perspective; others appeared more negative as they expressed their perspectives. There are different types of interventions teachers can use when ADHD learners struggle with mathematics because of their hyperactivity or distractibility. The teacher must, among other things, allow the learner to stand up and stretch their body when the learner is losing concentration (Mash & Wolfe, 2010). According to Sjöwall and Thorell (2022), brain gym activities can also support learners who struggle with distractibility or lose concentration. These interventions include cross crawl, brain buttons, drawing the lazy 8, hook-ups, and thinking caps.

According to Teacher A's statement, she had more of a negative perspective about some interventions in the curriculum. According to her, not all mathematics interventions work, and it depends on the learner's capacity. She stated: *"I think that some of the work is too difficult for learners diagnosed with severe ADHD*" (Q21).

Teacher C stated that her ADHD-identified learners need more "one-on-one" time when completing mathematics that they find challenging, regardless of the interventions given by the curriculum. She also mentioned:

> *"I do give them more attention and time. If I explain challenging mathematics concepts, I will repeat it to them again before they start their work. Sometimes I have to go back one step again with them and start with the basics" (Q22).*

Teacher D (Group 2) claimed that she has a "broad perspective" about the mathematics interventions, where she appeared more positive about her opinion. According to Teacher D, some interventions will work well but not with every learner. She claimed that the interventions taught to teachers are only compatible with an average learner and depend on the learner's individual capabilities. It depends on how that learner learns and understands the mathematical concepts given to them.

According to Nel *et al.* (2013), when teachers use mathematics interventions with learners diagnosed with ADHD, they have to listen attentively and respond as positively as possible when teaching them. Pratt (2002) earlier expressed the same sentiment as Nel *et al.* (2013), stating that for teachers to teach more effectively, they need to be caring and fair, have a respectful attitude towards the teaching profession, socially interact with ADHD learners with enthusiasm, be motivated for learning, and practise reflection. Teacher E also appeared optimistic when she spoke about her perspectives. She claimed that her best intervention strategy is to break the work down into smaller steps, although it is time-consuming. The paragraph below explains the challenges the participating teachers face when implementing the mathematics interventions linked to the curriculum. These challenges will give a better understanding of some of the participants' negative perspectives on the mathematics interventions used.

4.4.2.3 Challenges teachers face in implementing mathematics interventions.

According to Meier and Naude (2014), some challenges teachers can face when implementing mathematics interventions for learners with ADHD can be a loss of concentration. This loss of concentration is caused by mathematics, which can become boring, too difficult, or overwhelming for ADHD-identified learners. The information above can be used to support the statements of Teacher A, Teacher B, and Teacher C. According to the participating teachers, the learners forget steps (long multiplication), and they demonstrate a lack of understanding of some concepts, such as patterns and mental mathematics. Their attention deficit and distractibility influence their performance.

According to Teacher A (Group 1): *"I have one learner that struggles with mathematics interventions even when I give examples on the whiteboard over and over" (Q23).*

Teacher B (Group 1) that stated: *"It is difficult, even though you are using different teaching methods" (Q24).*

Furthermore, based on participant A's experience, she believes that when a teacher uses mathematical interventions, it is important to adapt teaching methods to accommodate the ADHD learner's needs. The challenge is that teachers do not always have the time or concrete apparatus/resources to adapt for specific learners. Teacher A and Teacher B (Group 1) also have to share the concrete materials. They complain that sometimes it can cause frustrations if one teacher needs something, and the other teacher has the materials; this can waste time.

Teacher D and Teacher E (Group 2) mentioned that using the "break instructions down into smaller pieces" strategy can be very time-consuming. ADHD-identified learners need extra time for teaching and learning because of their lack of concentration and hyperactivity, regardless of the mathematics interventions. Teacher A and Teacher B also mentioned the lack of time as a challenge caused by the poor concentration and memory of their ADHD-identified learners. Teacher B stated: *"I use small clocks, and it helps them a lot. But they do not like the clocks it makes them nervous" (Q25).*

Teacher C (Group 2) stated: *"The only way of working with the learner is one-on-one and to make sure he/she keeps up with the work. It requires a lot of time, work, and difficulty" (Q26).*

Bos *et al.* (2007) state that sometimes, the lack of concentration or distractibility can be caused by sensory hyperactivity. Nel *et al.* (2013) agree with Bos *et al*. (2007) and further state that a learner identified with ADHD in a classroom requires good planning by the teacher to ensure the learner is kept interested all the time. Too much visual and auditory stimulation in a classroom can cause ADHD learners to overreact and get out of hand (Bornman & Rose, 2010). Nel *et al.* (2017) agree and state that inappropriate learning styles, such as using the same teaching style every day, can cause challenges in teaching to ADHD-identified learners. In support of the study, it was clear that the teachers from Group 1 found their classrooms challenging to incorporate suitable mathematics interventions. During the observations, the researcher observed small classrooms with little space. The classrooms were tight, and teachers sometimes had to pass through each other's classes to go to the bathroom. The children's tables and chairs were also very close to each other, which caused overstimulation for the ADHD-identified learners. This led to a lack of concentration and frustration among the learners.

According to Teachers A and B (Group 1) and Teachers C, D, and E (Group 2) another challenge is the anger, aggression, irritability, and emotions of the learners diagnosed with ADHD. Teacher C (Group 2) mentioned that she sometimes struggles with her ADHD learners' emotional regulation if they are not in a good mood, which makes teaching difficult. She stated: *"They act busy, difficult, or very emotional" (Q27).*

Teacher E (Group 2) agrees and mentioned: *"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" (Q28).*

The participants also mentioned that finding additional time for preparing lessons and materials is a big challenge as they are overwhelmed with work. The teachers from the private school (Group 1) mentioned that they have to create new mathematics books themselves every term with worksheets, which is extremely time-consuming and overwhelming. If teachers face challenges when teaching mathematics, they must put more time into their work and seek support (Nel *et al*., 2017). The problem remains that the teachers get little support from the schools and DBE. Below, the challenges of support were discussed further.

4.4.3 The support teachers receive

According to Nel *et al.* (2017), teachers should get support from the South African Education Districts Based Support teams for lesson planning, classroom management, resources, and intervention provision.

4.4.3.1 Types of support teachers receive from the school.

During the interviews, the researcher observed negative body language from Teachers A and B (Group 1) when they spoke about support. According to Teacher A, the teachers from her school only receive little support from the school principal and management. Teacher A claimed they have to buy their own concrete material because of the schools' lack of finances.

Teacher B (Group 1) stated:

> *"From the school self, such as the principals and management we do get enough support and advice on how to teach learners struggling with ADHD. We also get some concrete tools from the school, but we also have to buy our own helping aids if we want more, nor do we have many workshops to spread our knowledge" (Q29).*

The participants from the mainstream school (Group 2) seemed content when they were asked about support from the school. Teacher C (Group 2) claimed:

> *"We get a lot of support from our school. We are constantly asked what training we need, but the only thing is there is not always time for some of those training. Our principal of academics is assigned to the subject of mathematics, and we especially get a lot of support from her" (Q30).*

Teacher D (Group 2) stated:

> *"Yes, we definitely get support from our school. We get workshops regularly and concrete materials and resources that we can use. We do not have to buy anything; the school provides us with that" (Q31).*

Teacher E (Group 2) agreed with Teachers C and D and further stated: *"We definitely get support from the school self, and they provide our concrete materials; we do not have to buy anything ourselves" (Q32).*

4.4.3.2 Types of support teachers receive from the DBE

When the researcher asked the participating teachers from Group 1 about the support from the DBE, they both seemed frustrated. According to Teacher A, the teachers from her school do not receive much support from the DBE, in this regard she stated:

> *"Okay, so from the DBE I do not think there is any support there, because they just expect you to teach according to the curriculum. They do however tell you that you can use teaching aids to assist the teaching of difficult mathematics. But it does not always work, because children with ADHD don't, they don't keep their full attention and they need something more concrete, they have to do something physical with their bodies in order to learn when they do mathematical concepts otherwise, they do not learn" (Q33).*

However, Teacher B stated: *"I personally feel that we do not get enough support from the district-based support teams" (Q34).*

The teachers from Group 2 seemed content about the support they receive from the DBE, and they mentioned that the support they are given is not always helpful. Teacher C maintained the following:

> *"We did, however, have one training from the Department of Education but to be honest the level of this training was not really on the same educational level of our learners. It was far too easy for them. They, for example, spend one full day explaining the concepts of double and halving. They explained work that we already know, so it kind of felt like wasting time" (Q35).*

According to Teacher E: "*Yes, we do get support and guidance from the Department" (Q36).*

According to the White Paper 6 policy, teachers must get further training about learners with learning barriers and remediation. Suppose teachers are not consistently trained and updated about the neurodevelopment of learners with learning barriers. In that case, it can have a negative outcome on the learning and future of those learners. Private schools mostly get their support from student tuition and scholarships. During the research study, the researcher could observe a lack of finances from Group 1 (private school), causing the teachers to lack the necessary funding support they need. It was also clear that the teachers from Group 1 had to purchase and supply most of their materials themselves, and they did not receive

enough training to enhance their knowledge about ADHD-identified learners. However, the teachers from Group 2 appeared very optimistic about the support they received from the school and the DBE. The researcher could not notice any lack of finances in the Group 2 school, and they also appeared content with their knowledge of difficult mathematics concepts. The participating teachers from Group 2 were clearly more knowledgeable regarding mathematics interventions.

4.4.4 Inclusive strategies used to help learners diagnosed with ADHD

According to Nel *et al.* (2013), the essence of inclusive strategies that are used to help ADHD-identified learners access mathematics concepts is to match the teaching and learning to the learning profile and to keep their learning barriers in mind when offering choices of what and how to learn and how to demonstrate mathematics learning.

4.4.4.1 Strategies and methods participating teachers used to make challenging mathematics easier for learners diagnosed with ADHD.

i. Physical bodies

According to Teacher A, she motivates her learners to make use of their "bodies" when doing mathematics. Bornman and Rose (2010) state that teachers can provide more opportunities for ADHD-identified learners to make use of their bodies and hands to help with their restlessness and distractibility.

Teacher D stated:

> *"I especially use the "body" method when doing word problems. I explain to the learners that there are three steps, and they make use of their bodies to remember the three steps. If we do open [a] number sentence, they make a square in front of their face. I believe that they should use their bodies to help remember the work" (Q37).*

ii. Repeating method

Teacher A also mentioned that she uses the repetition method for learners to internalise concepts taught; she stated: *"I basically repeat the work daily so that it helps them with memorialisation" (Q38).*

Teacher B also used a repetition method and mentioned that she gives examples on the whiteboard "over and over." Furthermore, Teacher C claimed the only way to keep the attention of her ADHD learners is to "repeat" the work numerous times.

iii. Concrete material methods

According to all five participants, the best strategies and methods to use include concrete materials. This includes materials and physical objects that can be seen and touched. Teachers A and B mentioned using counting cubes, key cards, and number cards.

Teacher D stated:

> *"I have a lot of learners on medication, so I make use of many concrete materials to support them. I make use of pictures, counting cubes, and their bodies" (Q39).*

> *"I make use of different textured teddies that the children can play with if they feel overwhelmed. I also like to give the learners a break if I see that they are distracted. There is also an App that I use; they call it Dojos. So, it is very cute; you determine the rules and rewards. This App helps a lot with the mathematics. This App consists of small alien figures. The learner is allowed to create his/her own alien character if they participate in the lessons or did well with an activity. They really enjoy this" (Q40).*

Teacher E mentioned:

> *"I use concrete materials such as counters and my ADHD diagnosed learners love working with them. I will also let the learners work in groups with the materials." Furthermore, she mentioned: "If we do multiplication, I will have the learners throw a ball to each other and the learner that catch the ball can ask the next multiplication sum and throw it to the next learner to answer." (Q41)*

iv. One-on-one strategy

According to Teacher B, "*one-on-one strategy*" is a method she uses to ensure the learner keeps up with the work and understands the concepts.

v. Praise method and songs

Teacher C stated:

> *"I use a star system, so if the learner gets something right that he or she finds challenging, I will give them a star and praise them for that." Furthermore, she mentions: "I help them to memorize the steps of multiplication sums by using rhymes or pictures. This is a method that helps them to remember how to complete long and challenging multiplication sums" (Q42).*

vi. Put on the spot method

According to Teachers A and B (Group 1), and Teachers C, D and E (Group 2), frequently asking the learners questions is also a good method. Teacher B stated: *"I try to ask them questions to keep their attention. Some of the learners feel proud if I ask them to give me an answer" (Q43).*

According to Teacher E:

> *"The learners also like it when they mark each other's tests, it's as if it motivates them more to do better. I will also have the learners explain a sum to each other in front of the class" (Q44).*

It was evident during the interviews and observations that the participating teachers used some of the curriculum's strategies, such as concrete materials, repeating methods, and visual methods, for example, pictures and semi-concrete materials. The researcher did, however, notice that the teachers also use their methods, such as praise methods, put-on-the-spot methods, and making use of the learners' bodies.

4.4.4.2 The benefits of the strategies teachers use on the neurodevelopment of learners diagnosed with ADHD.

According to Bakker (2015), the brain of ADHD learners is different from learners not affected by ADHD, and this is also where Greenblatt (2017) mentioned that children identified with ADHD have differently developing brains. Before explaining the benefits of the strategies on the neurodevelopment of the ADHD brain, it is important first to understand the difference between an ADHD brain and a normal functioning brain. Bakker (2015) claims that three parts of the brain can be affected by ADHD: the frontal lobe, temporal lobe, and parietal lobe.

First, the 'frontal lobe' is the part of the brain that helps with attention, organising, and decision-making (Getz, 2013). Greenblatt (2017) mentioned that this part of the brain in ADHD children matures a few years later than in non-ADHD learners. Sheppard (2022) agrees with the authors above and further states that the frontal lobe is also responsible for memory, impulsive control (behaviour), and time perception. As mentioned above, most participating teachers mentioned that the learners in their classrooms struggled with attention and time perception. Secondly, the 'temporal lobe' is also responsible for memory and emotions. According to Sjöwall and Thorell (2022), learners diagnosed with ADHD struggle with emotion regulation, demonstrating behaviours such as aggressiveness, depression, and anger. Furthermore, Sjöwall and Thorell (2022) explain that ADHD learners struggle to control their emotions, and this can be because of a dysfunction in the temporal lobe of the brain. Lastly, the parietal lobe is responsible for intelligence, sensations, and reasoning. According to Greenblatt (2017), children with severe ADHD have lower IQ's and poorer memory. Figure 4.8 below illustrates where the areas in the brain are affected by the disorder ADHD.

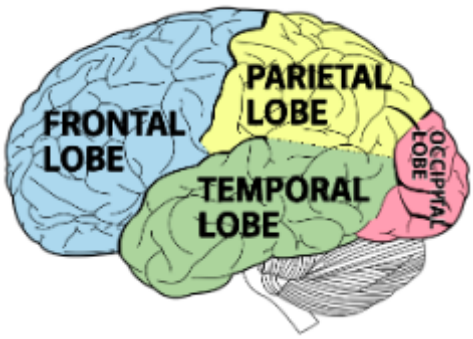


Figure 4.8: Illustration of the affected areas of an ADHD brain

Source (American Academy of Child and Adolescent Psychiatry, 2017)

According to Johnson and Reid (2012), academic difficulties are common among children diagnosed with ADHD. Teachers need to have a working knowledge of the legal rights of ADHD-identified learners and an understanding of their neurodevelopment. ADHD-identified learners often have deficits in working memory (Johnson & Reid, 2012). According to Bornman and Rose (2010), repetition and drill methods are great strategies to help with the neurodevelopment (frontal lobe and parietal lobe) of the ADHD brain. Greenblatt (2017)

agrees with the abovementioned authors and states that ADHD-identified children have smaller brain areas than non-ADHD children. These areas control the child's attention, impulsivity, and executive function. It also controls the child's ability to plan, organise, focus, and their ability to complete tasks. Furthermore, Nel *et al.* (2013) claim that the neurodevelopment of an ADHD brain lags about two to three years behind normal development. Repetition of complex mathematical steps helps with the muscle memory of the brain.

Concrete to abstract learning is also a method that can help the brain to learn and remember, enabling ADHD learners to fully understand the mathematics concepts they are learning. Using concrete, semi-concrete, and abstract learning methods can be related to three kinds of knowledge according to Piaget (physical knowledge, social knowledge, and conceptual knowledge). The first knowledge is physical knowledge, which is the knowledge ADHD learners discover using their senses and manipulating objects. According to all five participants (Teachers A, B, C, D, and E), the use of concrete methods is the most successful. Piaget claims that through play and engagement in mathematics activities that harbour the discovery of ideas, ADHD learners can gain knowledge and better understanding by using their senses (Meier & Naude, 2014).

Teacher D mentioned using "pictures, counting cubes, and the learners' bodies" by letting the learners feel, see, and manipulate objects, whereas Teacher E mentioned that her learners enjoy using "counters". According to Nel et al. (2013), teachers must provide learners with learning disabilities with lots of concrete experiences to help develop their physical knowledge of mathematical concepts, and the classroom environment should lean towards discovery and active participation. Teacher D also mentioned using different textured toys and fidgets to support her learners with emotional dysregulation and hyperactivity.

The second type of knowledge is social. According to Piaget, this knowledge is learned from others. Learners with ADHD gain this knowledge from the teacher when they observe what the teacher does and says. This knowledge fits in with the one-on-one method where the teachers explain examples again through communication and spending more time. As proved by Vygotsky, interaction is vital to an ADHD child's neurodevelopment; therefore, teachers must create opportunities for learners to discuss mathematical ideas with their peers and teacher. This knowledge can be seen in Teacher E's (Group 2) way of teaching when she mentioned: *"I will also have the learners explain a sum to each other in front of the class"*

(Q45).

The third kind of knowledge is conceptual knowledge, which is the more challenging knowledge for learners with ADHD. This knowledge consists of the learner's reflection on what they know, verbalising it, and telling others how they know what they know. This process of learning also utilises worksheets, tests, and doing mathematics in a book without using concrete materials (Meier & Naude, 2014). This means that children use prior knowledge to explore new concepts and ideas. Learners diagnosed with ADHD find this challenging because of their lack of memory and distractibility (Greenblatt, 2017).

Teacher C mentioned that she used a “praise method”. According to Johnson and Reid (2012), praise can be seen as a positive and motivating strategy. This strategy can help stimulate the temporal lobe which is in control of emotions. As mentioned earlier by Greenblatt (2017), ADHD often causes learners to struggle with emotional control, causing them to act impulsively in situations. Therefore, as mentioned by Teachers A (Group 1), C and E (Group 2), it is vital for the teacher to be positive around their learners; otherwise, they will withdraw from the mathematics activities. The praise method will boost and motivate the learners and give them a feeling of achievement.

The above strategies can be linked to the theories mentioned in the research. Piaget’s theory explained the importance of social knowledge linked to assimilation and accommodation. He further explains the importance of the teacher's knowledge in constructing new knowledge in challenging mathematics to support learners identified with ADHD. Social knowledge can only be learned from others. During the research, it was clear that the teachers from the private school (Group 1) did not have enough social knowledge to assimilate and accommodate their ADHD-identified learners with specific mathematics. The teachers from the mainstream school (Group 2) did, however, appear knowledgeable when explaining their methods for teaching difficult mathematics.

Vygotsky’s theory explains how cognitive development occurs through social interaction. During the interviews, the participants mentioned using the one-on-one strategy that could be seen as part of a social interaction with the ADHD-identified learner. Children construct shared meanings through social interactions. Vygotsky further explains that talking aloud becomes silent reflection, converting into an inner conversation and thought. This theory is evident in repetition when the learners practice their tables out loud. Furthermore, Hebb’s theory

explains the importance of the correct classroom atmosphere and settings. According to Hebb's theory, there must be an optimal level of stimulation to learn better. When the stimulation level in the classroom is too low, such as when the learner is drowsy, the child cannot use the sensory information transmitted to the brain. It was evident that some participants did not use this theory because of uncomfortable classroom setups. Hebb's theory also explains how learners' muscle memory can be trained. Teachers using more sensory experiences, such as concrete materials or music, could help set up a neural activity in the ADHD brain. The participating teachers did mention concrete materials but not music.

4.4.5 Curriculum differentiation

According to Davin and Naude (2017), curriculum differentiation is modifying and adapting a curriculum to provide meaningful learning experiences for all learners on different levels of learning. It is also when the curriculum content is adapted in a way as to fit different learning styles and needs. Nel et al. (2017) agree with the authors mentioned above and state that curriculum differentiation is a crucial strategy for responding to the needs of learners with learning barriers and diverse learning styles. Curriculum differentiation includes modifying, changing, adapting, varying, and extending learning and teaching strategies. Furthermore, curriculum differentiation considers the levels of learners' ability to approach the curriculum, their interests, and prior experiences/knowledge. Therefore, it takes place at the level of the curriculum content, the environment where teaching and learning occur, and the strategies and procedures used in teaching and learning mathematics (Davin and Naude, 2017). According to Nel *et al.* (2017) and Pratt (2002), multi-level teaching practices should hold fast to the requirements of curriculum differentiation. Multi-level teaching enables the teacher to develop different lessons with various objects for learners at different capability levels in the classroom. According to Teacher A, the teachers from Group 1 are not allowed to change the curriculum itself, and if so, teachers wouldn't know how. Figure 4.9 illustrates how teachers support learners with diverse learning needs through multi-level teaching and curriculum differentiation.

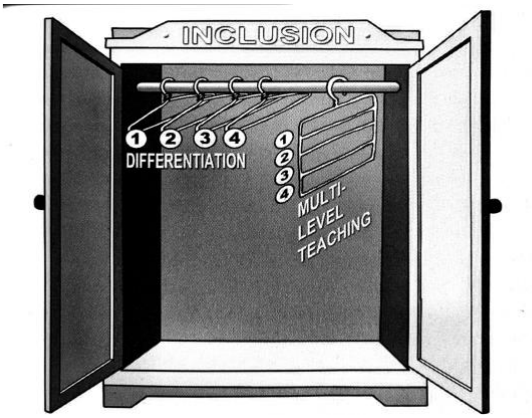


Figure 4.9: Curriculum differentiation

(Source Nel *et al*. 2013)

Figure 4.9 represents each hanger as an individual learner. The hanger with four levels represents the learner with a learning disability (ADHD) that needs more support. In other words, every learner is unique. Every learner can learn a concept, but confident learners need more time, practice, and sometimes one step back.

According to Teacher B, lesson planning can be overwhelming and exhausting and therefore, curriculum differentiation is not always possible for them. Teacher E agreed with Teacher B and further claimed that she experienced a lack of supporting policies, which causes negative attitudes among teachers, and it is not a good attitude among her learners diagnosed with ADHD. There is also a lack of support from education administrators, including the district staff. These staff members should ensure that teachers have enough knowledge strategies to support learners with learning challenges and implement policies (Nel *et al*., 2017 & Pratt, 2002).

Teacher A stated: *"every child is on the same standard" (Q46).*

According to Dreyer (2014), teachers take a one-size-fits-all approach and implement policies for which they are unprepared. Nel *et al*. (2017) agree with Dreyer (2014) and add that teachers who are more knowledgeable about multi-level teaching, learning, and assessment can help supply positive learning experiences for learners with or without ADHD.

4.4.5.1 Caps mathematics assessment policies for Grade 3 learners.

According to the curriculum, assessment is a planned process of recognizing, gathering, and interpreting information about the learners' performances using four assessment steps. These steps are generating and collecting evidence of achievement, evaluating the evidence, recording the findings, and using the information to assist the learner's development and, in helping, improve learners' learning process. Furthermore, assessing learners must be done formally and informally with regular feedback to help improve the learner's learning experience. During an informal assessment, the teacher monitors the learners' progress and makes daily decisions. However, informal assessment is not considered for certification

purposes, and formal assessment tasks are marked and considered by the teacher for progression and certification purposes. Different assessments are appropriate to the skills and concepts needed for different topics at different age groups. Assessment moderation is the process that ensures the assessment is a fair task (DBE, 2016).

According to the mathematics curriculum of South Africa, teachers are encouraged to conduct a baseline assessment in the first term. The learners' results in the baseline assessment should not be used to label their ability. This assessment should be used to understand how activities can be changed to give more attention to challenging aspects. Formal mathematics assessments include different topics. Numbers, Operations, and Relationships comprise sixty per cent of the mathematics in Grade 3. Recording is the process where the teacher writes down a learner's performance level in a specific assessment task. The recordings must give evidence of the conceptual progress of the learner and readiness for the next grade. Records of learners' performance should be used to verify the progress of the teacher and the learner in the teaching and learning mathematics. According to the curriculum, teachers must report grades in percentages. Figure 4.10 below is an example of the codes and percentages from the South African Curriculum.

Rating code	Description of competence	Percentage
7	Outstanding achievement	80 - 100
6	Meritorious achievement	70 - 79
5	Substantial achievement	60 - 69
4	Adequate achievement	50 - 59
3	Moderate achievement	40 - 49
2	Elementary achievement	30 - 39
1	Not achieved	0 - 29

Figure 4.10: Codes and percentages for recording and reporting mathematics

Source (Curriculum)

According to the curriculum, Grade 3 learners must be able to do the following multiplication mathematics: count pictures of grouped objects, order and compare numbers up to 500, read and write numbers 0-1000, doubling and halving, number patterns with multiplication, count forward and backwards in 2's up to 500, calculations about doubling and halving, number

patterns, number concepts, solve problems, and calculations (doubling). The moderate achievement level for Grade 3 learners in mathematics in South Africa is Level 3 (40%-49%) (Dreyer, 2014). Participating teachers from Group 1 and Group 2 claimed that the learners diagnosed with ADHD usually struggle with concepts, order, comparing, reading and writing of numbers, patterns, multiplication from numbers 8 and up, halving, and solving problems. These challenges are caused by the learner's hyperactivity, inattention, and poor concentration. The teachers felt that some of the concepts were too difficult for the ADHD-identified learners and that it was unfair to assess them in the same way as typically developing learners. This proves that the curriculum was created for the typical developmental age of learners and not necessarily for learners diagnosed with any disability.

4.4.5.2 The teachers' views on the effectiveness of the Curriculum for .ADHD-diagnosed learners and what to add or remove

The curriculum aims to ensure that children apply knowledge and skills in ways that are meaningful to their lives. It also equips the learners with the necessary knowledge, skills, and values regardless of their physical or intellectual ability. Furthermore, according to the curriculum, learners who experience barriers in mathematics must be exposed to activity-based learning. Teachers must use practical examples and concrete materials more often than with other learners. Dreyer (2014) states that moving to abstract work too soon might lead to learner frustration and regression.

Teacher A stated that the curriculum does not allow enough opportunities for concrete materials. Teacher B agreed with Teacher A and stated:

> *"I think that the National Curriculum Statement is too difficult for our ADHD-identified learners, if they made it a bit easier and simple it might have been more sufficient" (Q47).*

Furthermore, Teacher C mentioned: *"for the ADHD-diagnosed learners, the curriculum can be difficult, and they need more one-on-one time to understand and complete the mathematics" (Q48).*

Davin and Naude (2017) mention that according to the curriculum, these learners may and should require and be granted more time to complete assessment activities, tasks, and thinking skills. The number of activities should be adapted to the learner without compromising the concept and skills addressed (Davin & Naude, 2017).

Teacher D stated:

> *"On the one side, yes, but on the other side, there is ADHD diagnosed learners that find the curriculum very difficult. They feel overwhelmed because of information being overloaded. But I do have one ADHD diagnosed learner who finds it easy, so I think it depends on the learner's ability and capacity" (Q49).*

Teacher E mentioned: "*Yes, I do think so. My learners do not find the curriculum work too difficult" (Q50).*

Teacher A claimed that the curriculum keeps "hammering" that they must do mental mathematics in Grade 3. She stated:

> *"With my understanding they are supposed to use physical aids until they are at least going to High School. I think that some of the work is too difficult for learners diagnosed with ADHD" (Q51).*

According to the curriculum, teachers should never force learners to do mental calculations with which they struggle. Writing materials or counters should always be available for those learners who may need them. However, the work in the curriculum is developed at the "typical" developmental age of learners in different grades. For example, the typical age of Grade 3 is nine, so the curriculum's knowledge, concepts, and skills are developed according to the typical chronological and emotional development of the nine-year-old child and not necessarily the nine-year-old child diagnosed with ADHD (Nel *et al.,* 2017). According to the participating teachers, poor cognitive ability, cluttered classrooms, and inappropriate subject materials such as "too difficult" work is not very effective for the learners diagnosed with ADHD. Teacher E mentioned that she would want to remove some of the worksheets and materials that are too busy or "boring", and sometimes confusing for her ADHD-identified learners, for example, the mathematics books from the Department of Education. She stated: *"The learners do not enjoy the books from the Department, the methods in the books of the Department differ from the methods that we use, so it confuses them" (Q52).*

Furthermore, Teacher E mentioned she would rather set up worksheets with the same concept and only ask simpler questions with more pictorial examples and give extra time for the learner if he or she wants to work out the answer concretely.

4.4.5.3 Teachers' views about assessing children with learning disorders compared to typically developing children.

According to Teacher A:

> *"We have to assess them the same way because everybody is writing a specific test that is on the same standard. You can, however, explain a certain concept to them again, but you are not allowed to help them with the answers" (Q53).*

Teacher B stated:

> *"We are not allowed to adjust the assessment all the learners are assessed in the same way. However, the only advantage the ADHD diagnosed learners get is more time to complete challenging mathematics" (Q54).*

Teacher C mentioned: "*We are not really allowed to adjust the assessment; otherwise, it might be difficult to find the areas where the child struggles in his/her mathematics" (Q55).*

Teacher D and Teacher E also mentioned that they are not allowed to adjust assessments. However, they can give the learner extra time and more explanations. According to the White Paper 6 policy, assessment diversity should be accommodated. This diversity will be ensured through a flexible curriculum and assessment policy. However, a few issues arise from various parts of the curriculum. This includes the content of learning programs, the language and medium of learning and teaching, the organisation of classrooms, teaching styles and pace, time frames for completion of tasks, availability of concrete materials and equipment, and assessment methods.

Teacher A stated: "*so, from the District I do not think there is any support there" (Q56).*

Correspondingly to the White Paper 6 policy, the critical responsibility of the district support teams is to provide curriculum, assessment, and instructional support to schools in the form of illustrative learning programmes, learning support materials, and assessment instruments. According to White Paper 6, assessment processes will address barriers to learning, and current policies and practices will also be reviewed to ensure that the needs of all learners are recognised and addressed. However, Davin and Naude (2017) state that despite the radical transformation of education in South Africa, the assessment practices in most private and mainstream schools are still the same. Furthermore, the authors claim that though the

policies such as the Department of Basic Education's National curriculum statement (General Education and Training Assessment guidelines for Foundation Phase Grade R-3) give detailed outlines about what is expected from teachers, teachers still find it hard to implement the theory in real life in the classroom. Maringe and Prew (2015) agree with Davin and Naude (2017) and add that learners are not exposed to various assessment practices, and the old paradigms still govern assessment practices.

The participating teachers from Group 1 and Group 2 find it challenging to assess their ADHD-identified learners compared to typically developed learners, especially regarding concepts with which the ADHD learners struggle. The learners identified with ADHD need more time, explanations, examples, and sometimes different setup worksheets, tests, or activities. It depends on the severity of the ADHD diagnosis. The participating teachers claim that different activities and tests should be set up inclusively for struggling learners. It must still involve the same concepts and marks; the questions can just be set differently. But as observed from the interviews and mathematics books, it was clear that the teachers did not know how to set the questions on the worksheets differently. The teachers lack knowledge of supporting learners with ADHD in their classrooms.

4.5 SUMMARY

In Chapter 4, the research presented the findings per the themes that emerged from analysing the data across all data sets. The researcher contemplates the research to be trustworthy and feels confident that the research will enable her to answer the research questions mentioned in Chapter 1. According to the researcher, she has presented her research findings thoroughly and unambiguously, persisting in the strategies she had set for systematic data analysis. The research was presented in the 'third person format', supported by quotes from the structured interviews and quotes from other research studies correlating to the responses from the participating teachers and observations. The researcher also provided photographs of the observations made. In the next chapter, Chapter 5, the researcher will discuss the research study's findings, conclusions, and recommendations.

5 CHAPTER 5: INTERPRETATION OF RESEARCH FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

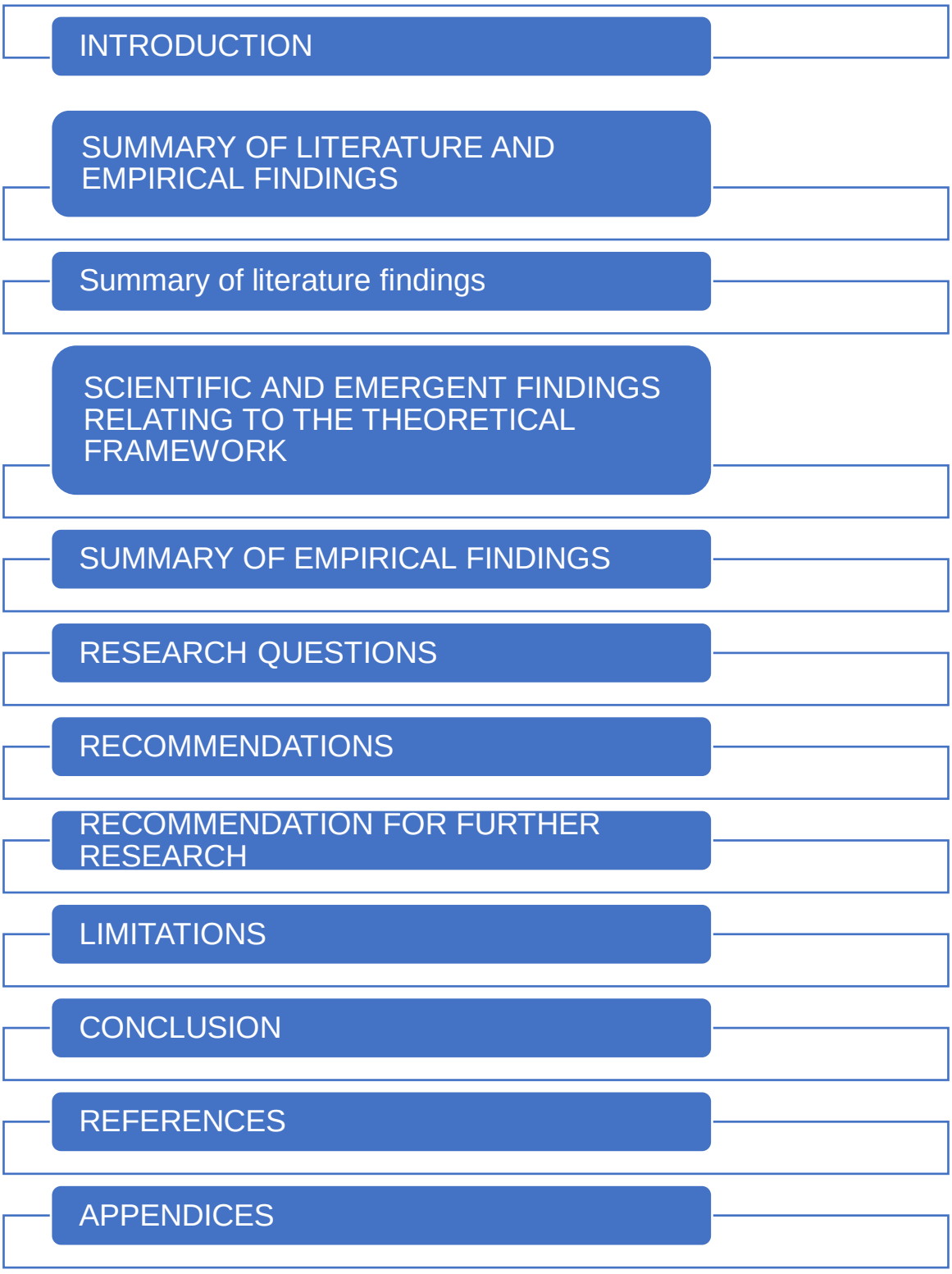


Figure 5.1: Outline of Chapter 5

5.1 INTRODUCTION

Chapter 4 presented descriptions of the participants, data analyses and emerging themes, and the research findings. Quotes and responses from the participants were presented and discussed with references from previous studies.

Chapter 5 elucidates the research findings in connection with relevant and imperative literature on teachers' conceptualisation of ADHD, neurodevelopment, and mathematical interventions in Grade 3 Foundation Phase classes. The study's theoretical frameworks, namely Piaget's neuroplasticity theory, Vygotsky's sociocultural theory, and Donald Olding Hebb's neurophysiological theory, provided an identifiable background against which the findings can be interpreted and explained. Furthermore, Chapter 5 referred to and endeavoured to answer the study's research questions mentioned in Chapter 1.

5.2 OVERVIEW OF THE PREVIOUS CHAPTERS

In this overview, the researcher summarised the research study by providing a brief synopsis of the five chapters, illustrating the important issues that were significant to the study. This overview also served as a background to the research's findings, recommendations, limitations, and conclusions.

CHAPTER 1

Chapter 1 introduced the study. This chapter provided the rationale, purpose of the study, research questions, and working assumptions. The chapter then outlined the literature review, embedded within Piaget's neuroplasticity theory, Vygotsky's sociocultural theory, and Hebb's predominantly neurophysiological theory as the conceptual framework. In addition, an outline of the epistemology and methodological paradigm was presented, as well as the ethical considerations, trustworthiness, and concluding remarks.

CHAPTER 2

Chapter 2 explored the literature review within the conceptual framework. The chapter first introduced scholarly literature about the conceptualisation of the concepts of ADHD and neurodevelopment and the different conceptualisations from an international, African, and South African perspective. From the literature review, it became evident that the conceptualisation of ADHD neurodevelopment is differently understood from different contexts. Furthermore, the chapter mentioned how dyscalculia could be understood from an

ADHD context. The chapter then provided an overview of the conceptual framework that underpinned the study. From the literature, it became apparent that teachers in the South African context do not know enough about ADHD neurodevelopment and how to differentiate the curriculum to make inclusive teaching easier for ADHD-identified learners. However, the education systems internationally and in South Africa are committed to ensuring that typically developing learners and learners with learning disabilities have access to quality education. The results of the literature reviewed revealed that teachers in South Africa do not have enough support from school management teams, DBE, and DBST to help them gain more knowledge about ADHD or any other learning disability. There is also a lack of funding to ensure the effectiveness of inclusive teaching. The literature also explored the importance of teachers' understanding of ADHD neurodevelopment to help with mathematics interventions.

CHAPTER 3

In Chapter 3, the methodology and research design were discussed as they form the foundation of the study. The chapter further provided a detailed discussion of the research paradigm. Furthermore, the research methods, the role of the researcher, the research sites, and the research participants were discussed in detail. Using a qualitative method framed within the interpretive paradigm enabled the researcher to hear the "true self" answers from the participating teacher. This research approach helped the researcher to understand the participating teacher's knowledge and experiences of the phenomenon under study. The principle of trustworthiness of this study was mentioned and discussed. This chapter concluded by justifying the research methodology in line with the research questions and objectives.

CHAPTER 4

In Chapter 4, the empirical results collected from the field notes and observations were analysed and interpreted. By presenting data in this chapter, the researcher considered the literature reviewed and the study's conceptual framework. This chapter began by mentioning the research questions again and with the presentation, analysis, and interpretation of the participating teacher's biographical data. This data were presented by individual case studies from interviews and observations within a mainstream and private school. The data were divided into five themes with categories. The themes identified were teachers' conceptualisation of neurodevelopment and the ADHD disorder, teachers' perspectives about ADHD neurodevelopment and the mathematical interventions in the Foundation Phase, the support teachers receive, inclusive strategies used to help learners diagnosed with ADHD, and curriculum differentiation. Discussion in this chapter also included verbatim participant

quotations during the interviews. Some participants, particularly the Afrikaans-speaking participants, preferred to express themselves in their mother language, and the researcher further translated into English for better clarification. However, only three teachers preferred to respond in Afrikaans, therefore, the meaning was not lost in translation as the researcher herself is an Afrikaans home language speaker.

5.3 SUMMARY OF LITERATURE AND EMPIRICAL FINDINGS

This section summarises the literature findings discussed in Chapters 2 and 3. This section also summarises the empirical findings that appear in Chapter 5.

5.3.1 Summary of literature findings

The aim of interpreting the literature findings was to obtain links between the research findings, the themes, and the sub-themes that emerged from data analysis. The utility of the theoretical frameworks was linked to the study's research findings. The interpretation of the research was also a discussion aimed at confirming the existing literature with a comparison to new insights of the study. The interpretation of the research findings needed a reference to the themes and sub-themes from Chapter 4. The themes and sub-themes enabled the organisation thereof. Table 5.1 below illustrates the interpretation of the research findings structured from the themes, sub-themes, and their relevance to the research sub-questions from the study.

Table 5.1: Illustration of the interpretation of research findings structured from the themes, sub-themes, and their relevance to the research questions.

Themes	Sub-themes	Relevance to primary, secondary, and sub-research questions
Theme 1: Teachers' conceptualisation of neurodevelopment and ADHD	**Sub-theme 1.1:** Teachers understanding of the terms neurodevelopment and ADHD **Sub-theme 1.2:** The importance of neurodevelopment in respect of ADHD. **Sub-theme 1.3** Impact of ADHD on learners' cognitive development and learning.	**Primary research question** How do Grade 3 FP teachers in mainstream and private schools conceptualise ADHD and mathematics access?
Theme 2:	**Sub-theme 2.1**:	**Secondary research question (sub-question 1)**

Themes	Sub-themes	Relevance to primary, secondary, and sub-research questions
Teachers' perspectives about ADHD neurodevelopment and the mathematical interventions in the Foundation Phase.	Mathematics interventions aligned with the Curriculum. **Sub-theme 2.2:** Grade 3 teachers' perspectives about mathematics interventions for learners diagnosed with ADHD in the Foundation Phase. **Sub-theme 2.3:** Challenges participants face in implementing the mathematics interventions.	What are teachers' perspectives on ADHD, neurodevelopment, and mathematics interventions in the Grade 3 Foundation Phase?
Theme 3: The support teachers receive	**Sub-theme 3.1**: Types of support teachers receive from the school. **Sub-theme 3.2:** Types of support teachers receive from the DBE	**Secondary research question (sub-question 2)** What kind of support do teachers in mainstream and private schools receive to enhance mathematics access for learners diagnosed with ADHD?
Theme 4: Inclusive strategies used to help learners diagnosed with ADHD	**Sub-theme 4.1:** Strategies and methods participating teachers used to make challenging mathematics easier for learners diagnosed with ADHD **Sub-theme 4.2:** The benefits of the strategies teachers use on the neurodevelopment of learners diagnosed with ADHD.	**Secondary research question (sub-question 3)** Which inclusive strategies do teachers in mainstream and private schools use that influence learners identified with ADHD with mathematics challenges?
Theme 5: Curriculum differentiation	**Sub-theme 5.1:** Caps mathematics assessments policies for Grade 3 learners. **Sub-theme 5.2** The teacher's views on the effectiveness of the Curriculum for ADHD diagnosed learners and what to add or remove.	**Secondary research question** What are teachers' perspectives on ADHD, neurodevelopment and mathematics interventions in the Grade 3 Foundation Phase?

Themes	Sub-themes	Relevance to primary, secondary, and sub-research questions
	Sub-theme 5.3: Teachers' views about assessing children with learning disorders compared to typically developing children.	What kind of support do teachers in mainstream and private schools receive to enhance mathematics access for learners diagnosed with ADHD? Which inclusive strategies do teachers in mainstream and private schools use that influence learners identified with ADHD with mathematics challenges?

Table 6.1 enabled an interpretation of findings based on the themes and sub-themes from Chapter 4. The column named "**Relevance to primary, secondary, and sub-research questions"** illustrates a connection between the themes, sub-themes, and the study's research questions. This, therefore, insinuates a connection between the interpretation of the research findings and the research questions. Table 6.1 provided credibility when answering the study's research question. The section below provides responses to the research primary, secondary and sub-questions.

5.3.2 Teachers' conceptualisation of neurodevelopment and ADHD relevant to the primary research question

During the interviews, it was evident that the participating teachers had little conceptualisation about the neurodevelopment of ADHD-identified learners. The responses also revealed that most teachers found the term neurodevelopment compared to ADHD interesting and wanted to know more about it. The teachers wanted to know more because they were not equipped with enough knowledge, including knowledge of materials and support available for ADHD-identified learners. The lack of knowledge about the neurodevelopment of ADHD-identified learners leads to less emotional closeness between the teacher and the learner.

5.3.2.1 Teachers' understanding of the term neurodevelopment and ADHD.

From the data analysis Theme 1, Sub-theme 1.1, it was evident that teachers had a narrow understanding of the neurodevelopment of ADHD. A recurring response from all the participants was that they thought it had something to do with the brain. The teachers' understanding of ADHD neurodevelopment gave credence to the statements of Donald *et al.* (2014:311), Nel *et al*. (2013:7), and Makoelle (2016), who noted that "most teachers do not have enough knowledge about the neurodevelopment of ADHD" (see Chapter 4: 111-112). It also came to light that the teachers only knew the basic symptoms of ADHD, such as hyperactivity and distractibility, but not enough to support these learners fully. A recurring response from the participating teachers understanding of ADHD was that learners struggle to concentrate and take longer to understand difficult concepts. Only one teacher mentioned that neurodevelopment is the study of the brain that have a connection with ADHD, but she could not elaborate further on that.

5.3.2.2 The importance of neurodevelopment in respect of ADHD.

It was evident that the teachers did not have enough knowledge about the importance of the ADHD neurodevelopment. This statement hinges on the response of one of the participating teachers that mentioned she believed teachers must be made more aware of the importance of neurodevelopment of learners with learning barriers (see Chapter 4, page 112-113). It also collaborated with the responses from the other teachers, who confirmed that they had never heard of the term before. It was also evident that not all teachers have enough understanding about ADHD neurodevelopment, as seen from the responses of one of the participants who read her answers from her computer. The teacher who read the answers from her computer mentioned definitions of ADHD and neurodevelopment that she had copied from the internet.

5.3.2.3 Impact of ADHD on learners' cognitive development and learning.

During the interviews, all five participating teachers had different responses about the impact of ADHD on learners' cognitive development and learning. However, it was evident that some of the participating teachers did not really understand the impact of ADHD on learners' cognitive development and, therefore, could not answer the question asked. This finding underpins the statement of Sternberg and Sternberg (2012) that not a lot of people understand the impact of ADHD on the brain functioning of a person. However, cognitive neuropsychologists have learned a great deal about the attentional processes in the brain; therefore, important points can be passed on to teachers when studying education, or special courses about ADHD can be held for teachers more often.

5.3.3 Teachers' perspectives about ADHD neurodevelopment and the mathematical interventions in the Foundation Phase

The data analysis in Chapter 4, Theme 2, showed that teachers did not feel comfortable with mathematics interventions because of the lack of resources and materials. This finding supports the statement of David (2020) mentioning more resources are necessary for developing training programmes that would prepare and equip teachers to provide better interventions for learners with learning disabilities such as ADHD.

5.3.3.1 Mathematics interventions aligned with the Curriculum.

The researcher examined the teachers' knowledge of the mathematics interventions for learners diagnosed with ADHD mentioned in the curriculum. It was clear that some participants did not have a thorough knowledge of the interventions suggested by the curriculum. This was evident when one of the participants mentioned that according to the curriculum, Grade 3 learners are not allowed to use concrete materials all the time (see Chapter 4). The curriculum clearly states teachers must use concrete helping aids, pictures, and supporting materials to help teach learners with severe ADHD process mathematics problems. To my dismay, not all teachers were aware or trained to differentiate the curriculum content for easy access to ADHD learners.

5.3.3.2 Grade 3 teachers' perspectives about mathematics interventions for learners diagnosed with ADHD in the Foundation Phase.

During the interviews, the teachers were allowed to give their perspectives about the mathematics interventions they use in their Grade 3 classrooms. Most participating teachers understood what interventions to use for their ADHD-identified learners. However, some participants felt negative about specific interventions mentioned in the curriculum because of constrained time and finances. Several times in the interviews, the teachers mentioned that the interventions in the curriculum were not always practical for the cohort of ADHD learners in their classrooms. They further explained that regardless of the availability of concrete materials, the ADHD learners mostly just needed more one-on-one time, which was impossible in a classroom with diverse learners with different abilities.

5.3.3.3 Challenges teachers face in implementing mathematics interventions.

Responding to challenges associated with implementing mathematics interventions, the teachers noted that difficult, time-consuming and boring activities, hyperactivity and distractibility, and the challenging emotions of the learners, posed a challenge to the teaching and learning of difficult mathematics. To my dismay, teachers do not understand the neurodevelopment of the learners and therefore find the learners' behaviours challenging.

5.3.4 The support teachers receive

The teachers from Group 1 reported receiving little support from the school management regarding ADHD mathematics interventions. The above includes the complete absence of support from the South African Education Districts Support teams, including the DBE, for lesson planning and classroom management. On the other hand, the teachers from Group 2's reasoning was different. According to Group 2, they received some support from the DBE and a lot of support from the school management teams. Their responses are listed in the sections below.

5.3.4.1 Types of support teachers receive from the school.

During the study, it was evident that the teachers from Group 1 (private school) received less support than Group 2 (mainstream school). Group 1 noted that they had to buy most of the materials with their own finances. They mentioned that their classrooms were very small and completely unsuitable for learners with ADHD. The classrooms were double stories, and the teachers had to walk through each other's classrooms if they needed to go somewhere. The infrastructural design added disturbances to the already compromised attention issues. The teachers from Group 1 also noted that they did not receive many workshops to enhance their knowledge capacity. According to my awareness, private schools must be particularly suited to support learners with barriers in all aspects. Because parents pay more money for their children to attend a private school, they expect them to receive more support for disabilities.

The teachers from Group 2 also frowned upon inadequate classroom space. However, they did not have a problem with the support they received from the school. The teachers mentioned that they frequently get asked about the training they need, the school provides concrete materials, and they also get a lot of support from their principal of academics. It was evident that the teachers from Group 2 also find time for training programs challenging.

5.3.4.2 Types of support teachers receive from the DBE.

The teachers from Group 1 stated that they do not receive much support from the DBE. On the other hand, Group 2 mentioned that they get support and guidance from the DBE, but it was not always helpful. Group 2 noted that the training they received from the DBE was not appropriate for learners diagnosed with ADHD. The teachers stated that the programmes were too boring or too difficult. During the study it was evident that teachers in general, do not receive enough support from the DBE and that the DBE does not make enough time and effort to equip the teachers to understand the requirements of learners with learning barriers better.

5.3.5 Inclusive strategies used to help learners diagnosed with ADHD

During the study, it was discovered that the teachers from the private school and mainstream school had some knowledge about strategies to help learners diagnosed with ADHD. However, their lack of knowledge about the neurodevelopment of ADHD learners made it challenging to implement these strategies according to their developmental levels.

5.3.5.1 Strategies and methods participating teachers used to make challenging mathematics easier for learners diagnosed with ADHD.

It was clear that the teachers in Group 1 and Group 2 used the same strategies; however, the difference was that the teachers from Group 2 used more concrete materials because the school management teams supplied them with the resources. The teachers from Group 1 had to share their materials. Sharing contributed to broken and lost materials. There were common strategies/practices from Group 1 and Group 2, such as the repeating method, concrete materials, and the one-on-one strategy. It was revealing that the teachers did not mention any strategies or methods to support the learners with their emotional challenges. However, one teacher mentioned she used textural toys that helped calm her learners. Many participants mentioned that although they use the methods described, but the learners' behaviour remains challenging on certain days. The above supports the researcher's assumption that understanding the neurodevelopment of ADHD learners is crucial to offer appropriate foundation for learning and teaching and to set the appropriate arousal level, as mentioned in Chapter 2.

5.3.5.2 The benefits of the strategies teachers use for the neurodevelopment of learners diagnosed with ADHD.

The study revealed that the teachers did not understand the concept of neurodevelopment. Chapter 4 showed that some teachers mentioned they had never heard of the term before. The participating teachers did, however, understand that concrete materials are an important strategy and a useful component for learners with learning barriers. It was evident that some teachers knew how to support the learners when they felt stressed. As mentioned earlier, one of the participants from Group 2 used soft toys to calm her learners.

5.3.6 Curriculum differentiation

Curriculum differentiation indicates the modification and adaption of a curriculum to provide quality learning experiences for learners experiencing learning barriers. Teachers, however, do not understand how to adapt the curriculum to make difficult concepts easier to process for learners with ADHD. During the interviews and observations, it was not obvious how the teachers adapted certain mathematical concepts from the curriculum to make learning

memorable. While the researcher observed the mathematical books and worksheets, no adaptions were visible; the severe ADHD learners had the same workbooks and assessment exercises as the learners experiencing no barriers. All learners were exposed to the same texts and expected to complete them in the same allocated time. The researcher could not observe any preferences from the ADHD learner's side. The negligence of the teachers' understanding of the impact of difficult work in the curriculum can worsen the learning process of ADHD learners and make teaching and achievement of outcomes more difficult for the learners and teacher. All five participants had the same response and responded with a "no" when the researcher asked if they made special adaptions during a test and difficult mathematics worksheets for ADHD-identified learners.

5.3.6.1 CAPS mathematics assessments policies for Grade 3 learners.

The teachers vaguely understood the assessment policies for Grade 3 learners; it was also not visible whether they understood how to adapt the assessment for learners with severe ADHD that struggle with hyperactivity, distractibility, and emotional regulation. During the interviews and observations, it was clear that all five participants assessed their learners the same. The only advantage the learners with ADHD get is more time.

5.3.6.2 The teachers' views on the effectiveness of the Curriculum for ADHD-diagnosed learners and what to add or remove.

The teachers mentioned that they use the work in the curriculum because it provides them with a measurable plan and structure for educating the learners. Therefore, the researcher will refer to the curriculum. The curriculum states that teachers must use practical examples with concrete materials for a longer period for learners with learning barriers. The teachers interviewed from Group 1 and Group 2 explained that the curriculum is too difficult for ADHD learners. The participating teachers claim that there was not enough time to support the learners fully, and the work was overwhelming for them. However, Teacher E from Group 2 disagreed. She stated that the work is not too difficult for her learners. The researcher noticed she was one of the participants with the most concrete materials in her classroom and one of the teachers with the calmest personality. The participant, however, mentioned that there were activities in the curriculum that she felt were unnecessary. She claimed some materials were too dull and might overwhelm the learners. Her submission supports the notion that teachers need to be intentional when choosing support materials and understand the developmental levels of ADHD learners in their classrooms.

5.3.6.3 Teachers' views about assessing children with learning disorders compared to typically developing learners

It was clear that all five participants had the same view on assessing learners with learning disorders. They claimed that learners with or without barriers must be assessed the same, according to the curriculum specification. It was visible from the mathematics books that the ADHD learners had no adaption made in their tests or worksheets. It appeared as if the teachers didn't understand how to make the adjustments in assessment activities or worksheets, or they thought they were not allowed to make adjustments.

5.4 SCIENTIFIC AND EMERGENT FINDINGS RELATING TO THE CONCEPTUAL FRAMEWORK EMBEDDED IN MANY THEORIES

5.4.1 Piaget's neuroplasticity theory

This study used Piaget's theory to understand the neurodevelopment of ADHD-identified learners. Piaget mentioned that educational experiences for children must be built around the child's cognitive structure. Piaget's theory was also used to help explain how the brain of ADHD learners can be trained and exercised to process mathematical problems and make the teaching easier. According to Piaget's neuroplasticity theory, the intellectual development of each learner unfolds in different ways at different stages. However, the development of each child is based on the interaction between the child and the environment (Tapia, 2012). As mentioned in Chapter 2, the researcher believes that Piaget's theory will help teachers better understand the neurodevelopment of ADHD learners and how to exercise the brain to improve mathematics conceptualisation. This insight was achieved by using Piaget's statement that teachers must know the level of functioning of each (ADHD) learner's cognitive structure and create an educational environment (safe classroom) that generates opportunities for discoveries (Hergenhahn & Olson, 2012).

During the semi-structured interviews, it was clear to the researcher that certain participating teachers did not understand the neurodevelopment occurring for learners diagnosed with ADHD. The study shows the effect training could have on a learner diagnosed with ADHD and why it can alleviate the challenges in teaching and learning mathematics for learners with ADHD. Before understanding the emergent findings relating to Piaget's neuroplasticity theory, one should first consider Piaget's four different stages of development. According to Tapia (2012) and Donald *et al.* (2010:49) Piaget's theory consists of the following four stages: "the sensorimotor stage, preoperational stage, concrete operation stage, and the formal operation stage".

During the first stage (birth to 1.5 years), the sensorimotor stage, children learn through experiencing and integrating sensory input through their movement, coordination, and imitation (Tapia, 2012). According to Sternberg and Sternberg's (2012) studies, some learners are born with genetic ADHD. The researcher found that only a few teachers understand that ADHD could be a brain dysfunction. Therefore, ADHD symptoms can be beyond the learner's control when they find certain mathematics concepts more difficult than typically developed learners. Symptoms such as distraction, hyperactivity, and emotional dysregulation can be innocent but can be managed if the teachers are knowledgeable about ADHD. The second stage, the preoperational stage (1.5 years to 7 years), mentions the development of motor movement and mobility skills of children. This stage includes improving many mental skills that impact the child's actions (Tapia, 2012). Sternberg and Sternberg's (2012) studies have shown that learners with ADHD exhibit slower understanding and vary in reaction times.

Batka and Deventer (2013) and Greenblatt (2017) argue that ADHD influences the frontal lobes of the brain. The frontal lobes regulate complex mental activities and behaviours. Piaget reiterates that the second stage (preoperational stage) plays an important role in a child's motor development. Batka and Deventer (2013) explain that ADHD causes a dysfunction in the frontal lobes that can influence the control of motor movement, memory, and the production of speech of a learner. During the interviews, the participating teachers mentioned several times that the ADHD-identified learners in their classroom struggle with memory, uncoordinated movements, and concentration. These symptoms are all side effects of the affected part of the frontal lobes of the brain. Although the participating teachers could name the symptoms, such as loss of concentration, hyperactivity, and memory challenges, they still did not really understand what and how they were caused. Furthermore, Greenblatt (2017) mentions that these parts of the brain can be stimulated with exercises such as drill methods and mindfulness meditation skill. This skill can help with self-regulation, control inattentiveness, and decrease hyperactivity and impulsivity.

The participating teachers mentioned using rewards and uplifting motivational words to support and motivate their learners. These statements fit with Leaf's (2013) statement, where he mentioned that teachers must engage learners at their level of understanding to teach mathematics more effectively and use positive words. The third stage, the concrete operations stage (11 years and onward), includes the logical thinking of children about specific concrete events. During this stage, the child also understands that a person can mentally hold more

than one thought simultaneously. According to Tapia (2012), children gain the mental skills to understand other people's perspectives and that people's perspectives can differ from each other. The fourth stage includes the formal operation stage. This is where children gain the ability to think abstractly and make conclusions from information. During the semi-structured interviews and observations, the researcher realised that the teachers used concrete materials to help learners remember and understand how to hold more than one thought at a time when doing mathematics. However, as Piaget's fourth stage mentions, children begin to learn to think abstractly at the ages of 11 years and onwards, whereas it was clear to the researcher that some of the participating teachers used more than necessary abstract materials. Many abstract materials can demotivate learners and cause many mathematical challenges. It was also clear that most of the worksheets and methods the teachers used were not "concrete" enough but rather too "abstract". The researcher agrees with Piaget's theory that learners are more ready for abstract work and materials at the age of 11 years (Grade 5).

The practice can be more challenging for learners diagnosed with ADHD because, according to Greenblatt (2017), the development of learners with ADHD lags two to three years behind compared to typically developing learners. For the researcher it was clear that the teachers being interviewed did not understand the importance of the neurodevelopment of an ADHD brain well enough to realise that concrete materials are essential still at the age of 9 years (Grade 3). The worksheets appeared as if they made little time for concrete work when doing mathematics, and to get all the mathematics done in time, most of the work is more abstract. The researcher realised that the teachers from Group 1 (private school) thought it was better and faster if learners worked abstractly, forgetting the information processing challenges for these learners. According to Krüger *et al.* (2016), ADHD learners must work concretely until the concept is fully grasped and internalised. Several times the teachers mentioned to the researcher that they did not have enough time for a lot of concrete work. This time pressure can overwhelm learners and teachers with little teaching and learning happening in the process.

As mentioned in Chapter 2, Piaget's theory also included the assimilation and accommodation in a situation. According to Krüger *et al*. (2016), Piaget's ideas of assimilation and accommodation can help learners with mathematics challenges through constructivism. Assimilation takes place when new information is taught that can fit into a child's existing map. During the interviews, the researcher noticed that because of teachers' time pressure, they

could not always wait until the information fits into the learner's existing map before proceeding. Therefore, the teachers taught new information (mathematics) even though the learner had not yet fully grasped the previous concept (mathematics). This time pressure became problematic for learners diagnosed with ADHD (Getz, 2013). According to Getz (2013), dopamine is reduced in the brain of learners with ADHD. This reduced dopamine level also influences those learners' frontal lobes, causing poor decision-making, lack of planning, inattention, and hyperactivity. The researcher believes that because of this challenge, ADHD-identified learners already experience these disadvantages. It is unfair to force these learners to learn new work if they have not thoroughly understood the previous work.

Piaget also spoke about the accommodation occurring when new information arises, contradicting the child's existing map. For example, the Grade 3 learner may learn about times tables in a different pattern than they were used to in the past. The teacher now has to use disequilibrium to help the brain restore concepts. During the interviews, the researcher realised that teachers do not always have time to "go back and restore learned concepts" Therefore, they ignore that the child struggles and move on to new concepts. The researcher believes that Piaget's theory can help teachers understand the neurodevelopment of ADHD learners and how to exercise the brain to improve in mathematics conceptualisation, and how important it is to help restore concepts when new concepts are being taught. Figure 5.2 below gives an example of the representation of Piaget's ideas compared to the problems the researcher found during the interviews with the participating teachers.

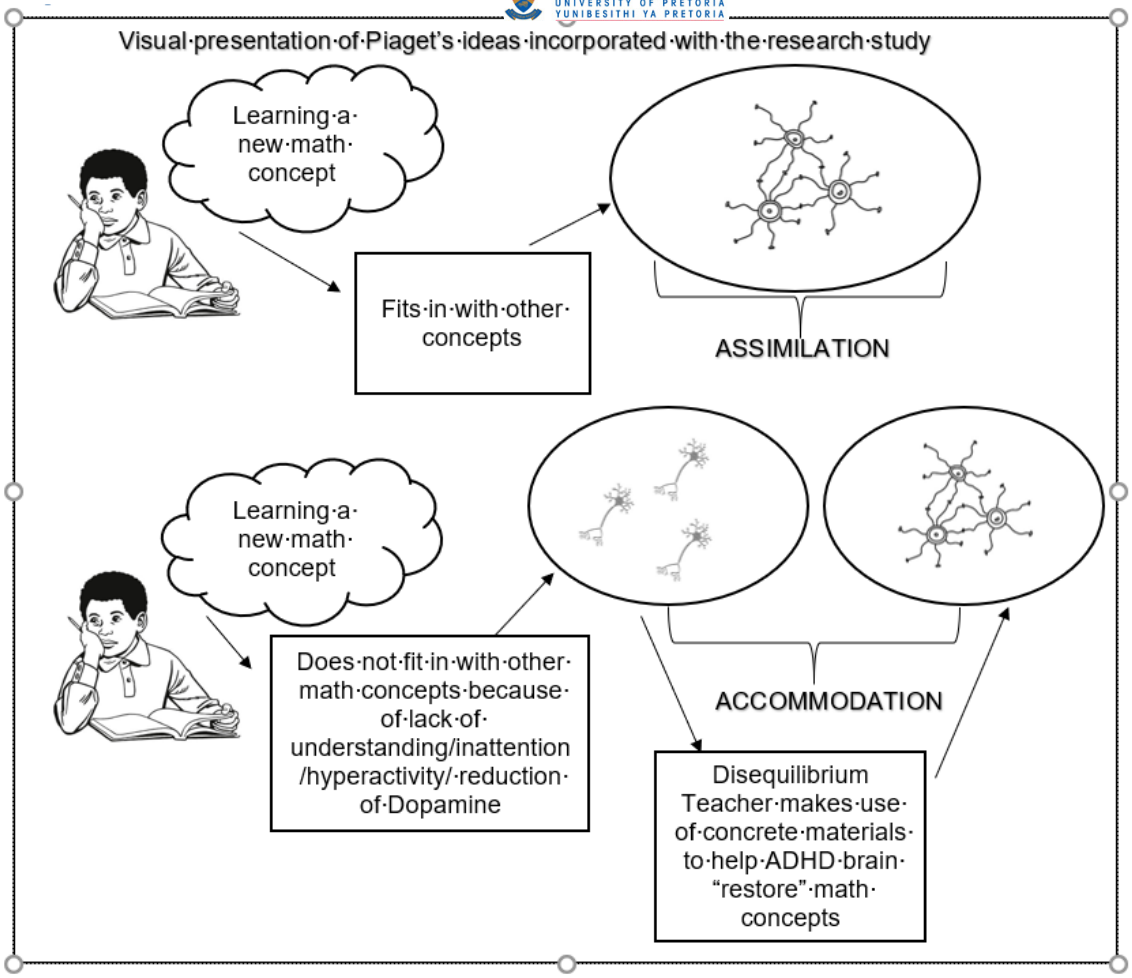


Figure 5.2: Illustration of the importance of Piaget's ideas incorporated in the research study

Figure 5.2 illustrates the importance of Piaget's ideas in the investigated research study. The first figure shows what happens when a learner learns a new concept that fits into their understanding. The second figure shows how different an ADHD-identified learner's brain work when they do not understand a concept and when it does not fit into their understanding. Several factors can cause the learner not to understand, like overstimulation, distractions, a teacher with a bad attitude, and overwhelmingness. The figures, therefore, illustrate the importance of using materials or exercises to help the ADHD-identified learner restore concepts in their brain so that they can move on to new concepts. The next theory is Vygotsky's sociocultural theory. Vygotsky is well known for the concept of the zone of proximal development (Muñoz-Silva *et al*., 2022). The zone of proximal development will help explain why the teacher is the main bridging force between the known and unknown for learners diagnosed with ADHD.

5.4.2 Vygotsky's sociocultural theory

This study used Vygotsky's sociocultural theory to help understand teachers' roles, personalities, and attitudes towards learners with ADHD. As mentioned in Chapter 2, the zone

of proximal development starts with the learner being unable to do the task. Vygotsky explains the importance of the assistance of an adult (teacher) to help the learner understand the task. During the interviews, the researcher asked each participating teacher what their attitude towards mathematics was and what impact it had towards their ADHD-identified learners. Most participating teachers could answer the question with the understanding that their attitudes significantly impact the learners. Teacher A from Group 1 (private school) immediately admitted that she does not like mathematics. The researcher also realised that the ADHD learners in her classroom struggled the most with mathematics by observing their mathematics books received. Teacher A also mentioned that when she presented mathematics, she mostly appeared despondent because she never looked forward to presenting the subject. Teacher A was enough proof for the researcher to understand the effect a teacher's attitude can have towards learners with ADHD, especially because ADHD learners have emotional dysfunctions (Greenblatt, 2017). Vygotsky's theory explains that the teacher must be the learner's mentor. Mentors need to be positive and motivated to teach. The zone of proximal development is the "continuum" between what a learner knows and can do independently and what a learner can do but with the assistance of a teacher (dependents) (Krüger *et al.* 2016:244).

Vygotsky emphasises the importance of the teacher being socially collaborative when learning and developing mathematics concepts occur. All five participating teachers mentioned that if they do not appear socially accommodative or "happy," they can easily lose the concentration of their ADHD learners. These comments fit into the statement of Getz (2013), where he mentions that imaging studies have implicated a difference in the corpus callosum of ADHD brains. This finding helps to explain the verbal abilities found in ADHD-identified learners. Therefore, if teachers are not social enough in a positive way, they might lose the concentration of ADHD learners, which can interfere with the zone of proximal development. However, as mentioned in Chapter 2, Swingle (2015) adds the importance of the arousal level of the classroom with ADHD-identified learners. Swingle (2015) and Leaf (2013) state that the arousal level in a teacher's classroom can influence the brain waves of an ADHD learner. Brain waves send communication from one mass of neurons to another, bringing together the regions of the brain to produce experience. This means that if the teacher is "too" social or "too" quiet, either way, she might lose the concentration of her ADHD learner, which can affect the learner trying to learn new mathematics concepts. Therefore the personality of a teacher is important to keep in mind when working with ADHD-identified learners. Figure 5.3 illustrates how the zone of proximal development works and the

importance of the sociocultural theory of Vygotsky on the neurodevelopment of an ADHD brain.

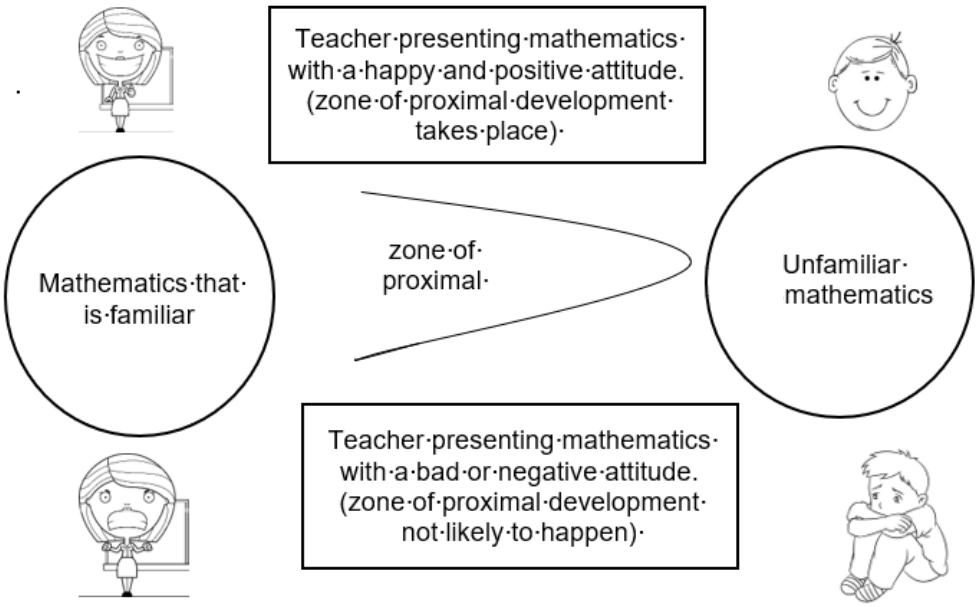


Figure 5.3: Illustration of the ZPD's importance on the sociocultural theory of Vygotsky on the neurodevelopment of ADHD

5.4.3 Donald Olding Hebb's predominantly neurophysiological theory

The study used Hebb's predominantly neurophysiological theory to help understand the neurodevelopment of the ADHD brain because it has a link between brain science and the learning of mathematics. As mentioned in Chapter 2, according to Hebb, there must be an optimal level of arousal in the classroom to learn better. It was clear during the interviews that some teachers were unhappy with their classroom setup, especially the teachers from the private school. They complained about being too close to each other's classrooms and having to walk through each other's classrooms to use the toilet facilities. These interruptions will influence the classroom's arousal level and the ADHD-identified learners' attention span. Hebb explained that if arousal is too high, it is likely that the learner will operate in the environment to reduce the arousal level. This high arousal level can be why some of the learners' mathematics books had upside-down worksheets or open spaces. Hebb's theory also emphasises the importance of the teacher's knowledge about the neurodevelopment of ADHD, because a neurological factor can cause ADHD. During the interviews, the teachers were uncertain when asked, "what is your conceptualisation of ADHD neurodevelopment?".

Most participating teachers said that ADHD is a learner with concentration challenges, but it is much more than just that. This comment indicated that they did not really understand the seriousness of ADHD. It was also unclear whether the teachers used scaffolding during their lessons. It appeared that most of the time, the teachers only presented the work as required of them. Although the teachers knew what scaffolding meant, it appeared as if they did not know how to apply it to their teaching. The teachers could mention specific methods they used to make learning easier for the learners, but nothing was mentioned about how they helped the learners strengthen their long- and short-term memory. Hebb emphasises the significance of understanding the short- and long-term memory of ADHD-identified learners to make teaching and learning sufficient for them.

The researcher also deduced that the teachers did not present multiplication tables and patterns with the right methods on certain worksheets presented in the mathematics books. Some of the multiplication patterns were too complicated, influencing the learners' short- and long-term memory. There were also not enough pictures and illustrations to help explain the mathematics activities. The researcher believes that Hebb's theory is relevant to the study as it can explain why ADHD learners struggle with the mathematics that consists of extended steps or work with no steps at all, because of their feeble concentration and memory. Furthermore, Hebb's assertion states that if teachers use more sensory experiences such as building blocks or music, it can help set up neural activity in the ADHD brain, and this can also support the learner's memory challenges. During the interviews, only one teacher mentioned more than one sensory resource she used to support her learners. However, three of the five participating teachers mentioned music or songs can help to remember challenging mathematics steps. Figure 5.4 below illustrates the different neural activity in a non-ADHD brain, an active ADHD brain, and an ADHD brain in remission. The diagrams below illustrate that ADHD is caused by a neurological factor and indicates the different activity taking place in the brain. This diagram fits into the research study as it indicates some activity taking place in the frontal lobes of the ADHD learner's brain that can cause challenges, such as worksheets that are not cut out well, are pasted upside down, and untidy writing.

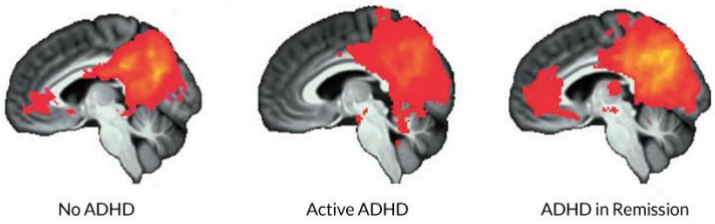


Figure 5.4: Illustration of the different activity in a non-ADHD brain versus an active ADHD brain

(Resources by science news, 2014)

The three theories made a great contribution to the study. Firstly, Piaget and Vygotsky's theories explained to the researcher and teacher why the role of a teacher is so important and why the teacher must first understand a learner's neurodevelopment before supporting the learner. In addition, Hebb's theory gave a good explanation of how a child's brain works and how it can be influenced. Secondly, all three theories helped the researcher to distinguish between which teaching methods are correct and which can be added to help understand the neurodevelopment of learners identified with ADHD. Lastly, important facts can be used from the theories to make the learning of mathematics easier for ADHD learners.

5.5 SUMMARY OF EMPIRICAL FINDINGS

This section presents a summary of the key empirical findings in terms of the five themes that were generated deductively: teachers' conceptualisation of neurodevelopment and ADHD, teachers' perspectives about ADHD neurodevelopment and the mathematical interventions in the Foundation Phase, the support teachers receive, inclusive strategies used to help learners diagnosed with ADHD, and curriculum differentiation. Data obtained from five Grade 3 teachers with more than three years of teaching experience working with ADHD-identified learners, who had a BEd or Bed (Hons) degree, and were teachers in a mainstream or private school, was analysed. This data analysis determined their understanding of ADHD, neurodevelopment, and mathematical interventions in the Grade 3 Foundation Phase classroom. ADHD neurodevelopment was investigated through the lens of the conceptual frameworks of Piaget's neuroplasticity theory, Vygotsky's sociocultural theory, and Hebb's predominantly neurophysiological theory.

If teachers have enough understanding about the neurodevelopment of ADHD-identified learners, it will help to improve the inclusive teaching and learning of mathematics. For teachers to gain more knowledge about ADHD neurodevelopment, they must get enough support from the DBE, DBST, school management, and principals. Teachers should also be educated more about ADHD through courses and teacher training programmes. In this study, only a few participating teachers gave a clear explanation of ADHD and the neurodevelopment thereof. It was also clear that the teachers from the private school received little support from their school management and DBST.

5.6 RESEARCH QUESTIONS

In Chapter 1, the researcher posed the main research and sub-research questions to guide the researcher's discussion about the collected data and analysis. The primary research question guided the researcher to collect data through semi-structured interviews with the participating teachers. The first sub-research questions dealt with the amount of knowledge teachers have about the neurodevelopment of ADHD and mathematics interventions in the Grade 3 Foundation Phase. The second sub-research question dealt with the support teachers receives in mainstream and private schools to enhance learners identified with ADHD's mathematics access. The last sub-research question served as a guide to observing teachers' understanding of inclusive strategies in connection with teaching challenging mathematics to ADHD-diagnosed learners.

5.6.1 Sub-research Question 1

What are teachers' perspectives on ADHD, neurodevelopment, and mathematics interventions in the Grade 3 Foundation Phase?

During the interviews, it was clear to the researcher that each teacher had their own perspective on ADHD, neurodevelopment, and mathematics interventions. The participating teachers could not explain the term "neurodevelopment", which made their perspective appear vague. However, most of the teachers could give one or two-sentence explanations of the ADHD disorder, but the question was not answered well enough for the researcher to conclude that the teachers know what ADHD entails. The teachers had one thing in common: to learn more about the neurodevelopment of learners diagnosed with ADHD to help improve the mathematics interventions they use.

5.6.2 Sub-research Question 2

What kind of support do teachers in mainstream and private schools receive to enhance mathematics access for learners diagnosed with ADHD?

During this question, the researcher realised that most teachers receive very little support from the school and the Department of Basic Education. This may explain why the teachers have little knowledge about ADHD and together with neurodevelopment. It also appeared that the teachers from the private school were getting less support due to financial challenges.

5.6.3 Sub-research Question 3

Which inclusive strategies do teachers in mainstream and private schools use that influence learners identified with ADHD with mathematical challenges?

The researcher concluded that the strategies used by mainstream schoolteachers are better than those in the private school. The reason for this is that the mainstream schoolteachers received more support from the school, including more suitable financial support to purchase aids and use better support for intervention strategies. From the observations of the mathematics books, it appeared that the learners did better with mathematics activities that included pictures and flow diagrams. The researcher noticed that the teachers from both schools (mainstream and private) did not always use the curriculum-prescribed work and "tips". The teachers' reasons were that the curriculum work was sometimes too much and too difficult for the ADHD-identified learners. It appeared that the teachers were not knowledgeable about curriculum differentiation. The researcher believes that the examples mentioned in the curriculum, such as flow diagrams, multiplication tables, and groups could be good examples to give teachers ideas on how to support the learners. The flowcharts and tables observed in the books appeared too difficult or too confusing for ADHD-identified learners. The researcher could also conclude that the teachers did not make enough use of concrete aids due to financial challenges.

5.6.4 Main research question

How do Grade 3 FP teachers in mainstream and private schools conceptualise ADHD and mathematics access?

Each teacher explained ADHD differently. There were only two out of the five participating teachers who could give a good explanation of the term ADHD. The other teachers "read off" the answer or could not explain the term ADHD further. Most teachers believed that some of the mathematics work mentioned in the curriculum was too difficult for ADHD-identified learners. They reckoned that the learners could not keep up with the time and amount of work expected from them, and they easily became overwhelmed.

5.7 RECOMMENDATIONS

In view of the key findings of this study, the literature review, and the aims of the study, I will provide eleven recommendations that are directed towards the National Department of Basic Education, the districts, to schools, to teachers at schools and the researcher.

5.7.1 Recommendations for the National Department of Basic Education

The following recommendations are for the National Department of Basic Education.

5.7.1.1 Recommendation 1: Implementation of policies

The National Department of Basic Education should ensure that all policies are implemented. This will help to ensure that the learning needs of not only “typically” developed learners but also learners with other learning barriers, such as ADHD, are met. This could be made possible by also involving all people responsible for the development of the policy, such as the district-based support teams and the school's management, to help identify any gaps and challenges faced around policies and their implementation.

5.7.1.2 Recommendation 2: Educating teachers more on ADHD neurodevelopment

The National Department of Basic Education should implement courses to inform teachers more about ADHD and the neurodevelopment thereof. They should also ensure enough information available for the teachers about ADHD and how to educate affected learners. This will assist teachers in learning and understanding more about their responsibilities and expectations in terms of working and understanding learners diagnosed with ADHD. This information must also include the ability to differentiate the curriculum. The National Department of Basic Education must also train teachers on the inclusive education as set out in the White Paper 6 policy guidelines for inclusive teaching and learning and the guidelines for how to work with diverse learner classrooms.

5.7.2 Recommendations for district officials

The following recommendation is intended for the district-based support teams.

5.7.2.1 Recommendation 3: Strengthening district-based support teams (DBST)

The DBST should support schools that cater to learners with learning disabilities. According to the participating teachers, they do not receive enough or any support from the DBST. The DBST’s support will help ensure that teachers are provided with support in addressing learning barriers, such as those experienced by learners diagnosed with ADHD. This support must also include creating the ability for teachers to understand the neurodevelopment of

ADHD and how to implement curriculum differentiation to make learning more accessible for ADHD-identified learners.

5.7.3 Recommendations for schools

The following recommendations are targeted at mainstream and private schools.

5.7.3.1 Recommendation 4: Establishing support networks in schools

The school must ensure that all teachers get enough support from the school's management teams. This support will help to ensure that the teachers are kept up to date about important learning disabilities and that they share resources. Furthermore, they should conduct workshops with each other at the school to share best practices on ADHD neurodevelopment and the learners' support needs. Teachers will share their knowledge and challenges regarding ADHD. The teachers can learn from each other about inclusive teaching practices and curriculum differentiation.

5.7.3.2 Recommendation 5: Developing a community of practice between schools and communities

If a school struggles financially it will be best to use available community human resources, such as retired teachers and student teachers, to help serve as assistants in the classroom. This will especially be helpful for ADHD-identified learners that need extra support. The above can also help minimise challenges, such as learners feeling overwhelmed in overcrowded classrooms that make curriculum differentiation difficult.

5.7.4 Recommendation for teacher training institutions

The following recommendations are targeted at the teacher training institutions.

5.7.4.1 Recommendation 6: Strong collaboration between the teacher training institutions, Department of Basic Education, and schools (mainstream or private)

The teacher training institutions must establish solid collaboration with the Department of Basic Education and the schools to eliminate misunderstandings between teachers and their needs. This will help ensure that the content taught in the teacher training institutions responds to the needs of the Department of Basic Education and the schools. In this case, the teachers' greatest need is to be more educated about the neurodevelopment of ADHD to help with curriculum differentiation and inclusive mathematics teaching.

5.7.4.2 Recommendation 7: Teacher's training must include an on-site approach

If a teacher is enrolled for the BEd Honours degree in Learning Support, it is still important for the teacher training programme to use on-site visits. In other words, teachers must conduct classroom visits to get a hands-on experience with the support needs of children diagnosed with ADHD. This experience will also help with the teacher's confidence in curriculum differentiation when working with these learners.

5.7.4.3 Recommendation 8: For the researcher

I am not convinced that my participants will necessarily get enough support from the Department of Basic Education or the DSBT. I am also unsure if the teachers will implement curriculum differentiation for learners with ADHD. The findings of this study have made me realise that teachers need more support to help educate them on how to understand ADHD neurodevelopment in young learners and how to educate them inclusively. Therefore, I will share the study's findings and recommendations with the participants to enlighten them on the insights for supporting ADHD learners. I can also do once-off awareness training with teachers to share scientific and research-based strategies.

5.8 RECOMMENDATION FOR FURTHER RESEARCH

Based on the findings of this study, I recommend the following for future research:

5.8.1 Recommendation 9: Teacher's knowledge of how to differentiate the curriculum for ADHD-identified learners

Since my study was based on teachers' conceptualisation of ADHD, neurodevelopment, and mathematical interventions, it would be interesting to research more deeply on teacher's conceptualisation and knowledge on how to differentiate the curriculum for ADHD learners.

5.8.2 Recommendation 10: Teacher's perspectives about their classrooms in support of ADHD neurodevelopment

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 with information processing of an ADHD learner and also to examine the resources available in the classrooms such as tables, chairs, pictures on the wall, and white boards.

5.8.3 Recommendation 11: The use of successful strategies to help ADHD-identified learners

During the study, I realised teachers do not understand which strategies are best when working with ADHD learners. It would be interesting to find out which strategies in South African schools relate to those recommended in the literature and identify which are beneficial in the context of ADHD.

5.9 LIMITATIONS

It is necessary to acknowledge that this research involved teachers of only one private school and one mainstream school. My selection of participating teachers renders the research trustworthy. I anticipated that the result of this study would help realise the importance of a teacher's job to understand their learners, especially if the learner has any learning disabilities. I believe that if the teachers are better trained in the neurodevelopment of ADHD, it could make their work as teachers easier and improve the future participation of that learner in society.

5.10 CONCLUSION

Undertaking this research study was very rewarding, and it contributed greatly to my growth as a teacher and tutor working with ADHD-identified learners. I view this study as an essential step in recognising the gaps in schools and the education of teachers that need to be addressed by the National Department of Basic Education and the DBST. Before this research study, I always relied on the literature, which encompassed the understanding of ADHD neurodevelopment and how beneficial it can be for teachers to understand the brain functioning of ADHD to improve mathematics teaching in inclusive teaching.

From this study as a researcher, I gained more information about the development of an ADHD brain, and the knowledge teachers have in this regard. I also learned about the differences between mainstream and private schools and teachers' challenges regarding support and finances. Receiving first-hand insights from teachers about their understanding of ADHD, neurodevelopment, and mathematics interventions was an eye opener and emotionally draining at times to realise how little passion some of the teachers had left. In particular, I felt deeply for learners diagnosed with severe ADHD, which they and their parents cannot resolve on their own. I also felt for the teachers who received little support from their school management and the District Based Support Teams.

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6 APPENDICES

6.1 APPENDIX A: EXAMPLE OF THE PREMISSION LETTER TO THE DEPARTMENT OF EDUCATION

Gauteng Department of Education
President Towers
265 Pretorius Street
Pretoria Central
Pretoria
0001

Dear Madam 27 June 2022

INFORMED CONSENT LETTER FOR TSHWANE EAST DISTRICT SCHOOLS: PUBLIC PRIMARY AND PRIVATE SCHOOLS

I am currently studying for a master's degree in the Faculty of Education at the University of Pretoria. I hereby wish to apply for permission to conduct my research study at some of the primary schools which fall under the jurisdiction of your department in the Pretoria East District. My research project will involve Grade 3 teachers and the mathematics books of learners diagnosed with ADHD in their classrooms. My research topic is: **Investigating teachers' conceptualisation of ADHD neurodevelopment and mathematical interventions in Grade 3 Foundation Phase classes**.

I want to conduct this research project because the literature has reported an increase in the number of children diagnosed with ADHD, and teachers are likely to have these learners in their classrooms. Children diagnosed with ADHD experience difficulties with mathematics because of their brain functions. Studies show that 84% of learners diagnosed with ADHD score poorly in mathematics, and most FP teachers are not well equipped to identify learners with ADHD. As the researcher in this study, I aim to find out how teachers support

learners identified with ADHD with mathematical challenges and to determine teachers' understanding of ADHD and neurodevelopment.

In order to achieve the aim of the research project I need to gather data from Grade 3 teachers with learners diagnosed with ADHD in their classrooms. Therefore, I am asking for permission to interview Grade 3 teachers and ask for worksheets and a narration of the methods they use to support learners diagnosed with ADHD and who are struggling with mathematics. If Covid-19 persists, I will conduct online interviews with the teachers and ask them to send the learners' worksheets and the narrations via email. The teachers' participation of this study will be voluntary, and they may withdraw at any time without any consequences. The data obtained will be used confidentially and anonymously for research purposes, as the data sets are the intellectual property of the University of Pretoria. The confidentiality and privacy applicable to this study will bind future research studies.

The research results will be made available upon request after completing the project. The research data will be stored in electronic format and as a hard copy at the University of Pretoria for 15 years in compliance with the ethical requirements of the university. The results of this study may also be shared with other professionals in articles or during conference presentations.

I hope this letter will provide you with adequate information to enable you to grant me the permission to conduct the proposed research project at schools falling under your jurisdiction. In the event of you requiring additional information, do not hesitate to contact me or my supervisor.

Kind regards
Stefnie Loots (Researcher)

Stefnie Loots (Researcher)
E-mail: stefnieloots@gmail.com
Cell: 0711006957

Dr Susan Thuketana (Supervisor)
E-mail: susan.thuketana@up.ac.za
Cell: 0836757899

6.2 APPENDIX B: EXAMPLE OF THE PERMISSION LETTER TO THE HEAD OFFICE

Head of The Department
Department of Education
PO Box 7710
JOHANNESBURG
2000

Dear Sir/ Madam 27 June 2022

INFORMED CONSENT LETTER FOR HEAD OF DEPARTMENT

I am currently studying for a master's degree in the Faculty of Education at the University of Pretoria. I hereby wish to apply for permission to conduct my research study at some of the primary schools, which fall under the jurisdiction of your department in the Tshwane East District. My research project will involve Grade 3 teachers and the mathematics books of learners diagnosed with ADHD in their classrooms. My research topic is: **Investigating teachers' conceptualisation of ADHD neurodevelopment and mathematical interventions in Grade 3 Foundation Phase classes**.

I want to conduct this research project because the literature has reported an increase in the number of children diagnosed with ADHD, and teachers are likely to have these learners in their classrooms. Children diagnosed with ADHD experience difficulties with mathematics because of their brain functions. Studies show that 84% of learners diagnosed with ADHD score poorly in mathematics, and most FP teachers are not well equipped to identify learners with ADHD. As the researcher in this study, I aim to find out how teachers support learners identified with ADHD with mathematical challenges and to determine teachers' understanding of ADHD and neurodevelopment.

In order to achieve the aim of the research project I need to gather data from Grade 3 teachers with learners diagnosed with ADHD in their classrooms. Therefore, I am asking for permission to interview Grade 3 teachers and ask for the worksheets and a narration of the methods they use to support learners diagnosed with ADHD and who are struggling with mathematics**.** If Covid-19 persists, I will conduct online interviews with the teachers and ask them to send the learners' worksheets and the narrations to me via email. Teacher participation of this study

will be voluntary, and they may withdraw at any time without any consequences. The data obtained will be used confidentially and anonymously for further research purposes, as the data sets are the intellectual property of the University of Pretoria. The confidentiality and privacy applicable to this study will bind future research studies.

The research results will be made available on request after completing the project. The research data will be stored in electronic format and as a hard copy at the University of Pretoria for 15 years in compliance with the ethical requirements of the university. The results may also be shared in articles or during conference presentations with other professionals.
I hope this letter will provide you with adequate information to enable you to grant me permission to conduct the proposed research project at schools falling under your jurisdiction. In the event of you requiring additional information, do not hesitate to contact me or my supervisor.

Kind regards
Stefnie Loots (Researcher)

Stefnie Loots (Researcher)
E-mail: stefnieloots@gmail.com

Cell: 0711006957

Dr Susan Thuketana (Supervisor)
E-mail: susan.thuketana@up.ac.za

Cell: 0836757899

6.3 APPENDIX C: EXAMPLE OF THE PERMISSION LETTER TO THE PRINCIPAL

Dear Principal 27 June 2022

INFORMED CONSENT LETTER FOR PRINCIPALS

REQUESTING PERMISSION TO CONDUCT RESEARCH AT YOUR SCHOOL

I am currently studying for a master's degree in the Faculty of Education at the University of Pretoria. I need to conduct a research project in partial fulfilment of the requirements for this degree. My research topic is**: Investigating teachers' conceptualisation of ADHD neurodevelopment and mathematical interventions in Grade 3 Foundation Phase classes.**

I want to conduct this research project because the literature has reported an increase in the number of children diagnosed with ADHD, and teachers are likely to have learners with ADHD in their classrooms. Children diagnosed with ADHD experience difficulties with mathematics because of their brain functions. Studies show that 84% of learners with ADHD score poorly in mathematics, and most FP teachers are not well equipped to identify these learners in their classes. As the researcher in this study, I aim to determine how teachers support ADHD learners with mathematical challenges and to learn more about their understanding of ADHD and neurodevelopment.

In view of the information provided above, I am requesting permission to interview the teachers at your school. I will conduct semi-structured interviews with Grade 3 teachers and ask for the learners' worksheets and teachers' narrations of the methods they use to support learners diagnosed with ADHD and struggling with mathematics**.** If Covid-19 still persists, I will conduct online interviews with the teachers and ask them to send the learners' documents via email. I have attached a copy of the interview schedule and observation protocol below for your information.

Parents will be given informed consent letters to explain the reason for and the objectives of the researchers' study. During this study, no learner will be interviewed, only the teachers. However, each Grade 3 learner will be requested to give their assent for the research project. Participation will be voluntary, and you may withdraw at any time without any consequences. All the information gathered will be treated as confidential, and the anonymity of the participants and that of the school will be maintained.

The research results will be made available on request after the completion of the project. The research data will be stored both in electronic format and as a hard copy at the University of Pretoria for 15 years in compliance with the ethical requirements of the university. The results may also be shared with other professionals in articles or during conference presentations, and all persons who will have access to the research data will be identified.
If you are willing to allow your school to participate in this research, please fill in the consent form provided below. If you have any questions, do not hesitate to contact me or my supervisor.

Kind regards
Stefnie Loots (Researcher)

_____ _____

Stefnie Loots (Researcher)
E-mail: stefnieloots@gmail.com
Cell: 0711006957

Dr Susan Thuketana (Supervisor)
E-mail: susan.thuketana@up.ac.za
Cell: 0836757899

PERMISSION TO CONDUCT RESEARCH PROJECT

I, _____, Principal of _____ agree / do not agree to allow Stefnie Loots to conduct research at my school. The topic of the research is: **Investigating teachers' conceptualisation of ADHD neurodevelopment and mathematical interventions in Grade 3 Foundation Phase classes**

Signature: _____ Date: _____

6.4 APPENDIX D: EXAMPLE OF PERMISSION LETTER TO PARENTS AND ASSENT LETTER FOR LEARNERS

Dear Sir/Madam 27 June 2022

INFORMED CONSENT LETTER FOR PARENTS/CAREGIVERS

I am currently studying for a master's degree in the Faculty of Education at the University of Pretoria. I need to conduct a research project in partial fulfilment of the requirements for this degree. My research topic is**: Investigating teachers' conceptualisation of ADHD neurodevelopment and mathematical interventions in Grade 3 Foundation Phase classes.**

I want to conduct this research project because the literature has reported an increase in the number of children diagnosed with ADHD, and teachers are likely to have these learners in their classrooms. Children diagnosed with ADHD experience difficulties with mathematics because of their brain functions. Studies show that 84% of ADHD learners score poorly in mathematics, and most FP teachers are not well equipped to identify learners with ADHD and provide them with the necessary support. As the researcher in this study, I aim to achieve the following objectives: to find out how teachers in schools support ADHD learners with mathematical challenges and to determine teachers' understanding of ADHD and neurodevelopment.

In the light of what has been mentioned above, I request permission to look at your child's mathematics book to gather data for the research project. If Covid-19 still persists, I will conduct online interviews with the teachers and ask them to send the learners' documents via email. I will also ask the principal to identify classes with learners diagnosed with ADHD. The data obtained will be used confidentially and anonymously for further research purposes, as the data sets are the intellectual property of the University of Pretoria. The confidentiality and privacy applicable to this study will bind future research studies. It is also important to

understand that you may choose to leave the research study at any time without any consequences to your child's mathematics or the teacher being interviewed. The research results will be made available upon request after completing the project. The research data will be stored in electronic format and as a hard copy at the University of Pretoria for 15 years in compliance with the ethical requirements of the University. The results may also be shared with other professionals in articles or during conference presentations.

I hope this letter has provided adequate information to enable you to consider giving your consent for the researcher to observe your child's books and worksheets for the proposed study. If you agree, please sign the reply slip; also feel free to contact the researcher and the supervisor at the email addresses and cell phone numbers given below.

Kind regards

Stefnie Loots (Researcher)

Stefnie Loots (Researcher)
Email: stefnieloots@gmail.com
Cell: 0711006957

Dr. Susan Thuketana (Supervisor)
Email: susan.thuketana@up.ac.za
Cell: 0836757899

CONSENT TO PARTICIPATE IN THE RESEARCH PROJECT: PARENTS/CAREGIVERS

INFORMED CONSENT: REPLY SLIP

I……. hereby give /do not give consent to the researcher to observe my child's mathematics worksheets and books. I also understand the contents of the abovementioned research project.

Signature: Parent……. Date: ……

ASSENT LETTER TO THE GRADE 3 LEARNERS

Dear Grade, 3 Learner 27 June 2022

I am currently studying for a master's degree in the Faculty of Education at the University of Pretoria. Your parents have already permitted me to observe your mathematics books and worksheets. If you do not agree with your parents you are allowed to say no, and there will be no consequences.

If you agree with your parents to allow me to observe your mathematics book and worksheets, you can circle the smiling face, if not, circle the angry face.

Thank you
Stefnie Loots (Researcher)

_____ _____

Stefnie Loots (Researcher) Dr Susan Thuketana (Supervisor)

6.5 APPENDIX E: EXAMPLE OF THE PERMISSION LETTER TO THE TEACHER

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

Dear Grade 3 teacher, 27 June 2022

INFORMED CONSENT LETTER FOR GRADE 3 TEACHER

I am currently studying for a master's degree in the Faculty of Education at the University of Pretoria. I need to conduct a research project in partial fulfilment of the requirements for this degree. My research topic is**: Investigating teachers' conceptualisation of ADHD neurodevelopment and mathematical interventions in Grade 3 Foundation Phase classes.**

I want to conduct this research project because the literature has reported an increase in the number of children diagnosed with ADHD, and teachers are likely to have learners diagnosed with ADHD in their classrooms. Children diagnosed with ADHD experience difficulties with mathematics because of their brain functions. Studies show that 84% of learners with ADHD score poorly in mathematics, and most FP teachers are not well equipped to identify these learners in their classes. As the researcher in this study, I aim to find out how teachers support learners identified with ADHD with mathematical challenges and to determine their understanding of ADHD and neurodevelopment.

In view of the information provided above, you are requested to participate in this research study. The participation that is requested from you, as a teacher, involves answering of a set of questions during a semi-structured interview. The researcher will also ask for learners' worksheets and teachers' narrations of the methods they use to support learners diagnosed with ADHD and who are struggling with mathematics. If Covid-19 still persists, I will conduct online interviews with the teachers and ask them to send learners' documents via email. The research project will have no direct benefit for you, but your input will contribute to more in-depth knowledge regarding how teachers understand

ADHD, neurodevelopment, and which steps can be taken to support teachers that are not well-equipped with regard to the requisite tools and knowledge to support learners diagnosed with ADHD, and who are struggling with mathematics.

Parents will be given informed consent letters to explain the reason for the researchers' study as well as her intentions with this research. During this study, no learner will be interviewed, only the teachers. However, each Grade 3 learner will give assent to be part of this research project. The teachers' participation in this study will be voluntary, and they may withdraw at any time without any consequences. All the information gathered will be treated as confidential and the anonymity of the participants and that of the school will be maintained.

The research results will be made available on request after the completion of the project. The research data will be stored in both electronic format and as a hard copy at the University of Pretoria for 15 years in compliance with the ethical requirements of the University. The results may also be shared with other professionals in articles or during conference presentations and all persons who may have access to the research data, will be identified.

In order to give your consent to participate in this study, please fill in the consent form provided below. One form gives consent to participate in the research project and the other form gives consent to have the proceedings of the interview voice recorded. If you have any questions, do not hesitate to contact me or my supervisor.

Kind regards
Stefnie Loots (Researcher)

Stefnie Loots (Researcher)
E-mail: stefnieloots@gmail.com
Cell: 0711006957

Dr Susan Thuketana (Supervisor)
E-mail: susan.thuketana@up.ac.za
Cell: 0836757899

CONSENT TO PARTICIPATE IN THE RESEARCH PROJECT: PRIMARY SCHOOL EDUCATORS

INFORMED CONSENT: REPLY SLIP

I……. hereby give /do not give consent of participation in the abovementioned research project. I understand that I can withdraw at any stage of the research project and that my identity will not be disclosed.

Signature: Participant …….. Date: ……

CONSENT TO ATTEND TO ZOOM MEETING: PRIMARY SCHOOL EDUCATORS

INFORMED CONSENT: REPLY SLIP
I……. hereby give /do not give consent for the interview that will take place through zoom meeting or in person to be voice recorded. I understand that the researcher needs to listen to the audio clip at a later stage so that the interview can be transcribed for the analysis of the data obtained from the interview session. I am well aware that I can withdraw at any stage of the research project and that my identity will not be disclosed.

Signature: Participant …….. Researcher: ……..
Date: ……

6.6 APPENDIX F: EXAMPLE OF THE TEACHER INTERVIEW PROTOCOL

The topic of the research is: **Investigating teachers' conceptualisation of ADHD neurodevelopment and mathematical interventions in Grade 3 Foundation Phase classes**

Time of interview: _____Duration: _____
Date: _____
Location: _____
Interviewer: _____
Interviewee: _____
Pseudonym: _____
Male/Female: _____

Teachers' conceptualisation of ADHD, neurodevelopment plays a critical role in the teaching of Foundation Phase mathematics interventions. The purpose of this study is to find out how Grade 3 teachers in mainstream and private schools' support ADHD learners with mathematics challenges, and to determine to what extent teachers, understand ADHD, and neurodevelopment. This study will also compare teachers' different strategies to support ADHD learners with regard to mathematics in mainstream and private schools. PCK (Pedagogical Content Knowledge) refers to the manner in which the teacher successfully carries his/her content knowledge across by means of instructional methods, and teaching strategies. Pseudonyms will be utilized in the interviews, data analysis and the findings. The data collected in this study will serve in research purposes only and treated as confidential. Access to the data will be granted to the researcher and the supervisor only. Please sign the consent form.

Thank you for your participation.

Questions:

1. What is your concept of neurodevelopment?
2. What is your concept of the diagnosis ADHD?
3. What are your views on ADHD, neurodevelopment, and mathematics interventions in the Foundation Phase?
4. What kind of support do you receive from the management or district-based support teams to enhance ADHD-identified learners' mathematics access?
5. Which inclusive education strategies do you use in your class that have a positive influence on learners identified with ADHD struggling with mathematics?
6. Which inclusive strategies do you use in your class that have a negative influence on learners identified with ADHD struggling with mathematics?
7. Which skills or methods do you teach learners diagnosed with ADHD to support them with multiplication in mathematics lessons?
8. How do you adjust mathematics assessments for ADHD learners?
9. Do you think the National Curriculum Statement (2003) places sufficient emphasis on mathematics for learners diagnosed with ADHD?
10. How do you support learners with ADHD to master the mathematics curricula?
11. How do you think can your attitude towards ADHD learners influence the teaching of the subject?

6.7 APPENDIX G: EXAMPLE OF THE OBSERVATION PROTOCOL

Date of observation: _____

Name of observer: _____

Teacher being observed (Pseudonym): _____

Grade: _____

Subject: _____

Reason for observation: _____

Time of observation: _____

End time of observation: _____

Teachers' conceptualisation of ADHD and neurodevelopment plays a critical role in the teaching of Foundation Phase mathematics. The purpose of this study is to investigate how Grade 3 teachers in mainstream and private schools support ADHD learners with mathematics challenges, and to understand their conceptualisation of ADHD, and neurodevelopment. This study will also compare the strategies teachers in mainstream and private schools use to support learners diagnosed with ADHD. During the observations, the researcher will observe the Grade 3 learners' mathematics books, worksheets, and the methods teachers use to assist learners struggling with mathematics.

Documents being observed:

DOCUMENTS BEING OBSERVED	MATHEMATICS BOOK	MATHEMATICS WORKSHEET	MATHEMATICS METHODS TEACHER USED
TOPIC OF THE DOCUMENT			
IS IT COMPREHENSIBLE?	Yes/ No Reason:	Yes/ No Reason:	Yes/ No Reason:
HAS THE OUTCOME BEEN ACHIEVED?	Yes/ No Reason:	Yes/ No Reason:	Yes/ No Reason:
WHAT COULD BE INCLUDED?			
WHAT COULD BE EXCLUDED?			
IS IT SUITABLE FOR LEARNERS DIAGNOSED WITH ADHD?	Yes/ No Reason:	Yes/ No Reason:	Yes/ No Reason:

6.8 APPENDIX H: EXAMPLE OF THE FIELDNOTES

DESCRIPTIVE FIELDNOTES:	**REFLECTIVE FIELDNOTES:**
Semi-structured interview: **Participant name (Pseudonym):** **Topic of interview:** **Estimated time of interview:** **Interview questions with teachers' reactions:** 1. How do you conceptualise neurodevelopment? **Teachers' reaction: comfortable/ uncomfortable** 2. How do you conceptualise the diagnosis of ADHD? **Teachers' reaction: comfortable/ uncomfortable** 3. What are your perspectives on ADHD, neurodevelopment, and mathematics interventions in the Foundation Phase? **Teachers' reaction: comfortable/ uncomfortable** 4. What kind of support do you receive from the management or district-based support teams to	

enhance ADHD learners' mastery of mathematics? **Teachers' reaction: comfortable/ uncomfortable** 5. Which inclusive education strategies do you use in your class that have a positive influence on learners identified with ADHD struggling with mathematics? **Teachers' reaction: comfortable/ uncomfortable** 6. Which inclusive strategies do you use in your class that have a negative influence on learners identified with ADHD struggling with mathematics? **Teachers' reaction: comfortable/ uncomfortable** 7. Which types of skills or methods do you teach learners diagnosed with ADHD to support them with multiplication in mathematics lessons? **Teachers' reaction: comfortable/ uncomfortable** 8. How do you adjust mathematics	

assessments for ADHD learners? **Teachers' reaction: comfortable/ uncomfortable** 9. Do you think the National Curriculum Statement (2003) places sufficient emphasis on mathematics for learners diagnosed with ADHD? **Teachers' reaction: comfortable/ uncomfortable** 10. How do you support learners with ADHD to master the mathematics curricula? **Teachers' reaction: comfortable/ uncomfortable** 11. How do you think your attitude towards ADHD learners can influence the teaching of the subject? **Teachers' reaction: comfortable/ uncomfortable**	

6.9 APPENDIX I: GDE RESEARCH APPROVAL LETTER

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	11 August 2022
Validity of Research Approval:	08 February 2022– 30 September 2022 2022/354
Name of Researcher:	S. Loots
Address of Researcher:	538 Oregon Street
	Faerie Glen
	Pretoria East
Telephone Number:	0711006957
Email address:	stefnieloots@gmail.com
Research Topic:	Investigating teachers' conceptualisation of ADHD, neuropsychology, and mathematical interventions in Grade 3 Foundation Phase classes
Type of qualification	Masters
Number and type of schools:	2 Primary Schools
District/s/HO	Gauteng East

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

16/08/2022

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below are met. Approval may be withdrawn should any of the conditions listed below be flouted:

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

1. *The letter would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. ***Because of the relaxation of COVID 19 regulations researchers can collect data online, telephonically, physically access schools, or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate.***
4. ***The Researchers are advised to wear a mask at all times, Social distance at all times, Provide a vaccination certificate or negative COVID-19 test, not older than 72 hours, and Sanitise frequently.***
5. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s has been granted permission from the Gauteng Department of Education to conduct the research study.*
6. *A letter/document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs, and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
7. *The Researcher will make every effort to obtain the goodwill and cooperation of all the GDE officials, principals, and chairpersons of the SGBs, teachers, and learners involved. Persons who offer their cooperation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
8. *Research may only be conducted after school hours so that the normal school program is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
9. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
10. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
11. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
12. *The researcher is responsible for supplying and utilising his/her research resources, such as stationery, photocopies, transport, faxes, and telephones, and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
13. *The names of the GDE officials, schools, principals, parents, teachers, and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
14. *On completion of the study, the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
15. *The researcher may be expected to provide short presentations on the purpose, findings, and recommendations of his/her research to both GDE officials and the schools concerned.*
16. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a summary of the purpose, findings, and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

.....

Mr. Gumani Mukatuni
Acting CES: Education Research and Knowledge Management

DATE: 16/08/2022

Office of the Director: Education Research and Knowledge Management
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