AN ACTIVE LEARNING STRATEGY FOR ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM

by

LINDIWE GLORIA MOKOTJO

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SUPERVISOR: PROFESSOR D.J. HLALELE

CO-SUPERVISOR: DOCTOR M.S. MOSIA

DECLARATION

I declare that the dissertation, AN ACTIVE LEARNING STRATEGY FOR ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM, hereby submitted for the qualification of Magister Artium at the University of the Free State, is my own sovereign work and that I have not previously submitted the same work for a qualification at/in another university/faculty.

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L.G. Mokotjo

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DEDICATION

to

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Your love, support and patience are unparalleled. You gave me the courage and tenacity to pursue my dreams and be the best that God wants me to be. I hope this has been an inspiration for all of you to pursue your dreams and never allow circumstances to determine your destiny. This hard work belongs to you.

LIST OF ABBREVIATIONS

ADHD	Attention Deficit Hyperactivity Disorder
AMESA	Association for Mathematics Education of South Africa
AL	Active Learning
CAPS	Curriculum and Assessment Policy Statement
CDA	Critical Discourse Analysis
CER	Critical Emancipatory Research
CET	Critical Emancipatory Theory
DBE	Department of Basic Education
DBST	District-Based Support Team
DoEE	Department of Education and Employment
DoE	Department of Education
ECP	Emancipatory-Critical Paradigm
FSDoE	Free State Department of Education
LSA	Learning Support Advisor
MEC	Member of Executive Council
PBS	Public Broadcasting Service
PAR	Participatory Action Research
PCAST	President's Council of Advisors on Science and Technology
RSA	Republic of South Africa
SASA	South African Schools Act
SBST	School-Based Support Team
SHU	Sheffield Hallam University
TIMSS	Trends in International Mathematics and Science Study
UFS	University of the Free State
UK	United Kingdom
USA	United States of America

ABSTRACT

According to the White Paper 6 (DoE, 2001:3), mainstream education should provide an equal and fair education to all learners, regardless of their abilities. In South Africa, there is limited information about learners affected by dyscalculia and about any interventions available for such learners. More research indicates that dyscalculia is as prevalent as dyslexia in the classroom environment. However, less research is done on dyscalculia than on dyslexia. This study seeks to formulate an active learning strategy for addressing dyscalculia in a mathematics classroom. The Participatory Action Research (PAR) method is the chosen method in the study to explore the effectiveness of an active learning strategy in addressing dyscalculia in a mathematics classroom. It also creates an awareness of an existing learning disability in a mathematics classroom. Critical Emancipatory Research (CER) is the theoretical framework that underpins the study because of its view to emancipate and award an opportunity to transform the lives of the previously oppressed, while maintaining the respect and dignity of those participating in the study. Participants in this study include individuals who are struggling to learn mathematics and simple numeracy due to dyscalculia, education stakeholders who are responsible for the teaching and learning of mathematics in a classroom, an education psychologist, parents of affected learners, and a local specialist in dyscalculia. The collected data are analysed, using Critical Discourse Analysis (CDA). In conclusion, two findings emerge – that there is very little awareness of dyscalculia in mainstream education and that an active learning strategy (AL strategy) is effective in improving mathematics performance for all learners, including learners with dyscalculia.

Key words: active learning strategy, compromised mathematical aptitude, cooperative learning, dyscalculia, mathematics, mathematical disability, Participatory Action Research, peer teaching

LIST OF TABLES AND FIGURES

TABLES

FIGURES

LIST OF APPENDICES

TABLE OF CONTENTS

CHAPTER 4

DATA PRESENTATION, ANALYSIS AND INTERPRETATION OF AN ACTIVE LEARNING STRATEGY FOR ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM 109

CHAPTER 1

OVERVIEW OF THE STUDY, AN ACTIVE LEARNING STRATEGY FOR ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM

1.1 INTRODUCTION

The aim of this study is to formulate an active learning strategy for addressing dyscalculia in a mathematics classroom. According to Röj-Lindberg (2001:1), mathematics is a subject that divides people into two groups – the first group is individuals who are confident about their mathematical aptitude and they look forward to mathematics lessons and the second group is those who are not. Individuals who have difficulty in mathematics and computation of numbers in adult life are often the same people who struggled with the subject in their primary school education. Rivera-Batiz (1992:314) and Adhikari (2013:1) further attested that mathematics scores have an impact on the career choices of students. Mathematical skills are a bare necessity in a numerate society for opening education and employment opportunities, which consequently earns individuals a particular socio-economic status. Withstanding the value of mathematics in our society and the individual's development, it becomes necessary to consider those learners who struggle with mathematics. According to the Department of Basic Education (DBE 2014:31), 28.9% of learners in Grade 6 do not achieve a pass mark in mathematics. This study, therefore, seeks to give all learners an equal opportunity in life by helping them to learn mathematics with understanding, beginning in the lower classes.

There are many causes for poor performance in mathematics. A specific difficulty in learning about numbers and arithmetic was discovered in 1974 and was termed "dyscalculia". Dyscalculia is claimed to affect between 2% and 10% of the population worldwide. There are unique problems encountered by students with dyscalculia. Broadly speaking, they have

difficulty in learning and recalling arithmetic facts and in executing calculation procedures (Butterworth, Varma & Laurillard 2011:1049). Dyscalculia is a mental condition that makes it hard for a learner to recognise numbers and, therefore, will have difficulty in conceptualising basic arithmetic concepts, for example addition and subtraction of single-digit numbers $(2 + 1 = 3, 1 + 5 = 6)$. It is a learning difficulty limited to mathematics and associated computational skills. Most scholars agree that children with dyscalculia have difficulty in learning and remembering arithmetic facts, for example the math times table $(2 \times 3 = 6)$, which is the same as $(3 \times 2 = 6)$ (Devine, Soltesz, Nobes, Goswami & Szucs 2013:31; Gear 1993:346; Landerl, Bevan & Butterworth 2004:101). Learners with dyscalculia show strikingly poor performance on very simple tasks, such as number comparison counting small numbers of dots. They are also not able to perform mathematical procedures, for example the concept of carry-over when the solution is more than 9. Dyscalculia is often equated to dyslexia. It is referred to as “number blindness”, whereas dyslexia is described as “word blindness” (Doyle 2010:4) and it affects the ability to acquire basic arithmetic skills (Price, Gavin & Ansari 2013:1). According to Butterworth (2003:9) and Bastos, Cecato, Martins, Grecca and Pierini (2016:202), dyscalculia is as prevalent as dyslexia, but less recognised by parents, teachers, education authorities and scientists. Dyscalculia is also thought to contribute to distress, low self-esteem, stigmatisation and disruptive behaviour in class.

There are three noted areas of mathematics difficulty for learners with dyscalculia that are noted within the function of the brain, namely semantic memory, procedural memory and visuospatial memory (Geary & Hoard 2005:261; Szucs, Devine, Soltesz, Nobes & Gabriel, 2013:2674; Wadlington & Wadlington 2008:3). The Curriculum and Assessment Policy Statement (CAPS) (DBE 2011:8) depicts mathematics as a language and a human activity that is crucial in mental processes that are responsible for the development of critical thinking and problem-solving. Therefore, with defects in any of the noted areas, the learner will find it difficult to learn mathematics and the development of mathematically related skills will be compromised.

This study proposes an active learning (AL) intervention strategy for learners with dyscalculia, which will give hope to learners with dyscalculia in a mathematics classroom. Without the intervention strategy, learners with dyscalculia are excluded from learning mathematics.

1.1.1 Intervention methods for addressing dyscalculia

The Department of Basic Education's Guidelines for Inclusive Teaching and Learning (DBE 2010:49) stipulate that the key to managing inclusivity is ensuring that learning barriers are identified and addressed by all relevant support structures within the community, the school, the district-based support team (DBST) and parents. It is recommended that in addressing inclusivity, teachers should use various means to adjust the curriculum to meet the needs of learners. Several intervention methods have been suggested to address dyscalculia in a mathematics classroom. Wilson, Revkin, Cohen, Cohen and Dehaene (2006:3) suggest a software programme, "The Number Race" as the remedial action for addressing dyscalculia. Zerafa (2015:1181) recommends the "Catch Up Numeracy programme" as another intervention method for assisting learners with dyscalculia. Brian Butterworth, a cognitive neuroscientist at the University College in London, who studies numerical cognition, has done extensive research in dyscalculia and suggests "Number Sense Games" in teaching a learner with dyscalculia. However, this method may not reach all learners, for example, learners with vision impediment.

The abovementioned intervention methods have proven to assist some learners. In South Africa, intervention under a programme called "Davis Dyslexia & ADHD" is offered in a private one-on-one consultation. The programme is only accessible to a few individuals who are aware of dyscalculia. As part of my study, I had to interact with teachers, school principals, parents, subject advisors, school-based support teams (SBSTs), and Inclusive Department officials. They have not heard of the word "dyscalculia" and did not know of a disability in mathematics. The education

psychologist had an idea of dyscalculia, but due to limitations in research on dyscalculia, believed there was very limited intervention that could be done for learners with dyscalculia.

Learners with dyscalculia depict several symptoms, such as loss of confidence, poor memory in relation to numbers and a very poor sense of direction. The other depicted elements of dyscalculia are associated with numbers, number facts, numerical operations and place value and principle exchange. Therefore, it is important that the intervention strategy assists learners with dyscalculia to regain their confidence, and that they are assisted to remember mathematical facts and have the ability to conceptualise numbers and solve simple to complex mathematical problems. That means the intervention strategy will deal with the three main areas of difficulty, namely semantic memory, procedural memory and visuospatial memory.

This study proposes an intervention strategy that could be implemented in a classroom, without excluding other learners. The strategy will ensure that learners with dyscalculia are spared the humiliation of being embarrassed due to failure to compute simple mathematical concepts. According to Chan (2000:188), learning and teaching through Multiple Intelligences are about teaching in a manner that acknowledges that each learner is unique and, therefore, cannot be treated the same way as everybody else and should not be taught the same subject the same way. Chan (2000:189) further attested that, when Hong Kong reviewed its curriculum, a curriculum was proposed that is focused on helping each learner to be an independent learner.

1.1.2 Proposed intervention strategy – active learning strategy

In this study, the active learning strategy (AL strategy) is the operational concept proposed as an intervention strategy for learners with dyscalculia. According to Drake and Battaglia (2014:6), an AL strategy encompasses teaching and learning activities that include a strategy, which introduces a student activity, and a strategy, which promotes student engagement, collaborative learning, cooperative learning and problem-based learning.

Active learning instructional strategies can be created and used to engage learner in the following aspects:

(a) Thinking critically or creatively,
(b) Speaking with a partner, in a small group, or with the entire class,
(c) Expressing ideas through writing,
(d) Exploring personal attitudes and values,
(e) Giving appropriate assessment and feedback, and
(f) Ensuring that the learning environment is stimulating and allows them to reflect and think creatively. (Eison 2010:1).

Active learning (AL) actively involves students in their learning. It discourages passive listening in a classroom. Faust and Paulson (1998:4) and Röj-Lindberg (2001:6) attested that, as part of AL, learners fully engage in the learning materials by engaging in learning practices that include listening exercises that help them absorb what they hear, and group exercises where they have to apply what they have learned in real life. Röj-Lindberg (2001:6) further indicated that learning and teaching of mathematics should be better supported by a pedagogical approach that has an active and social approach to dealing with difficult, anticipated or experienced problems in mathematics. This approach puts forward the importance of a social construction of mathematical meaning and the role of a teacher as a facilitator. The role of the learner is that of an active problem-solver, working individually and with small groups (Eison 2010; Röj-Lindberg 2001).

Most researchers refer to several elements of AL, including peer teaching, usage of manipulatives and the multisensory approach (Emerson & Babtie 2014:2), praising and encouraging, cooperative learning, writing and reflecting, and classroom environment (Lumpkin, Achen & Dodd 2015:3; Mazibuko 2014:181-182; Sivan, Leung, Woon & Kember 2000:381). Participatory Action Research (PAR) is the methodology that underpins this study and, therefore, from the discussion held with the participants, it was concluded that some elements were more appropriate for addressing the needs of learners with dyscalculia than others.

It is also equally important to understand the extent of the problem in devising the relevant pedagogical strategy. Butterworth (2005) recommended a

dyscalculia screener. A dyscalculia screener is a computer programme designed to assess children's mathematical achievement and their numeracy ability by measuring their response to number-based tasks (Gillum 2014:287). In South Africa, there is a screener test that was published 25 years ago; it can detect deficiencies in numbers and does not consider the age of a learner. Therefore, a comprehensive mathematics assessment from Davis Dyslexia and attention deficit hyperactivity disorder (ADHD) programmes for learners with dyscalculia was used. The test was used in conjunction with discussion with learners and parents, as well as analysis assessment of written work and workbooks of learners.

1.1.3 The implementation of AL

According to Beichner (2008:1) and Baepler and Walker (2014:30), the classroom environment is a very important aspect of the implementation of AL. The research team learned about the supportive classroom and that the classroom environment does not only refer to the physical environment; however, it considers what the classroom looks like, and the attitude of teachers as well as learners.

Having identified the challenges that make the implementation of AL difficult, the research team discussed these challenges. A workshop was conducted to inform participants about dyscalculia. Informative videos and discussions were also used to inform teachers on how elements of AL could be used in a way that learners with dyscalculia are addressed in a mathematics classroom. These informative sessions ensured that conditions conducive to the successful implementation of the strategy were implemented.

The plan of action of the implementation of AL in a mathematics classroom involved observation and reflection by the participants. From these sessions, threats that could hinder the implementation of AL were identified in order to address them during the implementation of the strategy.

1.2 RESEARCH PROBLEM

According to the White Paper 6 (DoE 2001:3), there is a need for all learners, regardless of their abilities, to be accommodated in mainstream education. Notwithstanding the statistics revealed by the Department of Education (DBE 2014:18), that from 927,562 learners who were registered for Grade 4 in 2013, only 27.1% of those learners achieved 50% and more. Part of the problem of the 72,9% learners who did not achieve a pass mark in mathematics is due the deficiencies in the system to accommodate their educational needs. The mainstream education process should allow all learners to extend their potential and participate as equal members of the society. The Ministry of Education has made a commitment to providing equal education opportunities to learners who experience barriers to learning and to accommodate the needs of those who drop out of school due to the failure of the education system. In South Africa, there is limited information about learners affected by dyscalculia and about any interventions available for such learners. However, according to Butterworth *et al.* (2011:1049), there is reason to believe that difficulty in learning numbers and arithmetic is as much of a challenge as well-known disorders relating to literacy development, such as dyslexia, are. The reality is that less research is done on dyscalculia than on dyslexia.

Dyscalculia presents a problem that is worth investigating, and this study seeks to formulate an active learning strategy for addressing dyscalculia in a mathematics classroom. This will not only derive an appropriate pedagogical strategy to address dyscalculia in the classroom, but will also create an awareness of an existing learning disability in a mathematics classroom. Learners with dyscalculia are found in mainstream schools and may not be receiving the necessary support. It is, therefore, important that learners with dyscalculia are supported in mainstream education through the application of an AL strategy. Mathematics is one of those school subjects that is linked with many other subjects, such as physics, history and geography. It also affects most of the activities that we engage in every day. It even affects career paths. With so much value that mathematics has in our daily lives and the

future aspects of our lives, it becomes a necessity that everyone should be given a fair opportunity to learn and understand mathematics.

1.3 RESEARCH QUESTIONS

Following the discussed background above, the primary research question posed by this study is:

> *How can we address dyscalculia in a mathematics classroom through an active learning strategy?*

The secondary questions for this study are as follows:

- What is the challenge pertaining to the need for an active learning strategy to address dyscalculia in a mathematics classroom?
- Is there a need to use an active learning strategy for addressing dyscalculia in a mathematics classroom?
- What are the elements of a successful active learning strategy that can address dyscalculia in a mathematics classroom?
- What are the conditions or circumstances under which the elements of active learning would contribute to the successful implementation of an active learning strategy in addressing dyscalculia in a mathematics classroom?
- How can we anticipate impediments or hindrances toward the implementation of an active learning strategy dealing with dyscalculia in a mathematics classroom?
- How do we use active learning in addressing dyscalculia in a mathematics classroom?

1.4 RESEARCH AIM AND OBJECTIVES

The purpose of the study is to propose a strategy for addressing dyscalculia in a mathematics classroom. It is important to devise a strategy to make mathematics learning accessible to all learners, regardless of their abilities or disabilities. Dyscalculia is not a life sentence; that means learners do not need

to lose hope or feel that they could never learn mathematics or may never be able to deal with numbers. Teachers do not need to be discouraged by the belief that there are learners who could never learn mathematics. An AL strategy is about giving hope to learners with dyscalculia and those who struggle with mathematics, but do not have dyscalculia. This strategy is presumed to empower both learners with dyscalculia and those who are mathematically capable. The strategy will conceptualise mathematical theories and demystify the myth that mathematics is both difficult and boring.

Therefore, the objectives of this study are outlined below:

- To investigate challenges pertaining to the need for an active learning strategy to address dyscalculia in a mathematics classroom.
- To explore the need for an active learning strategy in addressing dyscalculia in a mathematics classroom.
- To identify the elements of a successful active learning strategy that addresses dyscalculia in a mathematics classroom.
- To explore conditions or circumstances under which the elements of active learning would contribute to the successful implementation of an active learning strategy in addressing dyscalculia in a mathematics classroom.
- To anticipate impediments or hindrances toward the implementation of an active learning strategy dealing with dyscalculia in a mathematics classroom.
- To propose an active learning strategy as an effective tool in addressing dyscalculia in a mathematics classroom.

1.5 RESEARCH DESIGN AND METHODOLOGY

Van Wyk (2012) and Maxwell (2012:2) defined research design as an overall plan for researchers to connect conceptual research to the important and achievable empirical research. The research design communicates what data are necessary, the methods to use to collect and analyse the data and how this will answer the research question. I will, therefore, engage with participants from various lifestyles who have been diagnosed with dyscalculia.

I will identify their challenges and map them with diagnoses, as stipulated by Butterworth. Together with the psychologist, the representatives from the Free State Department of Education and teachers, I will work on an active learning strategy in teaching mathematical concepts that identifies these individuals as having dyscalculia. This study uses Participatory Action Research (PAR) as the method to explore the effectiveness of an active learning strategy in addressing dyscalculia in a mathematics classroom. PAR further emancipates marginalised individuals of the society and awards them due respect (Kemmis 2006:463).

According to Kemmis and McTaggart (2007:272), PAR is defined as fourth generation action research that existed in the connection between critical emancipatory action research and participatory research, which emerged in the context of social movement in the developing world. PAR encourages a bottom-up approach, focusing on the priorities and perspectives of individuals that the research questions seek to address. According to Baum, MacDougall and Smith (2006:854), PAR seeks to understand and improve the world by changing it. It allows participants and researchers to undertake an enquiry, so that they understand and improve the situation that they find themselves in. Participants are involved in determining the problem and the solution to the problem; the participants and the researcher have a positive relationship, where power is shared.

According to Cotes (2005:5), the action research process is cyclic, with stages that include a plan, action, observation and reflection. The study will engage participants in a discussion concerning dyscalculia, challenges that are faced and their views on the intervention strategy. There will be an opportunity to get feedback from the learners and through the analysis of their written work. My intention is to have lessons where a mathematics lesson is conducted using the active learning strategy. The lesson plan and delivery of the lesson will be planned with participants and all participants will reach the reflection of the outcomes.

1.6 THEORETICAL FRAMEWORK

Reason and Bradbury (2001:92) described critical or emancipatory research as a form of action that aims not only at improving the lives of individuals and researchers themselves, but also assisting researchers to reach critique of their social or educational work and work settings. Critical research further aims to intervene in the cultural, social and historical processes of individuals' everyday life. Dyscalculia is a disability that has robbed individuals of a normal life, where they could compute simple mathematics and numeracy. It is for that reason that Critical Emancipatory Theory will be employed in conducting this study. According to Maboya (2014:24), Critical Emancipatory Theory (CET) is a process of deconstructing the world for the purpose of liberating individuals from restricted ways of thinking. Most people would assume that not everybody could learn and understand mathematics. Most teachers at my school believed that learners who failed to compute mathematical ideas were failing purely because they were just not intelligent. Hence this study seeks to answer the question: How can dyscalculia be addressed in a mathematics classroom through an active learning strategy? Failing to answer this question, means as a society, we are failing certain individuals within our communities.

An active learning strategy (AL strategy) as a conceptual framework seeks to emancipate those with dyscalculia, not only to own the learning process, but also to have a sense of belonging in a society that demands understanding of basic mathematics. According to Semenza *et al.* (2014:1), numeracy and calculation are an important part of the modern culture – numbers are used for "counting, measuring, comparing, putting things in order". We also need to remember PIN codes, shoe sizes, telephone numbers, and ID numbers. These are basic needs of numerical understanding; therefore, an individual with dyscalculia is robbed of a better quality of life. An AL strategy seeks to rebalance such disadvantages. An AL strategy does not limit learning to any particular strategy, but allows various teaching strategies and respects each learner's different method of learning, thus encouraging them to be in charge of it, with the teachers only acting as facilitators (Eison 2010:1)

According to Maboya (2014:30), critical theory is concerned with issues of equality, domination and social justice in social structures and power relations. An AL strategy addresses inequalities and imbalances faced by individuals with dyscalculia. Sriraman, Ernest and Greer (2008:98) argued that unequal distribution of knowledge is more of a challenge in mathematics than in any other field, while Vithal (2004:1) held the view that mathematics education explores and strengthens the link between itself and concerns about democracy, equity and social justice. Valero (2008:50) further attested that general inequalities in society are reproduced within the parameters of the state, which includes the school, and within a mathematics classroom. The South African Schools Act (SASA) (1996) and Education Policy Act of 1996 have both awarded all South Africans the fundamental right to basic education that is equal and fair. As South Africa seeks to address the imbalances of the past, where learners with disabilities were the most marginalised, the rights of learners with dyscalculia cannot be ignored.

1.7 DATA GENERATION

According to Baskerville (1999:19), the collection of data for action research is generally through qualitative and interpretive methods. Participants are also allowed to keep diaries. MacDonald (2012:9) attested that various methods of data collection are recommended of PAR and these have to be agreed on with the participants. The focus group, workshops, discussions and observations are all preferred methods of data generation that were explored together with the participants. Data generation is discussed in detail in Chapter 3.

The workshop meetings aimed at elevating participants at the same level of understand of dyscalculia and an AL strategy was conducted with the help of the dyscalculia specialist in South Africa from Davis Dyslexia and ADHD programmes. A research presentation was held for the Free State MEC and the Inclusive Department Team. During the presentation, dyscalculia and AL were explained. Most of the present officials had never heard of dyscalculia before and there was a request for an awareness programme following the

study. The workshop meetings and presentation further helped participants understand more about dyscalculia and establish their own views about the proposed intervention strategy.

1.8 SELECTION OF PARTICIPANTS

The research team that conducted the study included the following: the researcher (myself), three teachers, two teachers who teach mathematics and another teacher who is a member of the school-based support team (SBST). As the member of the SBST, she is first point of contact for learners who have learning disabilities. The other research team members are the district-based psychologist, three parents, four learners who met the description of learners with dyscalculia in terms of their behaviour and mathematics performance, a university student diagnosed with dyscalculia and the Inclusive Education Department member. The specialist in dyscalculia was also invited to participate and share her views on the proposed intervention strategy. The teachers were selected as participants because of their in-depth experience in teaching mathematics. One of the participant teachers presented at the Association for Mathematics Education of South Africa (AMESA) on usage of manipulatives in a mathematics classroom.

The district education psychologist has experience as the education psychologist in the Free State and he showed a keen interest in knowing more about dyscalculia and how learners with dyscalculia could be assisted in understanding mathematics.

The research team was divided into two groups. The first group was composed of learners and parents. This allowed learners to express themselves freely without feeling intimidated by the presence of their teachers. Some of the meetings with the learners took place at the comfort of their homes. The other group was composed of teachers, the psychologist and officials from the Inclusive Education Department.

1.9 DATA ANALYSIS, INTERPRETATION AND REPORTING

The information was recorded, using voice, video and hand-written notes in a notebook. Participants were also given diary notes to record their reflection after the meetings or any information relevant to the study. The generated data in this study was analysed, using Critical Discourse Analysis (CDA). Van Dijk (1993:254) described CDA as a type of analytical research that focuses on the way social power, abuse, dominance and inequality are practiced in the social political context. It helps to establish the relationship between speakers and listeners. Fairclough (2004:2) further described CDA as a representation of particular aspects of social life, such as inequality, disadvantage, poverty and social exclusion in different ways. Hence CDA was regarded as relevant for this study because this study seeks justice for individuals with dyscalculia and ways for these learners to be taught mathematics through the usage of AL. This study seeks transformation through better understanding of numeracy and mathematics as a whole.

1.10 VALUE OF THE PROPOSED RESEARCH

There is currently very limited information about dyscalculia in South Africa. Therefore, individuals who struggle with such a disability continue to be excluded in the teaching and learning environment. It is hoped that the findings of this study will contribute to current and further research in addressing dyscalculia in a mathematics classroom. The study also seeks to suggest an AL strategy as an effective learning and teaching strategy in addressing dyscalculia in a mathematics classroom. It is therefore assumed that the findings will benefit the school, teachers, learners and ordinary citizens who struggle with dyscalculia. Individuals with dyscalculia struggle with simple numeracy, conceptualising numbers and memorising numbers. As a result, this creates a hindrance in their understanding of complex mathematical concepts. Their inability to deal with numbers robs them of normal social life because numeracy is part of our everyday culture. An AL strategy seeks to restore the understanding of numbers and give them a strategy of learning mathematics. According to Attwood, in the Special

Education Needs magazine, “research suggests that most children who gain appropriate help in school can overcome their dyscalculia difficulties and maximise their abilities in each subject area, despite their special need” (Attwood 2010).

1.11 ETHICAL CONSIDERATION

Participants were invited to participate in the study and given the free will to leave the study at any time, should they wish to. Consultation with minors was sought in the presence of their guardians, who signed consent forms on their behalf. During the research process, the level of respect was maintained at all times. The discussion notes were kept safe at all times and there was no mention of names in order to preserve the confidentiality of the participants.

1.12 CHAPTER SUMMARY

This chapter provided the introduction to and the background of the study, and provided explanations of dyscalculia and active learning (AL). The challenges and hindrances with regard to the implementation of AL were also emphasised. The solution to the challenges were briefly highlighted and provided some evidence of how AL could work in dealing with dyscalculia in a mathematics classroom. In this chapter, there was also a discussion on the research problem, the questions that the study seeks to answer, as well as the aim and objectives of the study. The chapter further presented the theoretical framework of the study, the methodology and the methods used to analyse the collected data. Finally, the chapter briefly discussed the value of the study and the ethical consideration of the study.

CHAPTER 2

THEORETICAL FRAMEWORK AND LITERATURE REVIEW ON THE ACTIVE LEARNING STRATEGY FOR ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM

2.1 INTRODUCTION

This study seeks to propose an active learning strategy for addressing dyscalculia in a mathematics classroom. In order to achieve the purpose of the study, the first part of Chapter 2 will elaborate on Critical Emancipatory Research (CER) as the theoretical framework that underpins the study and operational concepts that are pillars grounding this study.

The discussion will encompass discussions in subheadings on the choice of theoretical framework, focusing on the historical origins, the objectives, and the relationship between the researchers and the researched. The operational concepts will entail an in-depth definition and explanation of active learning (AL), dyscalculia, and mathematics classroom to enhance their understanding within the context of this study.

The last part of the chapter, will review the related literature with the intention to adopt the best strategies and practices as used in other countries. The discussion will incorporate how other countries have dealt with AL as a teaching strategy in a mathematics classroom. I will furthermore deliberate on the objectives of the study, that includes an understanding of dyscalculia and an active learning strategy (AL strategy) in addressing dyscalculia in a mathematics classroom, and an investigation and exploration of the elements, nature, characteristics and design features of AL in addressing dyscalculia. The discussion will further include the hindrances and impediments encountered in using AL as a teaching strategy.

2.2 THEORETICAL FRAMEWORK INFORMING THE STUDY

This study seeks to answer the following question: How can we address dyscalculia in a mathematics classroom through an active learning strategy? Labaree (2013:1) described theoretical framework as the pillar that supports a theory of a research study and seeks to explain why the research problem under the proposed study exists. This study forms its basis on Critical Emancipatory Research (CER) as a theoretical framework that seeks to restore the dignity and rights of individuals who are deemed never to be able to understand mathematics. This theory represents my view in different aspects of the study, as I will outline in this chapter.

The study seeks to emancipate those impacted by dyscalculia, either directly or indirectly. It is important to deal with challenges that limit equity in learning and understanding mathematics. Researchers acknowledge that proficiency in basic mathematics skills is of value in making numerate decisions pertaining to everyday life-decisions, including education opportunities, employment opportunities and, consequently, the impact thereof on the economic status of the country. According to Nfon (2016:438) “dyscalculia can affect many different areas of mathematics learning and performance”. The most common problem is with “number sense”. This is an intuitive understanding of how numbers work, and how to compare and estimate quantities on a number line. Most researchers agree that number sense is at the core of mathematics learning. If individuals, regardless of age, do not understand the basics about how numbers work, learning mathematics and using it every day can be very frustrating. Individuals with dyscalculia are therefore excluded from participating fully in their communities.

CER is used as a theory in this study and represents the views as attested by Larrotta and Yamamura (2011:76) that it is a paradigm that raises critical consciousness. It encourages the researcher and the participants to work together in understanding the problem and devising the solution to it. Knowledge and understanding are developed in this system of collaboration. CER is the chosen main framework in this study because it focuses on the

relationship between the researcher and participants themselves, and their position in the study – the view of the concept theory in relation to the study. CER as theoretical framework describes my view of dyscalculia in a mathematics classroom and how I value and perceive participants within this study. AL is a pedagogical strategy that I explore together with participants in dealing with dyscalculia. Throughout this chapter, I will discuss these theories in detail and their impact on an AL strategy in addressing dyscalculia in a mathematics classroom.

2.2.1 Critical Emancipatory Research

Critical Emancipatory Research (CER) is used as the paradigm through which I viewed participants and the circumstances around them to accomplish the objectives of this study. I believe that a society needs to have values and also respect the opinions and ideas of marginalised individuals in their communities. Democracy and social justice are in the process of unravelling in South Africa, as enshrined in the Constitution of the Republic (Act 108 of 1996), which advocates for respect of humanity. I believe in a society where every human being matters and all are encouraged to critically think and communicate and are thus able to provide solutions to their own problems. Myende (2014:25) advocated for CER as a theoretical framework because it bespeaks respect and equality between the researcher and participants. Nkoane (2012:98) added that CER aims to "critique and challenge, to transform and empower; it is geared towards social justice and enhances the principles of democracy".

2.2.1.1 Origin of CER

CER is a concept that was formulated by the leading European critical theorists – Horkheimer, Adorno, Habermas and the Frankfurt School. Their aim was to lay a foundation for a calibre of researches that advocated for the reproduction and transformation of society, the meaning of culture and relations between individuals and society (Balcazar *et al.* 1998:2; Boog 2003:426). Nkoane (2012:99) stipulated in his narration of the history of CER,

that it has its philosophical roots in Marx's understanding and interpretation of socioeconomic conditions – Habermas's emancipatory knowledge.

According to Heydenrych (2001:38) and Boog (2003:426), CER is one of the three types of action research. According to Maksimovic (2010:120), the term "action research" originates from Kurt Levin. Levin believed that "it is impossible to understand a system if you do not try to change". He believed in engaging and involving individuals who needed to benefit from the desired change. Action research was designed to improve the lives of the individuals who were being researched. Their lives are improved to give them the capacity to solve problems, develop skills that will improve their lives, increase their self-worth and determination with the organisation and institutions in which they participate.

2.2.1.2 Objectives of CER

This study seeks to address an under-researched mathematics disability for the benefit of the individuals with dyscalculia whom I describe as underprivileged. CER is observed as the fundamental process of producing knowledge that seeks to benefit the underprivileged. Individuals living with a disability need the establishment of a platform where they are engaged with the research community (Danieli & Woodhams 2005:284). CER aims to provide that platform, where those who need emancipation are being heard and they own the solution that seeks to benefit them. CER serve a purpose to restore the respect and dignity of those who are vulnerable in communities. It serves a special purpose of human existence, a feeling of belonging and being important solely for being human. According to Deeper (2012:10), CER serves people with disabilities by empowering them by using the human rights approach that creates an awareness and understanding of their rights. CER further aims to provide the platform to help individuals living with disabilities to identify strategies that will help them overcome barriers.

According to Heydenrych (2001:38), CER serves as a social element that is concrete and a practical aspiration of change in the social and educational

arenas by involving those involved in that social space. When CER is sought to influence change in the education practice, it empowers the educator to take custody of the educational environment, to become analytical and to engage in the practice and the systems of the educational environment. This thought is in line with this study's involvement of teachers as participants in the study. The study acknowledges the input and involvement of teachers as adding an important value to the study in addressing dyscalculia in a mathematics classroom.

2.2.1.3 Relationship between researcher and participants

Nkoane (2012:99) posited that Critical Emancipatory Research (CER) fosters a positive relationship between the researcher and the participants such that they are all engaged in conversations and intersections as interpreted from their wealth of knowledge and experience. Boog (2003:24) is of the opinion that CER implies that "all people are equal participants in the society". He believes that CER holds the sentiments of an equal and fair educational system where all learners, regardless of their position or circumstances, deserve the same opportunities for schooling and access to be taught all subjects taught at school, as well as to participate in decision-making regarding this. I share the same sentiments of equality and more so of involvement in the decision-making process. Therefore, participants in this study, including the researcher, have the same right to be heard and participate in the decision-making process.

An active learning strategy (AL strategy) is proposed as a teaching strategy in addressing dyscalculia and it will not be imposed upon those who participate in the study; however, its implementations and effectiveness will be reached together by all participants.

According to Jacobs (2008:228), the basic assumption of CER is an empowerment approach that people cannot fully realise their potential in life if they have no control over the internal and external factors that determine their lives. Mahlomaholo (2009:225) and Nkoane (2012:98) are of the same view

that in CER, participants are esteemed at the same level of the researcher. The focus is placed on the respect and contributions made by participants and that they should receive a sense of belonging and that their views matter in the study. The researcher and participants are equal partners. They are both interested in transforming their social stations to foster and advance democracy.

The researcher is regarded as a human being, who is to be respected, valued and recognised. The researcher is esteemed no higher than the participants and is tasked with the duty to understand and interpret their view. This view is contrary to the views held by positivists. According to Higgs (1995:10), “the worst effect of positivism is that it reduces human beings to quantifiable and measurable objects of investigation”. Positivists further ignore the human ability of being critical in their thinking. CER, as attested by Chilisa (2012:353), involves community members as participants who are involved in the collection of data. They further participate in the analysis and interpretation of the same data.

According to Mertens (2010:10-11), positivists believed that there is only one truth as described by science and that the social world could be studied as the natural world. That means the social world could be studied in experiments and measurements of that which is observed. This view ignores the fact that social views and feeling cannot be measured. Therefore, this approach will always leave a gap in the creation of knowledge.

On the other hand, CER is criticised because, even though it encourages critical thinking and values the views of the community in solving problems affecting the same community, the results cannot be measurable by scientific formulae. Chilisa (2012:243) argued that CER is a framework that is only problem-based and aims at discovering challenges experienced by communities. In other words, it is a crude solution for social problems. Therefore the nature of CER is emphasis on experienced problems by the marginalised members of the community. The marginalised members of the community are the ones who will have an understanding and views of their

own problem. The emphasis on problems is perceived as suppressive and could distort views and the desired solution. Through CER, participants – as members of the community – are encouraged to participate and be a part of the solution to their problem.

The involvement of participants allows participants to understand the existence of dyscalculia as a hindrance in learning mathematics. They will also take part through their views and experiences in providing the solution and conditions that will make the solution work.

2.3 OPERATIONAL CONCEPTS

The operational concepts within this study are active learning (AL), dyscalculia and the mathematics classroom. The discussion below covers the detailed meaning of the concepts within the study to ensure the understanding and appreciation of these concepts.

2.3.1 Active learning

The traditional mode of teaching is noted in Western European history as far back as 900 years ago. The traditional mode of teaching is centred on the teacher and the textbook. This mode of teaching has grown to raise concern, especially in the teaching of mathematics and science, because of the lack of increase in the number of learners who opt for these subjects. Learners are allowed to participate and own their learning. The section below discusses active learning (AL) with subsections covering the historical review and definition of AL. The link between CER and AL is also discussed to demonstrate the application of the theoretical framework on the chosen intervention strategy that defines this study.

2.3.1.1 Historical review of AL

According to Weltman (2007:6), ideas about AL are traced back to the 5th century BC to a Chinese philosopher named Lao-Tse, who remarked, “if you

tell me I will listen, if you show me, I will see. But if you let me experience, I will learn". Between 1859 and 1952, John Dewey, a renowned American philosopher wrote about education and the benefits of learning through active involvement, which included experiments. According to Suherman *et al.* (2011:104), AL could be traced to the work of education scholars, such as Maria Montessori of Scotland on her work dated in 1979 and Lev Vygotsky in his work dated in 1978. Between 1970 and 2003, the English scholar, R.W. Revans introduced the term "active learning". Revans has been instrumental in advocating for this concept worldwide. Charles Bonwell and James Eison are some of the modern-day recognised scholars who are well known for their promotion of effective AL techniques.

The modern-day concept of active learning goes back to 1990. Bonwell was one of the first scholars to investigate AL (White *et al.* 2016:620). White *et al.* (2016:620), Bonwell (1991:2) and Davey, Powell, Powell and Cooper 2002:10) described AL as a learning technique or pedagogical strategy that allows learners to participate in the process of learning through participation by actively doing something other than passively listening and reflecting on what they are doing. AL enhances the learning process and engages learners in high-order thinking (Punja, Kalludi, Pai, Rao & Dhar 2014:490).

Active learning has been advocated for since the discovery of the idea that learning in the form of learners who only sit and listen to the lecture was unproductive and yet a dominating form of learning. The implementation of AL in the education and work environment has been from the perspective that AL is an instructional activity that involves students in doing things and thinking about what they are doing. It encourages high-order thinking and learners are the focal point of their learning. Learners need to do more than just listen, and also need to be engaged in solving problems as a part of learning (Bonwell & Eison 1991:5; Martyn 2007:71; Samson 2015:153). They need to be engaged through reading, writing and discussion, or be engaged in solving problems (White *et al.* 2016:620). AL seeks to encourage learners to be committed to their learning. They should critically engage with the content and seek to understand the practical application of what they are learning. AL is inclusive

in nature because every learner has to own his or her learning process regardless of his or her abilities.

2.3.1.2 Definition of Active Learning

Delialioglu (2012:318) and Petersen and Gorman (2014:63) described active learning as a type of learning which encourages learners to actively search for information and to have a thorough understanding of the provided information during their lesson study. Learners are further encouraged to engage with their peers in sharing their understanding of learned concepts. AL is the opposite of the traditional learning approach where learners are expected to listen quietly to what they are being taught, with the aim of repeating it when asked in a test or examination. AL is mostly encouraged in problem-solving-type school subjects. According to Brooks (2012:1), a traditional classroom is designed with student seats facing forward in rows and easy side-lines to a central local at the front of the room with limited movement for the teacher. Lumpkin *et al.* (2015:3) held the view that AL does not displace a teacher; however, it creates an environment where learners can reflect, assess, explore, synthesise and discuss the information presented by the teacher.

The most described common feature of AL is that it is guided and implemented from the experiences of students (Samson 2015:153; Michael 2006:160) and provides a learning environment that allows learning that empowers learners with problem-solving skills (Diamond, Koernig & Iqbal 2008:116). That means learners are able to actively participate in their learning process and associate the relevance of what they have learned with the experiences outside their classroom.

According to Weltman (2007:8), “the concept of AL is open ended and evolving”. The flexibility of technology has been harnessed and through its usage the experience and practicality of learning is greatly enhanced. AL provides opportunities for learning experiences that are unique and innovative for learners of different abilities. Teachers also have an opportunity to create active learning ideas that are both unconventional and interesting in a learning

environment.

Various scholars articulate their views on what defines active learning in a classroom situation (Eison 2010:1; Samson 2015:154), stating that AL instructional strategies can be created and used to engage students in (a) thinking critically or creatively; (b) speaking with a partner, in a small group, or with the entire class; (c) expressing ideas through writing; (d) exploring personal attitudes and values; (e) giving and receiving feedback; and (f) reflecting upon the learning process. An AL strategy actively involves students in their learning and discourages passive listening in a classroom.

Faust and Paulson (1998:4), Röj-Lindberg (2001:6) and White *et al.* (2016:622) attested that as part of AL, students fully engage in the learning materials by engaging in learning practices that include listening exercises that help them absorb what they hear, and group exercises where they have to apply what they have learned in real life. Röj-Lindberg (2001:6) and Hott, Isbell and Montaini (2014:1) further stipulated that learning and teaching of mathematics should be better supported by a pedagogical approach that has an active and social approach to dealing with difficult, anticipated or experienced problems in mathematics. This approach puts forward the importance of social construction of mathematical meaning and the role of a teacher as facilitator. The role of the learner is that of an active problem-solver, working individually and within small groups.

2.3.1.3 Link between CER and an AL strategy

According to Jitendra *et al.* (2013:21), dyscalculia and other mathematical disabilities create a mathematics knowledge gap between learners with such a disability and their peers. Therefore an intervention strategy is necessary in order to bridge such a knowledge gap.

The study seeks to recommend an AL strategy as a pedagogical tool in addressing dyscalculia in a mathematics classroom. Chan, Sidhu and Lee (2015:519), Eison (2010:10) and Faust and Paulson (1998:4) postulated that

AL is any learning strategy that includes engagement of learners, as opposed to the strategy of teaching that includes passive listening as part of learning. AL involves learners in their learning process by talking, writing, reflection and engaging any form of practical engagement as part of the teaching process. That means AL is an education procedure that involves learners in their learning and challenges them to think about what they are doing as they learn. This form of teaching involves listening practices that help learners absorb what they hear, writing exercises where learners respond to what they read, and relates what they are learning to their personal experiences.

Lumpkin *et al.* (2015:5) and D'Andrea and Gosling (2005:25) held the view that the success of AL depends on the good relationship between a teacher and the student. Teachers need to believe that students in their classes can, in fact, learn. AL excludes the traditional teaching methods, which did not encourage active participation by learners.

2.3.2 Dyscalculia

In our society there are many individuals who struggle with most numerical and mathematical concepts. As I began to share my studies with friends and family, a friend who worked as a senior executive at a bank confessed to me the struggle she had in working at the bank when she was asked to work with money. She could not let her manager know that she had challenges in counting money. The friend further confessed that she never gives a 10% tip at restaurants because she could never figure out how to calculate the amount. She always gives a round figure amount, according to her inspiration. However, according to scholars, between 5% and 8% of learners in a mathematics classroom suffer the symptoms of dyscalculia. This section discusses the definition of dyscalculia, the historical background of dyscalculia and the elements of dyscalculia. Dyscalculia is argued to arise from abnormalities in the brain areas that support semantic, procedural and visuospatial memory. However, it is important to understand the wide perspective of dyscalculia from which these are derived from. This section discusses various perspectives of dyscalculia, namely biological, cognitive

and the behavioural approach that enhances the understanding of dyscalculia to justify the chosen intervention strategy and understand the source of the abnormalities in the brain that make mathematics learning a challenge for learners with dyscalculia.

2.3.2.1 Historical background of dyscalculia

Czechoslovakian psychologist Ladislav Kosc in 1974 introduced the term “dyscalculia” for the first time. According to Kosc (1970:192), there is a difference between dyscalculia and developmental dyscalculia. Dyscalculia is perceived as a structural mathematical disability that originates from the brain or a congenital disorder of those parts of the brain that are responsible for mathematical abilities.

From the recognition of the dysfunction associated with dyscalculia, there was general consensus that dyscalculia precludes poor mathematical performance as a result of other external factors (Kosc 1974:166). Doyle (2010:19) drew a distinction between dyscalculia and mathematics phobia or anxiety. She described mathematics phobia or anxiety as the position of discomfort which is observed in situations where mathematics tasks are perceived to challenge an individual’s self-esteem. Dyscalculia is involuntary from birth due to a brain element of an individual that affect the individual’s ability to process or conceptualise numbers. Hlalele (2012:268) and Wadlington and Wadlington (2008:3) referred to mathematical anxiety as the feeling of panic or fear, helplessness, mental paralysis and disorganisation that is experienced by individuals when trying to manipulate numbers or solving a mathematically related problem. Mathematics anxiety is different from dyscalculia because it is not a disability that makes it difficult for individuals to learn mathematics and, hence, they often have poor performance in mathematics.

Various studies, which have been conducted in various countries, indicate the prevalence of dyscalculia to be between 5% and 8%, which makes it as prevalent as dyslexia. However, the awareness of dyscalculia is less than that of dyslexia (Bastos *et al.* 2016:201; Ranpura *et al*. 2013:1). In conducted

studies, the prevalence of dyscalculia was noted to be 7.8% in Brazil (Bastos *et al.* 2016:203; Kosc 1974:57-58), 6.4% in Germany (Von Aster & Shalev 2007:870), estimated to be between 3% and 6.5% in the United States of America (USA) (Shalev 2004:766) and estimated to be between 3% and 6.5% in the United Kingdom (UK) (Butterworth 2004:455). Serbia has the highest prevalence outside the range by most researchers in various countries; the prevalence in Serbia is 9.9% (Jovanović, Jovanović, Banković-Gajić, Nikolić, Svetozarević and Ignjatović-Ristić 2013:173).

2.3.2.2 Definition of dyscalculia

"Dyscalculia" is a term used to describe difficulty in learning mathematics. The term encompasses other terms, such as "developmental dyscalculia", "mathematical disability", "numerical learning disability", and "number fact disorder". Geary (1993:345), Re *et al.* (2014:337) and Bastos *et al.* (2016:201) referred to dyscalculia as "mathematical disability". Reigosa *et al*. (2012:125), Von Aster and Shalev (2007:868) referred to dyscalculia as "developmental dyscalculia" and described it as "mathematical impairment, which occurs as a result of core numerical deficits" (Stark, Eve and Murphy 2016:68). Such learners have difficulty in remembering mathematical facts and procedures.

Temple *and Sherwood* (2002:733) and De Visscher, Szmalec, Linden and Noel (2015:39) referred to dyscalculia as the difficulty in retrieval of number facts and the ability to solve word problems. Such difficulty is observed as a challenge in mastering basic arithmetic skills, basic computational skills, time, money concepts and acquiring problem-solving skills. Learners with dyscalculia are also observed to have difficulty in representing the numbers in a number line and, therefore, may not solve estimation- and proportion-related tasks (Huber, Sury, Moeller, Rubinsten & Nuerk 2015:33).

Scholars such as Shalev (2004:765), Callaway 2013:150), Rosenberg-Lee, Ashkenazi, Chen, Young, Geary & Menon (2015:368-369) and Ranpura *et al.* (2013:1) described dyscalculia as a specific difficulty in learning mathematical concepts that is presumed to be because of a developmental cognitive

condition or acquired mathematical difficulty due to a brain malfunction or injury.

In the final analyses from various scholars, dyscalculia is viewed as a learning disability, which relates to the ability to conceptually understand numbers and perform basic calculations. The basis of the challenge is pointed at the basis of how the brain functions and processes numbers and mathematics-related aptitude. Different researchers propose mathematics disabilities arising from abnormalities in brain areas supporting semantic memory, procedural memory and visuospatial memory.

Dyscalculia refers to a specific learning disability that affects mastering of basic arithmetic skills and is linked to the development of the brain or to brain injury (De Visscher & Noël 2014:434; Shalev 2004:768). This gives an indication of dyscalculia emanating from defects on some mechanical functioning of the brain.

Dyscalculia due to brain development or injury is often observed in different kinds of neurological disorders, such as attention deficit hyperactivity disorder (ADHD), developmental language disorder, epilepsy, and fragile X syndrome. According to Kucian and Von Aster (2014:7), neurological investigations give proof that dyscalculia or compromised mathematical aptitude is found in cases where special centres of the brain have been damaged. Individuals learn and understand numbers at different phases of their development. Hence, this inability to compute numbers affects normal individuals who fail to perform basic arithmetic that someone of their age and exposure should be able to do.

2.3.2.3 Elements of dyscalculia

According to Cortiella and Horowitz (2014), dyscalculia is a phrase associated with difficulty with counting, number facts and doing mathematics calculations. Therefore, this has an impact on understanding concepts relating to measurement, telling time, counting money and estimating number quantities.

Individuals with dyscalculia have difficulties with mental mathematics and weak problem-solving strategies.

The definition of dyscalculia makes reference of difficulties that include numbers, number facts, numerical operations, and place value and principle exchange. Difficulty with numbers refers to the individual's ability of being numerate. Emerson and Babtie (2014:1), Kucian & Von Aster (2014:2) and Stark *et al.* (2016:70) referred to being numerate as the ability to understand the concept of a number and how numbers relate to one another.

Gillum (2014:277) further described numeracy as the basic awareness of quantity. Learners with dyscalculia have difficulty learning to count and remembering the sequence of numbers. They think of numbers as a string of sounds or see them as groups of ones.

According to Coch, Dawson and Fischer (2010:12) indicators of dyscalculia are when a learner tackles simple number comparisons and additions by first counting or using fingers for counting beyond the normal age; for example, "to say which is the larger of two playing cards showing 5 and 8, they count all the symbols on each card" (Kucian and Von Aster 2014:9).

Number facts refer to the number bonds of each of the numbers from 1 to 10. Learners with dyscalculia do not understand that numbers could be referred to as the combination of different numbers; they have a unit concept of a number.

According to Geary (2004:5), Bird (2011:xiii) and Re, Pedron, Tressoldi and Lucangeli (2014:343), learners with dyscalculia experience difficulties, such as estimating the quantities of objects and remembering number facts. They also experience difficulty in understanding and application of the time concept, realising number patterns, understanding money and they shy away from calculating money change. Learners with dyscalculia have a poor sense of direction, for example right or left is usually confusing to them.

It is generally agreed that children with dyscalculia have difficulty in learning and remembering arithmetic facts, despite normal intelligence (Kucian & Von Aster 2014:4; Prince 2004:223; Rosenberg-Lee et al. 2015:351; Shalev 2004:766).

Numerical operations are described as the actions performed on numbers, such as counting, addition, multiplication and division. Understanding of these operations leads to understanding of more abstract concepts of mathematics (Zerafa 2015:1178). Learners with dyscalculia have difficulty understanding the four operations and often struggle to remember the procedure to carry out the calculations. According to Semenza *et al.* (2014:1), it is possible that a learner may have difficulty with one or some operations, and the impairment may not exist in others.

Dyscalculia learners exhibits traits as stipulated by Bird (2011:xi) that they fail to conceptualise numbers, have a poor ability to estimate and show no understanding of whether the answer to a mathematical task is reasonable or not.

Shalev (2004:766) held the view that the elements of dyscalculia are linked to age and grade, and how they perform on mathematical concepts relating to mental calculation, written calculation, retrieval of arithmetic facts, and their numerical knowledge (Re *et al*. 2014:340-341). In the first year of schooling, dyscalculia is observed as the difficulty to remember or tackle basic arithmetic facts, and displaying immature counting skills. In older learners of about nine to ten years, such learners have difficulty in memorising mathematics times tables and conceptualising addition, subtraction, multiplication and division. There is also often constant observation of inappropriate usage of arithmetic signs, forgetting to carry over, misplacing digits, and tackling math problems in the wrong direction.

2.3.2.4 Dyscalculia as a learning disability

A question of whether dyscalculia is a learning disability often arises. The

Learning Disability Association of America (NCLD) (Kucian & Von Aster 2014:4; National Center for Learning Disabilities (NCLD) 2015:Online) defines dyscalculia as a type of learning disability, where learners' ability to understand numbers and learn mathematical facts is compromised. The American Psychiatric Association's Diagnostic Statistical Manuals DSM-IV (1994) describes mathematics disorders with reference to difficulties with mathematics word problems, lack of linguistic skills, recognition of numerical symbols, for example representation of Roman numerals (I, III, V, etc.), lack of perceptual skills, attention skills (remembering the rules), and the use and application of different operations (mathematical skills).

Re *et al.* (2014:337) and Price *et al.* (2013:1) defined dyscalculia as a learning disability that affects the ability to acquire the arithmetic level expected at school age. The recognition of dyscalculia as a disability is important for the provision of intervention strategies and the necessary assessments that need to be provided for learners with dyscalculia. Lewis (2016:39) held the view that learners with dyscalculia understand mathematics in peculiar ways. That means such learners could be assisted through appropriate intervention strategies.

2.3.2.5 Perspectives on dyscalculia

In my experience of teaching mathematics, I observed that mathematics is difficult for most learners, most importantly because of what they hear about the subject, which then affects their attitude toward the subject. I have also linked their failure rate to the information gap that makes it hard for them to understand taught mathematical concepts. This, in turn, could induce mathematics anxiety.

There is currently very limited research on dyscalculia around the world and in South Africa in particular. According to Bastos *et al.* (2016:202) and Wilson and Dehaene (2007:213), there is less research on and recognition of dyscalculia compared to dyslexia. However, dyscalculia is as prevalent as dyslexia, at between 5% and 8%, and it is as severe as dyslexia (Bastos *et al.*

2016:201; Butterworth *et al.* 2011:1049; Ranpura *et al.* 2013:1)

Poor mathematics performance continues to cause concern globally. Butterworth *et al.* (2011:1049) and Kucian and Von Aster (2014:1) argued that dyscalculia contributes to financial cost to governments and personal cost to individuals. A cohort study conducted in the UK found that individuals with low numeracy earned less income, spent less, were more likely to be sick and to be prosecuted, and needed more intervention at school. It is estimated that low numeracy costs the UK over 48 billion in South African Rand. According to Hlalele (2012:267), there is a crisis in mathematics education in South Africa. Numerical skills are essential in individuals' daily routines, especially with the need of usage of technology in the modern-day society (Kucian & Von Aster 2014:1). As a member of the Dyscalculia Group on a social network, I witness the frustration of individuals with dyscalculia in working in an environment where they have to handle money. They experience frustration for not being able to count out even small change.

Dyscalculia, as a concept, has different aspects that are identified by Doyle (2010:7) and Kucian and Von Aster (2014:3). There are identified perspectives of dyscalculia, namely biological, cognitive and behavioural perspectives of which some are used to classify dyscalculia to have in-depth understanding thereof.

2.3.2.5.1 Biological perspective

The biological aspect of dyscalculia refers to the genetic factors and brain conditions that contribute to dyscalculia. The biological aspect of dyscalculia is described as having three types of dyscalculia (Geary 2004:10). These three types of dyscalculia were identified and described in Chapter 1 above, namely according to procedural, semantic and visuospatial memory. In this study there will be no distinction drawn to the different types of dyscalculia, because the application of an AL strategy as the proposed intervention strategy is inclusive in nature. However, it important to understand the foundational existence of dyscalculia in order to ensure that the proposed

intervention strategy is relevant.

Starkey and Copper (1989:1033) and Stark *et al.* (2016:65) held the view that infants are capable of distinguishing, identifying and remembering particular small numbers. Zerafa (2015:1179) and Gliga and Alderdice (2015:445) proclaimed that infants are born with a sense of numbers.

According to De Visscher *et al.* (2014:434) and Shalev (2004:768), dyscalculia is a specific learning disability that affects mastering of basic arithmetic skills and is linked to the development of the brain or to brain injury. It observed in children born preterm at low and very low birth weights, or suffering from epilepsy or genetic disorder of X chromosomes, such as Turner's syndrome

The injury may be to a certain part of the brain due to external environmental factors, such as prematurity or low birth weight. Isaacs, Edmonds, Lucas and Gadian (2001:1706) and Gliga and Alderdice (2015:445) concluded from experiments conducted that babies born with very low body weight managed to solve simple addition and subtraction operations, but had difficulty with operations including carrying over and borrowing with multi-digit numbers. Dyscalculia due to brain development or injury is often observed in different kinds of neurological disorders, such as ADHD, developmental language disorder, epilepsy and fragile X syndrome. According to Kucian (2014:7) neurological investigations give proof that dyscalculia or compromised mathematical aptitude is found in cases where special centres of the brain have been damaged.

2.3.2.5.2 Cognitive perspective

According to Butterworth (2008:370) and Callaway (2013:150), the basis for cognitive deficit is the difficulty to grasp numerical concepts especially numerosity and this leads to difficulty to understand and develop more complex arithmetical concepts. They have difficulty to grasp numerical concepts that means a learner cannot comprehend the number system and

therefore guess the correct answer or uses fingers for various calculations.

The concept of numerosity is the foundation of arithmetic and any other mathematical concept. Butterworth (2003:4) and Kucian and Von Aster (2014:4) argued in favour of the link between numerosity and other mathematical concepts, and the influence of numerosity on the speed at which information is retrieved. Addition is described as a combination of collection. Subtraction is understood as removing a sub-collection from collection. "The speed of retrieving addition facts (such as $5 + 3 = 8$) or multiplication facts $(5 \times 3 = 15)$ is determined by the numerosity of the sum or product" (De Visscher 2015:38). According to Kucian and Von Aster (2014:7), difficulty in number sense (numerosity) is due to failure to develop the brain region responsible for number processing.

According to Dehaene and Cohen (1998:331-332), numbers can be processed mentally in different formats, such as "Arabic notation, spelled-out numeral and abstract quantity representation" (Kucian and Von Aster 2014:2). That means an individual is able to process the associate numbers in different formats. The human brain must have some mental representations and processes that are responsible for recognising, understanding, and producing various notations and for interpretations between them (for example, 2, two, ... or 20, twenty, two tens). According to Gillum (2014:279), children with dyscalculia demonstrate poor conceptual understanding of counting principles. This difficulty leads to difficulty in the aspect of solving arithmetic problems and the ability to identify and correct errors.

2.3.2.5.3 Behavioural perspective

According to Rosenberg-Lee *et al.* (2015:363), in an experiment that was done using students of normal intelligence to determine the ability of learners with dyscalculia to solve problems relating to addition and subtraction, it was found that, behaviourally, learners with dyscalculia were slower and made errors when preforming mathematical calculations, especially in subtraction. Learners were observed to have difficulty in remembering basic arithmetic

facts.

Kucian and Von Aster (2014:3) says the behavioural perspective of dyscalculia includes the precursor skills, number skills and calculation skills of an individual. The precursor skills refer to the ability to differentiate between small and large quantities. The number skills refer to counting, for example backward counting. The calculation skills refer to the counting skills that often dyscalculia learners resort to, using their fingers and struggling to retrieve basic arithmetic facts that they have learned (Stark *et al.* 2016:68).

Kucian and Von Aster (2014:1) and Price *et al.* (2013:1) held the view that our modern world requires constant processing of numerical information. Financial decisions that include buying on credit, investments, smart phones, computers, and choosing a medical aid are some of the many aspects of our lives that require numerical aptitude. Dyscalculia further affects schooling, professional careers of individuals, as well as the physical and emotional wellbeing of individuals. Competency in numeracy is regarded as one of the basic life skills and the consequences of failure to acquire such skill result in minimum choices of programme of study at tertiary educational institutions and limited opportunities of employment.

Therefore dyscalculia has a direct impact on the socioeconomic status, self-esteem and identity of an individual (Doyle 2010:16). Poor mathematics performance in South Africa is no exception and leads to the high unemployment rate and increase in poverty in many communities. The Centre for Developmental Enterprise 2013 states that South African numeracy is the worst in the world: In 2011, the Trends in International Mathematics and Science Study (TIMSS) showed that South African learners have the lowest performance among all 21 middle-income countries that participated (Reddy, Prinsloo, Arends, Visser, Winnaar, Feza, Rogers, Janse van Rensburg, Juan, Mthethwa & Ngema 2012:4). More research is needed to establish the prevalence of dyscalculia in South African schools and if the implementation of inclusive education policies includes such learners.

The impact of inadequacies that exists within education systems affects various countries, including the UK. In the UK, individuals with mathematical disabilities make up 25% of individuals who are economically inactive. These individuals are said to contribute to the rate of unemployment, mental and physical illness, and the number of individuals in incarceration. Their behaviour and inability to contribute to the society cost the UK government R54 billion in South African Rand (Butterworth *et al.* 2011:1049). Thus intervention in the form of addressing dyscalculia empowers learners with such mathematical difficulties and contributes to creating healthy, strong economies in their countries.

2.3.3 Mathematics

According to CAPS (DBE, 2011:8), mathematics is a language that makes use of "symbols and notations to describe numerical, geometric and graphical relationships". It involves analysis and understanding of patterns and relationships that exist between objects. Mathematics serves a purpose to enhance logic and critical thinking of learners, and to empower them with problem-solving skills. Mathematics learning generally involves calculation in various forms. The PBS (2012: Online) held the view that neurological and cognitive functioning is critical in learning mathematics. Learners use their memories to recall facts and formulas, recognising patterns, invoke rules about sequential ordering. The brain has to function at a certain level for them to apply various aspects of mathematics in solving a problem and to be able to understand and use the correct vocabulary involved in mathematics learning.

Mathematics learning also requires that students should understand the spatial ordering so that they may recognise symbols and also understand the three-dimensional representation of objects (PBS 2012:Online).

It is evident that mathematics learning is critical in our society; Henning (2010:Online) added that people with "poor numeracy skills are twice as likely to be unemployed". However, mathematics proficiency is a challenge to many

people and more so to individuals with dyscalculia.

2.4 RELATED LITERATURE

There is growing concern on how learning environments could be made accessible to all learners. However, in order to address this concern, more research is needed to understand challenges that exist in a classroom. Dyscalculia is one of the leading learning disabilities that exist in the classroom. Waiganjo (2013:1) classified learning disabilities in three main groups, namely dyslexia, dysgraphia and dyscalculia. Dyscalculia is a learning disability that is specific to learning and understanding mathematics. There is, therefore, a need to ensure that dyscalculia is addressed in a mathematics classroom to ensure effective learning for all learners.

According to Cranton (2012:94), effective learning requires interaction strategies that encourage communication among learners themselves, and between learners and their teachers. Such learning facilitates involvement, cooperation, collaboration and construction of knowledge.

In New Zealand, Bolstad *et al.* (2012:Online) presented an argument that effective learning is said to require active engagement and that "[l]earners need to be actively engaged in ways that allow them to process, interpret, and adapt an experience".

Learning is a process of knowledge construction and absorbing, or recording information. Moreover, knowledge is constructed from the already existing knowledge. The usage of an AL strategy in a mathematics classroom to address dyscalculia gives learners an opportunity to own their learning.

In this section I review literature pertaining to perspectives on the nature of and relation between dyscalculia and an AL strategy; and the need to use an AL strategy as a pedagogical strategy in addressing dyscalculia. The section further covers an elaborate discussion on the elements of an AL strategy and their conditions that are relevant in addressing dyscalculia in a mathematics

classroom. Change always poses challenges. Hence, a discussion of possible hindrances in the application of an AL strategy in addressing dyscalculia in a mathematics classroom and how these hindrances could be mitigated in a way that an AL strategy remains effective in addressing dyscalculia in a mathematics classroom is presented.

2.4.1 Perspectives pertaining to understanding of dyscalculia and an AL strategy

Dyscalculia is recognised globally to affect between 1% and 7% of learners in school (Perna, Loughan, Le, Hertza and Cohen 2015:158; Ranpura *et al.* 2013:1). In addition, without an intervention strategy to mitigate the challenges faced by such learners, the symptoms of dyscalculia persist to adulthood. The most commonly recognised difficulty that affects learners with dyscalculia is the difficulty to retrieve mathematical facts. De Visscher *et al.* (20015:38-39) and Landerl *et al.* (2004:105) noted that learners with dyscalculia have a basic problem with processing number functions, including subsitising, which means counting small numbers of objects, using number names and numerals, and transcoding, which refers to the ability to read and spell Arabic digits. Learners with dyscalculia are further noted to struggle with written calculation, arithmetic fact retrieval (Geary 1993:345; Temple & Sherwood 2002:750) and estimating numbers on a number line (Huber *et al.* 2015:39; Reeve, Paul & Butterworth 2015:1).

According to Von Aster and Shalev (2007:868), Wadlington and Wadlington (2008:3) and Wilson and Deahene 2007:213), the general agreement among researchers is that the underlying or core deficit in dyscalculia is the genetically determined disorder of numerosity or number sense. The term “number sense” communicates the special ability of an individual to represent and manipulate numbers nonverbally in a number line (Wilson and Deahene 2007:217). The communication of numbers on a number line is initially introduced at the primary level of education. It requires the cognitive components of learning, which includes memory skills and language skills in the form of number symbolisation. The numerosity of an individual underpins

the acquisition of arithmetic skills, which are lacking in an individual with dyscalculia.

There are other core mathematical deficits, which are divided into three subtypes of dyscalculia as mentioned in Chapter 1. They are difficulty in retrieving arithmetic facts, referred to as semantic memory; difficulty in understanding and applying mathematical procedures, described as procedural memory; and visuospatial memory, which refers to the difficulty in understanding spatial representation, for example, place value errors or geometry. The following question arises: How does AL mitigate such deficits in an individual? To enhance the understanding of dyscalculia for knowledge of whether dyscalculia exists or not, this section discusses mathematics weaknesses in these areas of the brain concerning learners with dyscalculia.

2.4.1.1 Recognition of dyscalculia

Understanding that learning of mathematics requires the usage of memory to "recall rules and formulas, recognising patterns, invoke rules about sequential ordering" (PBS 2012:Online). Starkey and Copper (1989:1033) and Stark *et al.* (2016:65) held the view that infants are capable of distinguishing, identifying and remembering particular small numbers. According to Zerafa (2015:1179) and Gliga and Alderdice (2015:445), infants are born with a sense of numbers. These views support the notion that mathematics learning is supported from the brain. Human beings are, therefore, born with a sense of numbers. Therefore, the inability to work with numbers has to emanate from the brain.

Different scholars argue that mathematics disabilities arise from disabilities in brain areas supporting semantic, procedural and semantic memories. According to Hall (2011:708), the number of neurons and their connectivity change during learning. During the learning and development process from birth, "many parts of the brain make connections with other neurons" (Hall 2011:708) and when the connection is compromised for whatever reason, this affects the function of certain areas of the brain. As part of learning, whereby

information has to be acquired and stored, the short-term memory has to be connected to the long-term memory. This process of storing information is called “consolidation”. Information is codified during the consolidation process (Evans & Ullman 2016:5; Hall 2011:708). Therefore, any brain abnormalities will cause problems in the storing of mathematical facts that are connected to the affected areas. The sections below discuss the identification of dyscalculia as a result of abnormalities associated with semantic, procedural and visuospatial memory.

2.4.1.2 Semantic memory difficulty

According to Geary and Hoard (2005:262) and Karagiannakis *et al.* (2014:2), a semantic memory deficit is when a learner has a challenge to retrieve and process information responsible for arithmetic facts and words from the long-term memory. When such learners try to retrieve facts, a high error rate is observed. The common arithmetic errors are often in computing simple addition and subtraction. They are also observed not to be able to make association between numbers, for example that 3 follows 2. Learners with a deficit in semantic memory also show confusion in understanding mathematics terminology, such as numerator and denominator. They also confuse basic arithmetic operation symbols (Karagiannakis *et al.* 2014:2). The ability to store and process arithmetic facts and the ability to remember facts and names in the long-term memory are imperative to the development of mathematics aptitude and the ability to transmit mathematics ideas (Chinn 2015:8).

This dysfunction appears on the left hemisphere’s posterior region where the cerebral cortex and basal ganglia are affected. The cerebral and basal ganglia are both grey matter located at different parts of the brain (Evans & Ullman 2016:2); however, they are both responsible for storing and transmitting information. For example, if a learner learns today that 2 x 3 = 6, naturally, they will associate that symbol “x” with multiplication, which means 2, added 3 times. However, in cases where the grey matter is thin, there is an observed deficiency to remember such information. Therefore, it means there was a

disruption in the processing of such information and this information was not stored and, therefore, cannot be remembered.

2.4.1.3 Procedural memory difficulty

Procedural learning memory is located at the left hemisphere and depends on the frontal, parietal, basal ganglia and cerebella structures of the brain. This area of the brain is a learning and memory system of the brain that is crucial for automatisation of non-conscience skills, for example driving (Evans & Ullman 2016:2). For an individual to drive a car, they have to remember all the steps that they need to follow in order to get the car to move. The same way in mathematics it is important to remember all the rules and the steps that need to be followed in order to arrive at the correct solution. Individuals with difficulties in this learning memory show difficulty in mentally following steps for mathematical procedures.

According to Geary and Hoard (2005:2) and Evans and Ullman (2016:2), the abnormalities in the basal ganglia (grey matter in the inside area of the brain) are linked with the difficulties of the procedural memory. A procedural deficit is observed through a delay in acquiring arithmetic strategies, for example adding on and carrying over (27 + 35 = 62, whereby the procedure is that you first add 7 and 5, which is 12, but you write 2 and carry over 1). Learners with a deficit in mathematics procedure get confused in following the procedure. They may write 12 if they managed to add correctly and forget to carry over. Sometimes they may confuse the addition and subtraction procedures.

According to Evans and Ullman (2016:2), “the procedural memory brain system underlies the implicit learning and processing of wide range of perceptual –motor and cognitive skills across domains, including motor skills, navigation, sequences, rules, and categories”. Therefore, learners with dyscalculia, with a deficit in procedural memory will show difficulties in the application of the BODMAS rule, whereby they are not sure whether they should add or subtract first. They struggle to follow steps when solving mathematical problems. Therefore, when a teacher has taught the BODMAS

rule a few times and all the learners in class understand it, but a few learners in class still appear totally confused, they need to pay attention to these learners in case it is indication that these learners have dyscalculia.

2.4.1.4 Visuospatial memory difficulty

The visuospatial memory, located at the right hemisphere, denotes a learning memory with spatial representation of numbers and other forms of mathematical information and relationships (Karagiannakis *et al.* 2014:3). Individuals with this form of dyscalculia misinterpret or misunderstand information relating to patterns and diagrams. The deficit is observed when solving geometry and word problems, or using a mental number line. According to Karagiannakis *et al.* (2014:3), a spatial deficit is found in the right hemisphere. Geary (1993:346), Molko *et al.* (2003:847) and the PBS (2012), refer to the visuospatial memory as the ability to visualise with the mind's eye and to have the ability to comprehend three-dimensional images and shapes. Learners with visuospatial difficulties show frequent misinterpretation of spatially represented information. Teachers observing trends in such difficulties in learners may start observing these learners closely or perhaps implement intervention strategies.

Semantic, procedural and visuospatial memory difficulties all emanate from weaknesses in the thin layer of the grey matter of the brain. The thin layer of the grey matter makes it harder for information to be stored and retrieved when required to for the processing of mathematical concepts. According to Hall (2011:703), long-term memory may be developed through consolidation of memory. The consolidation of memory is the process whereby information in the short-term memory is repeated or rehearsed. New memories are codified during consolidation. During the repetition, the grey matter quantity increases and that means the ability of the brain to store information is enhanced. This proposes active learning as an intervention strategy and the concept of AL encourages repetition of information in different forms. The section below discussed the need for an AL strategy in addressing dyscalculia.

2.4.2 Need for an AL strategy in addressing dyscalculia in a mathematics classroom

Lumpkin *et al.* (2015:2) held the opinion that an AL strategy is the pedagogical strategy of choice, which helps in the development of thinking skills and enhances learners' cognitive learning, instead of their simply answering questions. They encourage learners to conceptualise learned theories and to independently reason and derive answers. This is a needed skill and support for learners with dyscalculia. Learners with dyscalculia have difficulty with basic number concepts (Lewis 2014:40; Zerafa 2015:1178). They have no feel for numbers, and have poor estimating, recalling of number facts, counting backwards, understanding of and applying concepts of time, understanding of money, sequencing, direction to the left or right, and noting number patterns. According to Bird (2009:xiii), learners with dyscalculia have a weak concept of numbers and this results in their either guessing the correct answer or resorting to immature strategies of deriving the answer. The most common strategy is counting, using fingers for different calculations, including simple calculations.

In a conversation I had with a learner diagnosed with dyscalculia, she confided that she could never remember her South African ID number, she cannot remember her close family members' birthdays, she struggles to read numbers in digit form and she carries a calculator in her purse all the time.

It is a fundamental right of every child to have access to every aspect of education and, therefore, there is a need for an intervention strategy to meet the needs of learners with dyscalculia. According to Stark *et al*. (2016:68), the intervention strategy for learners with dyscalculia has to be composed of "high quality teaching, small-group support and individualised support". Hence, this study proposes an AL strategy as an intervention strategy because of its high involvement of learners in their learning, and the interaction with peers and the teacher as the facilitator ensuring high quality of education outcomes (Mazibuko 2014:181; Petersen & Gorman 2014:66).

A study was conducted by Freeman *et al.* (2014:8413) to investigate whether an AL strategy improved student performance in science, engineering, and mathematics. Moreover, they found that there were improved grades, a decreased failure rate and increased engagement in the taught subjects. Hence, an AL strategy is proposed in this study as a teaching strategy dealing with dyscalculia in a mathematics classroom. It will not only improve the grades, but further help create a positive learning environment.

An AL strategy presents key elements as described by Lumpkin *et al.* (2015:3), that include discussion, questioning techniques and writing activities that will be discussed below. These elements will be used as part of a teaching strategy in addressing dyscalculia in mathematics writing. Such a teaching technique will give learners an opportunity to learn at their own pace, to have time to reflect and to create their own understanding of what they have learned. Learners will have an opportunity to repeat what they are learning as much as it is necessary to assist in committing concepts to memory, as it is further noted that the quantity of grey matter increases when concepts are repeated. Consequently, the increase in grey matter allows the information to be stored and transmitted when needed in the brain.

2.4.2.1 Intervention strategies for learners with dyscalculia

Dyscalculia is a condition that makes it difficult to understand mathematics. Learners with dyscalculia often give up on learning mathematics because they believe it is too difficult or impossible to understand. I believe anybody can learn mathematics with the proper intervention strategy. The section below discusses the intervention strategy for learners with dyscalculia. However, it is important to understand mathematics in relation to dyscalculia in order to ensure that the intervention strategy is relevant to the problem. The discussion links the aspects of mathematics with those of dyscalculia. In order to propose an effective intervention strategy, it is important to understand what makes mathematics difficult for learners with dyscalculia. As attested by Shalev and Von Aster (2008) above, general difficulties facing learners with

dyscalculia are number processing and calculation abilities. Therefore, any intervention strategy should assist learners with conceptualising numbers and their ability to count from observation.

2.4.2.2 Mathematics for learners with dyscalculia

According to Perna *et al.* (2015:157), mathematics disorders have been recognised as long as language disabilities and yet the research conducted in mathematics disabilities is lagging behind. On the other hand, mathematics is noted as a complex subject and its understanding is dependent on various cognitive abilities, such as short-term memory, working memory, visuospatial skills, processing speed, and language skills

Without focusing on the aspect of dyscalculia, the intervention strategy for addressing dyscalculia in a mathematics classroom needs to consider information gaps that learners with dyscalculia have, and the difficulty to make spontaneous connections between numbers or groups of items. Learners with dyscalculia are also known to have difficulty with multiplication tables because they have compromised memory and have a low concentration span (Bird 2011:xiii).

Wadlington and Wadlington (2008:4) and Nfon (2016:437) held the view that dyscalculia is a unique learning disability, but not a life sentence in which learners could never learn mathematics. All learners can learn mathematics; however, it is important for teachers to understand that not all learners learn in the same way. Inclusive education means that all learners are equal, but not necessarily the same.

2.4.2.3 Intervention strategy in a mathematics classroom for dyscalculia learners

There is growing, but limited research on the relevant intervention strategy addressing dyscalculia in a mathematics classroom. Wadlington and Wadlington (2008:5) and Flores, Hinton, Strozier and Terry (2014:445) held

the view that learners with dyscalculia should receive an intervention strategy that actively engages them in a mathematics lesson and, therefore, the curriculum needs to be adjusted in order to be inclusive. The mathematics intervention needs to specifically strengthen the meaning of numbers. It is also crucial that it demonstrates the link between mathematical facts and the meaning of their components. Butterworth *et al.* (2011:1051-1052) and Mulaudzi and Runhare (2014:159) argued that specialised intervention is necessary in addressing dyscalculia and other disabilities affecting the learning of mathematics. Failure to devise an intervention strategy means that the educational system fails to reach other individuals within our societies. Therefore, inequality in education will continue to undermine the human rights of individuals with disabilities.

Hott *et al.* (2014:1) held the opinion that learners with mathematics difficulty need to be prepared to ensure that they meet new challenges as they successfully move up along grades. Dyscalculic learners are just as entitled to success as other learners in their mathematics classroom are. Special education teachers and general education teachers need to be empowered with skills and resources to ensure they are equipped to deal with challenges faced by learners in their mathematics classroom. Teachers and learners need to have strategies that will allow them to gain access to the general education curriculum and have success in tackling mathematical concepts and conceptual knowledge. Only a portion of learners is likely to have to deal with a special intervention that will address their deficit in learning mathematics. Hence, this study proposes AL as a teaching strategy to intervene in addressing dyscalculia in a mathematics classroom.

According to Shalev (2004:768), the intervention for dyscalculia should address multiple aspects of the disorder without losing focus of educational treatment that will improve their attitude toward mathematics and other subjects and also improve their mathematics understanding.

The recommended intervention strategy for learners with mathematics disability is that teachers may have training programmes that will help

learners transcribe numbers into appropriate value (Kucian & Von Aster 2014:9; Shalev 2004:769). This includes an understanding of place value. For example, in 6,349, “6” relates to thousands, “3” relates to hundreds, “4” relates to tens, and so forth. They also need to work on their ability to understand the concept (Huber *et al.* 2015:32). Therefore, it is important that their intervention would include the enhancement of automatic recall of number facts by way of repetition and addressing the mathematics information gap as a result of dyscalculia. Hence the study proposes an AL strategy because of its inclusive nature of meeting learners and various phases of their mathematical understanding. An AL strategy will, therefore, enhance learning through the application of various elements that will ensure that numerosity and its implication are addressed. The repetition of mathematics concepts that is done by the implementation of AL in a fun manner, makes learning exciting and also helps learners who have lost hope for learning mathematics.

2.4.2.4 Active learning as a teaching strategy

According to Berglund and Lister (2010:35), a didactics triangle describes a teaching situation that can be analysed and explained in detail in terms of the student, the teacher and the content as the three main components. Active learning is a pedagogical approach that seeks its bases on the learner, the teacher, learning task and the interaction in the mathematics classroom (Röj-Lindberg 2001:6). The following four elements mark the foundation of an active learning strategy:

- The learner is the key person in the active learning process, hence the prerequisite that mathematics teaching should be learner-centred. “Learner-centred” refers to the need to be active mentally, socially and physically.
- The teacher is an authority because of the possessed knowledge of mathematics and mathematics learning, and respect awarded to learners as both social and intellectual beings. The role of the teachers is perceived as that of a manager of the learning environment and resources.

- Open-ended and mathematically rich learning tasks are considered a prerequisite for the possibility of constructing a structure conducive for conceptual understanding of mathematics.
- The set-up of a mathematics classroom should support interaction in small groups, whole-class discussion and individual work, together with the needs of the learner and the learning tasks.

Mazibuko (2014:181) and Bonwell and Eison (1991:33) postulated AL as a teaching strategy promotes student achievement, enhancing motivation and changing learners' attitudes. With AL as a teaching strategy there are strengths and weaknesses that require the teachers' creativity and understanding of different learning styles.

According to Cranton (2012:21), it is important that a teacher should have an opinion about the learners in every lesson. The information should include the learning experiences of learners, how many have dyscalculia and their level of difficulty in understanding mathematics in association with dyscalculia.

2.4.2.5 Relevance of AL as a teaching strategy and link with dyscalculia

Active learning as a pedagogical technique has been adopted in the national curriculum of countries such as the UK and Indonesia (Northern Ireland 2002:2; Suherman *et al.* 2011:10). Northern Island wanted a curriculum that would allow learners to learn with conceptual understanding, such that learners are actively allowed to link what they learn in class with what they experience in real life. Northern Ireland (2002:2) reported that their revised curriculum aims to empower learners to develop their potential as individuals and make informed and responsible decisions for living and working in the 21st century. An active learning strategy is part of the revised curriculum in Northern Ireland because they believe it allows learners, regardless of their abilities, to solve problems, to make decisions, to think critically and to communicate ideas adequately.

According to Section 28 of the Constitution of the Republic of Indonesia of

1945 (as cited by Suherman *et al.* 2011:103), the national educational system is mandated with the responsibility to ensure that "Indonesians receive a good education designed to increase their competence in life skills, their responsibility, and their dignity as human beings". The inclusion of active learning in the curriculum will equip Indonesians with the competitive edge such that they have the ability to compete in the global arena and reach their own desired life goals.

In 2012, the president of the USA mandated the United States President's Council of Advisors on Science and Technology (PCAST) to improve the learning and teaching of mathematics and other science subjects. The PCAST is mandated to advise the president. They recommended the inclusion of active learning as a teaching strategy. Research had shown that through active learning, there was perceived increase in student retention and improvement in engineering related course: "Students in traditional lecture courses were twice as likely to leave engineering and three times as likely to drop out of college entirely compared with students taught using active learning techniques" (Olson and Riordan 2012:6).

2.4.3 The elements of a successful AL strategy that addresses dyscalculia in a mathematics classroom

This section discusses the essential aspects of active learning that are common to its implementation. According to Prince (2004:3), the core elements of an AL strategy are the introduction of activities into the traditional lecture and promoting student engagement. The introduction of activities is referred to as a strategy that allows an increase in the concentration span of learners. In a mathematics classroom, a learning activity is introduced with an aim to develop the learners' critical thinking skills, to enhance their problem-solving skills and to generate interest in the subject. According to Michael (2006:160) and Samson (2015:153), problem-solving is an important part of an AL strategy that allows learners to work creatively to solve a task that is based on reality, using the knowledge that they already have. Michael (2006:160) held the view that an AL strategy requires students to constantly

access their own understanding and skills of handling taught concepts in the discipline they are learning.

Mazibuko (2014:181-182) suggested the key elements of AL as peer teaching, cooperative learning, group case studies, and written exercises. Lumpkin *et al.* (2015:3) described the elements of an AL strategy as those elements that accommodate individuals of different learning styles. Such elements are questioning techniques and short writing activities in class. Berry (2008:149) further postulated that three key elements characterise all active learning approaches, namely critical thinking, individual responsibility for learning, and usage of manipulatives.

This study is focused on AL as an intervention strategy in a mathematics classroom for learners with dyscalculia. Therefore the elements below are perceived to be relevant for the objective of this study. The following are the selected key elements of active learning relevant in addressing dyscalculia in a mathematics classroom: effective questioning, usage of a manipulative and multisensory approach, peer teaching, writing and reflecting, and cooperative learning.

2.4.3.1 Promoting learners' engagement through effective questioning

Sivan *et al.* (2000:381) classifies elements of active learning that relate to the promotion of learners' engagement, as talking and listening, reading, writing and reflecting. The usage of manipulatives also fits in creating an active learning environment in a mathematics classroom.

The promotion of student engagement goes beyond the introduction of activities in the classroom. It is designed to increase the retention of information by designing activities around important learning outcomes and to encourage thoughtful engagement of learners about the taught concept (Prince 2004:4).

Cranton (2012:93) postulated that questioning is used as part of teaching and

learning. The purpose of questioning varies from monitoring whether learners understood, to receiving feedback on whether learners understood. Questioning leads learners to discover concepts, to construct knowledge or to generalise. Hence, there are questions that are asked by teachers to learners, and questions that are asked by learners to teachers.

Since questioning is an important part of learning in an active learning environment where learners' engagement in their learning is important, (Mason 2010:12) held the view that "what learners need is not for a teacher to resolve all their uncertainties, answer all their questions, or tell them what they need to remember. Rather what they need is become familiar with how to deal with getting stuck". Teachers need to clarify what they actually know and what they need to know to be able to solve the problem independently.

2.4.3.2 Usage of a manipulative and multisensory approach

According to Diamond *et al.* (2008:118), the usage of manipulatives allows a learner to link the problem to be solved to the acquired information.

Emerson and Babtie (2014:2) referred to the multisensory approach as a teaching method that allows learning mathematics by using real objects to explore mathematics ideas, whilst discussing what they are doing. A multisensory approach is beneficial; however, it may exclude learners who may be overwhelmed by seeing and touching concrete materials.

As discussed, learners with dyscalculia have a compromised sense of numerosity and difficulty in conceptualising numbers. This study expands on the elements of an AL strategy to include a multisensory approach as the element of an AL strategy that seeks to accommodate learner dyscalculia. AL as an instructional method seeks to engage learners in the learning process. On the other hand, according to Jordan and Brannon (2006:3487), multisensory representation is described as a fundamental part of infants' numerical knowledge or whether this level of abstraction highlights a unique developmental discontinuity between human infant and adult number

representation.

The use of manipulatives increases the number of sensory inputs a student uses while learning the new concept, which improves the chances for a student to remember the procedural steps needed to solve the problem (Witzel 2005).

2.4.3.3 Peer teaching

Peer learning is when a teacher gives learners a short time to reflect what they have learned by writing it on a paper or solve a question problem relating to what they have learned with a paired peer. Peer teaching is a technique that enhances the development of learners in their computational skills, and the moral, social and emotional aspects of their growth (Mazibuko 2014:182; Vasay 2010:161). When they are done reflecting or solving a problem, one of them presents the answer. The teacher will later explain the correct answer and explain various options.

Peer teaching gives learners an opportunity to learn, to reflect on their learning and to share their social values with their peers (Liu & Devitt 2011:146). In a study conducted by Lim (2014:37), that sought to assess the impact of peer learning, it was found that a majority of the learners indicated that peer learning motivated them to prepare for their own learning, so they could share what they have learned with their peers. There was an increase in morale in the classroom.

2.4.3.4 Writing and reflecting

According to Kenney, Shoffner and Norris (2013:787), writing and reflection are important parts of learning in a mathematics classroom. Dewey (1960:30) described reflection as a way of identifying issues of concern or interest within oneself and the explanation of or the solution to the same issues.

Going back in history, Shulman (1987:9) argued that writing and reflection

enhance the pedagogical knowledge of the teacher and consequently enhance knowledge and understanding of their learners. Ball, Thames and Phelps (2008:8) postulated that teaching requires that a teacher should have knowledge of mathematics and be able to reflect on the errors committed by the learners. This will, in turn, help learners reflect on their own errors.

Language subjects and history are often associated with writing, and mathematics is thought of as only solving mathematics problems in class. Historically, writing is known as a fundamental way of learning in all subjects, including mathematics (Kenney *et al.* 2013:789; Stehney 1990:27). Mathematics is generally the least favoured school subject of learners because they perceive it as difficult and they struggle to link its application with the theory.

There are questions that trigger thinking about mathematical facts that are rarely asked, such as why is the equation of the unit circle equals to πr^2 , why is pie (π) approximate to 3.14, or why is ½ greater than ¼ (Braun 2013:4; Kenney *et al.* 2013:789). Such questions are rarely asked; however, learners are expected to know and accept them as mathematical. Braun (2013:4) postulated that writing allows learners to engage with mathematics content and mathematical ideas and processes in a unique way. Kenney *et al.* (2013:789) held the view that such questions provide an opportunity to reflect on their existing mathematical knowledge. They are able to engage with their peers and teachers about their understanding of mathematically known facts. Therefore they could develop a perspective on their own work as the work of others. Through writing and reflection they could discover how much they know and lack in their understanding of mathematical concepts. When teachers know what learners are thinking, they are able to focus on the learners' problems and this helps them understand their students better (Amir & Lianghuo 2002:8; Lefler 2006:5).

2.4.3.5 Cooperative learning

Cooperative learning is defined as a structured and systematic teaching

technique that involves two or more learners working together toward a common objective (Adam 2013:7; Flynn 2013:2; Linton, Farmer & Peterson 2014:245). Cooperative learning refers to the joint production of ideas where learners share their thoughts and, at the same time, respond to the ideas shared by other learners in their group, so they can jointly share meaning and understandings.

Mathematics is regarded as a subject that is important in enhancing the problem-solving skills of learners. Therefore the traditional way of learning mathematics through memorisation of formulas does not help with understanding mathematics. It is important for learners to understand the links between mathematical ideas. Learners need to be actively engaged, rather than only listening and memorising facts (Felder & Brent 2009:2; Mazibuko 2014:181). According to Flynn (2013:2), classes with cooperative groups allow learners to actively engage in the processes of learning mathematics and learning through discussion. Through the discussion, they have an opportunity to justify, investigate and challenge their ideas. Cooperative learning allows them an opportunity to communicate learning mathematical ideas in a non-intimidating manner.

2.4.3.6 Classroom environment

According to Van de Walle (2004:32), one of the strategies for effective teaching is creating a mathematical environment. He described a mathematical environment as an environment where “students feel comfortable trying out ideas, sharing insights, challenging others, seeking advice from other students and the teacher, explaining their thinking, and taking risks”. A classroom is more than a physical space where learning takes place; it a space which supports the wellbeing of a learner for learning to take place. Baepler and Walker (2014:28) referred to a learning environment as a space where social bonds are created. A classroom environment is a space where there is mutual respect among learners themselves and respect between the teacher and learners. In this space, there is also a shared responsibility for learning, as well as trust and security. The learning

environment supports learning to take place by ensuring that the teacher treats learners with respect and vice versa. This means that the teacher will come to class prepared and on time. The learners will also prepare for class and engage with the teacher.

2.4.4 Conditions under which elements of AL would contribute to the successful implementation of an AL strategy in addressing dyscalculia

According to Freeman *et al.* (2014:8410), AL as an intervention strategy, has wide application and intensity with various approaches, such as group discussion, worksheets or tutorials completed in class or at home and interaction with peers by way of giving and receiving feedback. An AL strategy seeks to enhance learning by encouraging learners to take charge of their learning and the freedom to learn at their own pace. They are encouraged to share their understanding of concepts from their perspective in a manner that is not intimidating.

The elements of AL in this study entail effective questioning, usage of manipulatives and a multisensory approach, peer teaching, writing and reflecting, cooperative learning and the classroom environment. In this section, conditions or circumstances under which these elements would contribute to the successful implementation of an AL strategy in addressing dyscalculia in a mathematics classroom are discussed.

An AL strategy challenges a teacher to move from the traditional mode of teaching and assume a leadership role as a facilitator. The teacher is still expected to deliver the mathematical concepts, but to facilitate learning such that learners are fully involved in that learning. However, there are conditions or circumstances that would make the implementation of elements of an AL strategy conducive.

2.4.4.1 Effective usage of a questioning and assessment strategy

According to Sayeski and Paulsen (2010:13), learners with dyscalculia

experience challenges in mathematics learning that include lack of content knowledge due to failure to grasp basic mathematical facts. Wadlington and Wadlington (2008:5) made a recommendation that a learner needs to move to the next concept only when he or she has properly grasped the taught concept. A teacher should move on to the next concept only when the foundational concepts are understood. If this is not addressed, learners easily lose the logical meaning of mathematics and eventually lose interest in the subject alltogether. Wadlington and Wadlington (2008:5) held the view that when teaching learners with mathematics disability, it is important that, firstly, instructions are well organised, with new concepts building on the old ones. Secondly, teachers should preview the planned mathematics lesson and its objectives before the instruction. Thirdly, for learning to take place, learners need to construct their own knowledge in their own way; therefore, when a learner gets the answer wrong, the teacher needs to help the learner to arrive at the correct question. The teacher also needs to do research on the various questioning and assessment strategies that will give all learners in the classroom an opportunity to attempt answering a question during teaching time.

2.4.4.2 Effective usage of manipulatives or multisensory approach

Basic number processing skills include skills such as number naming and reading, number comparison, number writing, number sequences or counting and dot counting (Hornigold 2015:25; Landerl *et al.* 2004:116). The ability to remember is equally important to express what is learned; for example, if a learner has learned to associate five dots with the number “5” and Roman figure “v”. They will need to remember that next time and not start afresh every time a similar situation presents itself. The usage of manipulatives helps to create the memory of a number and associating the number with something that they have seen.

Mulaudzi and Runhare (2014:147) held the opinion that training of the working memory through various stimulations, including technology, involves repeated activities on the memory of events and problem-solving skills that link what

they already know with what they are seeing. In study conducted in Kenya on the usage of Information and Communications Technology in dealing with dyscalculia in a mathematics classroom, it was found that there was improvement in mathematics performance. However, the impact could be better if learners could have access to computers outside of schools. Teachers' attitudes were also not positive because most teachers believed that computers are a luxury for most learners and therefore improvement was short-lived (Waiganjo 2013:118-119).

According to Attwood (2009), when teaching mathematics to learners with dyscalculia, a teacher needs to focus on working on the same topic a few times, using manipulatives that also include multimedia elements (Ahmad, Ludin, Ekhsan, Rosmani & Ismail 2012:554) and encourage learners to verbalise what they are learning. The teacher also needs to ensure that topics follow a logical order; for example, to introduce a lesson on percentage after the lesson about fractions. Therefore a multisensory approach will work in addressing dyscalculia in a mathematics classroom with a positive attitude from the teacher, including various usages of manipulatives, including ICT.

2.4.4.3 Effective usage of peer teaching

Peer teaching encourages learners to reflect on their own and present to their fellow peers. It is, therefore, important for the teacher to ensure that the classroom environment and the confidence of learners have an impact on their attitude in teaching their peers as well as learning from their peers.

In a study conducted about challenges due to the physical arrangement of the room where learning takes place, the study found that classroom arrangements where it is possible to have student-to-student and student-to-teacher interactions, favoured instructional approaches that made the transmission of information easier (Petersen & Gorman 2014:63).

Samson (2015:154) held the view that student engagement with one another and the teacher is an important aspect of AL that engages learners and

enhances their communication skills. This will assist learners in the difficulty highlighted by Geary (2004:6) that learners with dyscalculia have immature problem-solving strategies and difficulty to retrieve mathematical facts and procedures.

According to Cranton (2012:98), "[p]eer teaching can be preplanned and carefully structured or it can be prompt and spontaneous". For peer teaching to be effective, a teacher will have to be vigilant in facilitating the process because there is a risk that misconception errors by some learners could be passed on to other learners. Therefore, in a favourable learning environment, peers are better able to communicate ideas in a simple but informative manner. However, teachers have to be mindful of the manner in which learners are paired.

2.4.4.4 Effective usage of cooperative learning

When learners work together and they have a positive relationship whereby they learn from one another, such a relationship fosters new insights and discoveries that often induce a higher level of reasoning strategies (Johnson & Johnson 2009:368). Cooperative learning is also known for building individual strengths through working together as a team in achieving a common goal. Such collaboration provides a psychological boost to individuals' esteem and confidence on the subject (Johnson & Johnson 2009:367; Punja *et al.* 2014:490).

2.4.4.5 The creation and implementation of an effective classroom environment

The effective learning environment is about consideration of the physical environment and the sitting arrangement in a class. The physical space and the sitting arrangement are a part of the classroom environment. The effective classroom is effective through the social relations that are built within that physical space. Such social relations will ensure that learners are supported such that they learn and the teacher is supported such that they are able to

teach what they have prepared. Amin, Dina, Razzaly and Akasah (2012:117) supported the following principles for creating effective learning spaces:

- Respect for learners and their experience
- Begin learning with the learners' experience of the subject matter
- Creating and holding a hospitable space for learning
- Making space for conversational learning
- Making space for development of expertise
- Making space for acting and reflecting
- Making space for feeling and thinking
- Making space for inside-out learning
- Making space for learners to take charge of their own learning

That means it is important for the teacher to create the space that support learning. The teacher also creates an effective learning environment by coming to class on time and preparing to deliver the lesson. The teacher would have thought in advance about how they would engage learners with dyscalculia. Learners with dyscalculia are known to easily forget what they have learned. That means they may not remember what they have learned yesterday. The teacher who anticipates this weakness will not be discouraged or think that these learners are not committed to learning.

2.4.5 Impediments or hindrances toward the implementation of AL in dealing with dyscalculia in a mathematics classroom

The section below entails a report on the anticipated impediments toward the implementation of the AL strategy planned, measured in dealing with such hindrances. Bonwell and Eison (1991:2) and Petersen *et al*. (2014:63) postulated that the nature of an AL strategy involves students' active participation in their learning. Therefore, the learning environment is proactive and students are not just listening, but are connecting with the teacher and their peers as part of learning.

However, there are challenges toward the implementation of an AL strategy in

a mathematics classroom, as described by Eison (2010:3-4), namely learners' attention, teacher attitude, the subject content knowledge, and the attitude of learners toward learning.

2.4.5.1 Learners' natural ability to pay attention during learning and teaching time

According to Weltman (2007:22), AL is well regarded for being appealing and fun to a wide variety of students. It moves learners away from a classroom environment that is boring and get learners to collaborate and interact with one another as part of learning. Such a learning environment could also be easily excitable; therefore, such a learning environment needs guidance and structured approach. On the same notion, the same learning environment may be too demanding for a teacher if the classroom is large. Learners will need guidance and support. In large classrooms, time could be wasted.

AL is also very engaging for learners requiring they actively engage with their peers as part of learning. This might be challenging to learners who are already shy. They may not be keen to work in a group and share their understanding of certain concepts as part of learning.

2.4.5.2 Teachers' content knowledge of mathematics and attitude in teaching mathematics

Felder (2011) held the view that the teacher's fundamental role in a classroom is to equip learners with problem-solving skills and creative thinking as part of the learning process. Chan *et al*. (2015:521-522) held the view that strategies that promote AL need to also promote the development of learners' thinking and writing skills. However, it is important to note that active learning is not possible without the commitment of the teacher. The teacher needs to seek knowledge about active learning and become knowledgeable about strategies that promote active learning.

2.4.5.3 Learners' attitude toward learning

According to Eison (2010:4), learners have become accustomed to passive teaching where they sit and listen. They tend to resist new approaches to learning. A learner is an important element of his or her own learning. Their commitment is important to ensure that learning takes place. A teacher can create an environment to learn, but can never guarantee that learning will take place. It is the responsibility of the learner to ensure that they use the opportunity to learn (Doyle 2008:4).

2.4.6 An AL strategy as an effective tool in addressing dyscalculia in a mathematics classroom

According to Njeru (2012:1), mathematics is historically known as the school subject for only intellectually gifted learners. These exclusive learners will be treated as members who understand and speak a secret language. Teachers were known to teach mathematics in a rigid and uncompromising manner and learners with dyscalculia would be regarded as stupid. This puts even more pressure on learners with mathematics disability and they give up on learning mathematics. Hence, an AL strategy seeks to address this myth and make mathematics accessible to all learners.

An AL strategy entails dealing with dyscalculia in its different levels. According to Suherman *et al.* (2011:104), the main characteristics of AL is involvement of students in activities and also the exploration of their own attitudes and perception of mathematics.

Anstrom (2006:4), Garforth (2014) and Nfon (2016:437) believed intervention strategies for learners with mathematics disability should include a strategy that includes usage of concrete materials as a representation of the theory in the real world. This will allow learners to better understand the abstract aspects of mathematics. This is in line with the finding by Rosenberg-Lee *et al.* (2015:368) that a learner with dyscalculia has "prominent impairments when attempting addition and subtraction problems".

Mazibuko (2014:181) postulated that active learning includes planned series of activities that encourages learners to “process, apply, interact and share experiences as part of teaching and learning experiences”. Michael (2006:159) further emphasised that AL involves learners in the learning process and enhances problem-solving skills and the ability to remember facts, which leads to an effective learning experience. Therefore, it is important for an effective strategy for learners with dyscalculia to include observation and application of the theory that they are learning to help them conceptualise mathematical concepts.

According to Weiser (2014:1), there is a general observation that learners with learning disabilities experience feelings of frustration in their school life. These negative feelings translate into demotivation and lacking the eagerness to read and write. They are generally observed not complete their tasks for fear of failure, or being embarrassed and disrespected by their peers.

AL is perceived to allow learners, regardless of their abilities, to own their learning. Hott *et al*. (2014:1) held the view that a teaching strategy that could meet the needs of learners with dyscalculia, will allow them to conceptualise a mathematics problem and persevere in solving it. They will have the freedom to reason abstractly and concretely, whether by usage of manipulatives or relevant quantitative material. They would look for and express regularity in repeated practices. This framework is in line with the description of an AL strategy by Röj-Lindberg (2001:5) – when a learner is given the opportunity to actively create structures of cognitive connections within and between mathematics concepts, they are given conceptual knowledge and intelligent learning. The AL approach creates an opportunity to actively construct their understanding of mathematical concepts.

2.5 CHAPTER SUMMARY

This chapter revealed what dyscalculia is and different elements of an AL strategy necessary for addressing dyscalculia in a mathematics classroom.

The theoretical framework underpinning this was discussed, together with its relevance to the study. There was also a discussion on the definitions of the operational concepts within the concept of the usage of an active learning strategy in addressing dyscalculia in a mathematics classroom.

The literature review noted the prevalence of dyscalculia by various countries, including Kenya, India, China, New Zealand, the USA and the UK. There is no present study that links AL as an intervention strategy. The literature review further deliberated on the usage of AL by the USA and the UK as a pedagogical tool in a mathematics classroom and the implications thereof. There was also a discussion about defects in the brain memory areas that make learning mathematics a challenge for learners with dyscalculia. The defects in the brain could be either genetic or due to external factors. However, the brain defect affects the quantity of the grey matter, which has an impact on the ability to remember and store information. The semantic, procedural and visuospatial memory areas of the brain are the most affected due to their intricate responsibility to process mathematical concepts.

Chapter 3 will present the research methodology, design and data generation of the study.

CHAPTER 3

DATA GENERATION ON AN ACTIVE LEARNING STRATEGY IN ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM

3.1 INTRODUCTION

This study seeks to formulate an active learning strategy (AL strategy) for addressing dyscalculia in a mathematics classroom. In order to achieve the objectives of the study, this chapter discusses the research design and methodology that is used to ensure that the goal is accomplished. Chapter 2 discussed in detail the theoretical framework and operational concepts underpinning the study. Chapter 2 also included a comprehensive discussion on the reviewed literature that embodies this study. Participatory Action Research (PAR) is the chosen research design and methodology for the generation of data for this study. Chapter 3 discusses the principles and key qualities that describe PAR as a methodology, the link between Critical Emancipatory Research (CER) and PAR, and the cyclic steps engaged in PAR.

The cyclic steps include the identification of the problem, drawing up a plan to address the identified problem, the implementation of the plan, observation and recording of the consequences of the plan in addressing the problem, and reflection on the consequences of the plan. The reflection will then form part of the re-planning and the cycle will continue in that manner.

PAR is a qualitative research methodology used for generating data through interactions with participants through narratives of their experiences, feelings and beliefs (Agarwal, Moya, Yasmi & Seymour 2015:24; MacDonald 2012:40). This chapter outlines in detail how data is generated using PAR. It describes the preparatory meetings with the participants before the implementation of the intervention strategy. There is an account of how the

research team participated during the engagement meeting to select relevant topics that would be covered as part of the intervention strategy.

It is also important to consider all factors around the successes and failures that the AL strategy has as an intervention strategy for addressing dyscalculia in a mathematics classroom. There will be a discussion on the elements of the AL strategy that are relevant in dealing with dyscalculia in a mathematics classroom. The strengths and hindrances of these elements will also be discussed during the research meetings. In working with the participants, the study will profile the participants, identify priorities and draw up the action plan. It is also imperative to discuss the data collection procedure briefly and to consider the connection between the data collection procedure and CER as a paradigm underpinning the study.

3.2 METHODOLOGY

The chosen methodology to generate data in this study is the Participatory Action Research (PAR) method. The discussion below entails the origin and historical view of PAR and its meaning. PAR also includes various stages as a means of generating data and hence, this section further discusses the various stages involved and their relevance to this study.

3.2.1 Origin and historical background of PAR

PAR is traced back as a research methodology that has a prominent approach in working with the marginalised members of the society with an aim to better the circumstances that make them vulnerable. Through PAR, members of the society who are affected by research questions have an opportunity to relate and interpret their personal experiences. PAR is committed to linking social justice with research (Bergold & Thomas 2012:191; Jordan & Brannon 2006:186). According to Mash (2014:3), PAR is a research methodology within the boundaries of this emancipatory-critical paradigm (ECP). Within the name itself, there is emancipation and participation. “People in the ECP are neither objects to be measured, nor

subjects to be understood, but are rather participants in both action and research" (Mash 2014:3), whereas in the other, conventional research methodology, the researcher does not have to include individuals affected by the research as co-researchers. People are thereby regarded as objects of study and there is no value for research to consider their views and ideas.

Hocevar (2016:Online) furthermore stated, "The intent of PAR is to serve the common people rather than the upper-class." PAR is a research methodology that seeks to elevate the marginalised individuals in a society by helping them participate in finding a solution to their problem, contrary to the traditional research methodology, which imposes a solution onto the marginalised and not necessarily elevating them to be better individuals.

In the 1930s the views of PAR were thought of as applied social science. PAR is linked to the work of Kurt Lewin and Paulo Freire which was prominent in the 1990s (Hocevar 2016).

Kurt Lewin, one of the acknowledged founding fathers of PAR, was himself a social scientist, who saw action research as a procedure that would allow workers to have a greater say in their work context (Bate 2000:3). He promoted action research on the basis that workers' greater involvement would probably improve their productivity (Gillis & Jackson 2002:264; McNiff & Whitehead 2006:21; Wheeler 2008:1638). According to Wheeler (2008:1639), Lewin was born in 1890 and started his intensive research work in 1930 until his death in 1945. His work advocated for studying volition, emotion and emotions, which was a taboo at the time. Lewin coined the term "action research" in describing a form of research which links the experiential approach of social science with programmes that are targeting social action in addressing social problems (Ozanne & Saatcioglu 2008:427).

PAR can also be traced back to the work of Paulo Freire, the Brazilian scholar who referred to PAR as "community action research" (CAR). Community action research is a type of research that seeks to address the neutrality of the researcher and to support the researcher who works with marginalised

groups (Hall 2005:7; Ozanne & Saatcioglu 2008:430).

Paulo Freire argued against the traditional education system that views learners as objects with no opinions. He advocated for the theory he called "conscientisation", which holds the notion of self-awareness and self-belief (McDonald 2012:37; McInttyre 2002:391; Ozanne & Saatcioglu 2008:430). In this notion, individuals have views and ideas and they have the freedom to share them as their contribution in making their world a better place. It advocates for a relationship between the teacher and the student (Armitage 2011:5; Ozanne & Saatcioglu 2008:430).

In the early 1970s, the term "Participatory Action Research "was used for the first time to describe a variety of community-based approaches to the creation of knowledge. These approached were focused on the creation of knowledge through social investigations. The concept was recognised as participatory research and the sister concept as participatory action research (Hall 2005:3).

Participatory Action Research (PAR) is defined as a type of research where people or communities participate actively with a researcher in a study (Whyte, Greenwood & Lazes 1989:514). PAR ideas are known to have taken strength around 1985 as part of the work initiated by William Foote Whyte. According to Whyte *et al.* (1989:515), Whyte did not initiate PAR, but influenced its development. The participatory approach was based on ownership of decision-making. This kind of approach challenges the "top-down" approach in making a development difference. The top-down approach gives power to the hands of external professionals. PAR, on the other hand, relinquishes power to partners, participants and stakeholders who are impacted by the need for social change or development.

PAR is known to be in contrast with the positivist ideas, which regard participants in a research as subjects. It is in contrast with types of research where members of the community or organisers are treated passively (Jordan 2003:187; Mash 2014:1; Whyte *et al.* 1989:515). PAR gives individuals who are affected by a particular issue an opportunity to participate in devising a

solution. According to Whyte (1991:7) and Johnson and Guzman (2013:405), PAR evolves around three streams of intellectual development and action, namely the social research methodology that ensures recognition and representation of the marginalised or oppressed, participation in decision-making by interested members of the community, regardless of their social ranking, and socio-technical systems thinking regarding organisational behaviour.

According to Moleko (2014:55-56), PAR is a methodology that humbles people, especially individuals from high social rankings because all participants are regarded as equal. The very nature of PAR is such that all participants are welcomed, important and appreciated. They are afforded an opportunity to make a positive contribution without intimidation.

3.2.2 Objectives of PAR

The underlying objective of PAR is both political and transformative. Eruera (2010:2) referred to PAR as a political process that supports activities within the community and social justice, and challenges inequalities within the community. According to Leftwich (2015:7), politics is the activity through which people make, preserve and amend general rules under which they live. Such activities maintain a human relationship that has power undertones. Hence, PAR empowers vulnerable members of the communities to gain knowledge and understanding of their circumstance and participate in making those changes. According to McTaggart (1997:585) and Hocevar (2016) the most important goal of PAR is to empower the marginalised individuals through social change and thereby encouraging capacity development of those individuals who participate in the study.

In PAR, participants are at the same level as the researcher and their views and experiences form an important part of the findings. Chapman and Dold (2009:1) and Eruera (2010:1) are of the opinion that in PAR, the researcher and participants are influencing a part of the community that the participants are a part of. Therefore the knowledge gained does not end with the

researcher and participants, but influences the lives where each member of the team comes from.

Dentith, Measor and O'Malley (2012) held the view that PAR is against the idea of an unequal power relationship between the researcher and the participants. Participants are encouraged to recognise and understand the dynamics of their world and participate in making the changes that they desire to see. Participants are empowered mostly through working with the researcher to plan and create social change (Eruera 2010:2). Contrary to the traditional research methodology, where the researcher is an observer, within PAR the researcher is also a participant, together with the selected participants (Mash 2014:1). In many respects, PAR aims to get information about the problem that exists in the community in a most responsible way of engaging the research population. It therefore promotes critical thinking, that leads to confident, informed communities who have a common goal of reaching solutions to their problems.

3.2.3 Principles of PAR

According to Bergold and Thomas (2012), the four fundamental principles of PAR are democracy, the need for freedom for individuals to express what they think and feel without fear, the definition of the community and those selected to participate, and various levels of participation. McDonald (2012:94) postulated that the most prominent principles in PAR are democracy, which underpins equality, freedom from oppression, and the political process. The two scholars share similar views on the principles that guide the success of PAR.

Firstly, the democratic nature of PAR was articulated by Bergold and Thomas (2012), who held the view that democracy is a precondition to participatory research. The participation of the marginalised in a PAR demands a system where they are recognised as underprivileged but with respect and of the same value as the researcher. Undertones of PAR is that all members of the research team are of equal value and there is no one who has views that are

superior to any other member in a team.

Secondly, PAR is liberating (McDonald 2012:39). Torre (2008:5) held the view that PAR gives a researcher an opportunity not to overpower participants; however, the researcher has an opportunity to be a committed participant, facilitator and learner in the research process. This ensures equal distribution of power to all the members of the team.

Thirdly, the success of PAR demands that participants feel free to express their views and disclose their personal views. According to Bergold and Thomas (2012), participants need a "safe space" where they are confident that whatever they share, will not be used against them. It is easier for individuals to express their views and experiences in an environment where they feel a sense of belonging, where they feel safe and accepted. On the contrary, Balcazar, Key, Kaplan and Saurez-Balcazar (2006:1) presented an argument that traditional positivist methodology views participants as subjects of study who do not have an input into a research other than to respond to research questions posed to them.

Fourthly, PAR emulates political processes, as it demands that individuals participating in the research team should be organised and respect the views of those in the team. The processes of PAR demand that participants state their views about institutions that they seek to test. Therefore, they have to do record-keeping and be critical in their reasoning. Furthermore, Mash (2014:2) presented an argument that PAR involves working with individuals, rather than working on individuals. This working relationship requires that hierarchy and power should be addressed to ensure that participants genuinely respect one another and similarly maintain an open and democratic working group.

3.2.4 Stages of PAR

The key identified features of PAR are the mechanical steps that are followed in achieving the objectives of the research. These steps are generally known to follow a spiral of self-reflective cycles (Kemmis & Taggart 2007:563).

Kemmis and Taggart (2007:563) further attested that the stages of PAR are dynamic and flexible, adapting to the knowledge and culture of the community where research is conducted. The identified steps, according to Kemmis and Taggart (2007:563) are planning a change, acting and observing the process and consequences of change, reflecting on these processes and consequences, re-planning, acting and observing again, and reflecting again. The planning phase of the self-reflexive cycle is described as the phase where the community is invited to participate in the proposed research study. This invitation is an opportunity to form partnerships with members of the research team who are from different lifestyles. During this phase, the research question is defined and the planning of the research design and the methods that will be used to collect data are explained.

The action phase of the self-reflexive cycle involves full participation of the community members in putting the plan of action to work. In this phase participants are involved in detailed discussions on the activities for data collection. Participants are further involved in getting the plan to work through observation, monitoring, analysing and evaluation of outcomes.

The reflecting phase of the self-reflexive cycle includes self-reflection by the researcher and the participants. In their reflections, they look into what they have learned, whether it challenges how they think or do things, whether they are willing to adapt the new change, how they evaluate the significance of the newly acquired information, and whether the proposed intervention is in line with the findings.

Re-planning of the self-reflexive cycle involves the researcher and the community implementing the intervention strategy and ensuring that it works. Acting and observing again in the self-reflexive cycle refers to a phase where the intervention strategy is implemented, observed, monitored and evaluated.

The cycle goes on by following the contributions of the participants. Participants identify the research problem as the initial stage and formulate the research question before they can start with the planning stage. Boog

(2003:427) stated that the cyclic nature of PAR steps simply means that it is not possible to be sure where the cycle ended and began, because each cycle is determined by the previous one. There is also no end to the number of stages and the time spent on each stage; it cannot be pre-determined. The team may spend time on any of the stage as deemed necessary. According to Kemmis and McTaggart (2007:277), the success of the study is not measured by how rigidly the participants have followed the steps. The important aspect of the PAR stages is that the participants grow in knowledge and understanding of the study and move toward achieving the set objective of the study.

Kemmis and McTaggart (2007:276) referred to PAR as a social process of collaborate learning between the researcher and co-researchers. The learning process involves sharing knowledge and ideas, thereby influencing one another. There are also other tasks other than discussions within the study that are necessary. It is important to establish the coordinating team, arranging of the logistics of meetings, communications channels, management of time for meetings, time management during the team meetings and also allowing time for reflection and feedback. The success of the steps does not depend on the rigid following of the defined steps; however, it depends on the communication and understanding of what has happened in each step. Each step in the spiral reflection needs to be taken collaboratively by all participants (Kemmis and McTaggart 2007:563).

3.2.4.1 Initial planning stage

In general, communities are familiar with research where they passively answer questions and never really see the impact of their answers. On the other hand, PAR is a kind of a research that utilises an approach that promotes collaboration with the “subordinates or oppressed groups” (Jordan 2003:186) of the society. Therefore, the idea of PAR was foreign to participants because they thought they were not educated enough to be engaged at that level. Kelly (2005:69) held the view that PAR is about presenting ideas to the community based on the assessment and working

with that community in creating the priority stages. Therefore, the important part of the planning phase in a research is to identify a variety of community members to form the research team. Once the participating community members are identified, it is important to foster a good relationship between the researcher and the participants. According to McDonald (2012:45), a good relationship between the researcher and participants is based on trust and respect.

Dyscalculia affects other aspects of learners' lives, including their confidence and other social aspect of their lives. Therefore, it is important to build that rapport of trust and confidence. It is important that all participants should feel welcome and believe that the study is there to influence their lives positively. This positive relationship enables them to share their stories. Dworski-Riggs and Langhout (2010:227) held the view that the researcher has to show compassion for the participants and thereby foster a relationship that is accommodative and respectful all times.

During the planning stage, it was evident that participants were not familiar with the concept of dyscalculia and active learning. There were also not aware of the existence of PAR. I explained the concept of PAR, emphasising that they are an important part of the research and that they are of equal value. Their level of education does not measure their views and knowledge. Participants were then given diaries to record their reflections and any ideas that they wished to contribute. Whyte (1991:21) emphasised that PAR requires commitment from all participants, mutual respect, being humble and flexible, and have a keen interest in solving the problem as identified by the research. Such ideas were communicated to the research team. The plan of action was then agreed on.

3.2.5 Ontology and epistemology of PAR

Qhosola (2016:107) refers to ontology as that which describes people's social reality and how they define that reality. This reality in PAR is considered as socially constructed from understanding of the experiences and ideas shared

by participants.

According to Kemmis and McTaggart (2007:565), PAR refers to how knowledge is transferred and the fruits of this knowledge are real and can be observed. The observation of the existence of this knowledge is seen from "what people do, how people interact with the world and with others; what people mean and what they value; the discourses in which people understand and interpret their world". In PAR, the beliefs about reality are that both the researcher and co-researcher create the perspective of the world. Their perception of the world is informed by their experiences, emotions and feelings. According to De Vos, Strydom, Fouche and Delport (2011:498), in PAR, reality is constructed by both the researcher and co-researchers when they work together in seeking to address the challenges that are experienced by the communities. Kincheloe (2009:110) held the view that a reality in PAR is to have various versions and it is not swayed by the views of the researcher at the expense of the communities that are being researched.

According to Qhosola (2016:108), the term "epistemology" is used to define the body of knowledge in terms of what can be known and the criteria that knowledge must meet to be regarded as the truth.

Mosia (2016:89) postulated that PAR creates a platform where the nature of knowledge is created from the relationship that is fostered between the researcher and the participants. Kincheloe (2009:107) held the view that the epistemological position in PAR is that there needs to exist a platform where views and ideas shared by the marginalised are heard. These views are then legitamised and translated into body of knowledge. This study responds to the challenge faced by learners with dyscalculia. The study further seeks to create the intervention strategy by involving the very marginalised members of the community and those that are affected by dyscalculia. The study involves learners, teachers, parents and a psychologist – they all share different backgrounds, but their various backgrounds are an important part of reality and they contribute in the creation of knowledge.

According to Mosia (2016:91), the epistemological position of PAR enables the co-researchers to make distinctive inputs by reporting their experiences of dyscalculia and how AL could be used to address dyscalculia in a mathematics classroom.

3.2.6 Usage of PAR within this study

Gillis and Jackson (2002:264) postulated that PAR is a type of research that seeks to collect data and analyse it with the sole aim of not merely knowing about the problem, but also making a difference through practical engagements. MacDonald (2012:36) embodies the idea that PAR creates a space where ordinary people have a right to participate meaningfully in analysing their problem and the solution to their problem. In this space they are free to think and reshape their knowledge on those issues that affect them daily. In this study, I acknowledge that mathematics is one of the most important subjects that are taught in the education system. However, the outcry of poor mathematics performance is very much in the public domain. On the other hand, there are individuals who have a mathematics disability who form part of the poor performance statistics as a result of dyscalculia. These individuals remain frustrated in the education system and in our communities. This study seeks to use AL as an intervention strategy in addressing dyscalculia in a mathematics classroom.

This study further uses PAR as a methodology because it seeks to inform and create space for knowledge, while at the same time emancipate those who have dyscalculia and the members of their communities who are directly and indirectly affected by their deficiencies.

PAR is acknowledged in situations where people feel marginalised and disadvantaged. However, they see a need to be engaged in a respectful and thoughtful manner (Denzin & Lincoln 2000:573). People generally do realise that they have a problem, but they are not sure how they can get a solution to their problem. However, when they are engaged in a manner presented by PAR, they make a difference in a manner that empowers them. This study will

present AL in addressing the problem posed by dyscalculia.

One of the advantages of PAR as a methodology is the involvement of participants as co-researchers because they are a part of a targeted audience. Goeke and Kubanski (2012) further attested that the involvement of individuals with disabilities as co-researchers is crucial. Individuals with disabilities are individuals with views and experiences, and they would understand and empathise with those in a similar condition as they are in. It is for this reason that this study includes individuals with dyscalculia and those that have an interest in issues affecting individuals with dyscalculia.

According to Eruera (2010:2) and Dold and Chapman (2011:512), PAR seeks to engage participants by giving them a voice and allowing them to reflect and identify the problem or what is perceived as an issue as according to the study. The PAR team represents the views of the community where they belong which has the problem. Participation in the study is then gained from all members from the acknowledgement of that problem and the desire to seek solution to the problem. PAR allows for an opportunity to share information and build knowledge of involved individuals. In this study, this information sharing and knowledge building were done to assist the research team to understand dyscalculia as a problem that exists in their community. Having spoken to teachers and members of the Inclusive Education Team, I realised that dyscalculia was not known as a condition that exists. Their general thought was that mathematics simply is difficult and hence the poor performance in some learners. As noted in Annexure 1, a workshop meeting was conducted with an expert in dyscalculia to clarify and educate members about such a mathematical disability that exists in their community.

Such information sessions were followed by sessions that included reflection, planning, clarification of terms, and agreeing on the logistics that would ensure the inclusion of all the participants. This was also to ensure the democracy and involvement of all participants, as suggested by McDonald (2012:39). PAR is further known for its important role in influencing change in education, mainly in the development of teachers and improvement in

learning and teaching (Elliot 1991; Mabuuke 2013:31). This study contributes to the development of teachers – on how they could intervene in teaching learners with dyscalculia and further ensuring that mathematics is learned by all learners, regardless of their abilities.

3.2.7 Relevance of PAR to the study

It is acknowledged that mathematics is an important subject in career selection and in everyday engagement activity. Learners with dyscalculia are therefore inhibited from participating in learning and understanding mathematics. Therefore, they are excluded from living a normal life and advancing careers that demand mathematical aptitude. This study seeks to propose AL in addressing dyscalculia in a mathematics classroom. Therefore, the study seeks justice on behalf of individuals excluded from learning mathematics. According to Qhosola (2016:96), PAR encompasses the process of changing lives of individuals within a community. Watters and Comeau (2014:10) further attested that empowerment of individuals through PAR in the community has a positive influence on the quality of their lives. Therefore PAR is relevant in this study, because it cares for the needs of underprivileged individuals. PAR echoes the sentiments of this study in making a difference in the lives of learners with dyscalculia.

According to Moleko (2014:56), PAR is a methodology that elevates participants to a standard of being co-researchers. As co-researchers, they share their feelings, knowledge and experiences that are a valuable contribution to the study. The researcher and the participants are all of the same value and no one is elevated above the other. Sithole and Mbele (2008:29) attested that PAR is a caring form of a methodology in research because it creates space for power-sharing and an exchange of ideas in an unthreatening manner.

CER is the theoretical framework that underpins this study. According to Tsotetsi and Mahlomaholo (2015:49), CER offers communal working relations between the researcher and the participants who are members of the affected

community. The researcher and the participants are the same level. PAR also encourages involvement of participants from diverse background and that their views and experiences are a valuable part of the research data. Furthermore, Balcazar *et al.* (2006:1) and Deepak (2012:21) attested that emancipatory research needs to involve different groups of people, including individuals with disabilities if they are to add value to the study. To ensure full engagement of all participants, regardless of their background, the researcher needs to be mindful of the compromised skills, especially where participants are not well equipped with communication skills because of the existing disabilities.

3.3 ETHICAL CONSIDERATIONS

It is a requirement at the University of the Free State that a proposal is written to two committees. As part of the initial stage of my research study, I had to write a proposal with the proposed title to the first committee. I then wrote a second proposal to the Ethical Clearance Committee, in order to obtain ethical clearance for the study.

According to Cohen, Marion and Morrison (2011:133) and Henning, Van Rensburg and Smit (2004:96), in order to gain access to the participants and the venue where the research will be held, it is important to first request permission to do so. Therefore I applied for permission to conduct the research from the research office at the Free State Department of Education. Participants were met individually and in small groups to explain the study. The letters of invitation and consent forms were read and explained to participants, even in their mother tongue where necessary.

Participants were then given the opportunity to read the consent forms with understanding and sign them if satisfied. They were given the assurance that the collected data would be anonymous and will be kept safe for no longer than six months as, according to Mkhwanazi (2007:30), the research personal information has to be destroyed after six months.

3.4 DATA GENERATION

According to Bergold and Thomas (2012), in PAR, methods of data collection should build around the everyday experiences of participants and this helps them get acquainted with their involvement in the study. This section explains the generation of data and the profiling of participants, whose experiences form the generated data. The discussion is then followed by the data generation procedures.

3.5 RESEARCH DESIGN

3.5.1 Initial meeting

In PAR, participants are responsible for collecting and analysing data and citing recommendations based on the interpreted results (Mertens 2010:374). The involvement of participants in PAR is central. Wicks and Reason (2009:243) attested that "the success or failure of an action research venture often depends on what happens at the beginning of the inquiry process: in the way access is established, and on how participants and co-researchers are engaged early on", notwithstanding the fact that their experiences are unique and some may not have the confidence to share their thoughts. However, the researcher has to be vigilant and engage all participants and encourage them to share their views and experiences. Failing to do so defeats the whole purpose of PAR. Khan and Chovanec (2010:40) conducted the believe that PAR should serve the interests of the marginalised and give them the platform to voice their views about the problem and the solution to the problem. However, this notion is compromised when the research is conducted on behalf of those in power. The researcher's liberty to engage the marginalised and collect their true experiences is compromised and so is the freedom of the marginalised to say exactly what they think and feel.

According to Angrosino, Barbour, Flick and Kvale (2007:8), the researcher can only generate data if the researcher interacts with participants to understand what they know and their perception of the world they live in.

Through this interaction, the researcher is able to get the information that they would probably have not asked. For example, from a casual conversation with a parent, I learned that her child (who is also a participant) normally sleeps during class. Teachers never mentioned this and it was through this casual conversation that I discovered that piece of information, which could have a contributory factor on the learner's poor mathematics performance. McDonald (2012:45) further attested that in order for PAR to be a success, there has to be a positive relationship between the researcher and the participants. The positive relationship is dependent on the level of trust and the feeling of being valued and appreciated. It was very important to explain to participants that I did not have all the answers and that, regardless of their level of education, I valued their opinions and looked forward to their sharing what they know. I further mentioned that I would share what I know and we would together conclude on the AL strategy in dealing with dyscalculia in a mathematics classroom.

Eruera (2010:3) held the view that there is a variety of activities that could be used to gain participation in order to gain data. Krishnaswamy (2004:7) stated that a researcher could use note card exercises. Patton (2003:5) announced that there has to be an appropriate physical space where the meeting with participants takes place; this space should be a human and social environment, where programme activities, informal interactions and unplanned activities take place, through native language usage and nonverbal communication. Dentith (2012:Online) also referred to the "safe space" as the environment that is welcoming in such a way that the individual is not intimidated to say what they think and feel about what is being discussed.

In this study, meetings took place at a school that learners attended and the parents were a walking distance from the school. All participants understand English and are fluent in Sesotho. They all live around the same community and already have relationships with one another on parent-teacher level.

I was invited by the Provincial Inclusive Department at the Free State Department of Education to make a presentation at their initial planning

meeting for 2017. The meeting was attended by the Member of Executive Council (MEC) of the Free State, the Curriculum Director and the Deputy Chief Education Specialist in Inclusive Education.

In this meeting, I explained the aim and objectives of the study and the key concepts: mainly dyscalculia and an AL strategy. The MEC asked questions relating to the symptoms of dyscalculia and these were explained in detail, as explained in Chapter 2. The MEC and the director expressed support toward the study and requested that once the study is completed, the Department would want to work with the University in conduction workshops to create awareness of dyscalculia and how teachers and learners could be supported in addressing the problem.

3.5.2 Formulating a research question

The research team met, following the conducted workshop on dyscalculia and active learning (AL). This was the second research meeting, which aimed to establish the common goal for participants involved in the research. The member of the school-based support team (SBST) led this meeting. The teacher was responsible for time-keeping. Participants were excited when they gained the knowledge that dyscalculia was not a life sentence. In this meeting, we discussed the link between dyscalculia and AL. We then identified the elements of AL that were relevant in addressing dyscalculia in a mathematics classroom.

We also looked into the mathematics test that is normally used to analyse the depth of dyscalculia in learners. It was then agreed that learners would write such a test so we could understand the areas of mathematics weakness. The results would also guide the lesson that would be prepared and taught in a mathematics classroom as part of the implementation phase.

3.5.3 Profiling the research site

The school is situated in Bloemfontein, Free State, in South Africa in the

Motheo district. It is a primary school with 700 learners in house. The school has a functioning school-based support team (SBST) that is responsible for referring learners that are observed to have learning difficulties. The school caters for learners form Grade 1 to Grade 7. There are 25 teachers and 6 non-teaching staff. The school has a very strong working team with an interest in mathematics. The school has a working mathematics laboratory. The research project was fully supported by the principal and the teachers in the school.

3.5.4 Co-researchers

The results of PAR are dependent on the selected participants and, therefore, it is important to select the relevant participants. When selecting participants for PAR, Balcazar *et al.* (2006:1) and Katigbak, Foley, Robert and Hutchinson (2016:210) declared that the focus group should include various members of the community who are affected by the problem that the research seeks to address. They further advocated for the involvement of individuals with disabilities; hence, the selection of co-researchers in this study included individuals with dyscalculia.

This section discusses the profile of participants and their roles as co-researchers in the study. According to Eruera (2010:1), PAR demands that individuals who are participants, should be motivated to identify the problem, find the solution to the problem and also deal with any issues that could emerge.

The participant team included the following individuals: learners who are underperforming in mathematics and excelling in other subjects, the two mathematics teachers, a teacher and Inclusive Education Team member, a psychologist, and a subject advisor at the inclusive education level.

3.5.5 Participant profiling

Table 3.1: Participant profiling

Participant	Contribution	Experience
Learners	The proposed intervention strategy is designed for learners with dyscalculia and these learners represent such a population. Their participation in the team is important so they could share their experiences in learning mathematics. They could be able suggest how the intervention could be adjusted to support them adequately.	These learners perform at level 1 in mathematics and perform at level 5 to 7 in other school subjects.
Mathematics teachers	They are aware of the mathematical challenges faced by learners. Their contribution includes implementing the intervention strategy.	They have experience in teaching mathematics. They have also been involved in the introduction of technology and manipulatives in the teaching and learning of mathematics.
Parents	They have relationships with learners. They can give input in motivating learners to learn mathematics.	They are the ordinary members of the community where these learners live. They engage with learners daily through normal social

	They can also give feedback on their perspective of how the intervention strategy is welcomed by learners at home.	interaction and assisting their children with mathematics homework. They get to experience the frustration that learners go through in trying to understand mathematical concepts.
District-based support team (DBST): Psychologist	As the experienced psychologist in dealing with learning disabilities, they will be able to share their experiences and knowledge in dealing with challenges faced by learners with dyscalculia. They will be able to give guidance on the psychological wellbeing of learners to ensure that the proposed intervention strategy meets the needs of the learners holistically.	They are professionals working with the parents and school upon the recommendation of the Learning Support Advisor (LSA).
Learning Support Advisor : LSA	They will share experience and knowledge in dealing with needs of learners with dyscalculia. They will closely guide the team in devising an intervention strategy that ensures that the mathematics needs of a learner are met, and closely monitor the	They are professionals working directly with the school upon the recommendation of the SBST member of the school.

	progress of a learner following the intervention strategy.	
School-based support team (SBST): Coordinator	As the experienced member of the site-based team at a school, she is experienced in handling learners with learning disabilities and parents, and also guide teachers on how they should adjust the curriculum to reach learners of all abilities. She has the ability to motivate learners, teachers and parents.	She is the first point of contact when the teacher suspects that the learner shows symptoms of a learning disability. She will either advise the teacher on the initial intervention and monitor progress with the teacher. She is also responsible for managing the referrals in case of advanced intervention needed.

3.6 Plan of action

As the initial stage of recruiting participants to form part of the research team, the title of the research study “An active learning strategy in addressing dyscalculia in a mathematics classroom” was discussed. As part of the initial one-on-one meeting with each participant, the terms “active learning” and “dyscalculia” were explained in detail. I further explained PAR as the methodology of the study and what the expectations would be from their side. Krishnaswamy (2004:2) held the view that the success of study pursued under PAR depends on the participants understanding the objectives of the study.

Participants understood that there are learners who struggle with basic arithmetic. They shared their personal stories relating to the struggle in memorising numbers and handling basic arithmetic in their everyday lives. However, they all agreed that they had never heard of dyscalculia. They have

always thought that such learners were just not intelligent enough.

This part of the research study followed after the workshop meeting that was conducted to assist participants in gaining basic knowledge and an understanding of dyscalculia and the proposed pedagogical strategy to deal with it. The minutes of the workshop are included as Appendix 2. There was general enthusiasm among the participants, as they now understood that it was possible for all learners to learn and understand mathematics. They understood that learners affected by dyscalculia were not dumb or stupid, but faced a challenge that affects a certain sector of the community. The teachers started acknowledging a few learners from their classes who they thought could be struggling with dyscalculia. Parents started pointing out how they could bring in mathematics learning when they send their children to the tuck shop or performing household tasks such as the folding of sock into pairs. The SBST member mentioned that she would like to have similar workshops for the teachers to create awareness.

It was clear that the teachers, SBST and parents should work together in assisting learners with dyscalculia to learn mathematics. Moloi (2014:123) held the view that an action research plan should indicate the goal of the research study, the objectives that the study seeks to achieve, the strategies that will be taken to achieve those goals, the timeframe, persons responsible, resources required, and the monitoring and evaluation framework. The phases are outlined in the discussion below:

3.6.1 Phase 1: Investigate the understanding of dyscalculia and an AL strategy

Forum meeting 1

The objective of this meeting was to investigate current perspectives pertaining to the nature of and relations between dyscalculia and active learning. To achieve this objective, the specialist in dyscalculia was invited (refer to Annexure A for the agenda). During this workshop, various symptoms

of dyscalculia were discussed. The speaker discussed the Davis Intervention Strategy that they have adopted. The Davis Intervention Strategy is largely used on private consultation. However, this study seeks to empower the teacher with relevant pedagogical strategies to deal with dyscalculia in a mathematics classroom. The invited guest was the main speaker in a workshop aimed to help participants understand the concept “dyscalculia” and the current remedy that is used to help individuals with dyscalculia. Participants would reflect on the acquired information to have an opinion about dyscalculia and be able to offer informed ideas about what could be done in addressing dyscalculia in a mathematics classroom. Their opinions would be based on the newly acquired information, as well their own encounters in living or dealing with individuals with dyscalculia.

The workshop presentation was divided into sections on what dyscalculia is, the struggles faced by learners with dyscalculia and the intervention strategy that is used in the one-on-one sessions. The dyscalculia specialist started the presentation with the following statement:

> *I draw my perspective of dyscalculia from my training. Dyscalculia refers to someone who struggles with computation. For example, plus and minuses and transferring information. Learners lack desire to go to school and they will go to various lengths to avoid school just so that they not encounter mathematics.*

The specialist in dyscalculia went on to discuss the various struggles faced by learners with dyscalculia.

3.6.1.1 Struggles faced by learners with dyscalculia in a learning environment

Learners with dyscalculia struggle with conceptualising time and this affects various aspects of their lives, including what time they should wake up in order to be on time for school. In addition, when at school, they struggle to understand what it means when told that they have five minutes to finish the task. Looking at the time, they are not sure how quickly they need to work to finish the test on time. Their challenges carry on during break time – when they stand in a queue to buy whatever they want, they are not sure how much change they need to expect back because they do not have a good concept

of money. They hand over their money, only hoping to get the correct change. They will not share this kind of frustration with their friends for fear of being bullied. They struggle with distance computation as well. They battle with remembering numbers, such as telephone numbers – the struggle with numbers affects learners in various aspects and for the rest of their lives.

3.6.1.2 Existing intervention strategy for learners with dyscalculia

The Davis Dyslexia Method was created in the 1980s in the USA by Ronald Dell Davis, a man who was dyslexic. Davis taught himself and later tried to help other learners to learn how to focus and how to control their anxiety. This intervention strategy was then called the "Davis Dyslexia Method". Davis was 38 when he finally overcame dyslexia from his experimental self-taught remedies. His remedies were later refined by scientists and are now used in private consultation to help learners with dyscalculia.

Learners work with a specialist for a week. Learners are encouraged to work on concrete material, for example to work on change by going outside, looking at the sky and observing the clouds changing.

The proposed learning strategy that the invited expert in dyscalculia currently uses is one-on-one consultation with the learner. Below is the current intervention strategy by the specialist.

Firstly, work on the learner's method to internally focus on them. Learners are aware of their struggles and hence they tend to drift away to try and avoid their reality.

> Teacher A: *To understand mathematics, you need to understand change. Change – not necessarily about money. Change is one thing becoming something else.*

Learners struggle to realise that change is constantly happening around them Therefore the first part about intervention involves **change**. For example, if an individual struggles with the concept of time, it is difficult to notice change, even in nature, for instance the time when the flowers bloom and when the

leaves fall off trees.

Secondly, they work with the concept of **consequence**. “Consequence is something making something else happen” (Whitehead 2007:Online). This is the idea of cause and effect – what causes the change and what effect does the change have? For example, if you have three marbles and then you add two marbles, the consequence is that you have five marbles.

The third concept that follows, is the concept of **time**. Time needs to be mastered in order to master the concept of mathematics. For example, from the above example of adding two marbles when there were three marbles already, there is an element of time because there was a time when the marbles were three and later that changed to five marbles.

Fourthly, learners need to understand the concept of **sequence** because if learners do not name the numbers in a correct sequence, then the numbers will not match the sequence. It is therefore important for learners to understand how things follow one another. They need to understand that 2 comes after 1.

The fifth concept to master is **order**. Learner will not understand how to count without an understanding of order. Learners need to understand that things need to be in their proper place and position or condition.

The activities to explain these concepts are done visually, using clay, for example. The brain is wired to work visually until that is mastered. Then, following the visual learning from real material, learners progress by using pen and paper.

We also played video sessions explaining active learning (AL) and there were further discussions about AL. From the discussions, participants could readily identify aspects of AL that could enhance the teaching and learning of mathematics.

After the workshop, the team met shortly for a reflection meeting.

> Teacher B: *There is a student in my class who sleeps a lot and struggles a lot with mathematics.*

We asked the learner's parent, who was also one of the participants, about whether the learner sleeps on time, understanding the symptoms shared by the presenter that some learners with dyscalculia have a poor concept of time. Does the learner sleep late because of a poor sense of time or is it only because of poor time management and lack of discipline?

The presenter articulated that learners with dyscalculia *"struggle with tracking of time or estimate of time, which means they often run late".*

The first part of the meeting was attended by most participants to inform them about the study and explain that their involvement included their unreserved participation. We planned and agreed on the workshop date, which was to be conducted to explain dyscalculia in detail.

3.6.2 Phase 2: Explore the need for an AL strategy in addressing dyscalculia in a mathematics classroom

Forum meeting 2

This was the second part of the meeting where participants were given questions to answer and they were helped to answer whether they thought there was a need for an AL strategy to be used in addressing dyscalculia in a mathematics classroom.

The discussion was drawn from the symptoms of dyscalculia and reflected against the obtained understanding of an AL strategy. AL is known to actively engage learners to participate in the learning process. Learners are encouraged to own their learning by allowing them to use their personal understanding to grasp an understanding of new concepts taught in class. Through AL, learners do not necessarily always have to be in class. The learning environment is not confined to one place. Learners are allowed to

engage with their peers, teacher and even family and friends as part of their learning. Various elements of AL are discussed in detail in Chapter 2. In Chapter 3, relevant elements are discussed with the focus group to come to an agreement about the relevant AL elements. During the workshop with an expert from Davis Dyslexia, attention was drawn to the following symptoms of dyscalculia: feeling sick when doing mathematics, confusing numbers (for example, confusing 6 with 9), confusing the sequencing of numbers, such as the number before and after 5. Dyscalculia learners make simple mistakes in mathematics for someone of their age and exposure; for example, they may confuse addition with subtraction.

Dyscalculia is also depicted through signs of low self-esteem and learners hiding through bad behaviour or isolation. Even though dyscalculic learners are often extremely talented in other areas, such as arts, drama, music, storytelling, sales, business and design, their inability to cope with daily activities, such as telling time and not having a proper sense of direction, affects their everyday life. They will often using their fingers to count and this can be embarrassing to them, as they grow older. According to Ranpura (2006:Online), in an interview with Brian Butterworth (a professor of cognitive neuropsychology), the first dyscalculia case they discovered in the UK was of an inmate who was sentenced because of shoplifting. When he was asked why he shoplifted, he said he stole because he could not handle change and to avoid being embarrassed, he decided to steal.

The presented symptoms of dyscalculia helped the research team to have an idea of what dyscalculia was. This will help to identify the existence of dyscalculia. From the discussions, the research team knew about AL, but not in the context of assisting learners with dyscalculia. It was therefore important to have a teaching strategy that would address the highlighted symptoms. It was then agreed by all participants that the next phase of the focus group would be to select the relevant AL elements in addressing dyscalculia in a mathematics classroom.

3.6.3 Phase 3: Explore conditions and circumstances under which elements of an AL strategy would contribute to the successful implementation of AL in addressing dyscalculia

It was agreed that the team would meet to discuss and reflect following the workshop meeting. The reflection meeting was held to revisit the content of the workshop. This allowed emphasis on the understanding of dyscalculia.

Forum meeting 3

The focus team met and discussed various elements of AL and selected the elements that were deemed relevant in addressing dyscalculia. The video explaining an AL strategy in general and in a mathematics classroom was watched. The aim was to select the elements of AL that participants believed could contribute in relieving some symptoms of dyscalculia.

The elements were chosen based on the information obtained from the workshop that was led by an expert in dyscalculia, the consultant from Davis Dyslexia. The focus team set out to discuss and agree on the AL elements that were relevant in addressing dyscalculia in a mathematics classroom. The following are these elements agreed on, with the reasons and motivation for their selection.

3.6.3.1 Cooperative learning

As part of cooperative learning, the teacher would divide learners according to groups. Each group will include learners with different learning and mathematical abilities. For example, if the teacher was focusing on a “number concept” that day, the learner may be asked to go outside the school premises to collect either five small stones or three twigs; some could be asked to count and record the number of cars parked in the school yard.

> Teacher A: *I can see this working well in my class because learners get excited when they get to work outside. Even those learners who often appear lost and confused will participate and bring something in class.*

As discussed in the conducted workshop that one of the symptoms of learners

with dyscalculia is that they struggle sustaining attention, they may appear hyperactive or daydreaming at times. Therefore, those learners who are hyperactive will be assisted to channel their energy in a positive manner and those learners who appear to be daydreaming will be engaged actively.

During the meeting it was agreed that the scope of information that the team has, was limited and there was, therefore, a need to understand how cooperative learning could be implemented to benefit learners with dyscalculia, without excluding those learners who do not have the same challenge. It was then agreed that there will be a meeting prior to the implementation where the team will watch videos about cooperative learning to enhance their understanding of cooperative learning and best practice of implementation.

3.6.3.2 Effective questioning and assessment

According to the information gained during the workshop, learners with dyscalculia are observed to have poor self-esteem. They often hide their weaknesses, using compensation strategies of any nature. The observation was, therefore, that such learners are not keen on answering questions in class.

Learners also confirmed that they get nervous when they have to write any form of assessment, partly because they know that they will always get the lowest marks in class. Mathematics that is basic and simple for their peers, is difficult for them. Hence, the whole questioning and assessing part of learning was an uncomfortable experience to them.

Teacher B reflected that Learner A often sleeps in class and *this could be because she is bored and sleeping is part of the compensation strategy*.

The team agreed that there was an issue there. However, the parent was encouraged to monitor the sleeping time of the learner to ensure that there were no other contributing factors toward the learner sleeping in class.

However, it was pointed out that the same learner participated very well during other subject lessons, especially in Arts and Culture. Therefore, there was a compelling suggestion that the issue was with the learner. Perhaps the learner was bored. The learner was very shy to express herself as to the reason why she slept in class.

The research team agreed that the researcher would also discuss this matter with the learners and get their perception of how they feel about learning and why they sleep during teaching time.

Parent A also made a note that Learner A is often very talkative and engaging at home until it is time to do mathematics. She enjoys watching television, but the problem starts when it is time to do her mathematics homework.

> Learner A: *I do not like doing mathematics homework or test because sometimes the teacher calls the marks in front of the whole class. This can be embarrassing sometimes.*

It was also discussed that teachers need to be engaging to their learners when marking individual assessments. It is important that the teacher should analyse the errors made by the learners and seek to help them to understand the concepts that they are not clear about. They should work with the learners to help them understand where they went wrong, so that they could improve next time. Learners with dyscalculia are known to easily get frustrated and emotional about school and assessment. Therefore, praising and encouraging them will assist and motivate them to be positive about school and assessments.

3.6.3.3 Peer teaching

As reference from the workshop with a specialist in dyscalculia, learners with dyscalculia *seems bright, highly intelligent and articulate but are still unable to do math at appropriate level*.

Teacher A reflected that *learners have a way of understanding each other. They use the language that is common to them in simplifying concepts.*

As part of peer teaching, a teacher may change the classroom sitting arrangement; however, they should ensure that the learners are comfortable with whom they are paired with. It is, however, important that a learner with dyscalculia is paired with a learner who has a strong mathematical aptitude.

> Teacher B: *The teacher will also need to communicate clearly to learners what they expect them to do and never ever pair learners at the same level together.*
>
> Teacher A: *As part of peer teaching, a learner who gets the answer correctly first, could move on to assist the learner who is still struggling.*

It was agreed by the focus team that peer teaching could be a brilliant confidence booster and help learners with dyscalculia to master mathematical concepts. The teacher will also need to change the pairing from time to time. At times, they may work like a hive, which is when the learner understands they may move to the next one to help them understand. They could constantly move like that, until they all understand.

3.6.3.4 Usage of manipulatives

Based on the obtained information from the workshop presentation, it was noted that learners with dyscalculia learn best through hands-on experience, demonstrations, experimentation, observation and visual aids.

> Teacher A*: I have noted that every time I ask my learners to work on blocks and other manipulatives that I have in my class, learners get very excited. And that tells me that they are having fun while learning. I therefore believe that even learners with dyscalculia will benefit.*
>
> Parent A: *I like that example about asking my child to get plates. For example, during dinnertime, I can ask my child to get plates for everybody in the family. We are a family of five. So I can say get plates for everyone or perhaps say, I will not be eating dinner tonight. Please get plates for everyone in the house, except myself.*

The focus team agreed that this would be a nice continuation of learning at home.

Parent C reflected:

> *I can also ask my child to get four slices of bread to make sandwiches. We could even count the time it takes to make a sandwich.*

3.6.3.5 Classroom environment

The research team discussed the idea that classroom environment has an impact on learning according to the ordering of learners without the challenge of dyscalculia to sit with learners who are dyscalculic. Teacher B reflected that the mood of learning changes when learners have to sit in groups, as opposed to the traditional way of sitting, where all learners face the teacher in front of them. The team decided that it was important to discuss the suitable classroom environment that would best support the implementation of AL. From the discussion it was evident that the definition of classroom environment went beyond the actual physical space where learning of mathematics took place.

> Teacher D: *The workshop about dyscalculia made me realise that there are a lot of factors that can stimulate learning for a learner with dyscalculia. For example, it would be good to have posters around the walls of the classroom for continuous stimulation of learning.*
>
> Teacher B: *The sitting arrangement will also have an impact on learning using active learning.*

It was agreed that the researcher would give a presentation about the classroom environment. The team will then reflect on the presented information. The reflection objective was to establish the conditions of the classroom environment that ensure implementation of AL.

3.6.4 Phase 4: Anticipate impediments or hindrances in the implementation of an AL strategy

Forum meeting 4 and 5

The team discussed AL elements to be used based on the results of the learners from the assessment test. It was agreed the expected challenge with

cooperative learning was that it would be easy for learner with outgoing personalities. The research team pointed out that it would be easy for learners with dyscalculia to shy away and be lost in class. On the other hand, it would be very easy for some learners to get carried away and lose concentration during the group activities.

> Teacher C: *Learners lose concentration easily in class. They are easily distracted. It is important that the teacher should be constantly on the look during class to ensure that learners are engaged.*
>
> Teacher A: *Questions are a good way of keeping them focused on the task.*

The research team agreed that the anticipated challenge would be to keep learners focused on the task, especially during the group activities. The general thought was that usage of manipulatives sometimes gets learners excited and they lose concentration of the planned task.

The other challenge was that the implementation of AL would require a teacher to spend a lot of time preparing a lesson to ensure that the manipulative tools are relevant to the presented lesson. The teacher will also need to know in advance about the learning because that will influence how they pair learners for peer teaching. Eison (2010:4) also presents the view that learners have become familiar to learning where a teacher presents a mathematics problem and then ask them to copy it and later do a similar exercise. The research team also felt that even the teachers have built a very rigid system of learning mathematics that has contributed to learners' attitude toward learning of mathematics.

> Teacher B: *The influence from the community is that mathematics is difficult. However, mathematics also carries that attribute that if you master mathematics, you are intelligent.*
>
> Teacher C: *Yes, indeed, and everyone want to be perceived as smart by peers and family members.*

The research team agreed that the attitude of learners toward mathematics would be a hindrance toward the implementation of AL. The attitude of learning mathematics may emanate from home and the communities where

learners come from. AL is a strategy that requires learners to be self-driven. According to Shankar and Seow (2010:79), AL requires learners to be engaging, sharing their ideas and reflecting. Such engagement of learners in learning requires that learners should have a positive attitude toward learning mathematics.

The research team also discussed that AL requires that the teacher should be able to move around with ease in a classroom. Learners too should be able to interact and share ideas. The following were the thoughts shared by the teachers in class:

> Teacher A: *AL requires the teacher to move around in class. However, our classes are overcrowded and therefore it is difficult to move around. The traditional method of sitting, on the other hand, is very restrictive.*
>
> Teacher C: *I also agree that overcrowding is a challenge.*

The research team was composed of experienced mathematics teachers. The research team discussed the demand of mathematics content knowledge during the implementation of AL:

> Teacher B: *I have been involved in teacher training and also giving presentation on teaching strategies. Some teachers teach mathematics with a limited level of exposure in mathematics. Consequently, these teachers would struggle to teach mathematics in different settings.*
>
> Teacher A: *When you ask a learner a question and they do not give you the correct answer it is important that you do not give them the correct answer, but work with them until they arrive at the correct answer. This would be difficult to do if your mathematics content knowledge is weak.*

3.6.5 Phase 5: Suggestion that AL is an effective strategy in addressing dyscalculia in a mathematics classroom

Forum meeting 5

The focus team felt it would be best to firstly understand the level of dyscalculia that learner participants have. This would assist in preparing the relevant mathematics lessons that would be targeting the areas of weakness.

The available assessment test for learners with dyscalculia was observed to be outdated. Therefore, the team decided to use the assessment test that was used by the Davis Dyslexia consultant. It was agreed that the test would be written under the supervision of the SBST member of the school. The results of the test would then be analysed by the focus team.

The Davis Dyslexia assessment quiz assesses learners' level of mathematics understanding and their spatial reasoning. The test is attached as Appendix B. This is in line with the discussion covered in Chapter 1 and 2 about the memory difficulties for learners with dyscalculia. We discussed that the following were the three key problem areas for learners with dyscalculia:

- Semantic memory – difficulty in retrieving arithmetic facts
- Procedural memory – difficulty in understanding and applying mathematical procedures
- Visuospatial memory – difficulty in understanding spatial representation

The questions in the assessment quiz covered their semantic, procedural and visuospatial memories.

The focus team met and decided that, based on the test results, most participant learners demonstrated areas of weakness mostly in their visuospatial abilities. All learners showed weaknesses in addition and weaknesses in their understanding of the concept of time.

It was therefore decided the chosen AL elements would be applied in the classroom environment in teaching patterns, number concepts and addition of numbers.

The implementation of the lesson in class was executed in class, where the teachers were observed and the attitude and the progress of learners were observed too. It was then decided that the chosen AL elements would be applied in class. The results from the dyscalculia assessment quiz were used to determine the mathematics topics that would be used in the implementation

of AL in a mathematics classroom. The research team agreed that the lessons would be presented in number concepts and patterns. The observation was done to ensure that the areas of difficulty for learners with dyscalculia are met, using the identified elements of AL:

I. Observation and feedback
   - Observation was done in class with the focus on the implementation of AL elements. It was agreed that it would be possible to use the selected elements during the teaching time in class. The engagement and the participation of learners with dyscalculia were observed.
   - Results of assessment of learners were analysed and discussed.

II. Reflection on the lesson
   - Reflection on the implementation by teachers and the response of the learners.
   - Reflection on the functionality of AL.

Forum meeting 6

3.6.5.1 Lesson 1: Presentation of basic number concepts

Reflection on the lesson presented

The lesson was presented by one of the teachers. The other participants were available in class for observation. The first lesson was presented on basic number sense. Basic number sense gives learners the ability to use and understand numbers. From the research team, Teacher B was requested to lead the activity by introducing the team to the learners. The lesson started with the number game where learners were requested to do mental addition.

They were presented with the following problem:

> When adding 32 + 9 = 41.To get the correct answer (41), you add 1 to the first number 3 and subtract 1 to the second number 2 then the answer is 41.

The activity encouraged learners to use their reasoning ability, as well realising that they can add large numbers without using the calculator.

Learners were then given basic ideas of addition and subtraction. A scenario was given: Thabo is given R20 by his mum to go buy bread, costing R17. How much is the change? They told the learners to ensure that Thabo does not forget what he is going to buy at the shop. It is essential that he builds the picture of bread in his head.

Using the call-out method for asking, the learners were asked: How many Rands are in R20. Then they were asked to take R17 from that R20.

Learners were also given counting blocks. They were asked to take out 20 counting blocks; the counting blocks represented the number of Rands. Then learners were asked to take out 17 counting blocks, representing the R17. Learners were then asked to count the number of remaining blocks.

Learners had various activities engaging them on numbers. They were given the number 265, using the given cards, they were able to take out 200, 60 and 5.

Reflection on the presented lesson: basic number concepts

Following the presentation of the lesson, the research team met to discuss and share views on the lesson. Normally the class sits in a traditional form. However, for the presentation of the lesson, the classroom sitting arrangement was changed into group form.

The research team reflected on the general reaction of learners on the application of AL:

> Teacher C: *I think the learners came alive when it was time to use the manipulatives.*
>
> Teacher B: *Yes, even Learner B was engaged. He had his hand up*

most of the time when a question was asked.

Teacher A: *I think the lesson went fine. However, we could still improve on the peer learning. I observed that the smart learners were not keen on sharing how they got the correct answer. Especially, in a group where Learner A was involved in, she seemed confused most of the time.*

The research team also felt that the sitting arrangement led to cooperative involvement. Learners could learn from one another and it was easy for them to share the manipulatives. This also allowed the teacher to reach more learners at the same time.

The research team also reflected on the presentation of the content itself by the teacher. The team felt the teacher moved too quickly to the concept of "abstract". The mental game that was first presented in class was difficult for most learners. Learners with dyscalculia failed to participate. The team felt the lesson could start on "concrete", then move to "pictorial" and then "abstract". This would allow learners to build the association of numbers from the beginning.

Teacher C: *I noticed that when Learner A was asked, "How many hundreds are in 200?" It seemed to me that she first did not understand the question. I suspect that the problem may not be only in mathematics but also the language.*

Teacher B: *That may be a possibility because the question had to be repeated a few times, presenting it in different scenarios.*

The team also observed that the other learners perceived to have dyscalculia, showed participation in class. However, when they were asked to build three-digit numbers, they struggled with units. The peers at the table were of good assistance.

3.6.5.2 Lesson 2: Presentation of patterns

Learners were given an opportunity to choose a number from the placed cards. If a learner chose 5, they had to clap their hands five times. If they choose 3, they had to jump three times. Some were asked to identify two boys wearing a sweater that day. The activity helped learners with core numbers,

as recommended by Hornigold (2015:26), that learners with dyscalculia need encouragement with core numbers and the activities that help learners make a connection between numbers and quantities and symbols.

The teacher shared the tower built with building blocks. The tower was composed of blocks in two colours: red, blue, blue, red, red… Learners were then asked to tell what the next colour block would be.

They then did the activity in groups where each group was asked to build the tower with the correct pattern. Groups presented their patterns in class. The correct presentations were selected.

Reflection from the presented lesson: patterns

The team research team reflected and there was consensus that the lesson went well. Learners were excited by the usage of manipulatives. However, there was room for improvement in building the lesson from simple to complex. This would ensure that learners who are struggling with a certain concept are incorporated.

> Teachers C*: Even when learners were asked to come up front to present their created patterns, there was excitement in class.*

The research team felt that the lesson started with a difficult pattern. It was difficult for most learners to see the pattern initially.

3.6.5.3 Lesson 3: Presentation of numbers concept

The research team met again for deliberation on how the lesson would be presented. This time, more attention would be placed on peer teaching, ensuring that learners assist one another. The teacher would also pay attention to the questioning. Learners would also be given tasks to perform at home as part of assessment.

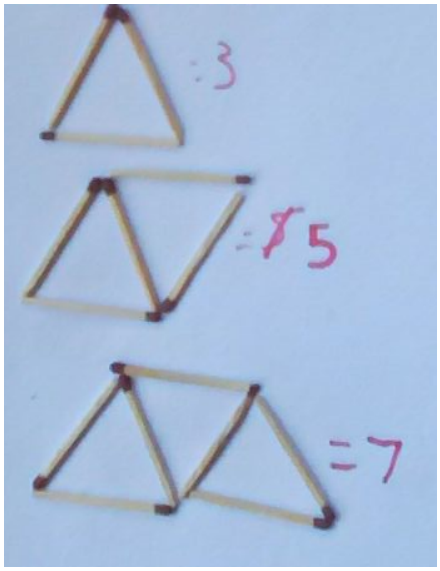
3.6.5.4 Lesson 4: Presentation of patterns

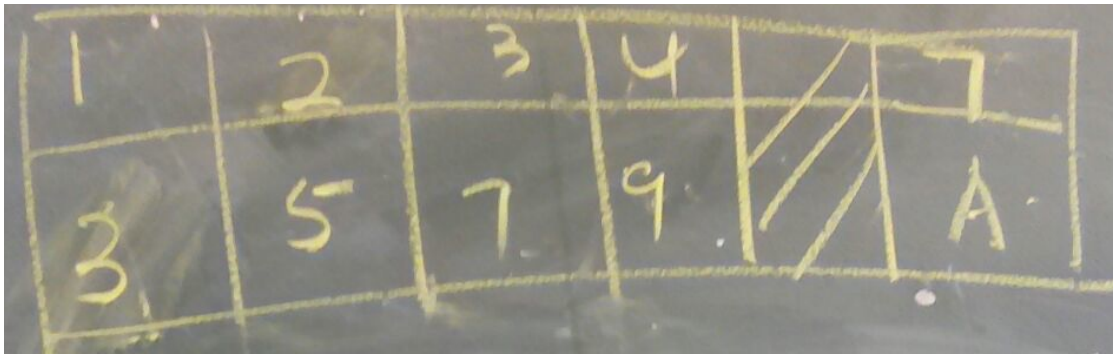
The lesson presentation started with the rhythm game where learners had to make a bit on numbers. They clapped hands on a bit 1231, 1231… When one finished, the other one started. The idea was that learners should get the sense of the number pattern in forming the rhythm and also understand that mathematics applies everywhere. The game broke the monotony, creating a fun learning environment.

The teacher introduced the lesson about patterns, following the work previously done. Learners were then divided into groups. Each group was given a pattern that they had to complete. For example: 123, 321,1234, 4321,12345, 54321… Each group was given a white paper with a bright marking pen. The group that has completed the work was required to lift up the paper for the teacher to see if they have the correct answer.

Some learners got the pattern wrong. The learners who got the pattern correct were requested to help the learners who did not get the answer correct. Learner A was then requested to look at the pattern and rewrite it after the teacher hid the pattern again. Learner A could not remember the pattern after it was wiped off the board.

The teacher gave the second task, which was the formation of triangles with matchsticks. For example, 3 matchsticks form 1 triangle, 5 matchsticks form two triangles and 7 matchsticks form 3 triangles. Learners had fun working on the pattern. Below are the examples of the completed work.





Learners were later given tasks to complete at home with parents or guardians.

Reflection on presented lesson: presentation of patterns

The research team met and discussed the lesson and the implementation of AL:

> Teacher C: *I liked the usage of the "white board" system. Learners were excited because it was a new method. Nevertheless, I think it helps shy learners as well to share their answers.*
>
> Teacher A: *Learners were excited and everyone was involved and keen on participating. I think this a good way of getting learners excited about learning.*
>
> Teacher B: *I also like the idea of them taking doing tasks with parents because that can get parents to participate in learning.*
>
> Learner A: *I enjoyed the lesson as well. It was fun. I enjoyed it the most when we play games.*
>
> Learner B: *I also enjoy it when we play with the block and also play*

with matchsticks.

Learner C: *It is nice when we learn together in groups. This could make coming to school to be fun.*

3.7 DATA ANALYSIS

This study seeks to employ Critical Discourse Analysis (CDA) to analyse and interpret the spoken words of participants. Van Dijk (1993:252) viewed CDA as a means by which social issues could be understood and interpreted. Qhosola (2016:132) further attested that CDA maintains a critical view that supports transformation in societies that are marginalised. Mahlomaholo and Netshandama (2012:43) supported the same notion, arguing that CDA offers freedom, equality and hope to the marginalised societies

According to Van Dijk (2008:85), CDA is used to understand inequalities that exist in communities and to ultimately expose and address such existing inequalities. Therefore, it is important that we listen to the views of those individuals who are affected by dyscalculia, either directly or indirectly.

The usage of CDA in this study is motivated by the same ideologies shared by CER. CER is the theoretical framework that underpins this study and was discussed in detail in Chapter 2. Both CDA and CER have a keen interest in addressing issues of inequality and seeking transformation for those who are marginalised. According to Van Dijk (2008:87), there are three levels of analysis that exist in employing CDA in analysing data, namely textual, contextual and sociological analysis. Tlali (2013:154) attested that these levels coexist in our everyday interactions and experiences in our communities.

3.8 CHAPTER SUMMARY

In this chapter, PAR as the methodology of choice to generate data was discussed and justified. The introduction of the chapter reiterated the objectives of the study to illustrate how the methodology links with the

objectives. Therefore PAR was discussed, starting with the history, objectives and PAR stages involved in ensuring that the objectives of the study are realised.

The chapter further discussed formats in PAR encapsulating the discourses with the team, how they unfolded and the profiling of the selected participants and the research site. The method used to analyse and interpret data and the observed ethical considerations were also discussed, as well as the impact of the selected method on the study. The next chapter comprises a detailed discussion of the analysis and interpretation of the data.

CHAPTER 4

DATA PRESENTATION, ANALYSIS AND INTERPRETATION OF AN ACTIVE LEARNING STRATEGY FOR ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM

4.1 INTRODUCTION

At a meeting, data were collected and the interpretation thereof indicates a need for an active learning strategy (AL strategy) in addressing dyscalculia in a mathematics classroom. The challenges regarding the implementation of the AL strategy included the need to understand dyscalculia, the existence of dyscalculia in a mathematics classroom and also a challenge posed by the implementation of active learning (AL) for learners with dyscalculia. The solutions to the challenges are attended to in accordance with the objectives of the study. Proposed solutions include the components of the AL strategy in addressing dyscalculia in a mathematics classroom.

The conditions or circumstances under which the proposed solutions and elements of AL would contribute to the successful implementation of the AL strategy in addressing dyscalculia in a mathematics classroom were also identified, among which were the creation of awareness, dyscalculia diagnosis knowledge, support for the usage of effective questioning, the contribution toward effective usage of manipulatives, the contribution toward the formation of peer teaching and the contribution toward successful encouragement of writing and reflecting.

This chapter also explores the possible threats that could hinder the successful implementation of AL, such as a lack of knowledge of dyscalculia, limitations of dyscalculia diagnosis knowledge, learners' natural inability to pay attention during learning and teaching time, a lack of teachers' content

knowledge of mathematics, negative attitudes in teaching mathematics and learners' negative attitudes toward learning and the classroom environment.

4.2 CHALLENGES PERTAINING TO THE NEED FOR AN AL STRATEGY TO ADDRESS DYSCALCULIA IN A MATHEMATICS CLASSROOM

As part of this study, it was important to establish the need for addressing dyscalculia in a mathematics classroom. It was noted in Section 2.3.2.1 that dyscalculia is as prevalent as dyslexia, according to statistics from countries such as the UK, the USA, Brazil and Germany. At the time of writing, there was no available statistics in South Africa about the prevalence of dyscalculia. Kirk and Payne (2012:17) also acknowledged that the information about dyscalculia is limited; however, it is important that teachers are aware of dyscalculia as a learning disability and they should consider strategies to support such students. Chinn (2014:407) further attested that "[w]ith increasing awareness of dyscalculia and greater consensus about its assessment earlier identification of dyscalculia is likely".

Research meetings were held to establish the challenge posed by the need for an AL strategy in addressing dyscalculia in a mathematics classroom, the establishment of the existence of dyscalculia at schools and the implementation of AL with dyscalculic learners.

4.2.1 The need to understand dyscalculia

In a meeting with a school research team, held to establish the need to understand dyscalculia, the following comments were made by the participants concerning their understanding of dyscalculia:

> Teacher C: *Please Mam, can you repeat that word "dyscalculia". I have not heard of it before.*
>
> Teacher A: *I also have not heard of the term "dyscalculia" before. I think, we will need help to understand dyscalculia.*

From the above extract it is clear that teachers did not know anything about dyscalculia. For instance, both Teacher A and Teacher B could not even

pronounce the word “dyscalculia”; however, they found it important to understand and learn more about it as they understood that it affects them as mathematics teachers. Lack of knowledge or awareness of dyscalculia was further evident from what another participant said.

> Teacher B: *I also have not heard of dyscalculia before. I thought some learners were just bad at mathematics.*

Teacher B’s extract above corroborates the foregoing claim that teachers lack an understanding of dyscalculia. Even more important from the above extract, it seems that a lack of knowledge of dyscalculia has led teachers to making epistemic assumptions, such as *I thought some learners were just bad at mathematics*. Arguably, such assumptions could contribute toward teachers thinking that learners’ poor performance has nothing to do with how they teach, but it is just because they are bad at mathematics. The diversity of the team enabled the study to capture the parents’ understanding of dyscalculia; two of the parents who were also part of the research team reflected during our reflection sessions by saying as follows:

> Parent A: *I thought my child just hated mathematics. She gets irritated when it is time to learn mathematics. However, I thought it was because of the poor grades and the fact that she avoided doing her mathematics homework.*

> Parent B: *I just thought he was bad in mathematics because of the fact that I was also poor in mathematics.*

The above reflections by parents were not surprising, partly because parents observed their children results and found them to be bad at mathematics compared to other subjects. However, what is further interesting is that poor performance in mathematics could also be associated with the parents’ performance in mathematics when they were at school. What is problematic about this thinking, is that not even the parents will make an effort to find out why their children’s performance in mathematics is so poor, since they are quick to think that they passed over to their children their own poor comprehension of mathematics concepts. Parents’ thoughts agree with the view shared by PBS (2012:Online) that “parents often dismiss math difficulty as a normal part of life, especially if they too struggled with the subject when they were young”.

The diversity of the team further enabled the study to capture the understanding of dyscalculia by the district officials; three of the officials that were also part of the research team, reflected during our reflection sessions by saying as follows:

> Official A: *I have heard about dyscalculia before but I think research is limited in that area. As a result, I have never encountered a learner with dyscalculia in my line of profession.*
>
> Official B: *I have also not witnessed a dyscalculia case before. When I meet a learner with poor mathematics performance, I have always assumed that it was because of factors like poor teaching, lack of parental support; or perhaps a learner is often absent from school.*
>
> Official C: *I have also never seen a dyscalculia case before. However, there is a numeracy test to detect learners with dyscalculia that has been in the education system for about 25 years now. I do not even think that this test is relevant anymore.*
>
> Official D*: I heard about dyscalculia during a training session I attended once. However, since there is no specific assessment tool for dyscalculia, we have, as a result, never had a learner that we thought had dyscalculia*.

From the extracts above, it is clear that the district officials have heard about dyscalculia. However, all the officials stated that they have never seen a dyscalculia case and this gave evidence of the need to understand dyscalculia. It is not possible to deduce that there are no dyscalculic learners within the South African education system, due to the evidence presented by other countries. However, the failure to detect the learners with dyscalculia is not surprising, due to the statement that was made by Official C that the numeracy test that they used, was 25 years old. The official was hesitant about whether the available test was relevant to detect dyscalculia when he made the statement*, "I don't even think that this test is relevant anymore".* Official D agrees with Official C, that learners with dyscalculia have not been identified due to lack of diagnostic tools. However, in as much as the diagnostic tool poses a major challenge, it will be discussed later on. Of note also is that officials appeared uncertain about what dyscalculia is:

> Official E: *I know about dyscalculia, I have read intensively about it. But there are many external factors in the cases I have seen.*

> *External factors such as poor teaching, lack of parental support, absenteeism, poor reading and writing skills. Therefore, it becomes difficult to know whether a learner has dyscalculia or not.*

It raises a concern that Official E knows about dyscalculia, but has not seen a learner with dyscalculia due to the noted external factors. However, the statement made by Official E supports the argument that the knowledge about dyscalculia is limited. In the same environment where the named external factors exist, there could be learners with dyscalculia. The official may have better understanding of how to detect such cases if they are knowledgeable about dyscalculia. These officials are supposed to support teachers in addressing dyscalculia and yet their own understanding of dyscalculia is limited.

In a research team meeting at the provincial office (Inclusive Department), which was attended by some senior officials from the Curriculum Department, whose aim was to establish the need to understand dyscalculia, some statements like the following were made:

> Provincial Official 1: *I have not heard of dyscalculia before. Perhaps there are more people who have dyscalculia than we think.*

> Provincial Official 2: *I have known that the state of our mathematics needs work, but I did not know that such a mathematical condition exists.*

The above reflections by the provincial officials were a concern because at their level, it is expected that dyscalculia should be known as a disability. The officials were aware of poor performance in mathematics in the country, but there was clear general knowledge gap of dyscalculia.

The study proposes AL as an intervention strategy in addressing dyscalculia. There were further discussions with the participants concerning how it could be established whether learners have dyscalculia. Morin (2014) agreed with sentiments on AL in her view that learners with dyscalculia have increased chances of understanding mathematics through instructive amusement and fun learning tools. Such methods of learning would give learners a practical manner of applying learned mathematics theories in real life or exploring how

they apply. The fun way of engaging learners would consequently encourage a positive perception of mathematics. From the discussion above, it was evident that participants did not have a clear understanding of what dyscalculia is. It is important to know whether dyscalculia exists, before AL can be implemented. It was therefore decided that the team would need to establish the existence of dyscalculia in a mathematics classroom.

4.2.2 Establish the existence of dyscalculia in a mathematics classroom

As discussed in Chapter 1, Geary (2004:11) and Wadlington and Wadlington (2008:3) identified the three areas that affect most learners with dyscalculia. Learners with dyscalculia have been identified to have difficulty retrieving arithmetic facts and memorisation (semantic memory); difficulty in understanding and applying mathematical procedures, and struggle to follow steps in solving a problem (procedural memory); and difficulty in understanding spatial representation and place value (visuospatial).

There are various diagnosis tools that are used for dyscalculic learners, based on the knowledge gained from the workshop with the specialist in dyscalculia and the gained information from the literature, as covered in Section (2.4.1) about the three prominent areas of difficulty for learners with dyscalculia, namely semantic memory, procedural memory and visuospatial memory. Learners with dyscalculia may have difficulties in one or two of these areas or perhaps even in all of them. The research team analysed the assessment work of four learners that were selected with the suspicion that they may have dyscalculia. The assessment was done based on their class assessment, quarterly assessment and dyscalculia assessment. Learners with dyscalculia have normal intelligence where they are able to perform well in other subjects, except in number-related subjects. This is true unless when dyscalculia is coupled with other learning disabilities, such dyslexia or autism.

During the meeting with the participants, reflection of the assessed work of learners was categorised into the three prominent areas of difficulty named above and their quarter assessment report for their mathematics performance

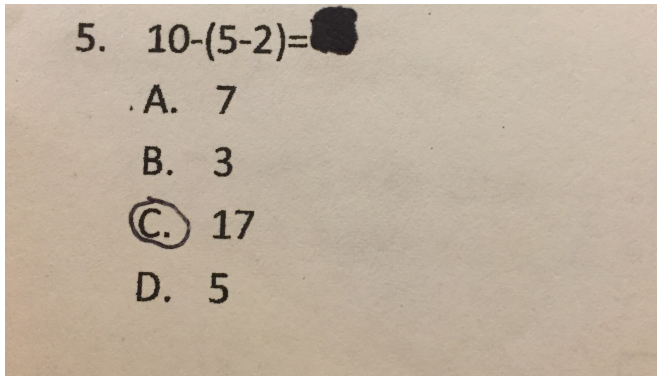
in relation to other subjects was analysed. In analysing the work of the learners the team took into consideration the overall class performance and the expected performance of the learner in relation to age at the time of the assessment.

4.2.2.1 Semantic memory

Semantic memory was earlier described as the difficulty in retrieving arithmetic facts (refer to Section 2.4.1 and 3.6.5 for detailed discussion). Semantic memory difficulty is observed when learners struggle to work with simple mathematical concepts. Such learners struggle with basic mathematics operation such $+, -, \div$ and $\times$. Below are the examples of the assessed work done by learners that were suspected to have dyscalculia. The research team analysed and reflected on their work

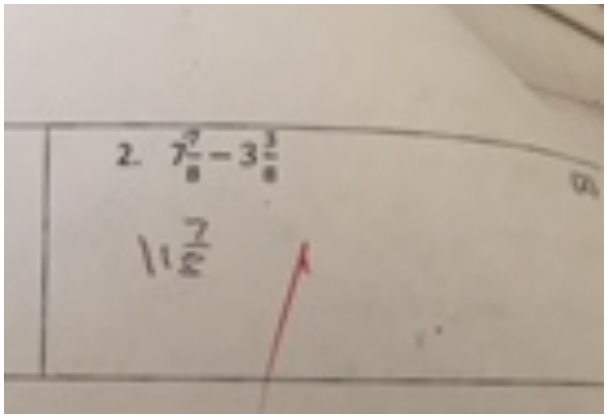
Semantic memory analysis: Learner A

Below is an example of the assessed work by Learner A. In this example 10 – (5 - 2) = 17.



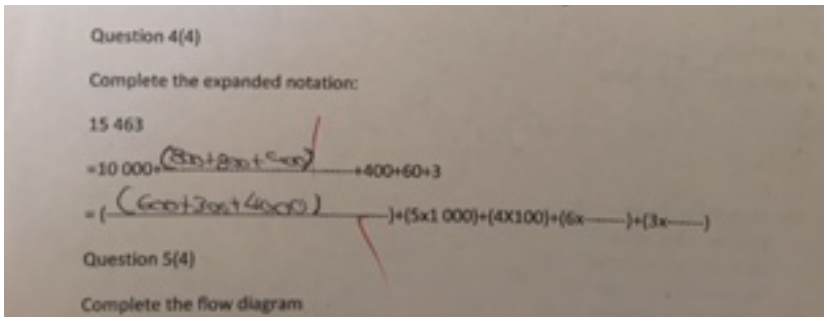
Teacher A: *In this example, Learner A appeared to have confused the addition and subtraction.*

Teacher B: *That may be true, in the assessed work below where the learner is asked to subtract mixed fractions/numbers, the learner appeared to have added the fractions instead of subtracting them.*



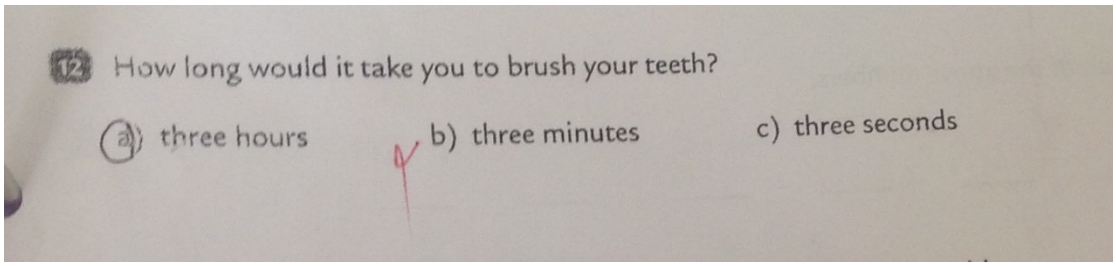
Based on the analyses provided by Teachers A and B above, Learner A shows difficulty in understanding basic addition and subtraction. Considering that Learner A is in Grade 5, the lack of level of aptitude for addition and subtraction gave reason to believe Learner A may be dyscalculic. However, difficulty with semantic memory does not only refer to difficulty with basic arithmetic, but also with the place value concept.

Below is an example of the assessed work on addition, as well as understanding of place value.



> Teacher A: *Learner is completely lost in working with the place value. The topic was covered in class and almost all learners can tackle the problem in class. Those who make mistakes still show basic understanding on place value at least.*

There were also questions from the diagnostic test from the dyscalculia specialist that sought to establish the conceptual understanding of basic numbers.



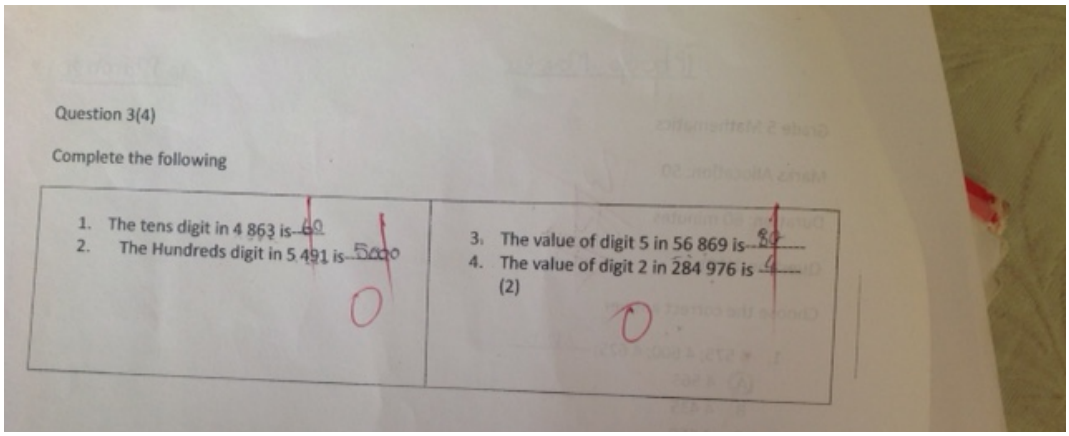
Teacher B: *The learner appears to have poor concept of time.*

Teacher A: *Considering that the learner is in Grade 6, they should have an estimate of how long it would take to brush their teeth.*

Based on the extract above from Teachers A and B, Learner A has difficulty in conceptualising time. This is not surprising, considering that Learner A had a challenge in computing basic arithmetic. The weakness therefore for Learner A to properly conclude that it could never take three hours to brush teeth, is an indication of the presence of dyscalculia. The perceived difficulty with this learner is in understanding basic mathematics operations, for example place value, and limitations in the conceptualisation of time, which is in line with difficulties pointed out by Arifin, Halin and Aziz (2017:470), who stated that learners with dyscalculia show difficulty in performing simple mathematical operations. They have difficulties in handling place value, addition and subtraction, and have trouble with borrowing and carrying over. Discussion in Section 2.3.2.3 further attests to this observation that learners with dyscalculia have the observed difficulty in understanding mathematics operations.

Semantic memory analysis: Learner B

Below are the examples of the assessed work of Learner B:



Question 3(4)

Complete the following

1. The tens digit in 4 863 is 60
2. The Hundreds digit in 5 491 is 5000

3. The value of digit 5 in 56 869 is 50
4. The value of digit 2 in 284 976 is 4

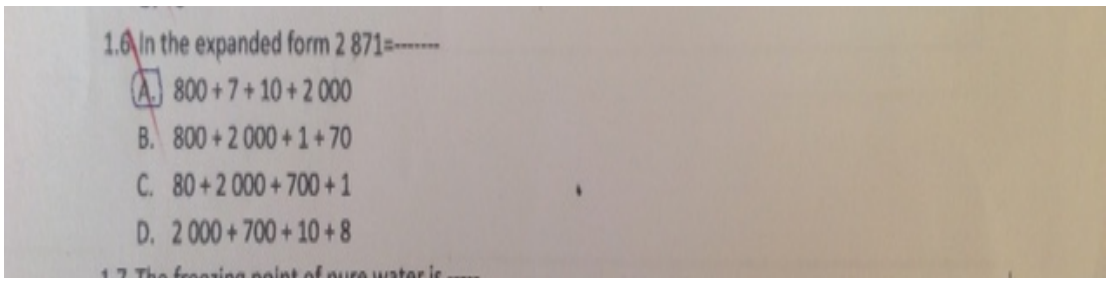
(2)

Teacher A: *Learner B generally struggles with the mathematics. In the above assessed work, it shows that Learner B has difficulty with place value.*

Teacher B: *No. 1 example shows that the learner has basic understanding but might have been confused with the word digit*

Teacher C: *However, No. 3 and 4 might be an indication that the learner is totally confused.*

The analysis done by Teachers A and B indicate that the learner is totally confused with the concept of place value. This analysis agrees with one of the indicators of dyscalculia, as discussed in Chapter 2, that learners with dyscalculia struggle with place value concepts. It is also expected that at Grade 5, learners are familiar with place value concepts. However, the analysis was made by Teacher C that the learner might have been just confused. The team analysed some work on place value for Learner B. Below is another example of the assessed work of Learner B on the place value concept:



1.6 In the expanded form 2 871=------

A. 800 + 7 + 10 + 2 000

B. 800 + 2 000 + 1 + 70

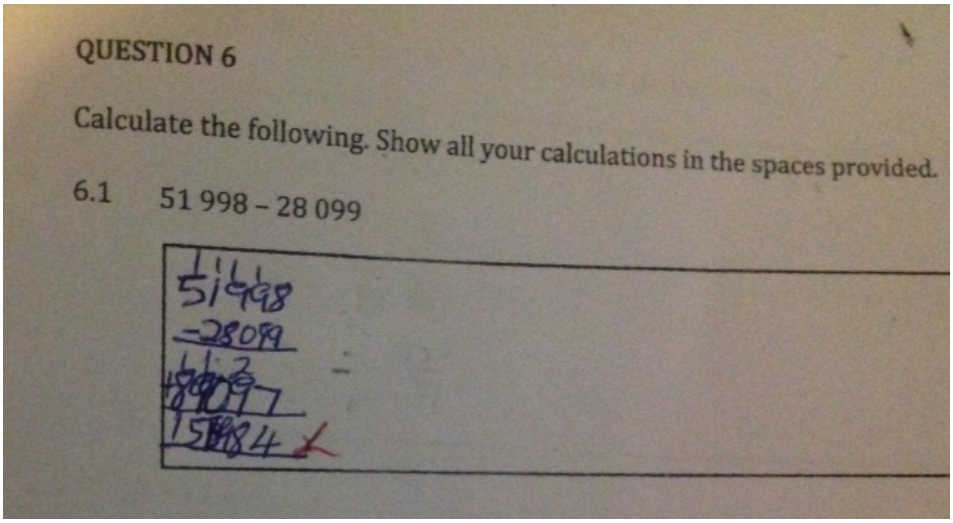
C. 80 + 2 000 + 700 + 1

D. 2 000 + 700 + 10 + 8

Teacher A: *The fact that the learner started the expansion on "8" tells that the learner has very limited understanding of place value.*

Semantic memory analysis: Learner C

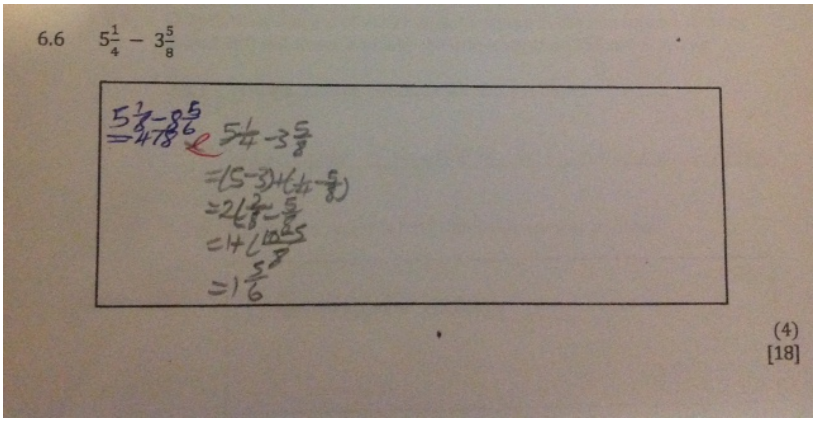
The research team analysed the assessment work of Learner C to establish the existence of possible difficulties with semantic memory and below are the reflection on the discussions:



> Teacher B: *Learner shows some knowledge about carry-over because of the indicated 1's on top of 51998.*
>
> Teacher A: *But also, the learner may be confused with addition and subtraction because the learner put 8 - 9 = 7 as the digit on the right. This could mean that they misunderstood 8 + 9 =17.*

Based on the extracts above and the analysis by Teachers A and B, Learner C shows difficulty in handling basic arithmetic concepts. As noted in Section 2.3.2.2 that learner with dyscalculia confuses the basic arithmetic operations and will therefore show difficulty in computing basic arithmetic facts.

The research team analysed more work done by Learner C to show their understanding of basic arithmetic facts. Below is an example of the work that was done by Learner C on fractions. Learner solution is 8 and the solution done in class as part of the correction is:

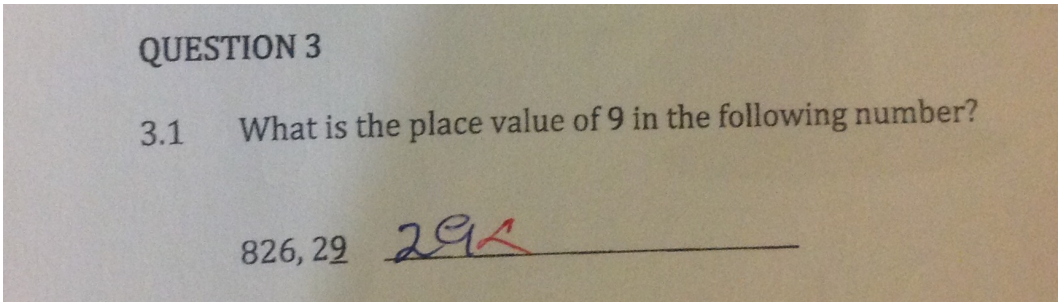


Teacher A: *Learner B shows limited understanding of fractions. To get such a solution they must have multiplied instead of subtracting.*

Teacher C: *Considering that the work was done in class, it could be that the learner could not remember what they had done in class.*

Based on the analysis done by Teachers A and C, there is an indication that Learner C has difficulty in working with basic fractions. Teacher C's comment that the learner might have forgotten what they needed to do is also consistent with the difficulties observed from learners with dyscalculia. As discussed in Chapter 2, learners with dyscalculia often show memory difficulties. It is therefore possible that Learner C might have forgotten what they needed to do in solving fraction problems and either guessed the answer or tried to multiply the numbers, possibly using the calculator.

The team further analysed work done by Learner C to establish their understanding of their place value. Below is the example of work that was done by Learner C.



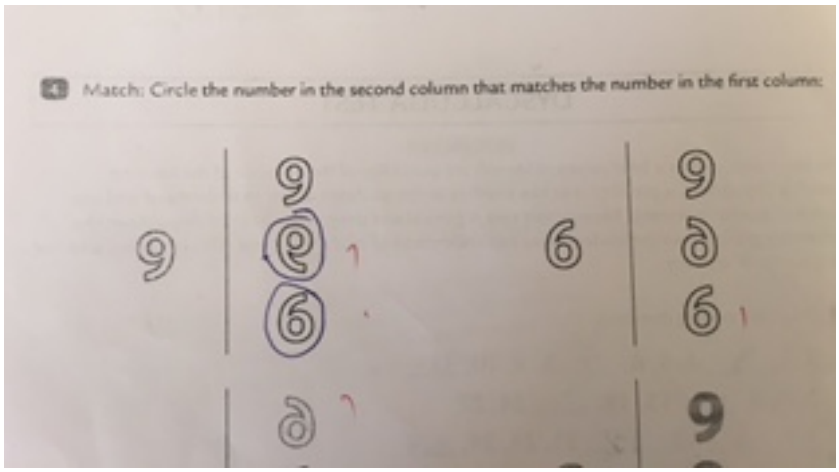
Teacher B: *Learner C did not answer the question at all. This could mean that the learner is simply not sure what the place value is.*

Teacher A: *Again, it could be that they simply forgot what the place value was and guessed to put 29 as the solution.*

Based on the analysis done by Teacher A, there is an indication that Learner C does not understand the place value or might have forgotten what they needed to do. Therefore, they guessed the answer. This analysis is an indication of Learner C showing symptoms of dyscalculia. Learner C also shows symptoms of dyscalculia, as indicated by Arifin *et al.* (2017:470) above that learners with dyscalculia show difficulty in handling addition and subtraction and the concept of carrying over and borrowing. Landerl *et al.* (2004:99) also attested that learners with dyscalculia show difficulty in remembering mathematics facts.

Semantic memory analysis: Learner D

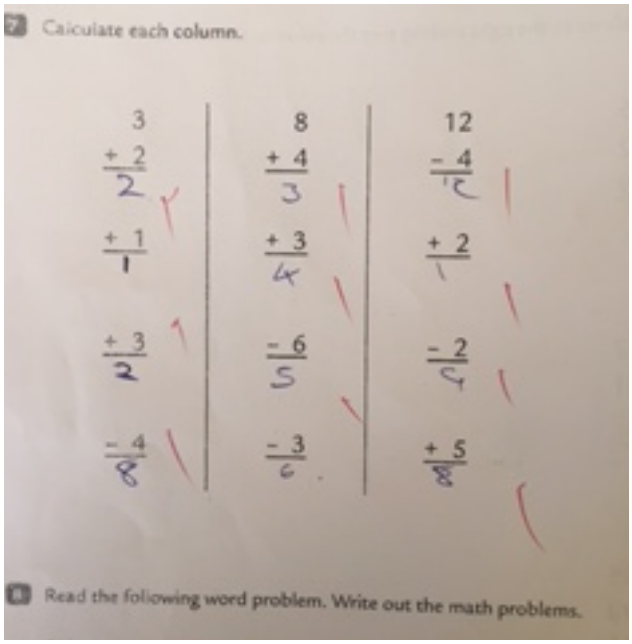
The research team analysed the work done by Learner D to establish the existence of dyscalculia. Below is the example of the assessed work from the diagnostic test from the dyscalculia specialist. The learner was asked to circle the matching number. The analysis that was done by the research team is as follows:



Teacher A: *Learner D appears to confuse number 9 and 6 because they have circled both 6 and 9 to represent 9 and when they were supposed to circle the number representing 6, they did not circle anything.*

Based on the analysis done by Teacher A above, Learner D appears to have

difficulty in computing numbers. The team further analysed the work where they were supposed to add numbers. Below is the example of the work done, where Learner D was required to add one-digit numbers:



> Official A: *Perhaps the learner confused the word "column" and hence they got the answers incorrectly.*

Based on the analysis done by the official that raised the concern with the understanding of the question and hence, Learner D's incorrect answers, if there was confusion with regard to what they thought "column" was. The first part of the question would give an indication of whether learners are able to handle basic arithmetic concepts. Teacher B made the comment below:

> Teacher B: *However, it is clear from the example above, it is noted that at least they have to add.*

Based on the comment by Teacher B, there is an indication that Learner D has difficulty in handling basic arithmetic facts and the fact that they are in Grade 6 is further evidence of this. It was noted in Chapter 2 that learners with dyscalculia have difficulties in handling basic arithmetic facts and hence this is an indication that Learner D may have symptoms of dyscalculia. Cunningham (2014) further attested to the mathematical difficulty noted on Learner D in that learners with dyscalculia have a weak number sense, as evidenced by their struggle with addition and subtraction. They even struggle with addition

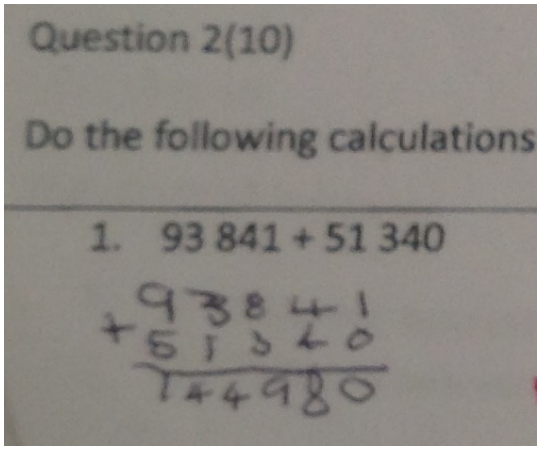
and subtraction from a group of items.

4.2.2.2 Procedural memory

Procedural memory difficulty was discussed earlier (refer to Section 2.4.1 and 3.6.5 for a detailed discussion). Procedural memory was understood in the context of the learners' failure to understand and apply mathematical procedures. The research team analysed the assessment work of learners who were suspected to have dyscalculia. Below are examples of the assessed work and the analysis done by the research team.

Procedural memory assessment: Learner A

Below is an example of the work that was done by Learner A to assess their ability to follow mathematical procedures. In the example below, it is expected that if a learner adds two digits and the solution is 10 or more, then they have to carry over.



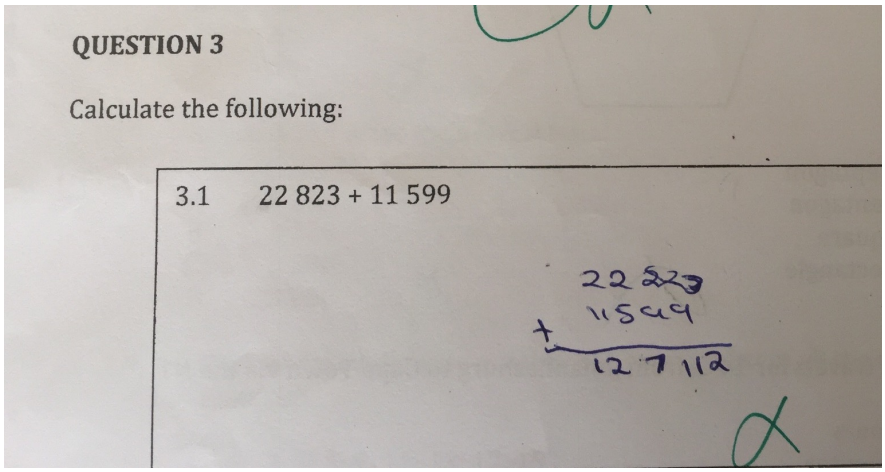
> Teacher A: *Learner A seems to have been confused by the concept of addition as well as no knowledge of carry over.*
>
> Teacher B: *Yes, they did not carry over*.

Based on the extracts above, Learner A shows difficulty in following mathematical procedures. A challenge in following such a simple mathematics procedure indicates that Learner A has challenges relating to following

mathematics procedures. The procedural difficulty noted with Learner A is also in accordance with the views shared by Price and Ansari (2013:4) that learners with dyscalculia fail to develop a mathematical facts retrieval system; hence they struggle to remember mathematical facts and follow mathematical procedures.

Procedural analysis: Learner B

Learner B was assessed on their ability to carry out addition and in order to do so correctly, it is important that they follow the mathematics procedure to carry over. Below is the example of the assessed work that was analysed by the research team:

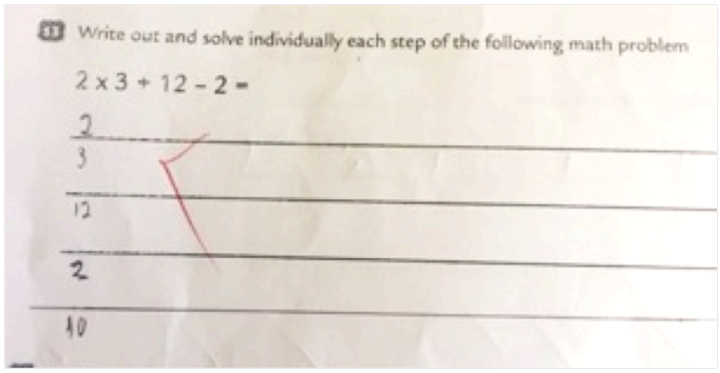


Teacher A: *Learner B appears to have added correctly that but did not carry over*.

Based on the above analysis done by Teacher A, Learner B appears to have a challenge in following a simple mathematics procedure. Considering that Learner B is in Grade 5, there is an indication that the learner has difficulty in this, which could be attributable to dyscalculia. Arifin, Halin & Aziz (2017:470) also noted that one of the challenges faced by learners with dyscalculia is that they show deficiencies in carrying over as a mathematics procedure.

Procedural assessment: Learner C

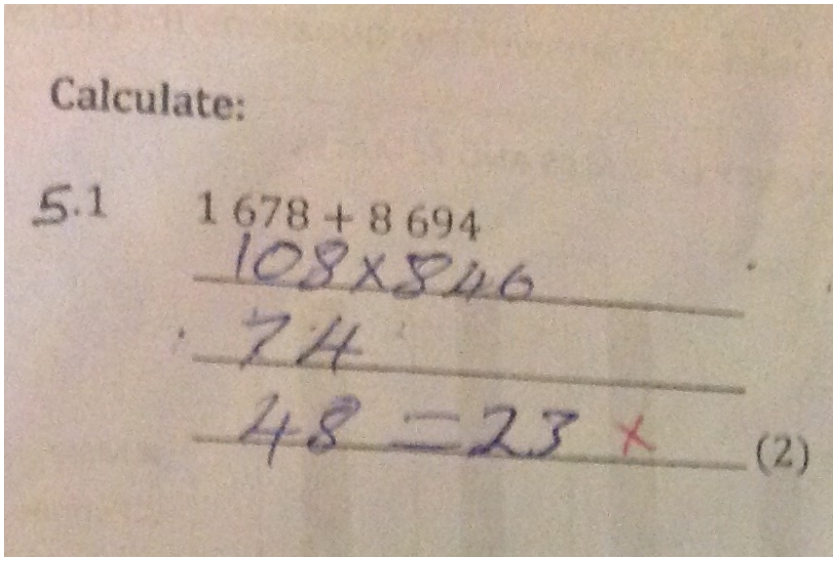
The research team discussed the assessment work of Learner C for the existence of procedural memory difficulties, as projected below. The following were the discussion points that were raised:



> Teacher A: *Based on this written work, the learner appears not to understand the instruction. They have rewritten the numbers without solving the problem.*
>
> Teacher B: *From the presented problem, the learner is supposed to apply the procedure as presented by the BODMAS rule.*

Based on the extracts above from Teacher A and Teacher B, Learner C seems not to understand the mathematics procedure to follow to solve the problem correctly. From the BODMAS rule, they will need to multiply first, then add and then subtract. However, from the example presented, Learner C appeared confused about what they needed to do.

The team analysed another assessment work done by Learner C. The team made the following observation:



Teacher C: *Here the learner seems to be confused by both the procedure to follow and also confusion with multiplication and addition mathematics operations.*

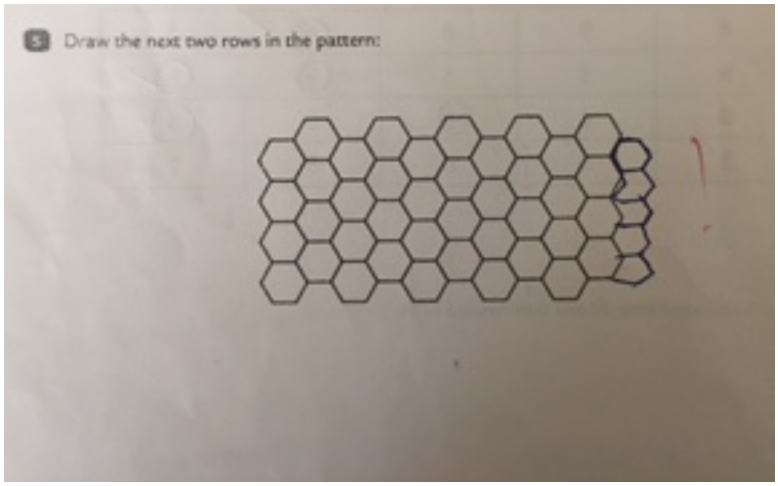
Based on Teacher C's analysis, there appears to be strong evidence that Learner C has symptoms of dyscalculia. Cunningham (2014) further attested that learners with dyscalculia have a compromised number sense where they confuse number operations. Learner C seemed confused about what they were expected to do.

4.2.2.3 Visuospatial memory

Visuospatial memory difficulty was described according to the discussion presented in Section 2.4.1 and 3.6.5, where it is described as the difficulty in understanding spatial representation. That means learners have difficulty in recognising mathematical shapes and patterns. The research team analysed the assessment work of learners who were suspected to have dyscalculia. Below are the details of the discussions:

Visuospatial analysis: Learner A

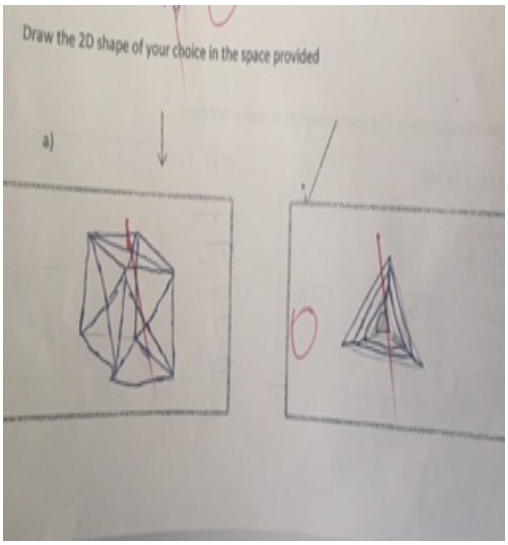
The team assessed the work done by Learner A to assess the level of understanding in following patterns. Below are the reflections that the team made:



Teacher C: *Learner A seems not understand the pattern even though the pattern seems very easy to follow.*

Teacher A: *It raises a concern for the learner of that age if they do not understand such a simple pattern.*

Based on the extracts above from Teacher C, who observed that the learner does not follow the pattern and from Teacher A, who is concerned because the pattern is so simple, it is indicated that Learner A should have been able to carry out the activity with ease. Evaluate other assessed work on the visuospatial skills, the research team made the following observation.



Teacher B: *The presented diagram, gives an idea that Learner A may not understand the difference between a 3D and 2D shape.*

Based on the extract above from Teacher B that Learner A may not understand the difference between a 3D and 2D shape, there seems to be strong evidence to indicate that Learner A has challenges with visuospatial memory. Zerafa (2015:1179) further supports the above evidence in his view that learners with dyscalculia have difficulty in recognising geometric shapes and noting patterns. Chinn (2014:271) also stated that learners with dyscalculia struggle in determining the elements of geometric shapes. A discussion in Section 2.4.1.4 further attests to the fact that learners with dyscalculia with a compromised visuospatial memory have been observed to misinterpret information relating to patterns and diagrams.

4.2.3 The need for AL to address dyscalculia in a mathematics classroom

During forums, brainstorming sessions and meetings with the participants, challenges with regard to the implementation of AL were discussed. In this section, these challenges are discussed. From the perspective of participants, these challenges hindered the functioning of AL and led to learners with dyscalculia not benefiting from AL in a mathematics classroom. The following were identified as challenges: the absence of a diagnosis tool for identifying learners with dyscalculia, overcrowding in classrooms, the teacher's inability to plan and apply effective teaching strategies, the teacher's inability to create a stimulating learning environment and inadequate feedback on assessment.

4.2.3.1 Absence of effective questioning

According to Kennedy, Tipps and Johnson (2007:98), analysis of the learner's achievement following an assessment is a necessary initial step in making informed decisions about whether a learner understands the concept or not. The second step is to analyse the work of the whole class collectively, focusing on the weak areas. It is also important to note that weak areas of learning may differ from learner to learner. Through the analysis of the assessment results, the teacher may learn about the strengths and

weaknesses of the whole class or of individuals, and about patterns of performance that help to detect the need. The teacher may further learn some anomalies about other individual learners. For example, from the assessment it was clear that Learner A could not differentiate between 6 and 9.

> Teacher C: *Assessment is very important and more so the feedback because they help us establish whether a learner has dyscalculia early in their academic life. However, the challenge we have is that there is no assessment criteria to determine whether a learner has a mathematical disability or not.*

According to Kennedy *et al.* (2007:72), "[t]eachers encourage or discourage talk and thinking with the questions they ask children while watching informal activities, checking for understanding in a lesson, or guiding an investigation". Johnson, Singh and Gonzalez (2014:419) further emphasised that questions are a way of interacting between children when playing and also between a teacher and a learner during the teaching and learning process. As discussed in Section 2.3.1.1, AL is a learning technique that encourages learners to participate in their learning through play, as opposed to just listening to the teacher. Therefore, teachers need to put thought into the questions they ask. It is therefore important that questions are planned as part of the teaching and learning process. A teacher can write a list of possible questions to ask with the aim to determine the learners' knowledge.

> Teacher A*: I have since realised that asking learners questions was an important part of learning. It helps to understand the learners' level of knowledge.*
>
> Teacher B*: Indeed even homework questions have to be well thought out. In a situation where a learner has answered a question, incorrectly, as a teacher, I should be able to ask a learner a question that will help them to rethink.*
>
> Teacher A*: Yes, indeed, through that questioning, you help them figure out the solution to the asked problem.*
>
> Learner*: I would like to be able to ask a question even if it may be stupid from another person's opinion.*

Parents in the team also felt they need to ask the correct questions at home about a learner's performance. When they ask, "How did you do in your math test?" and the answer is that they failed the assessment test, they should be

able to encourage the learner that they could do better next time. From that question, they too could take time to look at the completed work. If, for example, a learner is struggling with the concept of time, they could have family game activities where they practice the concept of time. For example, when a learner is brushing their teeth, monitor, with them, the time it takes to brush their teeth. If a learner starts brushing his or her teeth at 19h02 and finishes brushing his or her teeth at 19h04, how long did the learner take to brush his or her teeth?

The team agreed that effective questioning could provide a solution as the AL element in addressing dyscalculia in a mathematics classroom.

According to Attwood (2002:6), learners with dyscalculia do not benefit from being told the correct answer or shown the workings to the correct answer. However, they gain a better understanding when they are encouraged to figure out the problem themselves. A discussion in Section 2.3.1.1 further attests that the implementation of the AL strategy requires that learners are engaged with the content and understanding of the practical application of the concept. Therefore effective questioning gives learners an opportunity to engage with the content and to think about the practical application thereof. The feedback in assessments helps them understand the concepts better. Teachers, on the other hand, indicated that they faced challenges in giving comprehensive feedback.

> Teacher B: *We give all learners the same homework that gets marked in class. The corrections to these assessments are done in class the following day. Due to workload and number of learners in a class, it is difficult to spend time with each learner where as a teacher I could help the learners figure out the solutions by themselves.*

4.2.3.2 Lack of usage of manipulatives and a multisensory approach

Kennedy *et al.* (2007:74) described manipulatives as objects that are used to assist with thinking. Examples of manipulatives are building blocks, games, puzzles, stones, sticks and crayons. Manipulatives are used to match the concepts taught in class to help learners understand better.

> Teacher A*: I can see the value of using manipulatives in class but I don't think it is always possible. Teachers cannot always afford to create manipulatives, which they consider relevant.*
>
> Teacher C*: Other than the expense of bringing the appropriate manipulatives, learners perceived to have dyscalculia are really less interested in learning mathematics. That also contributes in creating a less stimulating learning environment.*

It was clear that the participants understood that there was a need to create a stimulating environment; however, that was not easy considering challenges faced by learners with dyscalculia. Learners with dyscalculia have a challenge to remember learned facts and conceptualising them. On the other hand, teachers often have overcrowded classes and this makes it difficult to create a stimulating learning environment.

4.2.3.3 The teacher's inability to apply peer teaching

According to Michael (2006:164), active learning does not automatically happen in a classroom. In order for AL to happen in a classroom, it is important that the teacher creates a learning environment that promotes key elements of AL in the classroom. It is furthermore important that the teacher is willing to learn ways of effective implementation and to go the extra mile in being creative. In a study conducted by Linton *et al*. (2014:245) to establish the effectiveness of peer teaching as an element of AL, it was established that learners who worked in a group performed better than learners who worked individually. Johnson and Johnson (2009:366) argued that for effective implementation of peer teaching, the teacher has to foster positive interdependence between learners. Positive interdependence exists when the individuals working at a task have a common goal to help each other succeed.

Therefore teachers need to be aware that they need to understand that the implementation of AL in general needs their dedication and a lively attitude. AL will not work if the teacher comes to class deflated, with a poor plan of what needs to happen in class. The effective implementation of peer learning depends on how learners are paired as well. During the research meeting,

participants pointed out challenges as follows:

> Teacher A: *The challenging aspect of peer learning is that we are expected by the department to follow the CAPS document. There is often no time to be creating peer teaching.*
>
> Teacher B: *I agree that there is a problem with the time to implement peer teaching. The other problem is that there has not been any training to assist us teachers to know how to implement peer teaching into our teaching method.*

From the discussion, it was evident that participants agreed that there was a lack of knowledge in how peer learning could be made a part of learning in a mathematics classroom.

Teacher C further pointed out that learners with dyscalculia become reserved when it is time to learn mathematics. Then the challenge arises how a teacher can foster positive interaction between the two learners to assist the paired learners to learn from each other.

It furthermore came to the fore from the discussion that teachers are keen on delivering the lesson as according to the CAPS time frame. They are not confident to venture into other ways of delivering the content because they might start trailing behind schedule. There was a consensus that planned activities needed a lot planning and an effort to be successful.

> Teacher C*: If you teach a big class, you seriously do not want to be making students regroup. You take time to get everyone in a learning mood. Imagine when you pair them! It is not all learners who will be discussing what you asked them to.*

It was discussed that learners with dyscalculia need to be encouraged to be working in pairs because they find it embarrassing that they struggle with simple mathematics concepts that their peers master. Therefore, if they work with someone that they are comfortable working with, it is less intimidating. Peer teaching is an important aspect of the implementation of AL. However, the inability of teachers to apply peer teaching in a mathematics classroom poses a challenge to the implementation of AL.

4.2.3.4 Inability to effectively engage learners through cooperative learning

According to Flynn (2013:2), cooperative learning allows learners an opportunity to actively engage in the process of learning mathematics. A well-formulated cooperative group will provide learners an opportunity to engage in learning through discussion. Learners will have an opportunity to investigate and challenge one another's ideas, while communicating mathematical ideas with one another as well. On the other hand, Altun (2015:464) held the view that the disadvantage of AL is that learners have to work as a team and be successful as a team. That means mistake or error of one learner can cost the entire team. This notion of cooperative learning creates an element of anxiety, especially to learners who have weak skills. The teacher has to be conscious that learners with dyscalculia might feel anxious in a cooperative learning environment.

The research team discussed the challenges in effectively using cooperative learning in the mathematics classroom. Below are the discussions with regard to the implementation of AL due to the inability of teachers to engage learners through cooperative learning:

> Teacher C: *Cooperative learning is good in getting learners to learn from each other. However, the big challenge is getting all learners engaged in that group. Learners with dyscalculia are not eager to learn mathematics. The challenge is getting them interested so they can actively participate.*
>
> Learner E: *I enjoyed it when we work in groups because I can get my friends to explain, but the problem is that the teacher sometimes leaves us alone working on the problem. When we get stuck, we go fetch him from the staff room. It would be better if we work as a group in front of the teacher.*
>
> Teacher A: *The issue is lack of understanding of how cooperative learning could be made part of learning in a mathematics classroom.*

In an active learning environment, a teacher may use small groups to explain difficult concepts to classmates, and applying the concepts in real-life situations allows learners to learn from one another from feedback. Therefore, following on a view raised by Learner E, it will not be possible to use

cooperative learning if a teacher leaves the room while the learners work on a mathematical problem. The teacher needs to be there to engage and guide learners.

> Teacher B: *I think it is lack of understanding of how cooperative learning could be implemented*.

The research team agreed that perhaps some teachers think of cooperative learning as a strategy of learning whereby learners are left alone to help one another.

4.2.3.5 The teacher's inability to create an effective learning environment

The learning environment is an important aspect of learning, especially when there is a need to get learners with dyscalculia to be a part of learning and get excited about learning. In this study, the focus is using AL in addressing dyscalculia in a mathematics classroom. AL requires creating a learning environment that propels learners to not only own their learning, but also participate in that learning process.

Reddy and Beyene (2014:1) viewed AL as a technique where students do more than simply listen to a lecture; students are doing something, including discovering, processing and applying information. The research team agreed that the learning environment had to be accommodative of AL. There were discussions as to what the learning environment is and an understanding of the learning environment that could support the implementation of AL. Understanding was sought from Kennedy *et al.* (2007:72), who postulated that management of the instructional environment requires a teacher to make a "decision about the time, space, materials, textbooks and other resources for teaching" in order to create a learning environment that is interactive. This will further allow learners to manage their own learning.

The management of time requires that there should be a plan in advance of the kinds of activities that learners will be engaged in. If a mathematics lesson is planned for 45 minutes, then a teacher needs to know the activities that they will be engaged in and for how long.

Therefore when a teacher applies an AL strategy in a mathematics classroom, the teacher needs to create a learning environment within the allocated time, space, and with the appropriate teaching resources that would encourage the learners to be able to connect the acquired information to what exist in the real world. The teacher should, therefore, give learners an opportunity to process the acquire information and make new discoveries from it.

> Teacher A: *Creating an effective learning environment such that active learning is important and requires that we create a stimulating learning environment. For example we could put mathematical posters around the walls. However, this is not always possible because we will have to spend from our pockets.*

> Teacher B: *I think as teachers, we know that we have to engage learners as much as possible. We need to help them apply the information they learned in the their real life. However, learners that are identified as possibly having dyscalculia often appear lost in class. They would hardly ask questions or participate during the mathematics lesson. Therefore, if we could give such learners time, I will not be able to cover the lesson for the day. Controlling time is a big challenge.*

According to Kennedy *et al.* (2007:73), creating a good learning space means the arrangement of desks in class. Desks that are arranged in lined-up rows suggest a teacher-centred approach, where learners need to sit and listen to the teacher. A learning space refers to the mathematical posters displayed around in class as well.

> Teacher B*: I understand that creating of good learning environment requires well-planned time and the correct space for learning. I agree with time being a challenge, but the learning space is also a problem. Our classes are crowded and therefore it can be difficult to have an interactive learning environment when space is a problem.*

> Teacher C*: Sometimes learners strip off the posters in class. It is therefore a challenge for a teacher to keep making posters for the class. Besides, the school does not give us money to make these posters. They have to come from our own pockets.*

During the research team meeting, there was a discussion about the importance of an extended learning environment at home as well. It was agreed that it would a good idea for parents to be involved in learning mathematics at home.

> Parent A: *I think I can create a learning environment at home by sending my daughter to the shop and asking her to take out plates for a number of family members. However, I see this as a challenge because my daughter forgets things easily. When I send her to the shop, she forgets what she went to the shop to buy. It is impossible to think that she could come back with the correct change.*
>
> Parent B*: When I am at home, my daughter gets very agitated when discussing anything with counting and therefore, to keep her happy, I avoid any activity that has mathematics in it. Therefore creating learning environments is important but it is not easy because of the child's attitude toward learning.*

The team agreed that creating an effective learning environment was a challenge because the learning environment is more than learning space. There is also a challenge with the availability of resources in creating such an environment for learning. It was evident from the discussion that it would be difficult to implement AL without addressing the challenge of an effective learning environment.

4.2.4 Summary

The discussion above entailed the challenges regarding the need to understand dyscalculia, the existence of dyscalculia in a mathematics classroom and the implementation of AL in addressing dyscalculia. The research team reflected on the identified challenges and agreed that there was a need for an awareness meeting and information session meeting to address challenges pertaining to an understanding of dyscalculia and the existence of dyscalculia in a mathematics classroom. There was also a need for an information session that covers the implementation of AL by taking dyscalculic learners into consideration. The successive sections will deliberate in the components of the solution, and demonstrate how the solutions were provided and systems put in place.

4.3 SOLUTION PERTAINING TO THE NEED FOR AN AL STRATEGY TO ADDRESS DYSCALCULIA IN A MATHEMATICS CLASSROOM

Kirk and Payne (2012:16) argued for the awareness and support of learners with dyscalculia; they presented a view that dyscalculia is “a difficulty with the concepts of numbers”. When there is awareness of dyscalculia, then learners may be supported. Indeed, it will be difficult to intervene in a mathematics classroom, unless teachers are aware of dyscalculia. To provide the solution with regard to the lack of awareness about dyscalculia, the research team decided it was important to discuss the workshop presentation by the dyscalculia specialist. Below are the reflections of how they could identify dyscalculia in a mathematics classroom:

> Teacher A: *Learners with dyscalculia find it difficult to recognise symbols and numbers. They will need assistance and continuous support to be able work with numbers.*
>
> Teacher C: *Learners with dyscalculia have a hard time in classifying objects by shape or size. They will struggle with simple concepts of addition, subtraction, multiplication and division. They may even confuse 6 with 9 and confuse 3 with 8.*

Teacher B nodded, stating that he can now recognise some learners in his class with dyscalculia. Parent C also indicated that she could think of some people in the community who struggle with numbers – they can never tell you time, and that it became clear to her that it was possibly because of dyscalculia.

> Teachers B: *I also noted difficulty to recognising patterns with learners with dyscalculia.*
>
> Official C: *I think as long as class average performance in mathematics assessment score is high and a particular learner still fails mathematics, I can note the availability of dyscalculia in that case.*

From the discussion with the research team, it was evident that participants were growing more aware of the existence of dyscalculia. They could note symptoms of dyscalculia based on the information shared during the workshop and the discussion meetings with the participants.

4.3.1 Information pertaining to the understanding of dyscalculia

Following a workshop presentation by a specialist in dyscalculia, as discussed

in Section 3.6.1.2 (the minutes of the workshop are included as Appendix 2), participants had the following views about dyscalculia:

> Teacher C*: From the presentation, I can now see a few learners in my class who I think might have dyscalculia. For example, there is a learner who never passed mathematics since Grade 1.*
>
> Teacher A*: There is also a learner in my class who often sleeps in class. He will never participate in a mathematics activity.*

Based on the extract above, it can be assumed that Teacher C and Teacher A got a basic understanding of what dyscalculia is. Hence, Teacher C could visualise some learners with dyscalculia. Teacher A reflected on one of the learners in class who gets bored and sleeps in class. There was, therefore, evidence that the information shared during the workshop was beneficial to the research team. Teacher B and C further shared their understanding of dyscalculia as follows:

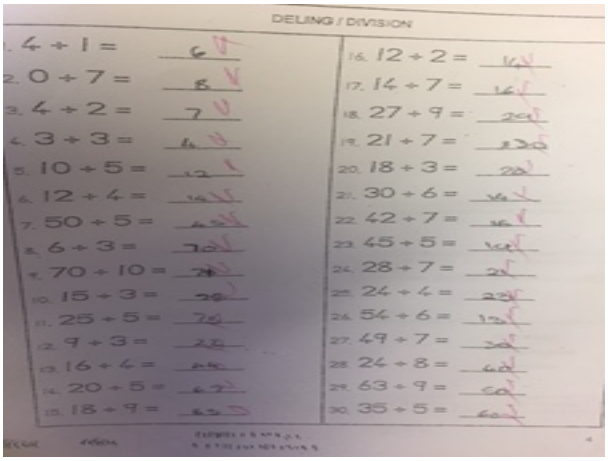
> Teacher B*: So dyscalculia is, basically, difficulty with numbers. Such learners have a problem in comprehending numbers.*

From the extract above, Teacher B suggested that after attending the workshop, there was a fair understanding of dyscalculia. Such understanding is attested by the realisation that dyscalculia may be reduced to difficulty with numbers. This realisation is observed by the teacher saying, *So dyscalculia is, basically, difficulty with numbers*. Teacher C also commented on the understanding of dyscalculia:

> Teacher C: *…such learners have problems in recognising numbers, for example they may confuse 6 for 9.*

From the extract above, Teacher C noted one of the many symptoms of dyscalculia. This understanding from Teachers B and C gives an impression that participants view dyscalculia as difficulty with numbers, which may also be observed when learners have difficulty in recognising numbers. This understanding is in line with the discussion on dyscalculia in Chapter 2, where the elements of dyscalculia were discussed in detail. In that section, it was discussed that difficulty in dyscalculia included difficulty with numbers, number facts, numerical operations, place value and principle exchange (refer to Section 2.3.2.3 for more detail). An official from the district also presented the

work below in accordance with the official's understanding of dyscalculia:



The presented work above is from the assessment work of a 16-year-old Grade 8 learner. The above work assesses the learner's understanding of division.

> Official D: *The above shows that the learner has no concept of division.*
>
> Official C: *There is other aspects of difficulty around this learner; however, one can note that such a learner has difficulty with numbers.*

From the above extract, the assessment work of a Grade 8 learner is noted. The observations by the officials that the learner has difficulty with numbers, regardless of the other existing external factors, were indications of their understanding of dyscalculia. This understanding is also supported by the observation of the above work that the named learners struggled with simple division such as 4/1 and 3/3. The above case was noted and the intervention was planned. This is also in line with the discussion about the semantic memory difficulty, in that such a learner will have difficulty in retrieving mathematical facts and a high error rate will be observed (refer to Sections 1 and 2.3.2.5.1).

As noted in Section 2.2.1.3, CER, which underpins this study, holds participants at the same level with the researcher. According to this view, all participants are respected and their contributions are valued. It is in that regard that parents were given the opportunity to also share their views. They also shared their personal stories, associating the gained information about

dyscalculia with their experiences. Below are their views of dyscalculia following the workshop:

> Parent A: *When I send my daughter to the shop to buy bread, most of the time, she comes back with nothing because she forgot the reason she went to the shop. Sometimes, she is not sure of the change from the given money.*

From the above extract it is clear that the parent associate dyscalculia with the memory loss, which is attested to by the statement that sometimes the learner is sent to the shop and she comes back with nothing because she has forgotten what she went to buy.

Parent B attested to the difficulty with memory, as noted by Parent A above, and also referred to the difficulty of telling time faced by learners with dyscalculia.

> Parent B: *I noticed that my son forgets things easily. He also struggles to tell the correct time.*

Parent C commented as well, expressing her daughter's frustration in dealing with mathematics activities with the following comment:

> Parent C: *I noticed that my daughter gets frustrated when it is time to do mathematics homework in particular.*

From the above extracts, it was noted that teachers and parents had an idea of what dyscalculia was. They related dyscalculia to the observed struggle in memorising and handling basic arithmetic in everyday lives.

> Parent A further noted with a smile: *I know individuals in the community who struggle with basic arithmetic and they struggle to tell the correct time.*

There was general enthusiasm among the participants, as they could identify dyscalculia by associating the knowledge gained and their personal experiences. This supported the notion that learners with dyscalculia are not mentally challenged or stupid, but face a challenge that affects a certain sector of the community.

The research team agreed that dyscalculia was not a life sentence. Something could be done to help individuals with dyscalculia. Participants'

engagement even on what could be done to assist learners with dyscalculia shows their level of understanding of dyscalculia. They understand that dyscalculia is a mathematical disability that could be managed through the appropriate intervention strategy. The discussion below captures the understanding of AL by participants with the perspective of assisting learners with dyscalculia.

4.3.2 Existence of dyscalculia

There are various diagnostic tools that are used for dyscalculia learners, based on the knowledge gained from the workshop with the specialist in dyscalculia and the gained information from the literature, as covered in Section 2.4.1, about the three prominent areas of difficulty for learners with dyscalculia, namely semantic memory, procedural memory and visuospatial memory. Based on the analysed work, it was noted that all the identified learners had challenges with semantic memory. However, visuospatial memory did not seem to be a challenge with most learners. Below are the discussions on how semantic, procedural, and visuospatial skills may be enhanced in assisting learners with dyscalculia. The solutions were discussed following the workshop meeting that was led by the specialist in dyscalculia.

4.3.2.1 Semantic memory understanding

Semantic memory was earlier described as the difficulty in retrieving arithmetic facts (refer to Sections 2.4.1 and 3.6.5 for further discussion). The research team reflected on the following experiences in their mathematics classrooms

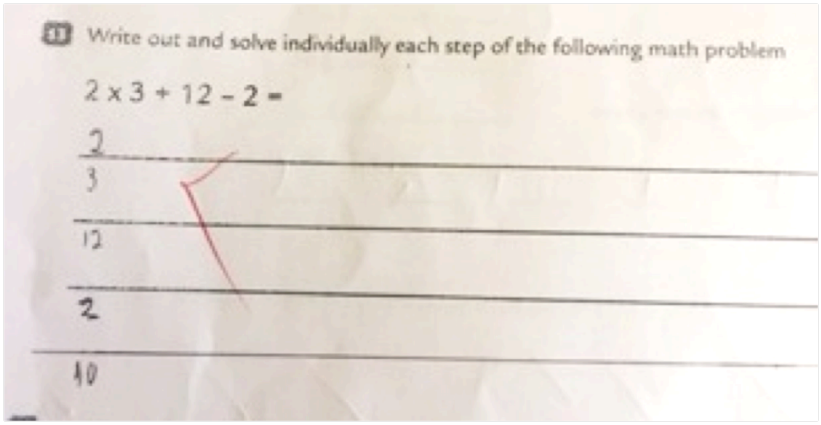
> Teacher A: *If you draw five oranges on the board and ask to tell you the number of oranges without counting them, learners with dyscalculia take time to answer the question because they cannot estimate. They need to count each orange to get to five.*
>
> Teacher B: *They also struggle with place value, for example when you verbally tell them to write 206, they may write 2006.*
>
> Parent C*: If I give my daughter R20 to go buy bread – costing R10, at the corner and ask how much change I should expect, she gets irritated and just ignores me. I understand that it is because she is*

probably afraid to get the answer incorrectly.

From the discussion, it was clear that the participants understood the semantic memory difficulty for learners with dyscalculia. The discussions and workshop information assisted in helping the research team to diagnose areas of dyscalculia.

4.3.2.2 Procedural memory understanding

Procedural memory was understood in the context of the learners' failure to remember and follow mathematics procedures to arrive at a mathematically correct solution. The following were the discussion points that were raised by the research team:



Teacher A*: It is clear that the learner does not understand the mathematics procedure here to follow. I, therefore, think repetition is important to help learners understand.*

Teacher B: *It would also be a good idea if the BODMAS is written next to the problem to probe the learner to remember.*

Based on the extract above from Teachers A and B, it is important to note they held the view that any form of repetition would assist the learner to understand and remember the procedure to follow as in the indicated mathematics problem.

4.3.2.3 Visuospatial memory understanding

The visuospatial memory difficulty was understood in the context that learners have difficulty in recognising mathematical shapes and completing a given pattern.

> Teacher *A*: *As it was noted from the analysed work, learners appear to forget. Therefore various ways of presenting the same concepts over time may help.*
>
> Teacher B: *I think it is important to see the shapes in real life and therefore learners can make the associations easily.*

Based on the extracts above, there is hope that learners with a weakness in visuospatial memory may be assisted through repetition and usage of manipulatives or presentation of the drawing in real life. The solution, as proposed by Teachers A and B, is in line with the recommendation by the dyscalculia specialist that learners with dyscalculia learn well with actual physical objects.

From the discussion above with the research team, it was evident that they understood how they could identify visuospatial difficulty in learners and how they could assist learners to deal with their visuospatial memory difficulty.

4.3.3 COMPONENTS OF THE AL STRATEGY IN ADDRESSING DYSCALCULIA

As part of this study, it was important to formulate a framework that would propose an AL strategy that will address dyscalculia in a mathematics classroom upon shared ideas. It was therefore crucial to provide a platform based upon principles of emancipation, tolerance, understanding and the desire to empower affected members of the community to voice their ideas in providing a solution to an existing problem.

When I first asked participants, they were not aware of dyscalculia as a mathematical learning disability. Once I had explained what dyscalculia was, they started engaging and wanting to provide a solution to individuals who are

written off as incapable of ever learning or understanding mathematics. Participants were also not familiar with a research study where they are regarded as co-researchers. I therefore communicated the concept of Participatory Action Research (PAR) as the underpinning methodology of this study. I explained the PAR idea, as explained by Tshelane (2013:417), that the development of PAR is rooted in liberating those who are in some form of oppression. It is a collaborative mechanism under which the researcher and participants work together to address issues in a specific system. Participants understood that they were all of equal value to the study and, hence, it was important they should feel comfortable to share their thoughts and ideas. They were all awarded with an opportunity to speak and cite their view on what they thought was a relevant solution in addressing dyscalculia in a mathematics classroom.

Following the workshop meeting with the specialist consultant in dyscalculia and discussion meetings pertaining understanding of AL, it became evident from the research team that we needed to deliberate on those elements that provided a solution in the implementation of AL. Below is such a discussion within the framework of this study.

4.3.3.1 Formulation of an effective questioning and assessment strategy

In our research meeting, led by one of the teachers, we watched a video that explained various elements of AL. We reflected on the symptoms of dyscalculia and those weaknesses that we perceived from learners with dyscalculia. Learners with dyscalculia achieved between Level 1 (0-10%) in mathematics. However, there was exceptional performance in Arts and Culture of Level 6 and above. We learned that dyscalculia is not a life sentence. However, it was important to establish those elements that would assist in the implementation of AL in a mathematics classroom. The formation of an effective questioning and assessment strategy was important in ensuring AL is effective in addressing dyscalculia in a mathematics classroom. In this meeting, there was a discussion that entails the understanding of a questioning and assessment strategy and how it could be

used in a mathematics classroom.

> Teacher A: *Assessment is an important aspect of learning, especially in a situation where we have learners with dyscalculia. It is through assessment that we will know the advancement of dyscalculia.*
>
> Teacher B: *Such learners have never passed any mathematics assessment. Therefore, we need to look into how we teach them and also how we ask them questions in order to propel them to achieve.*
>
> Teacher C: *A correct question could encourage or discourage a learner.*

During the discussion meeting, when the team was reflecting on what the learners thought about questioning and assessment, a learner shared the view below:

> Learner E: *My poor performance in mathematics is because I get nervous and confused during the assessment time. The problem I have is that after writing the test, the teacher will call the test results and my peers will laugh when the performance is poor. The fear of being ridiculed plays in my head and I get nervous.*

Teachers acknowledged that an assessment of learners' understanding after covering a mathematics topic was crucial. However, they needed to consider taking into consideration the feelings of their learners.

> Teacher B: *I had thought that calling the learners' test results in front of the class would be encouraging. I never thought of it as something that could affect the very assessment.*

It was agreed that learners with dyscalculia have a delicate attitude toward mathematics because of their lack of understanding of basic mathematics concepts. Their inability to recall things easily needs to be accommodated when asking questions. Perhaps they could be allowed to use calculators in certain assessment tasks.

It was also considered that it was important that teachers should pay attention to the questions that they ask learners during the teaching time. Teachers should choose questions that provoke learners to think. AL seeks to create learners who think critically. Therefore, the types of questions asked, should provoke them to think and reason.

It is important that the teacher does not only tell the learner that their answers are wrong, but quiz them about their solution. This will help the teacher establish the information gap and where the areas of mathematics weakness are.

In a separate meeting held with parents and learners, effective questioning was discussed by parents who shared the following views:

> Parent E: *The idea of asking questions is not only for teachers. It is not always possible for a teacher to know when learners do not understand.*
>
> Learner E: *Sometimes, as learners, we are shy to ask questions in front of our peers.*
>
> Parent D: *Then learners should make an effort to go ask in class.*
>
> Parent E: *As a student, I used to ask a lot of questions after school. I soon realize that when I asked questions alone, I received a lot of attention from the teacher. The teacher would even give me extra work to do at home as a way to help me understand.*
>
> Parents B: *Assessment is also an opportunity for us parents to see how our children are doing at school. We should therefore be encouraging when a learner did not do well in a test or exam. This way, learners will not hide their poor performance results.*

The research team reflected on the discussion points that were made by learners and parents. Teachers also agreed that asking questions was a responsibility of learners, as well as parents. It was, therefore, evident that collaboration between parents and teachers was very important in helping learners with dyscalculia, since they perform poorly in mathematics.

> Teacher E: *Even parents should go through the books of their children (learners) at home and when they feel that a learner is totally lost, they can ask the teacher to look into helping a learner.*
>
> Teacher B: *That kind of working together can help a learner. This will help us teachers to give learners with dyscalculia tasks that they could carry out at home with the help of the parents.*

The research team agreed that, indeed, extra homework, which is specific to learners with dyscalculia, could be given. In much the same way that extra

difficult homework could be given to gifted learners, dyscalculic learners could be given specific work to do at home. For example, in order to help learners understand the concept of time, the teacher may ask a learner to work with the parents on a task such as the following:
“During meal time, set up a timer from the time you start eating and until you finish. Record the starting time and the finishing time.” Suppose that they started eating a dinner meal at 6h30 pm and finished eating at 7h05. Then they would report that eating a meal took 35 minutes. They could do the same type of calculation for the bath time, etc. This way the learner can start understanding the concept of time, more so, because we noticed from the task that we gave the learners that some of them thought it would take three hours to brush their teeth.

Such tasks that learners can do at home will help parents to take part in what the learners are learning at school. This will also serve as motivation, especially to learners with dyscalculia because they could realise the relevance of mathematics in their everyday activities.

4.3.3.2 Usage of manipulatives in a mathematics classroom

An understanding of manipulatives is drawn from the description by Maboya (2014:68) of physical objects that are used as teaching tools. During the workshop meeting with the dyscalculia specialist, participants learned that learners with dyscalculia learned better when they touch and feel the objects. The dyscalculia specialist mentioned that she allows learners to work with clay balls. They can cut the clay into different sizes and shape it into different shapes as well. In a research meeting, when the usage of manipulatives was discussed, teachers reflected on how the dyscalculia specialist used manipulatives in addressing dyscalculia.

> The specialist illustrated: *Making pattern is a fundamental mathematics skill; all sorts of things can be used to make patterns – buttons, rice, dried peas, lentils, small pieces of shiny or coloured papers, the child’s toys, etc.”*
>
> Learner E: *I enjoy the mathematics lesson when we use different objects and we use colourings to create learning stuff. For example*

when we learn about fractions.

Learner A: *I also enjoyed the game of cards.*

The research team agreed that manipulatives have a way of making mathematics come alive in a learning environment. It is a concrete phase of learning mathematics ideas. Figure 4.1 below illustrates how addition could be taught from manipulatives. The teaching process starts with the concrete representation, which is the blue blocks, then the pictorial representation and later on the abstract representation of the same facts.

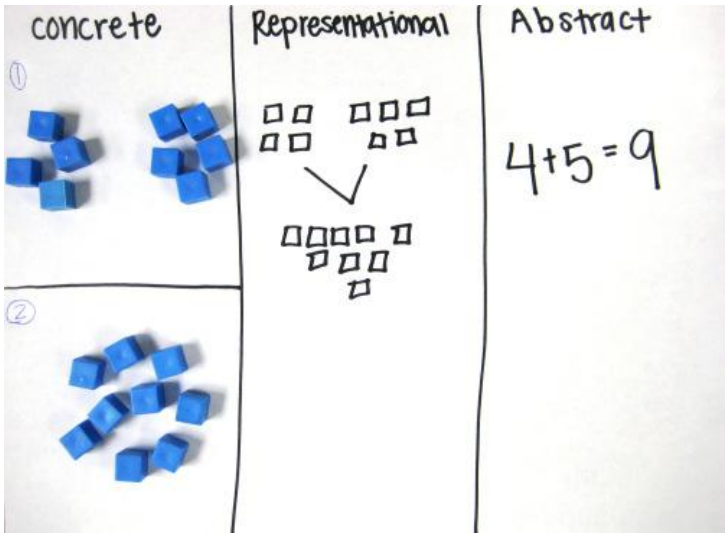


Figure 4.1: Manipulatives used to teach addition
(https://mathteachingstrategies.wordpress.com/2008/11/24/concrete-and-abstract-representations-using-mathematical-tools/)

The team agreed that they wanted to achieve AL and that usage of manipulatives was necessary in assisting learners with dyscalculia without excluding them from other learners. Teachers suggested that manipulatives should be a part of every lesson taught, because they bring to life the representation of the facts that are being taught in class. They reflected on the results of the learners with dyscalculia that assessments show these learners having difficulty in computing simple number facts. Therefore representation of numbers through usage of manipulatives strengthens their understanding. It will always help them with the conceptualisation of numbers.

4.3.3.3 Effective usage of peer teaching

Felder and Brent (2009:3) suggested activities for peer teaching, namely think-pair-share and think-aloud pair-problem-solving. In a think-pair-share activity, a teacher will pose the problem and ask learners to work on it individually for a short time (about five minutes). For example, Thabo drove 53 km to visit his grandma. Nomhle drove 70 km to visit her grandma. How many km did Nomhle travel more than Thabo? Then the teacher pairs the learners to compare their solutions and improve on them if necessary. A teacher may call a few different individuals to talk about their solutions to the posed problem. The problem could be complex, so as to allow learners to analyse it and think it through. However, in a case where there are learners with dyscalculia, it is important that the teacher remains mindful that they need to start from easier problems and grow from there.

The other suggested activity in peer teaching is that the teacher may use "think-aloud pair-problem-solving". Think-aloud pair-problem-solving is a technique used to assist learners to work through a problem independently. The technique allows learners to work through a problem and understand the solution to a problem; they have to do a case analysis or an interpretation of a problem. The teacher will arrange learners into pairs and one member will be responsible for explaining and the other will be responsible for asking questions. A learner explaining the question will be given time (2-3 minutes) to explain and give a detailed analysis of the problem. Then the learner responsible for asking questions will follow with the questions based on the explanation and the analysis provided. The questions will be directed on the explanations that were not clear or where there was missing information. Once a satisfactory explanation is given, the pair swaps places.

> Teacher A: *I often notice that learners understand each other. And when I pair learners, I reshuffle their sitting arrangement.*
>
> Teacher B: *When you reshuffle them, it is important that you ensure that they are comfortable with whom they sit with.*

Participants nodded that the pairing has to be comfortable for learners. There is, for instance, a phase when boys are extremely uncomfortable when they

have to associate with each other.

> Parent C: *Peer teaching is one of the best ways of allowing learners to learn from each other. The teacher can pair a best performing learner in mathematics with a learner who performs poorly in mathematics. Then the two learners can discuss.*
>
> Learner E: *I enjoy mathematics class when the teacher allows us to stand in front of the class to teach other learners the math problems that we understand. The teacher only assists us when we all get stuck*.

The learner participants were asked the following question: “Suppose one of your friends confuses + (addition) and x (multiplication). How will you explain the difference to your peers?

> Learner E: *Sometimes learners confuse the two signs because of the way they put the working book on the desk when writing. If the working book is not placed straight then the two signs can be confused.*
>
> Parent C: *I agree that the two signs can be confusing. When I write, I also slant the working book and when I do that (+) looks like (x). When learners write… are often set next to each other and it is easy to notice how the working book is placed at the desk.*

The research team agreed that it was important too that the teacher should communicate the expectation from the task.

> Teacher C: *Learners have to be clear what they need to discuss and what the teacher expects to know from them.*
>
> Teacher A: *Time management is also an important element in peer teaching. Learners should know for how long they should discuss.*
>
> Teacher C: *Further emphasised. The discussion should not go on endlessly. It should be clear when it will end.*
>
> Teacher B: *The other benefit of peer teaching is that it boosts confidence of the learner who is teaching.*
>
> Learner E*: As a learner, it is nice when I am the one who is explaining to the other learners.*
>
> Teacher B*: Peer teaching can work like a “bee hive”. For example, when one learner understands the taught concept, then they can move on to explain to the other learner.*

4.3.3.4 Effective usage of cooperative learning

During the research meeting, participants believed that effective usage of cooperative learning was an important element toward the implementation of AL. Participants shared the following views:

> Teacher A: *I put learners into groups to discuss a given activity. It is amazing how much learners learn from interacting with each other.*
>
> Teacher B*: It is still very important to mix learners according to their abilities.*
>
> Parent A: *Children always play together and get to know each other easily. It is therefore a good idea to give learners an opportunity to teach each other.*

Participants agreed that the traditional way of learning mathematics was about a teacher presenting a mathematics problem on a board. He or she would solve it in front of the class and then expect learners to be able to solve a similar problem on their own.

Teacher B reflected that the traditional manner of teaching will not actively engage learners and will certainly exclude learners with dyscalculia from the learning process. It was therefore agreed that cooperative learning was an important part of the implementation of AL.

4.3.3.5 Clear articulation on creation of an effective learning environment

The research team discussed that the idea of creating an effective learning environment is about creating a learning environment that considers appropriate usage of time, space and using the appropriate teaching resources. This environment will contribute to be a boosting environment for learning to take place. The research team also reflected on the knowledge gained about learners with dyscalculia that they have a challenge to forget easily. Therefore a supportive learning environment will include repetition of the concepts.

> Teacher A*: As teachers, for example, we may have posters in our classroom that we create together with the learners. The posters could be a representation of the concept that we are learning at that*

time. The posters will be a constant reminder of that which was learned.

Teacher B*: The idea of creating posters with learners is good because then learners will take pride in such posters and they will not destroy them.*

In a separate meeting held with the learners and parents, a consensus was reached that a beautiful class is welcoming and learners look forward to coming to it; it makes coming to school exciting.

Parents even suggested that perhaps learners could create posters as part of homework. That way the creation of posters does not become a financial burden on teachers only.

All research team members welcomed this idea and believed that it would enhance the learning environment. It was agreed that an effective learning environment means that the teachers need to plan their lessons in advance. They need to come to class on time as well. These factors contribute to the positive learning environment. If the teacher plans a lesson in advance, they will know in advance how they are going to roll out a particular lesson and help them to anticipate the questions that the learners might ask. They will also know in advance the time they will allocate to a particular lesson.

The team had a discussion of the classroom space. It was clear from the discussion that the traditional way of sitting was not suitable for AL. Drawing from the observation of an AL classroom from the videos and the experience that teachers have when teachers teach in a certain sitting arrangement, the team agreed that the ideal sitting environment was the one proposed by Harvey and Kenyon (2013:5), where learners sit in groups, but also in a circular form.

A presentation was done on the classroom environment. The presentation encapsulated various sitting arrangements. The research team felt the sitting arrangement presented in Figure 4.2 below, was the most appropriate for an AL classroom environment that would support learners with dyscalculia.

Teacher A commented: *However, the reality is that most of our schools do not have such desk facilities.*

Figure 4.2: Proposed classroom sitting for active learning (Harvey & Kenyon 2013:5)

The team reflected that the sitting arrangement was not the only aspect of the learning environment. Knowledge was drawn from the work of Harvey & Kenyon (2013:5) who believes that physical space for learning is a space that encourages collaboration and interaction for both educational and social interaction within an environment that stimulates critical reasoning.

The research team agreed that the above principles would be considered as part of the preparation of an effective classroom environment for learning mathematics for learners with dyscalculia.

4.4 CONDITIONS CONDUCIVE TO THE SUCCESSFUL IMPLEMENTATION OF AL

A workshop meeting was conducted to look into how the elements of AL could be best implemented in class to ensure that the pointed challenges in the implementation of the strategy are addressed.

According to Zerafa (2015:1181), there is no evidence of one intervention strategy that works absolutely in addressing mathematics learning for learners with dyscalculia. However, any appropriate intervention programme can help learners with dyscalculia make a substantial improvement. The discussion

below will focus on those factors that contributed to the effective usage of the elements of AL.

4.4.1 Factors that supported the usage of effective questioning

The research team agreed that it was necessary to understand how AL is implemented so they could be able to ensure that they understand assessment and effective questioning in the context of AL.

A video on effective questioning was organised and watched during the research meeting. The video highlighted that questioning is an important aspect of learning and is crucial in keeping learners attentive; questioning is also important for the teacher to know whether learners understand or not. The video is a lesson prepared by Kevin Ward (2014). In this video, it is stated that there are two types of questioning techniques, namely “cold-calling” and “no-opt-out”.

Cold-calling is referred to as the oldest form of questioning, whereby a learner is called out randomly to answer the question. This technique keeps the learners attentive to what is being learned in class. However, it is important to take note that when the name of the learner is called in class, if the teacher mentions the learner’s name first, before asking the question, the rest of the learners normally will not pay attention anymore. However, if the teacher calls the name of the learner after asking the question, the whole class will be attentive because any learner in class could be called.

The no-opt-out technique refers to the situation where the teacher asks a question and the learner does not know the answer. This could disturb the flow of a presentation for a teacher. The learners might also think that they are off the hook for the rest of the lesson because they do not know the answer. However, not knowing the answer, is a cry for help for the learner. A teacher may offer a hint to assist the learner to understand the question. Alternatively, the teacher may offer to come back to the question after making the question a teaching moment.

The research team reflected on what they had learned from the video. They appreciated the information from the video for simplifying the questioning techniques. The following were the comments from the teachers:

> Teacher C: *I never really thought about when to put the name of the learner when asking a question.*
>
> Teacher B: *I also think calling the name of the learner to answer the question may be intimidating for some learners for fear of getting the answer wrong in front of the whole class. Hence, the learner might say I do not know even if they know.*

Therefore, it becomes important to use the no-opt-out technique because the teacher may continue to engage with the learners to help them understand the question and leading them to the right answer.

> Teacher C: *I think at that time the learner might get confidence to know whether their answer is correct or not.*

The research team watched another video based on the experiment conducted by Professor Dylan William. Professor William has published work on assessment as part of learning. He believed that education is designed to cater for everyone. In a classroom, learners who answer questions get smarter, whereas learners who never answer questions in class are left behind. An experiment explored how teachers can get all learners to have an opportunity to answer questions in class.

The other experiment is called “whiteboard”. In this experiment, the teacher asks a question and each learner writes the answer on his or her mini whiteboard. After writing the answer, each learner puts up their whiteboard for the teacher to see their answer. In both these experiments, learners are all engaged in the questions asked.

The research team reflected on the video experiment as follows: The whiteboard experiment can work well in a classroom with dyscalculia learners because the teacher will not only see the correct or incorrect answer, but also where the mistake is. There was general agreement that such a questioning method will cater for shy students and those learners who are afraid to

embarrass themselves.

The research team agreed that they may not use whiteboards, but the teacher may give blank papers for learners to write on. Therefore it was concluded that there are various ways of asking questions, including the cold-calling method that may be used with a card or lollypop name system. Teachers may use the no-opt-out method as well to ensure that all learners are constantly engaged. The whiteboard method was perceived as being crucial in helping learners with dyscalculia to actively engage in learning.

4.4.2 Factors that contributed toward effective usage of manipulatives

The school where the research meeting was held and one of the participant teachers were given training in the usage of manipulatives. The school was therefore in possession of various manipulative tools. The research team members agreed that the teacher who was trained in the usage of manipulatives would lead the discussion meeting in establishing the factors that contribute toward the effective usage of manipulatives.

In the discussion it was agreed that planning in advance of the lesson was an important factor in effective usage of manipulatives. The other important factor was that the manipulative tools that are chosen for a particular lesson should be in line with the lesson. The research team felt that it was important for learners and parents to participate in the creation of manipulatives, in teaching some lessons where the tools are not available in schools.

4.4.3 Conditions that contributed to the formation of peer teaching

The research team felt that peer teaching was an important aspect of learning where learners can share ideas and learners may feel safe in expressing their views. However, the important condition is that the teacher has to think about whom they are pairing certain learners with. The learner should feel comfortable on working with that particular individual. Peer teaching would

also work if the teacher plans and thinks about the purpose and objectives of the pairing in advance. It is important that a learner who struggles with mathematics should be paired with a learner who excels in mathematics. Therefore, the prior consideration of how learners are paired, contributes to the formulation of peer learning.

During the implementation, the research team agreed that generally learners were not keen on sharing ideas with their peers because they each wanted to get the praise for doing the work individually. However, when learners are given an incentive for sharing information, they are motivated to share ideas with their peers. The team felt that a pep talk about sharing ideas helps learners to see sharing of ideas or information as a positive aspect of learning.

4.4.4 Conditions which made the use of cooperative learning effective

The research team had a presentation on cooperative learning. This presentation enabled the application of cooperative learning to be implemented with ease. During the implementation phase, learners were divided into working groups, which composed of learners with different abilities. The pep talk about sharing ideas and teamwork also helped learners understand the value of sharing. Therefore, the information session about how cooperative learning could be implemented, made the use of cooperative learning effective.

4.4.5 Factors that contributed in the creation of an effective learning environment

The research team had an information session where the creation of the learning environment was discussed. Following the discussion, there were a few mathematics posters that were posted in class. The research team understood that the classroom environment does not only refer to the physical space, but also how the learners feel about their classroom environment. During the implementation phase, the teacher had game activities to create a

friendly learning atmosphere. When a learner got an answer wrong, other learners were encouraged to assist that learner. This created a safe environment for learners who are normally afraid to share their ideas openly in class.

The class sitting arrangement creates a positive environment as well. Learners could easily share ideas with one another. During the information session, Parent E shared the following:

> *When I was a student at my school, we were made to sit according to our assessment results. For example, top achievers learners will sit in their own row, the underachievers in their own row. As students, we studied hard because we wanted to sit in a row associated with top achievers.*

There was therefore that general consensus that the sitting arrangement and emotional wellbeing in the classroom were important factors in the creation of an effective classroom environment.

Below follows the discussion about the threats that could hinder the successful implementation of AL and how these hindrances were encountered.

4.5 THREATS THAT COULD HINDER THE SUCCESSFUL IMPLEMENTATION OF AL

Active learning is all about enhancing learning through interaction and shared experiences. It encourages learning through practical experience. Weltman (2007:8) describes AL as a method of learning in which students are actively or experientially involved in the learning process and where there are different levels of active learning, depending on student involvement. The ideas that make up AL are evolving. In this section, the threats that could hinder the successful implementation of AL are discussed.

4.5.1 Learners' natural ability to pay attention during learning and teaching time

The research team realised that they were keen to see the AL strategy work; however, learners' ability to pay attention made it difficult for the implementation of AL. During the reflection meeting when the hindrances were discussed, participants made the following comments:

> Teacher A: *I noticed that when I bring the manipulatives to class, learners easily get excited and lose their concentration. Therefore, it becomes important to move around in class.*
>
> Teacher C: *I observed that the learner with dyscalculia gets discouraged when they are not sure what to do. I could see he was daydreaming when the other learners were working on a task about patterns on the triangles created by matchsticks.*
>
> Teacher B: *I also noticed that learners lose concentration when the task was too difficult for them.*

The research team thought it would be best that the teacher should explain the lesson before taking out the manipulatives. For example, when the manipulatives were placed in front of learners before the lesson, the learners were excited and it became difficult to get learners to pay attention.

The research team though it would be best to keep learners with dyscalculia engaged by making them the scribers in group tasks. This will help them stay engaged. It was noted that learners with dyscalculia have a low concentration span; therefore, the teacher needs to think in advance about how they will involve those learners in a class.

4.5.2 Teachers' content knowledge of mathematics and attitude in teaching mathematics

According to Felder and Brent (2009:2), the mistake that most teachers make when implementing AL, is that they will call for volunteers after every activity. Then learners tend to relax because they know someone else will do the activity and they can have a casual conversation with their friends. However, if they did not know who and when someone will be called, they will be doing

their best to engage and to prepare themselves, in case they are called.

Felder and Brent (2009) acknowledged an argument that there is a hindrance to AL in that the activities take time to plan. However, they also argued that preparing a good lesson takes time, regardless of whether there are planned activities or not. Therefore, the hindrance is the attitude toward planning a lesson, as opposed to spending more time preparing a lesson. In the reflection meeting, teachers echoed the same view by saying the following:

> Teacher *B: Changing of a teaching strategy takes time for preparation. Therefore, it is important that we gain knowledge of the topic that we are going to teach first. I have to consider what to do with learners who are struggling with mathematics. It is therefore important to think of certain examples on the spot.*
>
> Teacher A: *As teachers, our attitude has to change in order to reach all learners. Activities need advance planning.*

There was general agreement in the research team that it was important for teachers to have an understanding of the topic that they are going to teach. In order for AL to work, teachers have to also plan activities in advance. Ball *et al.* (2008:4) as well as Haylock and Manning (2014:1) are of the opinion that teachers need to know the content that they are going to teach and need to know the content that their learners are expected to master as well. Teachers need to know how to make the content they are going to teach understandable to their learners. Sometimes it would be necessary to think of certain questions to ask in class when a teacher realises that a learner is struggling to understand a concept.

Haylock and Manning (2014:3) alleged that in order for learners to enjoy learning mathematics, it is important that they should understand it, make sense of what they are doing in the subject and not just reproduce what they have learned. This is possible if the teacher understands mathematics and is also able to create activities that are engaging and to ask probing questions for learners to think about what they are learning.

4.5.3 Learners' attitude toward learning mathematics

During the implementation of AL, learners were asked about whether they would like to excel in mathematics. There was not a single learner in class who indicated that they would not like to excel in mathematics. When learners were then asked whether they thought mathematics was difficult, more than half of the class indicated that they thought mathematics was difficult.

One of the learner participants, who was in the group that indicated that mathematics was difficult, commented as follows:

> Learner A: *I am not sure if I could ever master mathematics. I have never passed mathematics in an assessment before*

Learner B was of the same opinion – that it was almost impossible to master mathematics.

This view was shared by most in the group. This kind of negative attitude toward learning mathematics is a threat in the implementation of AL because it is important that the negative perception is addressed, otherwise learners will be defeated before they could even try.

4.6 EVIDENCE TO SUGGEST THAT AL MAY BE SUCCESSFULLY IMPLEMENTED IN ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM

4.6.1 Assessment or questioning strategy

During the reflection meetings, the research team agreed that through an understanding of question and assessment, it was clear how all learners could be involved in learning. Teacher A made a comment that the learners with dyscalculia were seen smiling and interacting during the lesson. All the teachers nodded in agreement. Teacher C commented as follows:

> Teacher C*: The idea of the "whiteboard" is very good. It protects learners from being embarrassed. It also allows the teacher to see where learners are getting it wrong.*

The whiteboard idea was generally well received by the teachers, emphasising that it allows the teacher an opportunity too see what is not clear to some learners. Learners put their “whiteboards” up and thus the teacher can see the work without going through the learners individually. This was also helpful because the class is crowded and it is difficult for the teacher to move around.

> Teacher B: *I also like the idea of not just leaving the learner who got the answer wrong. But as a teacher you work with the learner until they get the answer correctly.*

There was a change in interaction of learners that were perceived to have dyscalculia. At the beginning of the study, they were very shy and had very little to say. We got the feedback that these learners appeared confused, at times, in class. They would hardly participate in activities in the mathematics classroom. The general feeling from learners was that they feel secure in class when the teacher asks questions in a manner that does not embarrass them in front of their peers. They also indicated that it was fun working on practical homework activities at home. For example, the following homework was given:

> *In class today, we learned about addition and subtraction. For homework, please send your child to go buy bread or any item at a nearby shop. Note down how much money you gave them, what they bought and how much that cost.*

The research team was excited about such an activity and similar activities because they make learning mathematics practical and get the parents involved in what their children are learning.

There was, therefore, general consensus that effective questioning and assessment showed successful implementation of AL in addressing dyscalculia in a mathematics classroom.

4.6.2 Manipulatives in a mathematics classroom

At the workshop meeting that we held with the specialist in dyscalculia, the specialist indicated that usage of manipulatives was very important when

teaching mathematics to learners with dyscalculia. The observation from the research team during teaching time was that “learners were at their happiest when using manipulatives”.

Learners also articulated the same notion that they enjoyed working with manipulatives. They made reference to the colour blocks and the matchsticks that they used to build triangles.

There was, therefore, evidence that manipulatives indicated a contribution of success in implementation of AL in addressing dyscalculia in a mathematics classroom.

4.6.3 Peer teaching

During the discussion meeting there was a discussion of how peer teaching worked in class. There was an indication that learners compete against each other to impress the teacher with what they know. Therefore they feel held back by a learner who has difficulty in learning mathematics. Most of the time, the teacher has to encourage learners to work together and even give incentives for learners to work together. The general feeling was that peer teaching worked in certain tasks but, in general, learners who could share their understanding are not always keen on sharing the information.

4.6.4 Cooperative learning

The discussion meetings on cooperative learning helped teachers understand how they could use cooperative learning in a manner that would benefit learners with dyscalculia. Teachers communicated what they expected learners to do and that they were in class while the learners were working together. The teacher was able to notice when learners who are weak in mathematics, were left behind, and encouraged group members to work together. In one of the groups, the learner with dyscalculia was leading in an activity.

Teachers commented that it was nice to see learners who are normally passive, engaging with other learners. It did not matter that their answers were not correct at times because they were sharing what they were thinking.

> Teacher A: *It is easy to correct a learner when you know what their thinking. Unlike when they are lost and you are not sure where to begin.*

4.6.5 Classroom environment

During the research discussion meeting, it was agreed that the classroom environment was an important element of AL. However, the sitting arrangement may be an issue still, because the class is full. Ideally the school would have desks that are comfortable for a group sitting arrangement. During the implementation, desks were moved around for learners to sit in groups. The teacher could move around but the movement was limited. On the other hand, learners were excited with the new sitting arrangement.

The research team agreed that the other elements of the classroom environment, of the teacher being in class on time and prepared, makes the lesson informative and inclusive.

> Teacher B*: I spend time before class thinking about how I could include learners who struggle with mathematics.*

The research team agreed that the classroom environment in terms of the teacher respecting the learners by coming to class prepared and on time, was good. The team agreed further that the traditional sitting arrangement will not work for the implementation of AL. It was therefore agreed that the group sitting arrangement was necessary.

Learners also attested that they liked sitting in group form, as opposed to sitting facing forward all the time. They indicated that they were able to interact with their peers with ease.

4.7 CHAPTER SUMMARY

In this chapter, the analysis, presentation and interpretation of the data were

presented, together with the findings. The chapter focused on how the data were presented, analysed, interpreted and discussed, in line with the objectives of this study, as presented in Chapter 1. There were various sources of data, which included the discussion meeting and a workshop, which affirmed that there was a need for an intervention strategy in dealing with dyscalculia in a mathematics classroom. Through the data, challenges pertaining to the implementation of AL were identified and solutions to those challenges were identified as well.

In this chapter, the conditions for the effective implementation of an active learning strategy were discussed. There was, furthermore, a discussion on the hindrances toward the implementation of AL and the solution in mitigating those identified hindrances to ensure that AL is used in addressing dyscalculia in a mathematics classroom. The next chapter discusses the findings of the study.

CHAPTER 5

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS OF AN ACTIVE LEARNING STRATEGY FOR ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM

5.1 INTRODUCTION

This study seeks to propose that an active learning strategy (AL strategy) is suitable for addressing dyscalculia in a mathematics classroom. This chapter presents a discussion on the summary of the findings, the conclusions reached and, finally, the recommendations for the implementation of active learning (AL) in addressing dyscalculia in a mathematics classroom. This chapter will further report on the challenges that confront the proposed implementation of the proposed intervention strategy. There is also a report on the components of AL; the conditions that made these elements work effectively are discussed, as well as the hindrances that could impede the successful implementation of the envisaged strategy. Lastly, this chapter provides a summary of the evidence which shows that the strategy worked.

It is the main purpose of this study to respond to the primary research question of this study: *How can we address dyscalculia in a mathematics classroom through an active learning strategy?* In order to achieve this primary main purpose, the study has six objectives that it aims to reach, namely:

- To investigate challenges pertaining to the need for an active learning strategy to address dyscalculia in a mathematics classroom.
- To explore the need for an active learning strategy in addressing dyscalculia in a mathematics classroom.
- To identify the elements of a successful active learning strategy that addresses dyscalculia in a mathematics classroom.

- To explore conditions or circumstances under which the elements of active learning would contribute to the successful implementation of an active learning strategy in addressing dyscalculia in a mathematics classroom.
- To anticipate impediments or hindrances toward the implementation of an active learning strategy dealing with dyscalculia in a mathematics classroom.
- To propose an active learning strategy as an effective tool in addressing dyscalculia in a mathematics classroom.

5.2 SUMMARY OF THE STUDY

This study seeks to formulate an AL strategy in addressing dyscalculia in a mathematics classroom. In order to establish the strategy to deal with dyscalculia in a mathematics classroom, it was, firstly, important to establish a team with varied experience and exposure in the learning and teaching of mathematics. It was also important to involve participants who have experience, knowledge and interest in an inclusive learning environment in our schools. Following the formation of the team, it was clear that most participants had never been involved in a PAR study before. PAR, as the methodology that underpins the study, had to be explained at the initial stage of the research. This was to help participants understand their role and engagement in this study. Schneider (2012:2334) described PAR as a means of emancipating individuals in developing areas. It was, therefore, clear that this research provided an opportunity for all participants to learn and emancipate one another. Teachers, parents, learners and those in education are concerned by the high failure rate in mathematics. In their eyes, there are learners who could just never learn mathematics. From the initial meeting, it was clear that participants were not familiar with active learning and dyscalculia.

It was, therefore, deemed necessary to organise a workshop meeting where the key terms would be explained and participants would be helped to understand and consequently be enabled make a meaningful contribution.

During this first meeting, a coordinator and a timekeeper were chosen. This was to ensure that the principles that underpin this study are adhered to at all times.

The principle that guided this study was Critical Emancipatory Research (CER) as the theoretical framework. CER was the lens through which individual participants in the study were viewed. This framework speaks to the notion of the researcher and participants working together. According to Mahlomaholo (2012:7), CER addresses issues of inequality, social justice and lack of hope that are demolished through the creation of an interaction space with the very marginalised individuals. Mathematics is a key learning subject in schools. The suggestion that some individuals with dyscalculia have less hope to learn mathematics is a social justice issue. CER supports the involvement of such individuals in the study for their experiences and views to be a part of the solution to the problem that they experience. Therefore, participants in the study were treated equally, regardless of their status in the social setting. Francis, Mahlomaholo and Nkoane (2010:32), held the view that equality amongst participants is a crucial part of CER. Therefore, the views of all participants were listened to during the discussion and the reflection meetings.

The definitions of operational concepts and the literature review were discussed in Chapter 2. The literature review composed of the wide consultation of literature on the prevalence of dyscalculia and how other countries are dealing with dyscalculia. The literature review also discussed the usage of AL in other countries and specifically in teaching mathematics.

PAR as the research methodology in the study was used to collect empirical data. Once PAR was explained to participants, they understood their value within the study and that their views, opinions and experience form part of the data in this study. The data were collected during the discussion forum, reflection meetings and at the implementation of the AL strategy.

Critical Discourse Analysis (CDA) was used to analyse and interpret the data.

The discussion about CDA is found in Chapter 3.

The generated data was then reviewed and analysed and the conclusion was reached with regard to the implementation of AL in addressing dyscalculia in a mathematics classroom. According to the generated data, AL could be effective in a mathematics classroom with the usage of an effective questioning and assessment strategy, usage of manipulatives in a classroom, effective usage of peer teaching and cooperative learning, and also the clear articulation of the creation of an effective classroom environment.

In order for the teaching strategy to work, it was necessary to have information sessions and watch information videos to ensure that that teachers understood how they need to implement the strategy in classroom. It was necessary too to check the relevance of the suggested intervention strategy, AL, in addressing dyscalculia; hence, the information that was shared during the first workshop was important. During this workshop, the symptoms of dyscalculia were explained and the key elements of AL were discussed. This was done to trigger the conversation and also assess the relevance of AL in addressing dyscalculia. From the achievement of the study, findings were drawn and consequently conclusions as discussed in Chapter 5 below, were reached.

5.3 FINDINGS OF THE NATURE AND RELATION BETWEEN DYSCALCULIA AND AN AL STRATEGY

The sections below report on the findings according to the objectives of the study, as stipulated in Chapter 1. The discussion commences with the findings pertaining to the knowledge gained on the level of dyscalculia, the formulation of the diagnosis tool and the coordination between the teacher, the SBST and the Inclusive Department.

5.3.1 Understanding of the level of dyscalculia

As part of the literature review, Doyle (2010:8-16) referred to three levels of

dyscalculia, namely biological, cognitive and behavioural dyscalculia. Geary (2004) referred to the three subtypes of dyscalculia as the areas of difficulty experienced by learners with dyscalculia. The three levels of difficulty are procedural difficulty, semantic difficulty and visuospatial difficulty. The found literature on the intervention strategy addresses the three levels of difficulty when creating an intervention strategy for learners with dyscalculia. Hornigold (2015:3) suggested intervention strategies focusing on addressing the three identified levels of dyscalculia. Therefore, the proposed intervention strategy will seek to address the identified three areas of difficulty.

The learners were selected as perceived to have dyscalculia, based on the detected symptoms and the assessment in test results. It was also observed that they did not experience the same levels of difficulty. However, their areas of difficulty were experienced in the three identified levels of difficulty.

5.3.2 Formulation of the diagnosis tool for learners with dyscalculia

The existing diagnosis tool for learners with dyscalculia in South Africa is not relevant anymore. There was, therefore, an identified need to create a diagnosis tool that could be used to identify the existence of dyscalculia in learners across the country. The tool will have to be relevant to the demographic profile of the learners in South Africa. It will have to consider the age of the learner and also that most learners in South Africa do not have formal education prior to Grade 1. According to the Education Statistics (DBE 2014:18), the table below reflects that only 2.1% of learners receive pre-Grade R education and that means most learners in Grade 1 would not have been exposed to numerical learning by the time they start Grade 1. This level gap has an impact on their aptitude of mathematics. This also means that a lot of learners may lack early stimulation, which could easily be detected as dyscalculia.

Therefore, the formulation of a relevant diagnosis tool is necessary and could inform early detection and, consequently, early intervention.

Table 5.2: Number of learners who are exposed to formal education before Grade 1 in South Africa

Grade	Year of Registration	Number of Learners
Pre-Grade R	2012	24 888
Grade R	2013	747 326
Grade 1	2014	1182807

5.4 FINDINGS ON CHALLENGES TO THE IMPLEMENTATION OF AL

5.4.1 Lack of understanding of dyscalculia

There is a growing concern of a lack of awareness of dyscalculia, as opposed to dyslexia, while dyscalculia is as prevalent as dyslexia. In a research meeting with participants, the lack of understanding of dyscalculia was highlighted. Senior officials responsible for inclusive education were not clear on what dyscalculia was. Both teachers and parents indicated that they had never heard of dyscalculia. It was, therefore, prevalent in the discussions that an understanding of dyscalculia was crucial in order for learners to be included in the learning of mathematics. It was also noted that it is important for teachers to understand the symptoms of dyscalculia in order for them to adjust their teaching strategies and offer learners the necessary support to understand mathematics. When teachers are aware of learners with dyscalculia, they may also engage parents differently when giving learners with dyscalculia homework.

5.4.2 Absence of a questioning and assessment strategy

During the research meeting, the research team identified challenges posed by the absence of a questioning and assessment strategy in the implementation of AL. Based on the revealed challenges that learners with

dyscalculia face, it was noted that it is important that question in class are such that learners are motivated to answer. It was revealed that learners with dyscalculia are easily embarrassed because of their lack of understanding of simple mathematics. Learners with dyscalculia would never put their hand up, for fear of getting the answer incorrect. Parents also indicated challenges in assisting learners with mathematics homework because learners did not have any interest in it and would avoid mathematics homework at whatever cost.

It is, therefore, important that questions in class are asked in an unthreatening manner. The teacher needs to have questioning strategies that allow each learner to feel safe and to not be intimidated by smarter learners. The assessments need to be accommodative, trying to involve the family and make it as practical as possible. Assessment that supports the implementation of AL will cater for all the learners in class and it will create a fun manner of learning.

5.4.3 Lack of availability of manipulatives

The research team had discussion meetings, where the usage of manipulatives was discussed. It emerged that creating manipulatives was an issue because of the monetary cost and that the schools do not have a variety of manipulatives that teachers could use in a mathematics classroom. The issue of availability of manipulatives was, therefore, a serious concern as manipulatives are important for learners with dyscalculia because they need to touch, feel and see in order to understand certain concepts. According to Hornigold (2015:3), in teaching learners with dyscalculia, the teacher has to make the mathematical concepts real and fun to help learners make the connection. This also helps them reduce the mental load.

5.4.4 Inability to apply a peer teaching strategy

The usage of AL as a teaching strategy encourages learners to work together in the classroom. According to Baepler, Brooks and Walker (2014:63), peer teaching ensures that learners work together and there is no opportunity to

hide or avoid participating in a classroom. This way of working together encourages support. In large classrooms, learners have an opportunity to create social relationships with other learners. However, the challenge is posed by a lack of understanding on the side of teachers on how they could best implement it in such a way that a learning atmosphere is maintained in a classroom. During the research meetings, it was observed that learners are not always keen to share knowledge because they want be perceived by the teacher as being the smartest. The lack of unwillingness to share with other learners pushes learners with dyscalculia further away from involvement. Therefore, it is a challenge when the teacher lacks the skill of making peer teaching work in their classroom.

5.4.5 Inability to effectively engage learners through cooperative learning

AL is designed to focus on the learner, whereby learners are actively engaged with one another in the learning process (Baepler *et al.* 2014:66). This means that the teacher is not the focal point in the classroom as is normally the case in a traditional classroom. The teacher could be easily frustrated and unsure what to do when learners are busy working. Hence, during the research meeting, learners pointed out that teachers often leave the classroom during group activities. However, the teacher needs to be in class to facilitate the learning process within designed groups. Therefore, the inability of teachers to effectively engage learners through cooperative learning poses a challenge in the implementation of AL.

5.4.6 The teacher's inability to create an effective learning environment

According to Murugan and Rajoo (2013:328), learners learn better when they perceive their classroom environment positively and he found that the classroom environment has an impact on the mathematics performance of learners. In the research meeting and interaction with literature, it was agreed that the classroom encompasses more that the physical environment. It was further established that the sitting arrangement was a crucial part of AL.

Therefore, a sitting arrangement that does not encourage interaction between learners will create a challenge for the implementation of AL. It is also important that all learners have a sense of belonging and of being respected by the teacher. A respectful teacher arrives at the class on time and prepared. Failure of the teacher to create an effective learning environment compromises the implementation of AL in addressing dyscalculia in a mathematics classroom.

5.5 FINDINGS ON THE COMPONENTS OF THE AL STRATEGY IN ADDRESSING DYSCALCULIA

The sections below focus on the findings on the components of the solution to the experienced challenges.

5.5.1 Establishment of an effective questioning and assessment strategy

According to the generated data, in order for AL to be effective, it is important that the teacher is able to devise questioning and assessment strategies that encourage all learners to participate. An effective questioning strategy, such as the usage of a “whiteboard”, protects learners with dyscalculia from being embarrassed and also allows the teacher to know when learners do not understand what is being taught. The usage of the “whiteboard” was effective in getting learners with dyscalculia engaged. The teacher could assist struggling learners from the information from the “whiteboard”. At times, the teacher could change the question and make it simpler, depending on how learners answered that particular question.

It was important to establish a calling strategy that would allow all learners to participate. According to Suherman *et al.* (2011:104), in an AL classroom, learners are engaged in more than just listening, as they are actively engaged.

The practical assessment homework was well received by parents and learners. It allowed the practical application of what was learned in class.

Mazibuko (2014:181) held the view that AL activities have to be planned in such a way that learners have an opportunity to interact and apply the learned information as part of teaching and learning process. The practical homework helped in creating positive associations with the learning of mathematics. Learners were not anxious about doing homework, but looked forward to engaging in practical activities.

The findings show that teachers need to take time to devise questioning strategies that encourage all learners to participate in learning. The other finding is that practical homework gets the learners excited about learning mathematics. This is also a good opportunity to get parents involved in learning of mathematics to benefit their children.

5.5.2 Establishment of effective usage of manipulatives

Our discussion with the research team revealed that learners were excited about the usage of manipulatives. There was strong evidence of learners engaging actively when the manipulatives were used. Learners confirmed that they enjoyed the usage of manipulatives. Their experience of using manipulatives allowed learners to connect the theory of mathematics with the application of mathematics in real-life situations.

The findings indicate that the awareness about the usage of manipulatives was an effective component of AL in addressing dyscalculia in a mathematics classroom.

5.5.3 Content capacity development for usage of peer teaching

The research team welcomed the usage of peer teaching. However, during the reflection meeting following the implementation, the observation was that learners are not keen on sharing. They were keen on sharing only with the provision of an incentive for helping a peer. There was, therefore, mixed feelings about the usage of peer teaching. Learners know one another and they know the weak learners in mathematics and, therefore, are often not

keen to help because they might miss an opportunity to impress the teacher.

The finding is that peer teaching works effectively when learners are encouraged to work together.

5.5.4 Capacity development on the effective usage of cooperative learning

From the discussion with the research team, capacity development on the usage of cooperative learning created confidence for teachers to use the strategy in class. They understood that activities had to be thought of in advance. It was important for the teacher to consider how they group learners and that the presence of the teacher was important during the activity.

The finding is that cooperative learning is an important aspect of AL to assist learners with dyscalculia in building confidence. It also helps learners with dyscalculia to engage and not appear lost in the middle of a mathematics lesson. It was, furthermore, found that teachers needed to be a part of an activity during the cooperative learning activity. Their presence encourages learners to learn and to ask questions when they are stuck.

5.5.5 Establishment of the creation of an effective learning environment

The discussion of the classroom, as viewed by Baepler *et al.* (2014:28), articulated that the classroom presents the features of mutual respect, shared responsibility for learning, effective communication, trust and security. The teacher made the conscious decision of preparing for the lesson to be presented – he knew when he was going to give them which activity and the reason for that activity. The teacher further protected learners who have dyscalculia by asking them questions in a manner that was less threatening.

The sitting arrangement was also changed to a sitting arrangement that encouraged interaction among learners. This created an exciting atmosphere and the teacher moved around the class, even though the movement was

somewhat restricted.

The establishment of a positive classroom environment created an effective learning environment. Learners who are normally reserved in class were engaging and smiling.

5.6 CONDITIONS CONDUCIVE TO THE SUCCESSFUL IMPLEMENTATION OF AL

The following sections report on the conditions that contributed to the successful implementation of AL.

5.6.1 Factors that supported the understanding of dyscalculia

The collected data in this study brought to light that there was a need to understand dyscalculia in order for learners with dyscalculia to be supported effectively. The research team indicated that it was necessary to have a workshop led by a specialist in dyscalculia. During the workshop, participants gained an understanding of what dyscalculia is, as well as an understanding of how they may notice learners with dyscalculia in their classroom environment. From this workshop meeting, the research team was able to analyse the assessment of the selected learners to identify their areas of weakness. The identified areas of weakness were then used to plan and implement the AL strategy in a mathematics classroom.

5.6.2 Factors that supported effective usage of questioning and assessment

The collected data in this study indicates that it was necessary to establish factors that support effective usage of questioning and assessment. During the research meetings, it was evident that there was a need to understand how effective questioning and assessment could be used effectively to benefit learners with dyscalculia. Information videos that addressed various questioning strategies were watched. Following the discussion meeting, there

was consensus about the questioning strategies that were more accommodative of learners with dyscalculia

5.6.2 Factors that made effective usage of manipulatives successful

The usage of an information session on manipulatives, led by one of the teachers, gave participants an indication of how manipulatives could be used to the advantage of learners with dyscalculia. From the discussion, it was noted that the creation of manipulation should not always involve spending money. It was noted that a teacher needed to plan in advance the manipulatives to be used and the purpose thereof.

5.6.3 Conditions that contributed to the formation of peer teaching

The discussion during the research team meeting revealed that peer teaching was an important aspect of AL. During the discussion meeting, teachers shared how peer teaching could be implemented. When learners were not keen on sharing ideas or correct answers with their peers, incentives were given as a motivation. Learners with dyscalculia forget number-related concepts easily, therefore peer teaching allows them to share their understanding and this is another form of repetition and drilling to ensure that they do not forget easily.

5.6.4 Conditions that contributed to effective usage of cooperative learning

The discussion from the research team revealed that the information session about cooperative learning allowed teachers to be informed on how they could better use cooperative learning such that it contributes in addressing dyscalculia in a mathematics classroom. Teachers were aware of the need to prepare and to continuously engage with learners during the cooperative learning activity. Learners with dyscalculia should also have an opportunity to share their ideas without the fear of being embarrassed.

5.6.5 Factors that made the creation of an effective learning environment successful

Discussions further revealed that creation of an effective learning environment was an aspect of successful implementation of AL. It was important for teachers to understand the broader view of the classroom in the context of helping learners who have lost their self-esteem because they cannot solve simple arithmetic concepts. They have a poor sense of direction and forget numbers easily. Dyscalculia is a symptom of a malfunctioning in certain areas of the brain. Therefore, stability is important in a mathematics classroom. The stability is communicated by not only supportive physical environment, but also the conduct of the teacher and peers in the mathematics classroom, which has an impact on the emotional wellbeing of learners. Therefore, an understanding of the creation of an effective learning environment is crucial to the successful implementation of AL.

5.7 THREATS TO THE SUCCESSFUL IMPLEMENTATION OF AL

The discussions below outline the findings of the threats, which were anticipated, and the measures put in place to mitigate them.

5.7.1 Learners' natural ability to pay attention during learning and teaching time

During the discussion meeting, the research team observed that it could be noisy in class during the implementation of AL in a mathematics classroom. There could be noise because of all the interaction going on. Petersen and Gorman (2014:68) pointed out that there are multiple distractions in an AL classroom. Therefore learners could easily lose concentration and start discussing and playing outside the context of what is being taught. It is, therefore, important that the teacher should maintain the role of facilitator by explaining the task and ensuring that all learners understand what they need to do. It is important too that the teacher should plan the activities in advance. When the activities are planned, the teacher can anticipate what learners with

dyscalculia are likely to get wrong. Then have a pre-planned strategy as to how they will meet the rising challenge. It is found in this study that learners can easily get distracted when there is a lot happening in the classroom. This could easily cause them to lose focus on the lesson.

5.7.2 Teachers' content knowledge of mathematics and their attitude in teaching mathematics

Another finding was that taking into consideration the needs of learners with dyscalculia in a mathematics classroom, required that the teachers should have mathematics content knowledge. The content knowledge will allow the teacher to guide the learner to reach the correct answer. Understanding that learners with dyscalculia forget easily, the teacher should be able to bring informative games for learners to remember what they have learned. This will also help learners repeat what was learned as a way of reinforcing and drilling the learned concepts.

It was evident from the discussion that learners were excited about practical homework. It is for this reason too that mathematics content knowledge is important to help the teacher to be creative about practical mathematics homework for learners with dyscalculia.

There was an observation that learners with dyscalculia have less information because of their failure to master simple mathematics concepts. Therefore, there is a challenge for a teacher when a simple question is asked and a learner with dyscalculia gets it wrong, then the teacher tries to explain it and still the learner gets it wrong. At that time the teacher may get discouraged and want to move on without addressing the identified need of the dyscalculic learner.

5.7.3 Learners' attitude toward learning mathematics

It was found that learners have an attitude toward mathematics that is influenced by what is said at home, in their communities and at school. They,

therefore, have the preconceived notion that mathematics is difficult. Learners believe that learners who master mathematics are smart and respected by teachers. Therefore, learners who are good in mathematics are the first ones to answer the question, but learners who are weak in mathematics are shy and never keen to answer any questions. During peer learning, most learners were reluctant to share their knowledge with learners who were weak in mathematics. The teacher had to encourage learners and tell them about the importance of sharing knowledge. The negative attitudes of learners toward mathematics affect their working relations with their peers. It also affects teachers because the teacher has to work harder to bring them on board all the time.

5.8 EVIDENCE TO SUGGEST THAT AL MAY BE SUCCESSFULLY IMPLEMENTED IN ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM

The following discussion presents the evidence to suggest that AL may be successfully implemented in addressing dyscalculia in a mathematics classroom.

5.8.1 An understanding of dyscalculia

Findings indicate that when teachers, parents and education officials first understood what dyscalculia was, they were then committed to the intervention strategy that would help learners understand mathematics. It was also a relief to parents to know that their children have hope of learning and understanding mathematics. The district officials realised that there was a need to have a diagnosis tool that encompasses the information that was shared during the research meeting.

5.8.2 Presence of a questioning and assessment strategy

Findings indicate that the understanding of asking questions in a manner that encourages learners to participate without fear of getting the answer wrong

and being ridiculed by peers, was beneficial to learners with dyscalculia.

Through the strategy of using the “whiteboard”, learners were keen to share their answers because only the teacher could see their answers. The displayed answers were beneficial to the teacher as well because the teacher could tell whether learners understood the concept or not.

The other finding was that the practical homework provided learners with an opportunity to associate the mathematical concepts learned in class to the real-life situations. The practical homework was important in addressing the procedural memory where learners show difficulty in understanding and applying mathematical procedures.

Learners with dyscalculia were normally not keen on going to school. When they are in school, they usually do not participate in any activities in class. Through the implementation of AL, there was an observed change in attitude toward their learning of mathematics. There was an improvement in the mathematics score of some learners as well. Learners who were achieving level 1 in mathematics, were later performing at level 2 in mathematics after a few AL sessions.

5.8.3 Usage of manipulatives in a mathematics classroom

Findings from this study indicate that the usage of manipulatives in a mathematics classroom awarded learners with dyscalculia an opportunity to participate in learning mathematics. They were able to engage with their peers and to observe the practical application of mathematics. Learners with dyscalculia were assisted with their difficulty with semantic memory, where they are observed to have difficulty in retrieving arithmetic facts. It was easy for them to retrieve certain facts when they had seen the concept in real-life application. When they worked with building blocks, which were aimed at helping them with spatial representation, it is plausible that this may have helped develop their visuospatial memory as well. They were excited and eventually able to build patterns, following the instruction from the teacher.

5.8.4 Capacity development on peer teaching

Findings from this study indicate that peer teaching is an important element of AL; however, it may be effective only when learners are given incentives to work together. It may also work with a teacher's motivation for learners to work together.

It was also found that learners are not always keen to work together, especially because mathematics holds a prestige that if you master mathematics, you are seen as the smart one. Therefore, learners do not want to be held back by other learners who struggle with mathematics and, as a result, they are not readily keen to work in pairs.

5.8.5 Usage of cooperative learning

Findings from this study indicate that learners were keen to work in groups, especially when they had to make a presentation in front of the class. Learners with dyscalculia were observed participating and even leading in some activities.

There was an observed social interaction among learners and there was excitement in the classroom. It was found that learners could easily get distracted in that excited learning atmosphere and the presence of the teacher as a facilitator was crucial to help guide learners to stay on track.

5.8.6 Creation of an effective classroom environment

The finding from this study is that a teaching environment where learners are respected and valued, creates a positive learning atmosphere. The classroom environment, in terms of the teacher taking time to prepare for the lesson to ensure that all learners are catered for, was beneficial to learners with dyscalculia. The teacher anticipated difficulties and planned to get them engaged.

The classroom environment in terms of the physical space was beneficial to learners as well. They were able to sit next to each other and share ideas. The group sitting arrangement was valuable for the teacher to be able to reach more students at the same time.

5.9 RECOMMENDATIONS

There are a lot more learners in mathematics classrooms who depict symptoms of dyscalculia than was expected. Therefore, a recommendation that could be made from this study is that a diagnosis tool is an urgent need in our schools.

It is also recommended that AL should be an adopted teaching strategy because learners with dyscalculia excel in subjects that require acting and performing. AL encourages interaction as part of learning. This allowed learners to be excited about learning mathematics. The introduction of a teaching strategy will require a workshop for teachers to enable them to explore various elements of AL and how they could incorporate them in their mathematics classroom.

An observation was also made that most teachers and education stakeholders are not aware of the existence of dyscalculia. It is, therefore recommended, that there should be an awareness of the existence of dyscalculia in our society. The awareness is crucial in order for the intervention to start early and learners could have opportunities of learning mathematics even at a higher level.

Based on the observation that most members of the society, including learners, have a negative view of mathematics as a subject, the implementation of an AL strategy in a mathematics classroom will remain a challenge unless parents and learners change their attitude toward mathematics. It is therefore recommended that there should be regular talks aimed at demystifying mathematics as a difficult subject. Through the effective

usage of the AL strategy, mathematics may be learned in a fun and engaging manner.

5.10 LIMITATIONS OF THE STUDY

The limitations of the study were with regard to the availability of meetings with participants and with the availability of the diagnosis tool to establish whether learners have dyscalculia or not.

The research included parents who were not always available to meet immediately after school hours and they had to make special arrangements at work to attend discussion meetings. However, provisions were made to meet with parents over the weekend. They were comfortable with that arrangement and it allowed continuity to study, as well as an opportunity to interact in a different environment.

The other limitation was due to limitations of the available information and resources for learners with dyscalculia. Learners who were selected as having dyscalculia, were selected based on the perception that they have dyscalculia as informed by literature, interaction with a specialist and analyses of the workbooks and formal assessment school reports.

5.11 RECOMMENDATIONS FOR FURTHER RESEARCH

The aim of the study is to formulate an active learning strategy for addressing dyscalculia in a mathematics classroom. In an endeavour to do that, participants shared their views and experiences. There was sharing of knowledge and skills in a critical and enlightening manner. The study addressed challenges that were experienced with regard to the implementation of AL. During the implementation, there were more students who showed symptoms of dyscalculia than those who had been selected. There is, therefore, a need for further research to establish the prevalence of dyscalculia in South African schools. It was alarming that, during peer teaching, learners were not keen to share information and answers with

learners with dyscalculia. Such an attitude among learners may bear an impact on the classroom environment. More research is, therefore, recommended to establish the value of peer teaching in addressing dyscalculia in a mathematics classroom.

Writing and reflection is one of the recommended elements of AL. According to Braun (2013:4), through writing and reflecting, learners are able to express how they feel about what they know and also discover what they understand. Writing is known to help deepen an understanding of and commitment to mathematics. In this study, writing and reflecting was raised as an element of AL that could be used during the implementation. However, in the research team, writing and reflection were found to be a challenge for teachers and therefore a big task for learners. However, more research is recommended of whether reading and writing could indeed benefit learners with dyscalculia.

5.12 CONCLUSION

This chapter has presented the findings of the study as presented in the objective of this study as noted in Chapter 1. Chapter 5 provided the summary of this study, as well as the recommendations made with the view of the findings of the study. The limitations of the study were discussed as well.

CHAPTER 6

THE PROPOSED ACTIVE LEARNING STRATEGY FOR ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM

6.1 THE PILLARS

There are seven pillars of AL, namely the learners, the teachers, the SBST, the subject advisor, the psychologist, the Inclusive Department and the parents, as indicated in Table 7.1 below. The teachers, SBST, subject advisor, psychologist, Inclusive Department and parents need to work together effectively to support learners with dyscalculia to learn and understand mathematics.

6.2 UNDERSTANDING OF CHALLENGES FACED BY LEARNERS WITH DYSCALCULIA

In order to address challenges faced by learners with dyscalculia in a mathematics classroom, it is important that the supporting pillars, which have been identified as the learners, teachers, SBST, subject advisor, psychologist, the Inclusive Department and the parents should understand the challenges that are faced by learners with dyscalculia in a mathematics classroom.

According to Zerafa (2015:1178), catering for learners with dyscalculia is not a task that may be taken lightly because learners often lack basic mathematics skills and concepts. Therefore, it is important that the pillars that are involved in supporting a learner to master these concepts are aware of the kind of knowledge gap that may exist in the life of a learner with dyscalculia. For example, it was established in Chapter 2 that numerosity is the natural ability of every child to compute simple mathematical ideas. It was also noted that a learner with dyscalculia lacks such a basic numeracy skill. Therefore, this may

be embarrassing to learners, especially when they have progressed to the upper grades.

Zerafa (2015:1178) further stipulated that learners with dyscalculia lack basic skills, such as estimating, recalling number facts, counting, telling time, counting money and being able to use mathematical language. The difficulties faced by learners with dyscalculia were discussed in detail in Chapter 2. Challenges faced by learners with dyscalculia vary according to the learner. In order for the support to be effective, it is important for the supporting pillars to understand such challenges. Table 7.1 below indicates the support that each pillar can award to a learner with dyscalculia. Table 7.3 below illustrates how an understanding of the challenges they face could better support learners with dyscalculia. It is important that each pillar understands their contributory role when they understand the challenges that learners with dyscalculia face.

6.3 APPLICATION OF AN EFFECTIVE QUESTIONING STRATEGY

Table 7.3 below further illustrates that an effective questioning strategy also assists the learner and the teacher to enhance the teaching and learning experience. The study indicates that questioning and assessment are important aspects of learning. It is also acknowledged that learners with dyscalculia have low self-esteem and are often shy to ask questions for fear of being exposed that they do not know simple concepts. Through effective questioning, the teacher may be able to ask learners with dyscalculia questions, without exposing them for their deficiencies in basic mathematics concepts. Through effective questioning, the teacher is also able to establish the existing knowledge gap that may be addressed during teaching time in class or during a planned one-on-one teaching session.

6.4 EFFECTIVE USAGE OF MANIPULATIVES

Table 7.3 indicates that in order for AL to be effective, it is important that the teacher plans for the usage of manipulatives in advance. Manipulatives create a fun way of learning mathematics and also help learners with dyscalculia link

the abstract aspect of mathematics with the real-life aspect of mathematics. Table 7.3 also illustrates that usage of manipulatives is an aspect of learning that involves both the teacher and the learner. The learner would benefit from the creation of some of the manipulatives. However, the teacher has to think about the manipulatives to create or to use in class in advance. Manipulatives do not always have to be bought, but the creation of manipulatives is another aspect of teaching and learning.

6.5 EFFECTIVE USAGE OF COOPERATIVE LEARNING

Cooperative learning is a fun way of learning mathematics, through which learners have an opportunity to share their gained knowledge and understanding. Table 7.3 below illustrates how the teacher and the learners could participate in ensuring that learners with dyscalculia learn mathematics. Learners with dyscalculia are known to forget mathematical concepts easily; therefore, cooperative learning allows learners to learn from one another and to share their own understanding of mathematics concepts in a less threatening setting.

6.6 EFFECTIVE USAGE OF PEER TEACHING

The study illustrates that learners are not always keen to share information or answers with their peers unless when they are motivated to share. They generally tend to compete with one another. The research also illustrates the benefit of peer teaching, when learners share with one another. Peer teaching is more effective when a learner's self esteem is at its lowest. Table 7.3 below illustrates how the teacher could better use peer teaching to enhance an understanding of mathematics in learners with dyscalculia. The subject advisor's role is to support the teacher in implementing the curriculum in an inclusive manner. Therefore, it is equally important that the subject advisor is aware of how peer teaching could be better used to the benefit of learners with dyscalculia.

6.7 EFFECTIVE CLASSROOM ENVIRONMENT

Table 7.3 below further articulates the benefits of an effective classroom environment. The study revealed that the classroom environment refers to the physical space, the sitting arrangement, and the relations between the teacher and the learners and vice versa. Therefore it is important that the teacher and the learners create the supportive learning environment. The supportive learning environment ensures that there is a stimulating learning environment. The psychologist can play an important role in assisting to create such an environment from their understanding of the emotional wellbeing of all learners, including those with dyscalculia.

The sitting arrangement is also an important aspect of AL, which encourages learning through AL.

6.8 CAPACITY DEVELOPMENT

It was established from the study that dyscalculia and active learning are foreign concepts to the pillars responsible for supporting learners with dyscalculia in a mathematics classroom. As illustrated in Table 7.2 below, teachers, the subject advisor, the SBST and the psychologist need to have a reference information guide, as well as workshop training to help them understand dyscalculia as a learning disability. AL also needs to be understood in the context of dyscalculia and how learners with dyscalculia could be best supported. The research about dyscalculia is growing; hence, it is important that the education stakeholders continuously upgrade themselves in their understanding of dyscalculia.

6.9 DETERMINATION OF PRIORITIES

As noted from the study that dyscalculia and AL are not common concepts in the South African mathematics classroom and it can be expected that challenges will be encountered. Table 7.5 below illustrates the determined priorities in addressing the gathered challenges. It is important that the

research team agrees on how these challenges will be dealt with. A detailed plan on how challenges will be addressed is crucial, starting with the need to move away from the traditional sitting arrangement in class. It means there is a priority in raising funds for the resources that will help transform the classroom sitting arrangement from the traditional form to the circular sitting arrangement that supports implementation of AL.

6.9 STRATEGIC PLAN

In accordance with the implementation of a teaching strategy, Shangase (2013:26) attested that strategic planning is an important aspect of the improvement of the academic performance. Table 7.5 below indicates how the strategic plan needs to be formulated to ensure how priorities will be met to ensure effective implementation of AL.

6.10 MONITORING AND EVALUATION

Table 7.6 below indicates how the implementation of AL will be monitored and evaluated in anticipation of the challenges that may be encountered. Table 7.5 below illustrates how the priorities will be dealt with to ensure effective implementation of the strategy. Monitoring and evaluation will give the team an opportunity to reflect on their roles in the implementation. This will also ensure that learners and parents are allowed an opportunity to give feedback on their experiences, as well as on how to enhance the implementation of AL. Therefore, monitoring and evaluation will give all pillars an opportunity to learn and grow on the effective ways of implementing AL.

CHAPTER 7

A PROPOSED FRAMEWORK FOR ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM

7.1 INVOLVEMENT OF PILLARS IN THE IMPLEMENTATION OF AL

Table 7.1: Involvement of pillars in the implementation of AL

Pillars / AL participants	**Actions**	**Objective(s)**	**When?**
Learners	Attend school regularly	Mathematics learning is continuous and therefore regular attendance of mathematics class ensures continuity To encourage learners to have a positive attitude toward learning of mathematics	From the beginning of the academic year until the end
	Ask questions in class when unsure		During teaching time
	Do homework as required by the teacher Participate in class activities		Every time when homework is given
Teachers	Attend class regularly	To ensure that they are aware of strengths and weaknesses of learners with dyscalculia To plan activities	From the beginning of the academic year until the end
	Read assigned notes about symptoms of dyscalculia		During lesson preparation time to ensure that needs of learners

		relating to the lesson in advance To link relevant AL elements to the related lesson and also considering needs of learners with dyscalculia	with dyscalculia are catered for
	Prepare lessons in advance, with learners with dyscalculia in mind		Every week before the lesson
	Seek to use an AL strategy		Every week, before the lesson
Parents	Check learners' books	To ensure that they are aware of the learners' progress and can offer relevant support to both the learner and the teacher. To ensure that there is continuity of learning at home.	Everyday after school
	Participate in doing homework		Every time when homework is given
	Engage learners with mathematically related activities at home		That should be a lifestyle at home
	Meet with mathematics teacher, psychologist and SBST to discuss progress of the learners		At the beginning and end of every term
SBST	Read assigned notes about dyscalculia	To have knowledge about dyscalculia to be able to give necessary support to parents, teachers and learners with	Once every year at the beginning of teaching time
	Have a plan about the involvement of parents in assisting learners with dyscalculia		

	Have an understanding of AL and its linking in supporting learners with dyscalculia	dyscalculia To have an understanding of AL as an intervention strategy in addressing dyscalculia in a mathematics classroom	
Psychologist	Read assigned material about dyscalculia and AL Assist in creation of an effective learning environment	To enhance knowledge about challenges experienced by learners with dyscalculia and how they could be supported	Once every year at the beginning of the teaching time and as often as required
	Visit the class regularly to ensure that learners with dyscalculia to not fall behind	To make relevant recommendations when learners are falling behind despite the correct implementation of AL	Once every year
Inclusive Department	Read assigned material about dyscalculia and AL		Once every year as part of planning

	Have a strategic plan on how the SBST is supported in dealing with challenges faced by learners with dyscalculia		
Subject advisor	Read the assigned material about dyscalculia and AL	To ensure that the subject advisor is well-informed about dyscalculia and AL	Before the consultation time with the mathematics teacher
	Assist the teacher to prepare a lesson plan that is relevant in addressing dyscalculia	To assist the teacher incorporate AL in the planned mathematics lessons	Once a term
	Ensure the Professional Learning Communities (PLC) include lesson presentations that encapsulate AL elements	To create awareness to as many teachers as possible about dyscalculia and the inclusive teaching strategies that support all learners, including learners with dyscalculia	Once a term

7.2 CAPACITY DEVELOPMENT OF PILLARS IN SUPPORT OF LEARNERS WITH DYSCALCULIA

Table 7.2: Capacity development of pillars in support of learners with dyscalculia

Pillar	Capacity development	Objectives	When?
Teacher	Content knowledge capacity development	Enhanced knowledge of mathematics	Once, per semester
	Knowledge development of dyscalculia as a learning disability	Ability to recognise learners with dyscalculia	Once, beginning of the year
Subject advisor	Content knowledge capacity development	Enhanced knowledge of mathematics	Once, beginning of the year
	Knowledge development of dyscalculia as a learning disability	To offer informed support to teachers who teach learners with dyscalculia	
SBST	Knowledge of dyscalculia and how teachers and parents could support learners with dyscalculia	To support the teacher and parents to offer a learner an effective opportunity to learn mathematics	Once per semester
Psychologist	Have knowledge	To support the	Once per

	of challenges and possible intervention strategies available to support learners with dyscalculia	learner, teacher, SBST and parents to ensure that the learner is motivated and has an opportunity to learn mathematics	semester

7.3 ROLE OF THE INDIVIDUAL PILLARS IN THE IMPLEMENTATION OF AL

Table 7.3: Role of the individual pillars in the implementation of AL

Action	Who?	When?	Objective
Understanding of challenges faced by learners with dyscalculia	Learners Teachers SBST Psychologist Subject advisor	Continuously	To ensure that learners understand their deficiency in learning numbers Teacher – To offer learners relevant support in their disability to learn numbers Subject advisor, psychologist, and SBST member – Need to be able to offer the teacher and the learner relevant support to ensure that the learners increase their mathematical knowledge Parent – Need to understand how they could support the

			learner at home to learn mathematics
Application of an effective questioning strategy	Teacher Learner	During mathematics learning	To ensure that the learner gains confidence in learning mathematics To ensure that the learners is encouraged to actively participate during the learning process and also that they discover answers and solutions to the problems they are trying to solve
Usage of manipulatives	Teacher Learner	During mathematics learning	To have knowledge of the relevant manipulatives to use in order to support learners with dyscalculia To assist the learner to make connections of mathematics theory and real-life situations To get the learners involved in their learning and enhance their ability to remember learnt concepts
Effective usage of cooperative learning	Learner Teacher	During mathematics learning	To get learners involved in learning and motivate them to actively engage in the mathematics learning process To get learners to explain the concept to other learners to help them gain confidence

			and express what they have learned through their personal understanding
Effective usage of peer teaching	Learner Teacher Subject advisor	During mathematics learning	To get learners to learn from one another, while allowing them an opportunity to gain confidence of expressing mathematics concepts that they have learned
Effective classroom environment	Learner Teacher Psychologist	Beginning of the year	To assist in the creation of a classroom environment that will stimulate learning and offer necessary emotional support to learners

7.4 CAPACITY DEVELOPMENT OF THE TEAM IN THE IMPLEMENTATION OF AL

Table 7.4: Capacity development of the team in the implementation of AL

Pillar	**Capacity development**	**Objective**	**When?**
Teacher	Development on the usage of AL techniques in a mathematics classroom	To increase the knowledge of AL to benefit learners with dyscalculia	At the beginning of each term on the content to be covered that term
Subject advisor	Development on the usage of AL techniques in a mathematics classroom to be able to support teachers better	To increase the knowledge of AL to benefit the teacher under the supervision of the subject advisor	At the beginning of the first term

Parent	Development of knowledge about activities that could enhance learning at home	To have knowledge about how to support learners with dyscalculia and how they apply AL at home through various activities at home	Once every term
Psychologist SBST	Knowledge of various AL techniques to use	How to recognise learners with dyscalculia or mathematics difficulty	At the beginning of the first and third semester

7.5 DETERMINATION OF PRIORITIES TO MITIGATE ENCOUNTERED CHALLENGES

Table 7.5: Determination of priorities to mitigate encountered challenges

Priorities	**Who?**	**Objective**	**Deliverable**
Effective usage of questioning and assessment	Teacher Parents	To articulate a plan that could be used in class to ensure that learners with dyscalculia are a part of a learning process	A clearly defined plan which articulates questioning and assessment techniques that can be used in a mathematics classroom which is facilitated by an expert will benefit learners with dyscalculia such that they do not feel intimidated by asking questions in class

			Learners with dyscalculia will get a sense of belonging in class whereby they are protected from being ridiculed by their peers for their inability to answer simple arithmetic questions
Effective usage of manipulatives	Teacher	To plan in advance the different manipulatives to use for different lessons	A detailed plan of the manipulatives to use for specific lessons
Usage of cooperative learning	Teacher	To empower the teachers by enhancing their knowledge on how they can involve learners with dyscalculia in a group setting	A detailed plan on how to use a cooperative learning strategy such that learners with dyscalculia are able to participate
Usage of peer teaching	Teacher	To empower the teachers by enhancing their knowledge on how they can strategically assist learners	A detailed plan of how to use peer teaching in a mathematics classroom and help learners realise the importance of sharing ideas and knowledge without competing among

		with dyscalculia to learn from their peers	themselves
Creation of an effective classroom environment	Teacher Psychologist Learners SBST Parents	To have a sitting arrangement that promotes AL To get the involvement of various education stakeholders in the creation of an effective learning environment To have relevant stimulation tools around the classroom walls that may be suggested by the psychologist; the parents, SBST, teachers and learners may get involved in creating a stimulating working environment in education	A detailed plan and strategy of fundraising to get resources to improve sitting arrangement in class A strategy that facilitates the creation of a learner-centred teaching environment

7.6 MONITORING AND EVALUATION OF INTERVENTION STRATEGY

Table 7.6 Monitoring and evaluation of intervention strategy

Action	Who?	Objective	When?
Monitoring	SA SBST Inclusive Department	To ensure that learners with dyscalculia are given an opportunity to participate in class To ensure that there is grade improvement in mathematics for all learners, including learners with dyscalculia To be able to identify challenges experienced so that necessary steps are taken to address the challenges encountered	Continuously
Evaluation	Psychologist SBST Teacher Subject advisor	To evaluate how the strategy to ensure that the set objectives were met.	End of each semester

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APPENDIX A: PERMISSION TO CONDUCT RESEARCH

Enquiries: KK Motshumi
Ref: Research Permission: Mrs. Lindiwe Mokotjo
Tel. 051 404 9207/ 079 503 4943
Email: K.Motshumi@fseducation.gov.za

education
Department of Education
FREE STATE PROVINCE

Me. Lindiwe Mokotjo
67 Kochlani Road
Olivehill
Bloemfontein
9301 073 872 9175

Dear Me. Lindiwe Mokotjo

APPROVAL TO CONDUCT RESEARCH IN THE FREE STATE DEPARTMENT OF EDUCATION

1. This letter serves as an acknowledgement of receipt of your request to conduct research in the Free State Department of Education.

   Research Topic: An active learning strategy for addressing dyscalculia in a mathematics classroom

   Schools: Kgato Primary School.

   Target Population: Grade 4-6 learners, Mathematics teachers, School Based Support Team member, District Based Support Team (DBST: Psychologist), Deputy Chief Education Specialist (Inclusive Education) Motheo District.

2. **Period of research**: From the date of signature of this letter until September 2017. Please note the department does not allow any research to be conducted during the fourth term (quarter) of the academic year.
3. Should you fall behind your schedule by three months to complete your research project in the approved period, you will need to apply for an extension.
4. The approval is subject to the following conditions:
   - 4.1 The collection of data should not interfere with the normal tuition time or teaching process.
   - 4.2 A bound copy of the research document or a CD, should be submitted to the Free State Department of Education, Room 319, 3rd Floor, Old CNA Building, Charlotte Maxeke Street, Bloemfontein.
   - 4.3 You will be expected, on completion of your research study to make a presentation to the relevant stakeholders in the Department.
   - 4.4 The attached ethics documents must be adhered to in the discourse of your study in our department.
5. Please note that costs relating to all the conditions mentioned above are your own responsibility.

Yours sincerely

DR JEM SEKOLANYANE DATE: 03/05/2015

APPENDIX B: ETHICAL CLEARANCE LETTER

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS·UV
EDUCATION
OPVOEDKUNDE

Faculty of Education

25-Jul-2016

Dear **Mrs Lindiwe Mokotjo**

Ethics Clearance: **An active learning strategy for addressing dyscalculia in a mathematics classroom**

Principal Investigator: **Mrs Lindiwe Mokotjo**

Department: **School of Education Studies (Bloemfontein Campus)**

APPLICATION APPROVED

With reference to you application for ethical clearance with the Faculty of Education, I am pleased to inform you on behalf of the Ethics Board of the faculty that you have been granted ethical clearance for your research.

Your ethical clearance number, to be used in all correspondence is: **UFS-HSD2016/0405**

This ethical clearance number is valid for research conducted for one year from issuance. Should you require more time to complete this research, please apply for an extension.

We request that any changes that may take place during the course of your research project be submitted to the ethics office to ensure we are kept up to date with your progress and any ethical implications that may arise.

Thank you for submitting this proposal for ethical clearance and we wish you every success with your research.

Yours faithfully

Dr. Juliet Ramohai
Chairperson: Ethics Committee

APPENDIX C: CONSENT BY THE TEACHER

Researcher
Lindiwe Mokotjo
P.O. Box 1185
Bloemfontein
9300
Contacts: 0738729175
Email: lmokotjo@yahoo.com

Study Leader
Dr. D.J. Hlalele
8 New Education Building
School of Education Studies
QwaQwa UFS
Contacts: 0587185003
Email: hlaleleDJ@ufs.ac.za

Date: February 2017

INFORMED CONSENT

Dear Participant: Teacher

I hereby request your assistance in conducting this research study titled: **An active learning strategy for addressing dyscalculia in a mathematics classroom.**

This study is aimed at formulating an active learning strategy for addressing dyscalculia in a mathematics classroom. Dyscalculia is a learning difficulty limited to mathematics and associated computation skills that are often equated to dyslexia. Mathematics is an important subject in understanding other subjects, choosing careers and in making financial decisions in real life. However, there are individuals who are excluded in learning mathematics. Dyscalculia is also thought to contribute to distress, low self-esteem, stigmatisation and disruptive behaviour in class. This study seeks to give all learners an equal opportunity to learn mathematics with understanding, beginning with lower classes up to adults at tertiary level. The study uses an active learning strategy and its elements enhance learning of mathematics for individuals with dyscalculia. As part of this research study, participants will engage on mathematics lessons using active learning strategy. The content and time will be discussed and agreed upon in advance.

Please note that your participation is on a voluntary basis and your basic human rights will be protected and respected during this study.

To ensure that the information is recorded accurately, voice recordings and visual aids will be used as part of the collected data. Confidentiality and anonymity will be discussed and maintained and the details will be discussed to ensure your understanding of the study and its purpose. It is within your rights to leave or discontinue participating in the study anytime you wish to; that will not be held against you.

The study is expected to resume from March 2017 to May 2017 with two to four meetings per month. The initial agenda will be communicated in advance and future meetings will be planned with your input. The information during the sessions will be recorded by taking notes on a computer; usage of the

voice recorder to help capture the exact words and flip charts will be used during the task or workshop meetings.

Yours thankfully

Lindiwe Mokotjo

1. I have read and understand the nature and purpose of the research study

2. I hereby agree to participate in the above-named study and have not been pressured in doing so

3. The implications and risks of participating in this research study have been brought to my attention and I understand them

4. My permission for the usage of information obtained during the study and the findings to the study is hereby granted.

_____ _____/_____/_____
Signature Date

APPENDIX D: CONSENT BY THE PARENT IN BEHALF OF THE LEARNER

Researcher
Lindiwe Mokotjo
P.O. Box 1185
Bloemfontein
9300
Contacts: 0738729175
Email: lmokotjo@yahoo.com

Study Leader
Dr. D.J. Hlalele
8 New Education Building
School of Education Studies
QwaQwa UFS
Contacts: 0587185003
Email: hlaleleDJ@ufs.ac.za

Date: February 2017

INFORMED CONSENT

Dear Participant: Parent on behalf of a learner

I hereby request your assistance in conducting this research study titled: **An active learning strategy for addressing dyscalculia in a mathematics classroom.**

This study is aimed at formulating an active learning strategy for addressing dyscalculia in a mathematics classroom. Dyscalculia is a learning difficulty limited to mathematics and associated computation skills that are often equated to dyslexia. Mathematics is an important subject in understanding other subjects, choosing careers and in making financial decisions in real life. However, there are individuals who are excluded in learning mathematics. Dyscalculia is also thought to contribute to distress, low self-esteem, stigmatisation and disruptive behaviour in class. This study seeks to give all learners an equal opportunity to learn mathematics with understanding, beginning with lower classes up to adults at tertiary level. The study uses an active learning strategy and its elements enhance learning of mathematics for individuals with dyscalculia. As part of this research study, participants will engage on mathematics lessons using active learning strategy. The content and time will be discussed and agreed upon in advance.

Please note that your participation is on a voluntary basis and your basic human rights will be protected and respected during this study.

To ensure that the information is recorded accurately, voice recordings and visual aids will be used as part of the collected data. Confidentiality and anonymity will be discussed and maintained and the details will be discussed to ensure your understanding of the study and its purpose. It is within your rights to leave or discontinue participating in the study anytime you wish to; that will not be held against you.

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the sessions will be recorded by taking notes on a computer; usage of the voice recorder to help capture the exact words and flip charts will be used during the task or workshop meetings.

Please sign below for consent on behalf of the learner for their participation.

Yours thankfully

Lindiwe Mokotjo

1. I have read and understand the nature and purpose of the research study

2. I hereby agree to participate in the above-named study and have not been pressured in doing so

3. The implications and risks of participating in this research study have been brought to my attention and I understand them

4. My permission for the usage of information obtained during the study and the findings to the study is hereby granted.

_____ _____/_____/_____
Signature Date

APPENDIX E: CONSENT BY THE PARENTS

Researcher
Lindiwe Mokotjo
P.O. Box 1185
Bloemfontein
9300
Contacts: 0738729175
Email: lmokotjo@yahoo.com

Study Leader
Dr. D.J. Hlalele
8 New Education Building
School of Education Studies
QwaQwa UFS
Contacts: 0587185003
Email: hlaleleDJ@ufs.ac.za

Date: February 2017

INFORMED CONSENT

Dear Participant: Parent

I hereby request your assistance in conducting this research study titled: **An active learning strategy for addressing dyscalculia in a mathematics classroom.**

This study is aimed at formulating an active learning strategy for addressing dyscalculia in a mathematics classroom. Dyscalculia is a learning difficulty limited to mathematics and associated computation skills that are often equated to dyslexia. Mathematics is an important subject in understanding other subjects, choosing careers and in making financial decisions in real life. However, there are individuals who are excluded in learning mathematics. Dyscalculia is also thought to contribute to distress, low self-esteem, stigmatisation and disruptive behaviour in class. This study seeks to give all learners an equal opportunity to learn mathematics with understanding, beginning with lower classes up to adults at tertiary level. The study uses an active learning strategy and its elements enhance learning of mathematics for individuals with dyscalculia. As part of this research study, participants will engage on mathematics lessons using active learning strategy. The content and time will be discussed and agreed upon in advance.

Please note that your participation is on a voluntary basis and your basic human rights will be protected and respected during this study.

To ensure that the information is recorded accurately, voice recordings and visual aids will be used as part of the collected data. Confidentiality and anonymity will be discussed and maintained and the details will be discussed to ensure your understanding of the study and its purpose. It is within your rights to leave or discontinue participating in the study anytime you wish to; that will not be held against you.

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voice recorder to help capture the exact words and flip charts will be used during the task or workshop meetings.

Yours thankfully

Lindiwe Mokotjo

1. I have read and understand the nature and purpose of the research study

2. I hereby agree to participate in the above-named study and have not been pressured in doing so

3. The implications and risks of participating in this research study have been brought to my attention and I understand them

4. My permission for the usage of information obtained during the study and the findings to the study is hereby granted.

_____ _____/_____/_____
Signature Date

APPENDIX F: CONSENT BY THE SCHOOL-BASED SUPPORT TEAM MEMBER (SBST)

Researcher
Lindiwe Mokotjo
P.O. Box 1185
Bloemfontein
9300
Contacts: 0738729175
Email: lmokotjo@yahoo.com

Study Leader
Dr. D.J. Hlalele
8 New Education Building
School of Education Studies
QwaQwa UFS
Contacts: 0587185003
Email: hlaleleDJ@ufs.ac.za

Date: February 2017

INFORMED CONSENT

Dear Participant: School-Based Support Team member (SBST)

I hereby request your assistance in conducting this research study titled: **An active learning strategy for addressing dyscalculia in a mathematics classroom.**

This study is aimed at formulating an active learning strategy for addressing dyscalculia in a mathematics classroom. Dyscalculia is a learning difficulty limited to mathematics and associated computation skills that are often equated to dyslexia. Mathematics is an important subject in understanding other subjects, choosing careers and in making financial decisions in real life. However, there are individuals who are excluded in learning mathematics. Dyscalculia is also thought to contribute to distress, low self-esteem, stigmatisation and disruptive behaviour in class. This study seeks to give all learners an equal opportunity to learn mathematics with understanding, beginning with lower classes up to adults at tertiary level. The study uses an active learning strategy and its elements enhance learning of mathematics for individuals with dyscalculia. As part of this research study, participants will engage on mathematics lessons using active learning strategy. The content and time will be discussed and agreed upon in advance.

Please note that your participation is on a voluntary basis and your basic human rights will be protected and respected during this study.

To ensure that the information is recorded accurately, voice recordings and visual aids will be used as part of the collected data. Confidentiality and anonymity will be discussed and maintained and the details will be discussed to ensure your understanding of the study and its purpose. It is within your rights to leave or discontinue participating in the study anytime you wish to; that will not be held against you.

The study is expected to resume from March 2017 to May 2017 with two to four meetings per month. The initial agenda will be communicated in advance and future meetings will be planned with your input. The information during

the sessions will be recorded by taking notes on a computer; usage of the voice recorder to help capture the exact words and flip charts will be used during the task or workshop meetings.

Yours thankfully

Lindiwe Mokotjo

1. I have read and understand the nature and purpose of the research study

2. I hereby agree to participate in the above-named study and have not been pressured in doing so

3. The implications and risks of participating in this research study have been brought to my attention and I understand them

4. My permission for the usage of information obtained during the study and the findings to the study is hereby granted.

_____ _____/_____/_____
Signature Date

APPENDIX G: CONSENT BY THE DEPUTY CHIEF EDUCATION SPECIALIST

Researcher
Lindiwe Mokotjo
P.O. Box 1185
Bloemfontein
9300
Contacts: 0738729175
Email: lmokotjo@yahoo.com

Study Leader
Dr. D.J. Hlalele
8 New Education Building
School of Education Studies
QwaQwa UFS
Contacts: 0587185003
Email: hlaleleDJ@ufs.ac.za

Date: February 2017

INFORMED CONSENT

Dear Participant: Deputy Chief Education Specialist

I hereby request your assistance in conducting this research study titled: **An active learning strategy for addressing dyscalculia in a mathematics classroom.**

This study is aimed at formulating an active learning strategy for addressing dyscalculia in a mathematics classroom. Dyscalculia is a learning difficulty limited to mathematics and associated computation skills that are often equated to dyslexia. Mathematics is an important subject in understanding other subjects, choosing careers and in making financial decisions in real life. However, there are individuals who are excluded in learning mathematics. Dyscalculia is also thought to contribute to distress, low self-esteem, stigmatisation and disruptive behaviour in class. This study seeks to give all learners an equal opportunity to learn mathematics with understanding, beginning with lower classes up to adults at tertiary level. The study uses an active learning strategy and its elements enhance learning of mathematics for individuals with dyscalculia. As part of this research study, participants will engage on mathematics lessons using active learning strategy. The content and time will be discussed and agreed upon in advance.

Please note that your participation is on a voluntary basis and your basic human rights will be protected and respected during this study.

To ensure that the information is recorded accurately, voice recordings and visual aids will be used as part of the collected data. Confidentiality and anonymity will be discussed and maintained and the details will be discussed to ensure your understanding of the study and its purpose. It is within your rights to leave or discontinue participating in the study anytime you wish to; that will not be held against you.

The study is expected to resume from March 2017 to May 2017 with two to four meetings per month. The initial agenda will be communicated in advance and future meetings will be planned with your input. The information during the sessions will be recorded by taking notes on a computer; usage of the voice recorder to help capture the exact words and flip charts will be used during the task or workshop meetings.

Yours thankfully

Lindiwe Mokotjo

1. I have read and understand the nature and purpose of the research study

2. I hereby agree to participate in the above-named study and have not been pressured in doing so

3. The implications and risks of participating in this research study have been brought to my attention and I understand them

4. My permission for the usage of information obtained during the study and the findings to the study is hereby granted.

_____ _____/_____/_____
Signature Date

APPENDIX H: DISTRICT-BASED SUPPORT TEAM

Researcher
Lindiwe Mokotjo
P.O. Box 1185
Bloemfontein
9300
Contacts: 0738729175
Email: lmokotjo@yahoo.com

Study Leader
Dr. D.J. Hlalele
8 New Education Building
School of Education Studies
QwaQwa UFS
Contacts: 0587185003
Email: hlaleleDJ@ufs.ac.za

Date: February 2017

INFORMED CONSENT

Dear Participant: District-Based Support Team member

I hereby request your assistance in conducting this research study titled: **An active learning strategy for addressing dyscalculia in a mathematics classroom.**

This study is aimed at formulating an active learning strategy for addressing dyscalculia in a mathematics classroom. Dyscalculia is a learning difficulty limited to mathematics and associated computation skills that are often equated to dyslexia. Mathematics is an important subject in understanding other subjects, choosing careers and in making financial decisions in real life. However, there are individuals who are excluded in learning mathematics. Dyscalculia is also thought to contribute to distress, low self-esteem, stigmatisation and disruptive behaviour in class. This study seeks to give all learners an equal opportunity to learn mathematics with understanding, beginning with lower classes up to adults at tertiary level. The study uses an active learning strategy and its elements enhance learning of mathematics for individuals with dyscalculia. As part of this research study, participants will engage on mathematics lessons using active learning strategy. The content and time will be discussed and agreed upon in advance.

Please note that your participation is on a voluntary basis and your basic human rights will be protected and respected during this study.

To ensure that the information is recorded accurately, voice recordings and visual aids will be used as part of the collected data. Confidentiality and anonymity will be discussed and maintained and the details will be discussed to ensure your understanding of the study and its purpose. It is within your rights to leave or discontinue participating in the study anytime you wish to; that will not be held against you.

The study is expected to resume from March 2017 to May 2017 with two to four meetings per month. The initial agenda will be communicated in advance and future meetings will be planned with your input. The information during the sessions will be recorded by taking notes on a computer; usage of the voice recorder to help capture the exact words and flip charts will be used

during the task or workshop meetings.

Yours thankfully

Lindiwe Mokotjo

1. I have read and understand the nature and purpose of the research study

2. I hereby agree to participate in the above-named study and have not been pressured in doing so

3. The implications and risks of participating in this research study have been brought to my attention and I understand them

4. My permission for the usage of information obtained during the study and the findings to the study is hereby granted.

_____ _____/_____/_____
Signature Date

APPENDIX I: CONSENT BY THE SCHOOL PRINCIPAL

Researcher
Lindiwe Mokotjo
P.O. Box 1185
Bloemfontein
9300
Contacts: 0738729175
Email: lmokotjo@yahoo.com

Study Leader
Dr. D.J. Hlalele
8 New Education Building
School of Education Studies
QwaQwa UFS
Contacts: 0587185003
Email: hlaleleDJ@ufs.ac.za

Date: January 2017

INFORMED CONSENT

Dear Participant: School Principal

I hereby request your permission in conducting this research study titled: **An active learning strategy for addressing dyscalculia in a mathematics classroom** at your school.

This study is aimed at formulating an active learning strategy for addressing dyscalculia in a mathematics classroom. Dyscalculia is learning difficulty limited to mathematics and associated computation skills that are often equated to dyslexia. Mathematics is an important subject in understanding other subjects, choosing careers and in making financial decisions in real life. However, there are individuals who are excluded in learning mathematics. Dyscalculia is also thought to contribute to distress, low self-esteem, stigmatisation and disruptive behaviour in class. This study seeks to give all learners an equal opportunity to learn mathematics with understanding, beginning with lower classes up to adults at tertiary level. The study uses an active learning strategy and its elements enhance learning of mathematics for individuals with dyscalculia.

The study is expected to resume from March 2017 to May 2017 with two to three meetings per month. The initial agenda and future meetings will be communicated in advance. The study will need the following participants from your school: mathematics teachers (2), learners (4), and school-based team member (1). The following participants will visit the school for research meetings: district education psychologist (1), CES from mathematics curriculum (1), parents (4) and inclusive education directorate personnel (1). The information during the sessions will be recorded by taking notes on a computer; usage of the voice recorder to help capture the exact words and flip charts will be used during the task or workshop meetings.

Please note that participation in this study is on a voluntary basis and participants' basic human rights will be protected and respected during this study.

To ensure that the information is recorded accurately, voice recordings and visual aids will be used as part of the collected data. Confidentiality and anonymity will be maintained and therefore names and details of participants will not be published. All participants have a right to leave or discontinue participating in the study anytime they wish to; that will not be held against them.

Your participation will add great value to this study. Please sign below for consent of your participation.

Yours thankfully

Lindiwe Mokotjo

1. I have read and understand the nature and purpose of the research study.

2. I hereby agree to participate in the above-named study and have not been pressured in doing so.

3. The implications and risks of participating in this research study have been brought to my attention and I understand them

4. My permission for the usage of information obtained during the study and the findings to the study is hereby granted.

_____ **_____/_____/_____**
Signature **Date**

APPENDIX J: TURN IT IN REPORT

Dssertation

ORIGINALITY REPORT

4%	3%	1%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

1%

★ Submitted to University of KwaZulu-Natal

Student Paper

EXCLUDE QUOTES	OFF	EXCLUDE MATCHES	OFF
EXCLUDE BIBLIOGRAPHY	OFF		

APPENDIX K: CERTIFICATE OF LANGUAGE EDITING

CERTIFICATE OF LANGUAGE EDITING

Dr. L. Hoffman

Kroonstad

BA, BA(Hons), MA (Afrikaans), DLitt et Phil (Afrikaans)

Cell no: 079 193 5256 Email: larizahoffman@gmail.com

DECLARATION

To whom it may concern

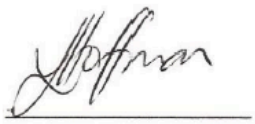
I hereby certify that the English language of the following dissertation meets the requirements of academic publishing. This dissertation was linguistically edited and proofread by me, Dr. L. Hoffman.

Title of dissertation

AN ACTIVE LEARNING STRATEGY FOR ADDRESSING DYSCALCULIA IN A MATHEMATICS CLASSROOM

Candidate

LINDIWE GLORIA MOKOTJO



Lariza Hoffman

Kroonstad

29 June 2017