Designing a supportive intervention in Mathematics for Grade 1 learners

by

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Submitted in fulfilment of the requirements for the degree

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(Learning Support, Guidance and Counselling)

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Ethics Statement

The author, whose name appears on the title page of this thesis, has obtained, for the research described in this work, the applicable research ethics approval. The author declares that he/she has observed the ethical standards required in terms of the University of Pretoria's *Code of ethics for researchers and the Policy guidelines for responsible research.*

Veronique Wolfaardt
April 2016

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Summary

Learners' poor performance in mathematics is a critical topic of discussion for South Africa. Shortcomings in the macro-system have prevented the effective implementation of a theoretically sound intended curriculum. Only certain extrinsic barriers have been addressed through educational research and many fundamental problems remain at the Foundation Phase, which has been largely neglected in studies addressing performance in mathematics. The necessity for a supportive intervention emerged as an important theme throughout the literature. The purpose of the research reported here was to design a supportive intervention aimed at improving Grade 1 learners' mathematics results.

Two methodological approaches which are rooted in pragmatism were employed in this study, mixed methods (methodology) and design research (method). The sample included in the study ranged from expert appraisers (one foundational mathematics specialist and one remedial specialist), two schools (high performance and low performance), Grade 1 class teachers and Grade 1 learners. Qualitative data was attained by means of semi-structured interviews and quantitative data through a designed assessment instrument.

Quantitative analysis revealed that learners subjected to the intervention (experimental group) showed a more significant overall improvement than those not subjected to the intervention (control group). The qualitative assessment of the intervention revealed teacher satisfaction in implementation of the intervention. While this dissertation provides a practical framework for intervention design, additional research should be conducted on a national scale in order to account for the complete range of mathematical difficulties encountered by South African learners as well as the extrinsic barriers that potentially influence them.

Keywords:

- *mathematics, Foundation Phase, response to intervention, design research, Grade 1, South Africa, assessment, mixed methods, pragmatism*

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List of Acronyms

ANA	Annual Numeracy Assessment
CAPS	Curriculum Assessment Policy Statement
LOLT	Language of Learning and Teaching
MLD	Mathematics learning difficulty
NCS	National Curriculum Statement
NKT	Number knowledge test
OBE	Outcomes-Based Education
Qual	Qualitative
Quan	Quantitative
RNCS	Revised National Curriculum Statement
RTI	Response to intervention
SACMEQ	Southern Africa Consortium for Monitoring Educational Quality
SAMP	South African Monitoring system for Primary Schools
SES	Socio economic standing
STEEP	Screening to Enhance Equitable Placement
TIMSS	Third International Mathematics and Science Study
UNICE	United Nations Children's Fund
ZPD	Zone of Proximal Development

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Chapter 1
Introduction

1.1 INTRODUCTION

The purpose of this research was to develop an intervention that focuses on the prevention and targeting of potential learning difficulties presented by Grade 1 learners in mathematics.

The need arose for this research owing to a paucity of discourse and research into Foundation Phase (FP: 5-9 years) mathematics teaching and learning in South Africa (Machaba, 2013, p. 2). Numerous studies have been conducted in the South African context regarding learner performance in mathematics but most of the studies have focused on secondary schools (Fricke, Horak, Meyer & Van Lingen, 2008; Le Roux, 2008; Themane, 2003). The studies often focused predominantly on classroom variables including teaching recourses and textbooks but not on the various components applicable to the different systemic levels and how they impact mathematics performance (this will be discussed further in Chapter 2, Section 2.4.1.2).

As will be discussed further in this chapter the argument presented is that when failures in the system occur, they culminate and have the potential to compound into serious mathematics learning difficulties in higher grades. Owing to this, it is essential to address these difficulties as early as possible. The growing body of literature surrounding the benefits to young learners of early exposure to quality mathematics teaching and learning has been well documented worldwide (Clements & Sarama, 2011; Barnett, 2011; Bryant, Bryant, Roberts, Vaughn, Pfannenstiel, Porterfield & Gersten, 2011).

It is clear that for Foundation Phase learners, a proper grounding in mathematics is necessary in order to help them gain an easier comprehension of the more complex and sophisticated mathematics concepts that they will eventually meet at a later stage (as will be reviewed in Chapter 2, Sections: 2.3.1.1 & 2.6.4). It seems, however, from the poor performance in Foundation Phase mathematics, that the teaching and learning landscape in South Africa is far from being well developed and it is this statement that will be discussed in this chapter.

The importance of this research cannot be overstated, as South African learners have performed poorly in mathematics in both national and international studies (Machaba, 2013, p. 2). This poor performance can be shown in three main studies: the Annual National Assessments (2011 & 2012); Trends in Mathematics and Science Study (2003) and the Southern and East African Consortium for Monitoring Education Quality (2010) (Department of Basic Education, 2011 & 2012; Foy, Martin & Mullis, 2003; Moloi & Strauss, 2005; Moloi & Chetty, 2010; Cappelle & Saito, 2010).

The South African Government has conducted Annual National Assessments (ANAs), which act as a tool in the monitoring and improvement of basic education (Department of Basic Education 2012, p. 1).

The results of the ANAs in 2011 showed that the national average score for numeracy in Grade 1 was 63%. In Grade 2 it was 55% and in Grade 3: 28%, demonstrating a consistent downward trend (Department of Basic Education, 2012, p. 24). Although the 2014 results showed improvement in results (with Grade 1 attainment at 68%, Grade 2, 62% and Grade 3 attainment of 56%), the drastic realisation has to be that, in Grade 4 the average is 37% and Grade 9 the average is 11%, with a trend emerging depicting a correspondence of averages decreasing in relation to a higher grade (Department of Basic Education, 2014, p. 9). In 2003, South Africa participated in the Trends in Mathematics and Science study (TIMSS). Through this, an average scale score of 264 in Grade 8 mathematics was attained, compared to the international average of 467 (Foy et al. 2003, p. 12). This result meant that South Africa was the lowest scoring country in mathematics achievement internationally (among the participating countries).

The Southern and East African Consortium for Monitoring Education Quality II (SACMEQ II), a systemic study conducted in 2000, showed that more than half of Grade 6 learners performed at a Grade 3 level or lower in mathematics. Further, within that percentage of learners, few had even reached a basic level of numeracy (Louw & Van der Berg, 2006 p. 7). Observation of achievement within the SACMEQ III study (2007), involving 15 African countries (14 of which participated in a mathematics study), shows that South Africa scored below a scale score of 500, placing the country in the lower scoring percentile, with a scale score of 494,8 (Saito & Van Cappelle, 2010, p. 19).

The overall trend that emerges from the above mentioned assessments shows that South African learners perform poorly from Grade 3 through to Grade 9. In addition this trend carries through to Grade 12. The South African government has praised the 76% Grade 12 pass rate, but according to Jansen (2014, para. 5) the South African education system is a “massive fraud” stemming from the governments reliance on the Grade 12 results as a barometer to determine education success. An alarming statistic shows that only 55% of learners that entered school in 2003 where able to complete their schooling through to Grade 12 (Business Tech, 2015). The Grade 12 results show no indication of the learners that were left behind owing to as Jansen (2014, para. 19) explains as a “culling process” where many learners fail and are forced to drop out. Drop-outs can be attributed to many additional socio-economic reasons but the core argument remains the same. In addition to the dropout rate, Grade 12 pass rates are influenced by the strong performance of a minority of schools that tend to conceal the poor performance of the majority, according to Jansen (2014), “If you removed the top 20% of schools – mainly former white, privileged schools – from the national averages, then a very dark picture emerges of a mainly black and poor school system performing far below what the combined results show,” (para. 26). The trend of poor performance throughout the schooling years points towards a lack of solid foundation in their early years. Within these early years, when a child is most susceptible and responsive to learning experiences, the development of mathematical skills is critical and importantly, these foundational skills will be retained throughout a child’s years of schooling (Cross, Woods & Schweingruber, 2009, p. 331). The importance of intervention at an early age will be discussed further in Chapter 2 of this study.

When addressing the education system (in addition to the acknowledgement of the negative trend in performance), it is imperative to acknowledge the curriculum and the effect it has on the outcomes of the individual learners (Van den Akker, 2009, p. 38). South Africa has undergone significant transformation in curriculum since the beginning of democracy in 1994 (Machaba, 2013, p. 49). Through an analysis of the intended, implemented and attained curriculum (McKenney, 2007, p. 38), through the various shifts, one is able to ascertain the quality of education being received by learners. In the *intended* curriculum, government has established by use of policy, what outcomes the education system aims to achieve. These outcomes are specified in a curriculum document. In the *implemented* curriculum, the curriculum is interpreted by its users (teachers) and the process of communicating said curriculum is undertaken through teaching and learning. The *attained* curriculum is the final output of the process whereby the learners demonstrate their acquired outcomes and the levels at which these outcomes have been achieved. When viewing the process of curriculum design, it is imperative to ensure the alignment of the intended curriculum and the implementation of the curriculum in order for results in the attained curriculum to be efficient (Gravemeijer, 2006, p. 68-69).

In Table 1.1 the three main curriculum transformations that occurred since 1994 (South Africa's democracy) are discussed with emphasis on the *intended*, *implemented* and *attained* curriculum as mentioned above.

Table 1.1: An analysis of the curricula implemented in South Africa from 1994

	Intended	**Implemented**	**Attained**
Curriculum 2005	**Aimed to:** • Based on Outcomes-based Education: • Displace emphasis on content. • Make explicit what learners should attend to. • Direct assessment towards specific goals. • Signal what is worth learning in a content-heavy curriculum. • Enforces child centeredness. • Can be a measure of accountability, i.e. a means of evaluating the quality and impact of teaching in a specific school. (Jansen, 1998, p. 322)	• Language of innovation associated with OBE too complex, confusing and at times contradictory. • OBE based on flawed assumptions about what happens inside schools, how classrooms are organised and what kinds of teachers exist within the system. • A large majority of teachers do not have access to information on OBE or understand OBE in instances where such information may be available. • OBE multiplied the administrative burden on teachers (Jansen, 1998, p. 323-329)	As evident from 2000. Learners: • Unable to read, write and count. • Lacked general knowledge. (Department of Education, 2009, p. 12)
	Aimed to: • Simplify and clarify Curriculum 2005 Attempt to shift the curriculum agenda from a local, mainly skills-based and context-dependent body of knowledge, which was not appropriate for a schooling system, to one that was more appropriate for a national curriculum (more coherent,	• No clear or detailed implementation plan. • No clear message and national communication plan regarding the new curriculum. • Blending the new curriculum with the previous curriculum.	Learners: • Unprepared for the change of LOLT in Grade 4. Underperformance in assessments

The Revised National Curriculum Statement (RNCS)/ National Curriculum Statement (NCS)	• explicit and systemic body of knowledge) and better suited to be recognised regionally and internationally. • Develop a high knowledge, high skills curriculum (Department of Education, 2009, p. 13)	• Confusion on what was national policy and what was not. • Insufficient detail and no assessment policy, forcing a use of C2005's assessment policies. • Large contradictions across documentation. • Superficial teacher training. • Language policy never implemented. (Department of Education, 2009, p. 14)	• Teachers: • Overload of work • Confusion • Stress (Department of Education, 2009, p. 14)
Curriculum and Assessment Policy Statement (CAPS)	**Aims to:** • Adjust what is taught (curriculum), rather than how one teaches (methods). • Not move far from OBE. • Address implementation problems identified in the RNCS and NCS. (Du Plessis, 2013, p. 1-2) According to the DoE (CAPS, 2011:3): • Ensure that all children acquire and apply knowledge and skills in ways that are meaningful to their own lives. Therefore it is important that examples for children should stem from their own environment. • Equip children, irrespective of their socio-economic background, race, gender, physical ability or intellectual ability, with knowledge, skills and values necessary for self-fulfilment, and meaningful participation in the society as citizens of a free country. • Find foundation in constructivism (when teaching Foundation Phase, teachers must start with what children know and then build on it). • Produce children that are able to identify and solve problems and make decisions using critical and creative thinking. • Make inclusivity a central part of the organisation, planning and teaching at school. Teachers must be equipped to handle learners that cope well as well as those that have difficulties.	of South African learners from a low SES leading to: 1. Poor foundational knowledge 2. Learners experience a broken journey through school 3. Lack of service delivery • Shortcomings associated with LOLT. • Failure of previous and current government based interventions. (Discussion & references in Section 1.2)	Learners: • Unprepared for the change of LOLT in Grade 4. • Underperformance in national and international assessments. (Department of Basic Education, 2011 & 2012; Foy et al., 2003; Moloi & Strauss, 2005; Moloi & Chetty, 2010).

Adapted from various sources as acknowledged within the table

There is an emerging trend presented in the table above where stated outcomes are not being achieved in the implementation phase (Anderson, Case & Lam, 2001; Wittenberg, 2005). This weakness has had and continues to have a negative effect on the attained curriculum, resulting in poor performance by learners. This weakness, present in the implemented curriculum, is the niche that my study has targeted. Based on this perspective, the utilisation of an intervention strategy to target some of the shortcomings of the South African education system can be justified (Gersten, Jordan & Flojo, 2005; Fuchs & Fuchs, 2001; Fuchs, Fuchs & Hollenbeck, 2007; Barnett, 2011). That said, within the limitations of a Masters study one had to look at aspects that could realistically be addressed and ascertain the direction one had to take to make an effective difference. This was addressed on a micro level whilst acknowledging and understanding the influences of the macro-level discussed in the problem statement of this chapter.

1.2 PROBLEM STATEMENT

Development of the comprehension and skills associated with mathematical understanding is imperative in the Foundation Phase (Starkey, Klein & Wakeley, 2004, p. 99). There is contention that the lack of attainment of the skills and understanding of mathematical concepts in a learner's early years will negatively impact their future abilities in mathematics (Machaba, 2013, p. 2). Through the acknowledgement of past systemic mathematics evaluations and the resulting low performance of learners at both Foundation Phase and in high school, one can deduce that there is an apparent flaw in the South African education system. When looking at the South African education system it is necessary to highlight the key issues pertaining to the shortcomings of and within that particular system. The education system, in its entirety, consists of three main levels: the macro, micro and nano-levels (Van den Akker, 2009, p. 37). The different levels need to be acknowledged in order to fully gauge the influences, interconnections and potential shortcomings that occur within the system. In this chapter the shortcomings identified in the macro-level will be discussed as this level is the foundation for potential flaws in an education system. In Chapter 2 (2.4.1.2) the three levels will be represented schematically and discussed in detail.

At the macro-level, government has established aims in policy that are expected to be achieved and within these aims, through literature, shortcomings have been identified. The first identifiable shortcoming is the inadequate level of teacher training and qualification. According to Steyn, Harris and Hartell (2011) "there is a serious shortage of well-trained, qualified teachers for early childhood and foundation phases" (p. 583). Beyond this basic lack of training, it's no secret that teachers in South Africa are overworked and underappreciated (Wood & Govender, 2013, p. 9). The average size of South African classrooms is 38 learners and a survey completed in 2008 showed that 6% of classrooms had an average of 60 learners, whilst 10% had an average of between 51 and 60 learners (Chuenyane, 2010). A study conducted by Machaba (2013) showed that most of the Foundation Phase teachers utilised as the study's sample (5 participants) where not qualified to teach in the Foundation Phase. As mentioned in the introduction of this chapter (as well as discussed in Chapter 2, Section 2.2.1) the implementation process is a key part of the process to attain the desired intended curriculum and policies. The teacher is crucial to the implementation of said policies and curriculum goals and, if not adequately qualified to carry forward that implementation, the teacher hinders the child attainment of the concepts and skills necessary to achieve in mathematics (Handal & Herrington 2003, p. 60; Van den Akker, 2009, p. 38; Machaba, 2013).

A significant percentage of the South African population are from a low Soci Economic Status (SES). According to Statistics South Africa (2015), in 2014, 21,5% of the South African population fell below the poverty line. A low SES (from the macro-level) affects the micro-level (school) quite significantly. Firstly, children from a low SES do not garner the foundations of a knowledge base that children from a higher SES are afforded and, therefore, the basis of knowledge to construct upon is not present (discussed further in Chapter 2, Section 2.4.1.1). Secondly, according to UNICEF (2009, p. 6), "many children experience a broken journey through school, interrupted by irregular attendance, absent teachers, teenage pregnancy and school-related abuse and violence." In a country where there are large discrepancies in the socio-economic standing (SES) of population groups, large education gaps are the result of unequal learning (Fleisch, 2008, p. 2).

Another repercussion of a group's SES, and very evident in the South African context, is a lack of service delivery (McDonald & Pape, 2002). In 2012, there was a profound demonstration of the severity of the lack of service delivery in South Africa as textbooks were not delivered to schools in Limpopo Province, leading to a backlog of desperately needed resources and a resultant detrimental effect on the education provided to learners (SAPA, 2012). A lack of textbooks and study materials hinders teachers and learners in that subject matter is not available to allow teaching and learning to take place; this affects implementation of the curriculum and negatively impacts the potential attainment of curriculum outcomes (Van den Akker, 2009, p. 38).

In the Foundation Phase it seems as if the language of learning is important for the teaching and learning of mathematical knowledge and concepts. There is a persistent debate in South Africa on whether learners should be taught in their mother tongue (Wium & Louw, 2012, p. 8; Owen-Smith, 2010). It is well established that a child who is taught in his/her mother tongue will learn more efficiently and a child who does not receive mother tongue instruction is usually at a large disadvantage, potentially affecting their performance (Owen-Smith, 2010, p. 31; Van der Berg, Taylor, Gustaffson, Spaull & Armstrong, 2011, p. 19). Learners have the right to choose their language of instruction through the duration of Foundation Phase (any of the 11 official languages). A particular problem arises when learners have to make a switch in their LOLT to English/Afrikaans in Grade 4 and are then expected to understand English/Afrikaans on a Grade 4 level (Foley, 2008, p. 2; Van der Berg et al. 2011, p. 19). Howie (2003) goes as far as to state that "the most significant factor in learning science and mathematics isn't whether the learners are rich or poor, it's whether they are fluent in English." This statement has significant value in the support of the importance of mother tongue instruction but one must not forget the other resultant factors of a low SES that may affect learning mathematics as discussed above. In Chapter 2 LOLT as an extrinsic barrier will be discussed further.

The final shortcoming in the macro-level identified through the literature is the failure of previous and current government-based interventions with context specific focus on mathematics and the accommodation of learners with learning difficulties. Government has implemented a number of education interventions to target the poor mathematics level in South Africa and following the evident results in universal and national assessments they are not providing the desired change. The specific mathematics and inclusive education interventions and their purposes are represented in Table 1.2. The shortcomings of said interventions will be discussed in Chapter 2 (specifically Section 2.5).

Table: 1.2: A representation of the interventions implemented by South African government

Intervention	Timeline	Purpose
Education Quality Improvement Partnership Programme (EQUIP)	1995-2008	• To improve school leadership and management. • To improve the effectiveness of school governance. • To improve the effectiveness of science and maths teaching. • To improve the strategic planning that leads to a development plan that is owned and implemented by the school. (Gallie, 2013, p. 321)
Foundations for Learning Campaign (FLC)	2008-2011	By 2011: • All learners would be able to demonstrate age-appropriate levels of literacy and numeracy in all South African schools. • Ultimately learners and students will acquire and maintain a solid foundation for learning. (Meier, 2011, p. 550)
Systemic Evaluations	2001 and 2007	• To benchmark performance and monitor progress made towards the attainment of goals aimed at transformation including: access, redress, equity and quality. • Establish the context in which learning and teaching is taking place • Attain information on learner achievement • Identify factors that affect learner achievement • Review and make conclusions regarding appropriate education interventions (Department of Education, 2003, p. 3)
Annual National Assessments (ANA)	2012-Current	• Contributes towards better learning in schools. • Provides the necessary information to planners, from the Minister all the way to teachers who need to plan their work in the classroom. • A tool designed to measure progress in language and mathematics as well as diagnose in which specific areas teachers need most support and how the learning materials used by learners need to be improved. • Provides the necessary information for potential intervention development. (Department of Basic Education, 2011, p. 5)
Education White Paper 6	2001-Current	• Changing the education system to be more inclusive where all learners can access education and training no matter what their individual needs are. (Department of Basic Education, 2001)

Adapted from various sources as acknowledged

Mathematical difficulties may potentially manifest as a result of one or a combination of the above discussed macro factors. This is caused by the macro-level shortcomings filtering through and affecting the micro and nano-levels in the system (as elaborated on in Chapter 2, Section 2.4.1.1).

The level of education a child receives in their foundational years affects their success in later years as evident in the results of the universal and national assessments (Department of Basic Education, 2011 & 2012). This result suggests that certain foundations are not present in lower grades, possibly even pre-primary school as many learners do not go to nursery school in South Africa (Fleisch, 2008). If the foundation of a new concept is not laid correctly, gaps may emerge in the educational development of a child as they mature, if these gaps are not addressed and corrected one will find the child in a progressive downward spiral whereby new concepts are not understood and the child suffers academically (Starkey et al., 2004; Vaughn & Fuchs, 2003, p. 139). Research from the World Bank (World Bank Press Release, 2012) pertaining to South Africa has pointed out that, “completion of primary school on time and progress on providing early childhood development programs has been inadequate across all circumstance groups” (para. 6). The macro-level shortcomings identified in the South African education system potentially adversely affect a learner on the nano-level; this establishes a need for a mathematics intervention and leads to the rationale of this study.

1.3 RATIONALE

Historically, South African schools at the Foundation Phase have been shown to perform poorly (Askew, Venkat & Mathews, 2012, p. 27). This can be attributed to the shortcomings, which are not being addressed by Government, and which have been acknowledged in the Problem Statement.

From the list of shortcomings that have been identified, those relevant to the context of this study are as follows:

- An acknowledgement of the lack of performance in mathematics and language (reading and writing) in learners throughout school years, which has been identified by comparative studies conducted at national and international levels (Department of Basic Education, 2011 & 2012; Foy et al., 2003; Moloi & Strauss, 2005; Moloi & Chetty, 2010; Hungi, Makuwa, Ross, Saito, Dolata, Cappelle & Vellien, 2010).
- The language barriers that present in learners owing to the failure of government to provide instruction in all languages (Wium & Louw, 2012, p. 8).
- The qualification/abilities of teachers (Steyn et al., 2011, p. 583).
- A failure of previous and current interventions established by government to address education shortcomings (Gallie, 2013, p. 321; Meier, 2011, p. 550; Department of Basic Education, 2011, p. 5; Department of Basic Education, 2001).

Therefore, when interventions are discussed, an acknowledgement needs to be made to the above mentioned shortcomings. According to Meier (2011, p. 550), South Africa’s government acknowledged the ‘quality problem’ in education and their solution was the launch of ambitious intervention initiatives and assessment programmes as mentioned in the problem statement of this study. De Clercq (1997) puts forward a compelling argument about the government’s educational policy implementation and the failures presented as a result, particularly emphasising the inability to accommodate the needs of the disadvantaged. This can be attributed to the first world approach to the implementation of educational policies, an argument supported by Jansen (2007, p. 37). The policies are geared towards, according to de Clercq (1997, p. 127), “the interests of the more organized and privileged sections of society.”

Even though the South African government have put interventions in place, it would appear that these interventions have not, necessarily, been thought through. It could be argued that they have not been planned properly to allow for effective implementation, whilst monitoring and evaluation have not taken place. As a result, therefore, there is a gap in the system in terms of a particular intervention focusing on the key areas starting at Grade One (Meier, 2011). De Clercq’s (1997, p. 144) research supports that of Meier (2011) by stating that government needs to change the process of thinking in terms of policy design and implementation so that intervention strategies empower and benefit those who are disadvantaged within the education system. While the state is implementing these interventions, there is an underlying trend that shows that the interventions don’t necessarily seem to achieve the goals the way that the state intends, as Sayed (2002, p. 394) acknowledges, there is “disjuncture between policy intention and outcome.”

The present study will focus on three main aspects:

- Identification of learners at the Grade 1 level who display indicators of developing learning difficulties with specific focus on potential barriers to learning, affecting the learner. This will be discussed further in the literature review of this study,
- The implementation of a classroom intervention focused at improving the attainment level of the class as a whole
- The tutoring of the identified learners after school (Fuchs et al., 2007a).

The research is established on the theoretical basis that confronting mathematics in an intuitive and consistent way from as early an age as possible, leads to the child having a firm conceptual foundation on which to construct knowledge (Jordan, Kaplan, Ramineni & Locuniak, 2009). This makes the potential for further learning barriers in mathematics diminish significantly as long as the foundation is built upon correctly using appropriate methods in a solid and consistent manner in order to enhance the mathematics experience (Dowker, 2005; Fuchs et al., 2007a; Beane, 1988; Barnett, 2011).

1.4 AIMS

The ultimate aim of this study was to develop an intervention that was focused on improving the mathematics performance and understanding of Grade 1 learners regardless of the average performance of the school.

The specific aims for this study were as follows:

- **To develop an intervention which would support learning and improve mathematics performance**

I wanted to develop an intervention that focused on incorporating a three-part approach (Response To Intervention, RTI) in two Grade 1 classes (one low performing and one high performing school) where the input would include specific intervention materials and a thorough review of curriculum interpretation as implemented by the teachers.

- **To implement the intervention (and verify whether it held up scientifically)**

For my intervention to hold up scientifically I needed to design a prototype for implementation. The prototype was thoroughly evaluated before being approved for the school field test (Plomp, 2007, p. 28).

- **To have made the necessary changes during the prototype phase of the project**

Design research is cyclical in nature and for my intervention to be successful; it required a repetition of process (different iterations) which would contribute to a refinement of my aims for the study and the overall alignment of my intervention with my initial anticipated design outputs.

- **To have evaluated the intervention, once the project was finalised**

I expected positive outcomes in the form of: improved learning conditions; better mathematics achievement on the part of the learners; improved learner attitudes towards mathematics; and an enhanced teaching experience owing to contentment.

Efficacy of the intervention was measured through a comparison of data from experimental groups against control groups and the determination of whether desired outcomes were achieved.

1.5 RESEARCH QUESTIONS

1.5.1 Main Research Question

What are the characteristics of an intervention for the purpose of improving Grade 1 learners' mathematics in the South African context?

1.5.2 Sub-questions

- **What concepts in mathematics present as most problematic for Grade 1 learners?**

To answer this question qualitative data attained through semi-structured interviews with Grade 1 teachers, as well as screening of learners, was conducted to determine the prominent trends they could identify regarding Mathematical difficulties. This data contributed to the design of the intervention in Phase II of the process.

❖ **How do Grade 1 teachers assist learners with learning difficulties?**

Qualitative data attained through semi-structured interviews with Grade 1 teachers was utilised to answer this question. This data contributed to the design of the intervention in Phase II of the process.

❖ **What are the challenges of designing and implementing an intervention in the South African context?**

As acknowledged in the problem statement, there are vast challenges present in the South African context regarding the implementation of intervention strategies. This question was addressed through the design process and provided a solid foundation on which to base the intervention. In addition qualitative data attained through the interviews with the teachers of the poor performance school contributed further to the answering of this question.

❖ **How effective was the intervention in the improvement of Mathematics achievement in the Foundation Phase?**

In attaining the answer to this question, two means of data were collected and analysed following the implementation of the intervention (Phase III). Quantitative data was attained from the implemented assessment instrument throughout three intervals (pre, intermediate and post) for each test (Number knowledge, SAMP, Problem solving and the combined average). Qualitative data was attained through interviews with Grade 1 class teachers, determining intervention successes, failures and implementation potential. The culmination of the quantitative and qualitative data allowed the researcher to determine which aspects of the intervention where successful and which were not.

1.6 DEFINITION OF CORE CONCEPTS

Throughout this dissertation certain concepts are referred to regularly. In this section the concepts will be identified and simplified.

1.6.1 BARRIERS TO LEARNING

According to Inclusive Education South Africa (n.d), "a barrier to learning is anything that stands in the way of a child being able to learn effectively. A learner may experience one or more barriers to learning throughout his or her education," (p.1). In the context of this study the barriers to learning are focused on those that influence mathematics ability specifically. In addition, owing to the limitations of this study and the focus on the mainstream, difficulties as influenced by extrinsic barriers are acknowledged rather than disabilities influenced by intrinsic barriers (Chapter 2, Section 2.4.1).

1.6.2 LEARNING DIFFICULTY

A distinction is made between a learning difficulty and a learning disability in this study. A learning disability is influenced by intrinsic barriers (within the child) and refers to physical and/or mental "handicaps" that stand in the way of the child learning (Van Vuuren, 2009; Engelbrecht & Swanepoel, 2009). A learning difficulty implies a problem the child acquires when learning is influenced by an extrinsic barrier (outside the child) (Engelbrecht & Swanepoel, 2009). The extrinsic barriers discussed in this study include: Socio Economic Standing (SES); didactical situation; poor language acquisition and/or inadequate vocabulary.

1.6.3 FOUNDATION PHASE MATHEMATICS

Mathematics can be viewed as an extensive domain incorporating the various areas of algebra, arithmetic, calculus, geometry, and trigonometry (Fletcher, Lyon, Fuchs & Barnes, 2006, p. 29). According to Askew, Brown, Rhodes, Wilium and Johnson (1997) mathematics "is the ability to process, communicate and interpret numerical information in a variety of contexts" (p. 4). In this study, mathematics is viewed in the context of Foundation Phase and the core themes applicable to mathematics are outlined in Chapter 2 (Section 2.6.4). These core themes culminate in the concept of number sense and are discussed at length in terms of assessment and use in the designed intervention.

1.6.4 FOUNDATION PHASE LEARNER

According to the Oxford Dictionary (n.d.), a learner is "a person who is learning a subject or skill." In South Africa a Foundation Phase learner (Grade R-3) normally ranges from five to ten years of age (Department of Education, 2003, p. 19). In this study the "person/s" referred to are Grade 1 learners; the "subject" is mathematics; and the "skill" refers to the skills associated with understanding mathematical concepts.

1.6.5 FOUNDATION PHASE

Foundation Phase refers to Grade R (reception year) to Grade 3, where learners are (normally) aged between five and ten. The focus subjects within this phase are Mathematics, English and Life Skills (Department of Education, 2003, p. 19). This study's focus is on the design and implementation of an intervention to address the learning of mathematics in Grade 1.

1.6.6 INTERVENTION

In the context of this study the intervention is systematic in nature, providing early and intensive assistance to those learners who are at risk for or are already underperforming in mathematics as compared to learners of the same age or grade-level (Fuchs & Fuchs, 2006).

1.7 SUMMARY OF THE METHODOLOGY

Various methodologies were employed in order to answer the research questions and to assist in the design of the intervention. Methodologies were founded in the pragmatic paradigm owing to the researcher's ability to have access to various methods, different world views, different assumptions and different forms of data collection and analysis (Creswell, 2013, p. 10-11). In this section, the methodologies utilised will be acknowledged in a summary. In Chapter 4 the methodology will be elaborated on, and discussed in detail.

1.7.1 RESEARCH PARADIGM

A pragmatic approach was adopted in this study. In a pragmatic approach the researcher focuses on the research problem rather than on the method. This is not to say that method is unimportant but rather that various methods are addressed and tested for inquiry to establish effectiveness in attaining a specific goal (Maxcy, 2003, p. 81). The suitability of pragmatism as applicable to mixed methods research emerges, in that the researcher can draw from both quantitative and qualitative assumptions to attain the specified goal in their research (Creswell, 2013, p. 10). It was shown in Section 4.2 that pragmatism is an effective underpinning for mixed methods. Through this underpinning it emerged that the researcher had access to various methods, different world views, different assumptions and different forms of data collection and analysis. Further, in the section the philosophical assumptions regarding epistemology, axiology and ontology were addressed.

1.7.2 RESEARCH METHODOLOGY

A methodology of a mixed methods approach is employed for this study (Section 4.3). The mixed methods approach was selected based on the characteristics and the investigative nature of the aims and research questions identified in Chapter 1. Further, in this study it is utilised as an approach to the collection and analysis of data within the design research method, forming part of the cyclical process in the development of the prototypes. The mixed methods design approach can be viewed as the collection, analysis and integration of findings from qualitative and quantitative data, within a single study or inquiry (Tashakkori & Creswell, 2007, p. 4). The mixed methods approach was further refined by the adoption of the embedded mixed methods design; this follows on the premise of one data set providing a supportive secondary role in this study which is based primarily on another data set. The embedded mixed methods design was presented in a figure (Figure 4.1) to illustrate the above mentioned process. The final aspect on the section of mixed methods is notation, establishing which aspects (qualitative or quantitative) are more dominant or less dominant in the research process.

1.7.3 RESEARCH METHOD

The primary research method for this study was design research (Section 4.4). Design research has a twofold purpose, it is viewed as a research design aimed at the development of research based solutions to complex educational problems (*development studies*) or it can be utilised as a method to validate theories about learning processes, learning environments and similar concepts (*validation studies).* Design research is founded in its systematic nature and establishes its success through the use of iterations which likens it to the systemic variations in experiments (Gravemeijer et al., 2009, p. 13; Cobb, Confrey, Lehrer & Schauble, 2003, p. 9). As discussed previously in this section this research is divided into phases: Phase I – Preliminary research; Phase II – Prototyping and Phase III – Assessment. Within the phases iterations occur and contribute to the overall design process. The cyclical process of design research involves: analysis, design, evaluation and revision. This process continually 'repeats' until balance is achieved between the 'ideals/intended' and 'realization' (Plomp 2007, p. 7).

1.7.4 METHODOLOGY APPLICABLE TO THE THREE PHASES OF DESIGN RESEARCH

Sample, instruments, data collection and data analysis are discussed in Section 4.5. In Figure 4.4 the design research model for the development of an intervention aimed at the improvement of Grade 1 learners' mathematics results is illustrated to provide clarity in regards to the methodological processes associated with the relevant phases and cycles. Within the design research process, cycles 3, 5, 8 & 9 are empirical in nature and cycles 1, 2, 4, 6 & 7 are conceptual in nature.

1.7.4.1 Sample

In Section 4.5.2.1, the sampling process for this study is described. Purposive sampling is employed and the samples utilised include: expert appraisers; two schools (high performance and low performance); Grade 1 class teachers and Grade 1 learners.

1.7.4.2 Instruments

Two types of instruments were used in this study (Section 4.5.2.2), interview schedules and an assessment. Interview schedules were conducted with expert appraisers and Grade 1 teachers (pre-implementation) in Phase II of the design process (Section 4.5.2.4). An Interview with Grade 1 class teachers of the experimental groups (group of learners that received the intervention) was conducted in Phase III (post-implementation).

1.7.4.3 Data collection

Research techniques in terms of data collection included expert appraisal, an assessment, a walk-through and interviews.

- ***Expert appraisal.*** During the design phase of the intervention (Phase II) the first prototype was submitted to two experts for review. The first appraiser was a Foundation Phase mathematics specialist and the second a remedial specialist. The purpose of the appraisal was to enhance the overall construct of the intervention improving suitability and content.

- ***Walk-through.*** During the design phase (Phase II) of the intervention the assessment instrument was implemented with two learners of the target audience. Criteria adhered to for the evaluation of the walk-through were: time efficiency, age and level appropriateness and whether the assessment was easily administered.

- ***Interviews.*** Interviews were conducted at two intervals in the research process. The first was conducted with the class teachers in the design phase of the intervention in order to further refine the intervention prototype before implementation in the two schools. The second interview schedule was conducted in the final phase of research, contributing to the embedded mixed methods approach (qualitative data). The data assisted in establishing the efficiency of the implemented intervention.

- ***Assessment.*** The assessment comprised three distinct sections: the Number Knowledge Test; SAMP and problem solving. The assessment instrument was implemented at three intervals within the final phase of the research process to attain pre, intermediate and post quantitative data. This was the primary source of data in this study in terms of establishing whether the intervention was efficient.

1.7.4.4 Data analysis

For data analysis, thematic content analysis was employed for the qualitative data and for the quantitative data the Wilcoxon signed-ranked test was utilised. Data analysis for Phase II is discussed in Section 4.5.2.5 and for Phase III in Section 4.5.3.3.

1.8 STRUCTURE OF THE DISSERTATION

Six chapters compose this dissertation.

1.8.1 CHAPTER 2: LITERATURE REVIEW

In Chapter 2 the foundational aspects established within this chapter are elaborated upon and new themes emerge in terms of mathematics and intervention success. The purpose of the chapter is to establish a solid theoretical basis from which the study would progress. Core themes that are presented in detail include: a focus on the curriculum (as introduced in this chapter) with focus on the curriculum design process and the current South African Foundation Phase mathematics curriculum (Section 2.2). Learning and teaching approaches are addressed with specific focus on the influence from the influential constructivist theorists, Lev Vygotsky and Jean Piaget (Section 2.3). Learning difficulties as influenced by extrinsic barriers will be discussed as relevant to the South African context (Section 2.4). In addition, a model emerged through the literature review that presents how a learner with mathematics difficulties presents compared to a “normally” performing learner (Section 2.4.2) In the final sections of Chapter 2, a review is performed on previously implemented interventions (Section 2.5) and a discussion on how to target mathematics-related learning difficulties forms the conclusion of the chapter (Section 2.6). All relevant sections culminate as a theoretical foundation for the subsequent chapter.

1.8.2 CHAPTER 3: CONCEPTUAL FRAMEWORK

In Chapter 3 the foundational themes identified through the literature review give rise to the identification of a model, isolated owing to its relevance to this study. The RTI (Response to Intervention) model as well as an adjoining model, STEEP (Screening to Enhance Equitable Placement) were combined and adapted for the purpose of this study (Section 3.2). Within the chapter the two models are introduced and the relevant phases established through the merging of the models as applicable to this study are discussed (Section 3.3). In the final sub-section the mathematical areas that are relevant to the stages are examined and within this section the core foundational assessment concepts emerge contributing to the assessment instrument design (Section 3.3.6).

1.8.3 CHAPTER 4: METHODOLOGY

The research design and methodology are discussed in Chapter 4. The philosophical underpinnings relevant to this study are identified and discussed as well as the pragmatic foundation (Section 4.2). Sampling, instruments, validity issues, data collection and data analysis are all elaborated upon within the relevant phases of the design research process (Section 4.5). The chapter concludes with the methodological norms (Section 4.6), the ethical considerations (Section 4.7), and the methodological constraints identified through the study (Section 4.8).

1.8.4 CHAPTER 5: RESULTS

The data analysis techniques identified and discussed in Chapter 4 were employed to present the final analysis of data and to interpret the results. The chapter includes the analysis of the all the interview schedules (expert appraisers, pre and post interviews with the class teachers) (Sections 5.2-5.4), the walk-through (Section 5.3) of the assessment and the final assessment instrument data (School A and B) (Section 5.4). Analysis methods for the data included thematic content analysis (qualitative), observation for the walk-through and the Wilcoxon sign-rank test (quantitative data).

1.8.5 CHAPTER 6: CONCLUSION

Within this chapter a summary of the research (Section 6.2) and the findings from literature, the conceptual framework and data will be presented in relation to the research questions (Section 6.3). In addition, reflections on the conceptual framework (Section 6.4) and methodology (Section 6.5), as well as recommendations for research, policy (Section 6.6) and practice (Section 6.7) will be discussed.

1.9 CONCLUSION

This chapter serves to establish the foundational aspects of this study. The introduction, background, problem statement, rationale, research questions and aims are presented. It is through this foundation that concepts emerged, necessary to fuel the progression of this study. In the forthcoming chapters the basis of this study will be enhanced and strengthened with the emerging key concepts identified in this chapter being discussed and augmented.

In the following chapter a literature review is conducted. It is in this review that the concepts that were brought forward in this chapter along with additional foundational themes are addressed and discussed in detail. It is through the establishment of core themes that the research process could conceptualise. The curriculum will be discussed with the two sub-sections focusing on curriculum design and the South African Foundation Phase mathematics curriculum (Section 2.2). Contributions of educational theorists and their theories will be presented in Section 2.3.1 as well as learning and teaching processes in

Section 2.3.2. A comparison will be made between the concepts of learning difficulties and learning disabilities as background theory for this study (Section 2.4). The various mathematics intervention studies (as well as an inclusive education intervention) that have been implemented in South Africa will be discussed in terms of their shortcomings (Section 2.5) and the chapter will be concluded with the targeting of mathematics learning difficulties (Section 2.6).

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Chapter 2
Literature Review

2.1 INTRODUCTION

In addressing the problems associated with mathematics learning and teaching in the Foundation Phase it is necessary to review literature in order to establish a solid theoretical foundation for this study. In Chapter 1, Section 1.4, the main aim of this study was introduced: To develop an intervention that is focused on improving the mathematics performance and understanding of Grade 1 learners regardless of the average performance of the school.

The literature reviewed in this chapter will be included based on its premise of assisting in the foundational aspects of the intervention design process. In Section 2.2, curriculum will be discussed with the two sub-sections focusing on curriculum design and the South African Foundation Phase mathematics curriculum. It is in this section (Section 2.2.1) that the curriculum design process (introduced in Chapter 1), of the *intended*, *implemented* and *attained* curriculum will be discussed and within these levels this study's focus of the sub-level (micro level) will be brought forward with the use and importance of the curriculum spiderweb as illustrated by Van den Akker (2009, p. 41).

The acknowledgement of the Foundation Phase Mathematics curriculum establishes the intended curriculum and its aims. This is a foundational aspect of this study as the researcher aims to utilise the curriculum (intended) and address the implementation of said curriculum in the form of an intervention. In Section 2.3.1, the contributions of educational constructivist theorists Jean Piaget and Lev Vygotsky will be discussed in terms of their respective theories: strengths, weaknesses, differences and similarities. In addition, teaching strategies (Section 2.3.2) will be discussed to elaborate on improving the learning experience for learners (attained curriculum). The teaching strategies that will be discussed are: teaching developmentally; teaching through problem solving; and preventative teaching. The above mentioned sections are included to add to the mirco-level (implementation success) as a mechanism to counteract potential inadequate implementation of the curriculum and potentially improve mathematics results.

In Section 2.4 a comparison is made between the concepts of learning difficulties and learning disabilities as background theory for this study. The distinction between the two concepts is used as a delimiting factor; owing to this study's focus on difficulties rather than disabilities. Linking to the difference between difficulties and disabilities, extrinsic and intrinsic barriers emerge. The following sub-section discusses the influences of extrinsic barriers on the child through the use of systemic levels (Section 2.4.1). These levels will be discussed in detail pertaining to a learner's ability to grasp mathematical concepts and will establish a baseline for understanding difficulties and how to address them in the classroom through intervention. The final sub-section (2.4.2) will present a model of a typically performing learner *versus* a learner with mathematics learning difficulties; this section will serve as a baseline for understanding MLD specific problems and, as a result, establish components to focus on in intervention design in Chapter 3.

Section 2.5 pertains to various mathematics intervention studies (as well as an inclusive education intervention) that have been implemented in South Africa. These are analysed to determine the factors that attribute to the failures of said interventions and the potential for the need of a mathematics intervention in South Africa. The final section in this chapter (Section 2.6) focuses on the targeting of themes attached to mathematics learning difficulties that emerged through the isolation of successful factors that will attribute to the validity of this study's designed intervention and will establish the conceptual framework for Chapter 3.

In Chapter 1 (Section 1.1) the South African curriculum was introduced in terms of its transformation since the beginning of democracy from 1994 and the *intended*, *implemented* and *attained* curricula were acknowledged (Van den Akker 2009, p. 38; Handal & Herrington 2003, p. 60). In the following section, the above mentioned curriculum representations will be elaborated upon in terms of curriculum design, owing to the importance of this study's focus on the implemented curriculum. In addition, the components of the South African Foundation Phase Mathematics Curriculum will be presented (intended curriculum) as it is foundational to this study's intervention.

2.2 CURRICULUM

An analysis of the curricula implemented in South Africa from 1994 was presented in the previous chapter (Section 1.1). This analysis showed that whilst the curricula implemented had solid and effective aims (intended), in all transformations an evident shortcoming in terms of implementation failures occurred. These failures resulted in unsatisfactory performance of learners in the attained curriculum (Department of Basic Education 2009 p. 12-14; Department of Basic Education, 2011 & 2012). In this section an expansion on the concept of Van den Akker's (2009, p. 37-50) curriculum design will occur, relevant to this study, and the Foundation Phase maths curriculum will be addressed.

2.2.1 CURRICULUM DESIGN

In Van den Akker's curriculum design (2009, p. 37-38) each curriculum dimension represents a particular set of variables and a societal context in which they are associated. The intended curriculum associates with the macro-level (system/society/nation/state), the implemented curriculum associates with the micro-level (classroom) and the attained curriculum reflects in the nano-level (individual/personal). The curriculum domains are depicted by Van den Akker (2009, p. 38) in Table 2.1 providing a refined typology.

Table 2.1: A typology of curriculum representations

INTENDED	**Ideal**	Vision (rational or basic philosophy underlying a curriculum)
	Formal/Written	Intentions as specified in curriculum documents and/or materials

IMPLEMENTED	**Perceived**	Curriculum as interpreted by its users (especially teachers)
	Operational	Actual process of teaching and learning (also: curriculum-in-action)
ATTAINED	**Experiential**	Learning experience as perceived by learners
	Learned	Resulting learning outcomes of learners

Note. From *An Introduction to Educational Design Research* edited by T. Plomp & N. Nieveen, 2009, p. 38.

Van den Akker's (2009, p. 38) topology breaks down the three curriculum dimensions into focused sub-levels. These sub-levels further refine the focus of this study pertaining to the implemented curriculum and the potential of influencing the learning experience of the learners. By adhering to this practice the shortcomings of the South African curriculum (as discussed in Chapter 1, Section 1.1) should be addressed. In addition to the above mentioned curriculum dimensions, Van den Akker (2009) delves further into the micro-level by addressing curriculum components, stating that, "one of the major challenges for curriculum improvement is creating balance and consistency between the various components of a curriculum" (p. 39). In addressing the statement, for the curriculum to be implemented effectively, a model that establishes a framework has emerged: Van den Akker's Curricular Spiderweb (McKenney, Nieveen & Van den Akker, 2006, p. 69).

In this framework, nine components (assessment; time; aims & objectives; content; learning activities; teacher role; materials & resources; grouping; and location) will be addressed in order to form linkages and attain balance in the classroom system (micro-level) (Gravemeijer, McKenney, Nieveen & Van den Akker, 2006).

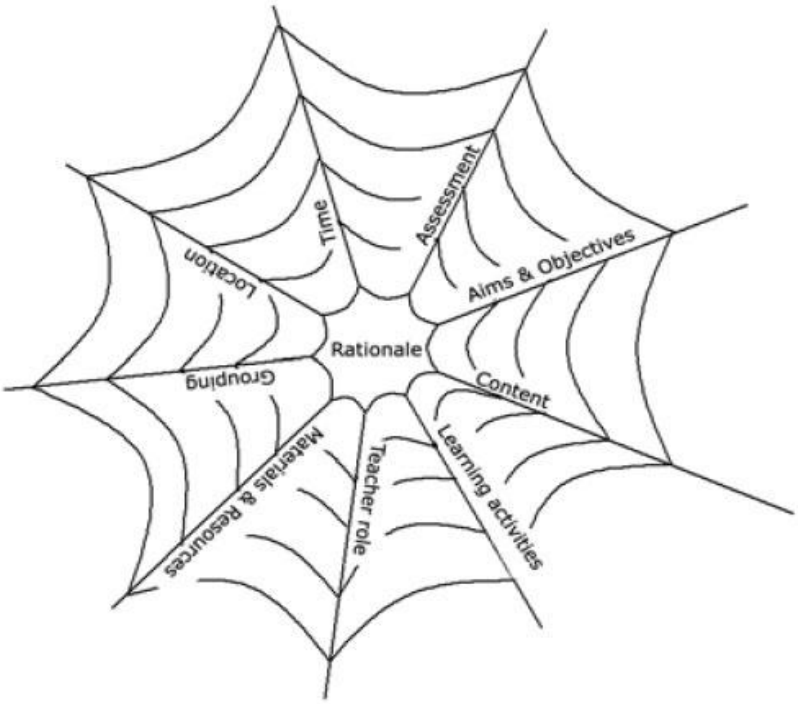

Figure 2.1: Visual model illustrating a Curricular spiderweb (from *Educational design research,* edited by Van den Akker et al. 2006, p. 69)

The various component accents within the classroom environment will vary over time; it is dramatic shifts in balance that potentially lead to the system being unbalanced and therefore affect learners negatively. When implementing the curriculum, specific attention needs to be paid to the linkages between the components in order to maintain balance and consistency. In order to adhere to the framework of the curricular spiderweb, specific questions need to addressed and answered and will be described in Table 2.2 (Van den Akker 2009, p. 39). It is these questions that establish a framework for the designed lesson plans that were implemented at the schools (Further discussed in Chapter 3, Section 3.3.3).

Table 2.2: Curriculum components

Component	Question
Rationale or Vision	Why are they learning?
Aims & Objectives	Towards what goals are they learning?
Content	What are they learning?
Learning activities	How are they learning?
Teacher role	How is the teacher facilitating learning?
Materials & Resources	With what are they learning?
Grouping	With whom are they learning?
Location	Where are they learning?
Time	When are they learning?
Assessment	How to measure how far the learning has progressed?

Note. From *An Introduction to Educational Design Research,* edited by Nieveen & Plomp, 2009, p. 39.

The above-mentioned curriculum components can vary across the systemic levels and can attribute to various barriers affecting the child (discussed further in Section 2.4.1), but the core principles remain the same. The rationale serves as a central point to which the other components link. Grouping, location and time are core organisational aspects. The rationale; aims and objectives; and content pertain to curriculum documents on the macro-level. Learning activities; teacher role; materials and resources; and assessment encompass the micro-level and is the focus of this phase in the intervention.

In addition, for each question associated with a component, various sub-questions emerge and need to be thought about and acknowledged during planning and implementation. For example, when referring to grouping one can ask, “How are learners allocated to various learning trajectories?” and “Are learners learning individually, in small groups or the whole class?”

If the questions established in the above table are used as a framework for lesson planning a resultant balance and consistency in the micro-environment should emerge allowing for learners to receive high quality instruction stemming from successful implementation (Van den Akker, 2009). In Chapter 3

(Section 3.3.3), the curriculum components will be addressed in relation to their contribution towards the design of the intervention.

2.2.2 Foundation Phase Mathematics curriculum

The current CAPS curriculum aims to ensure that learners attain and apply knowledge and skills in a constructive manner relating to their own lives. Adhering to this aim, the curriculum intends to encourage knowledge applicable to local contexts whilst acknowledging and being aware of global standards. Further, the curriculum aims to produce learners that are knowledgeable, skilled, able to solve problems and to think critically, all the while finding foundation in inclusivity where, regardless of SES, race, physical disability or intellectual ability, learners are offered an equal and fair chance to attain these aims (Department of Basic Education, 2011, p. 4). All learning areas, in addition to the main curriculum aims, have their own focused aims and guidelines and in the context of this study Foundation Phase mathematics is the focus.

According to the Department of Basic Education (2011, p. 8), the current curriculum (CAPS) establishes specific aims for the teaching and learning of mathematics which are set out to develop the following in learners:

- critical awareness of how mathematical relationships are used in social, environmental, cultural and economic relations;
- confidence and competence to deal with any mathematical situation without being hindered by a fear of Mathematics;
- a spirit of curiosity and a love of Mathematics;
- appreciation for the beauty and elegance of Mathematics;
- recognition that Mathematics is a creative part of human activity;
- deep conceptual understanding in order to make sense of Mathematics; and
- acquisition of specific knowledge and skills necessary for:
  - the application of Mathematics to physical, social and mathematical problems,;
  - the study of related subject matter (e.g. other subjects); and
  - further study in Mathematics.

In addition the Department of Basic Education (2011, p.8), establishes the guidelines to develop specific mathematical skills:

- develop the correct use of the language of Mathematics;
- develop number vocabulary, number concept and calculation and application skills;
- learn to listen, communicate, think, reason logically and apply the mathematical knowledge gained;
- learn to investigate, analyse, represent and interpret information;
- learn to pose and solve problems; and

- build an awareness of the important role that Mathematics plays in real-life situations, including the personal development of the learner.

In Table 2.3 the content areas, weighting of said content areas and the topics applicable to Grade 1 mathematics are presented.

Table 2.3: Content areas, weighting of content areas and topics relevant to Grade 1 mathematics

Content Area	Weighting of content area	Topic
Numbers, Operations and Relationships	65%	• Count objects • Count forwards and backwards • Number symbols and number names • Describe, compare and order numbers • Place value • Problem solving Techniques • Addition and subtraction • Repeated addition leading to multiplication • Grouping and sharing leading to division • Money • Techniques (methods or strategies) • Mental mathematics
Patterns, Functions and Algebra	10%	• Geometric • Patterns • Number • Patterns
Space and Shape (Geometry)	11%	• Position, orientation and views • 3-D objects • 2-D shapes • Symmetry
Measurement	9%	• Time • Length • Mass • Capacity/Volume
Data Handling	5%	• Collect and sort objects • Represent sorted collection of objects • Discuss and report on sorted collection of objects • Collect and organise data • Represent data • Analyse and interpret data

Adapted from the Department of Basic Education (2011, p. 10-35)

The content of the CAPS Grade 1 mathematics curriculum is sound and corresponds effectively with literature on the importance of certain core concepts that a learner must be presented with in early childhood for improvement in mathematical ability. It is important to note that in Grade R-3 the area of

Numbers, operations and relationships is the main focus of Mathematics (65%) (Department of Basic Education, 2011, p. 10). This, in addition to the findings in literature, influenced the intervention design accordingly. Numbers, operations and relationships (Number sense) were core to the design of the assessment instrument, lesson plans and remedial lessons. Where the additional content areas were acknowledged and incorporated, they were only presented on a small scale owing to limitations (discussed in Chapter 4, Section 4.7) of this study. The importance of number sense will be discussed in Section 2.6.4 in this chapter.

It was found in Chapter 1 (Section 1.1) that the problem with the curriculum arises from outcomes not being achieved in the implementation phase and, as a result, the attained curriculum is influenced. A key aspect of the implemented and attained curriculum emerges as teaching and learning. In the implementation of the curriculum teachers are mentioned regularly (refer to Chapter 1, Table 1.1). Inadequate level of teacher training and qualification and a lack of access to information are mentioned.

Owing to the lack of clarity from intended to implemented curriculum the researcher aimed to ensure that efficient teaching and learning approaches were acknowledged in order to counteract the effect of possible inadequate teacher implementation. This was achieved through thorough understanding of the intended curriculum as well as incorporating constructivism in the classroom. The curriculum stipulates the importance of constructivism (Department of Education, 2011, p. 3). It is from this acknowledgement that the theories from two foundational theorists were consulted. The theorists and their theories will be discussed in the following section.

2.3 TEACHING AND LEARNING APPROACHES

According to the Department of Education (2011) one of the aims in the curriculum is to "find foundation in constructivism (when teaching Foundation Phase, teachers must start with what learners know and then build on it)," (p. 3). Constructivism finds its roots in the cognitive school of psychology and in the theories of Piaget (Von Glasersfeld, 1982). It is a theory that focuses on the way in which knowledge is constructed, through a process where one builds new ideas and concepts through experience in an active manner (Powell & Kalina, 2009, p. 241), and according to Troelstra and Van Dalen (2014) is an important theory utilised in mathematics learning and teaching. According to the theory, a child's learning is based on their cognitive structures, social interactions, previous learning and their environment, and may be modified and transformed according to these. The development of mathematical knowledge occurs through interaction and manipulation of mathematical programmes (Kutz, 1991, p. 10). In constructing knowledge one requires tools (existing ideas), materials (what one acts on to build understanding) and effort (active thought) (Van de Walle, Karp & Bay-Williams, 2007, p. 22). In the classroom, learners must be adequately stimulated to think reflectively; actively participating in their learning processes (Henderson & Trotta 2016, p. 1). In this section, teaching and learning approaches will be discussed, focusing primarily on the foundation of constructivist influence.

2.3.1 LEARNING APPROACHES

There has been a fundamental change, over the past 25 years, in the way in which the early development of mathematical thinking is understood. This shift gives rise to an understanding of how to target the learner on a developmental level within the micro-system, potentially assisting the achievement of the highest level of performance out of the learner. This, in addition to adjusted teaching strategies discussed further on in this section, will contribute to improving the implementation of curriculum (Section 2.2). A general consensus emerged from traditional learning theorists that mathematical knowledge development begins in primary school once formal instruction commences (Bereiter & Engelman, 1966). The understanding revolved around the notion that learners were not able to possess mathematical knowledge owing to the inability to meaningfully use abstract numerical notation (written numeral or operation signs) (Starkey et al., 2004, p. 99). A shift in focus regarding mathematical knowledge was instigated by Piaget in 1952, who acknowledged the development of mathematical knowledge prior to formal schooling in the learning area (Starkey et al. 2004, p 99). An argument was presented by Piaget and a generation of researchers that followed him, that young learners' mathematical thinking is informal, as opposed to the reliance on the use of abstract numerical notation by learners as an indicator for the onset of mathematical cognition, because of the dependence on the actual presence (mental representation) of concrete entities and the transformation of said entities (Starkey et al., 2004, p. 100).

The two theorists that will be discussed in this section owing to their views on constructivist learning are Jean Piaget and Lev Vygotsky. Each theorist's theories as well as the pros and cons of their particular theories will be acknowledged.

2.3.1.1 Piaget

Piaget hypothesised that the form of learners's operational structures is different at different stages of their development and that this gives their thought at each stage a unique character (Piaget, 1952). In addition to the developmental stages, the strengths and weaknesses of Piaget's theory will be established. The developmental stages hypothesised by Piaget (1976) are as follows.

❖ **Stage I: Sensory motor stage (approximately 0-2 years)**

Initially the child goes through a pre-verbal and pre-symbolic stage; information is gained from the senses (sensory) and from the body (motor). Actions progress from unintended (reflex) to intended (goal directed). A one year old, a child progresses to a stage of object manipulation for an intended goal (action and response). The child, through trial-and-error learns that if he/she performs an action that receives a desirable response they can do it again with the same response expected. Development of the realisation that objects exist and are "out there" whether perceived or not (object permanence) is a main characteristic that develops in the Sensory motor stage. At the end of this stage the child has a basic foundation for organisation and adaptation to his/her environment. At the end of the stage the child should be able to move, grasp, sense, imitate, explore, practise, form mental images and talk.

❖ **Stage II: Pre-operational stage (2-4 years & 4-7 years)**

Operations are only beginning to be mastered by the child (actions carried out mentally rather than physically). Piaget enforces the step internalisation of action in this stage, establishing the movement from action to thinking. There are two phases within the Pre-operational stage, the pre-conceptual (2-4 years) and the intuitive phase (4-7 years). In the pre-conceptual phase: symbols are being used by the child for better broadcasting of their intentions. In this phase the child progresses to asking questions and giving answers, establishing what he/she wants. At this phase the child is not ready to understand mathematical concepts (mathematics problems by means of symbols). Reverse thinking is not developed, for instance, a quantity of water poured from a glass to a saucer is, in the child's mind, less in quantity once in the saucer (appearance based/centration). To solve centration the child requires time experimenting and manipulating different objects to gauge shapes, sizes and volumes to lead him/her to future solutions to problems. Piaget's opinion is that number concepts develop at an early age, with the child being aware through experience that quantity, shape and size exist. Through this phase words and meanings establish themselves to develop an understanding of concepts of quantity (more; little; give two more). Sequencing is also revealed to the child through experiences through playing and stacking blocks. Piaget enforces that the above mentioned is pivotal in the efficient development of number concepts.

The intuitive phase (4-7 years) is the point in a child's mathematical development that the child is prepared for mathematics instruction. The above mentioned pre-conceptual experiences need to be focused on and enforced by the child's teacher and parents to ensure a solid foundation of experiences to construct formal mathematics instruction on.

❖ **Stage III: Concrete operational (7-11 years)**

It is at this stage that formal schooling begins for the child and logical mathematical thinking begins (thinking becomes operational). According to Piaget objects and events are still concrete in the child's mind therefore hands-on problems are solved in a logical fashion by the child. Concrete operations include grouping and classifying (according to length, size ect.).

❖ **Stage IV: Formal operations (11 years and older)**

Abstract thinking develops in this stage. The child's language correlates with good logic and a separation occurs between emotional meanings and objective meanings. Concrete objects are no longer required for the child to solve a problem. Owing to this separation from concrete thinking, actions no longer have to be connected to previous experiences for the child to understand a problem and argue about it effectively. Combinations and relationships between numbers develop. Knowledge can now be reconstructed and manipulated.

It is through the above mentioned stages that Piaget's view emerges, learners attain knowledge through construction. This construction occurs through their continuous interactions with the environment and their making sense of all stimuli encountered (Forman & Kuschner, 1977). According to Charlesworth and Lind (2013, p. 11), Piaget divides knowledge into three areas: *physical knowledge* (learning about objects in the environment and their characteristics), *logico-mathematical knowledge* (relationships that each individual constructs to make sense out of the world and to organise information) and *social knowledge* (is created by people).

Strengths and weaknesses in Piaget's theory emerge through literature. Following Piaget's theory of the developmental stages, cognitive development has become far more understandable and this has had a significant impact on education. In addition clarification has occurred on the developmental process of learners's reasoning skills about mathematics and science. Finally, the fact that learners think differently to adults can be defined by Piaget's theory (Bruner, 1997; Shayer, 2003).

In contrast to the strengths of the theory discussed above there are several shortcomings that emerge. Piaget's theory underestimates the competence of learners and, social and cultural factors have been drastically underestimated in cognitive development. Cognitive development does not always occur as neatly as Piaget stipulates where some learners are more advanced than others and progress to the formal operations stage is not guaranteed. Lastly, emotional and social phenomena are excessively generalised (Lourenco & Machado, 1999; Santrock, 2008).

2.3.1.2 Vygotsky

Whilst Piaget's theories were widely utilised and acknowledged, a large body of research has since been undertaken that shows that young learners possess informal mathematical knowledge that is more extensive and occurs at a younger age than Piaget theorised (Starkey et al. 2004, p. 100). Further theorists began to assert that learners's thought is more responsive to external influence and more dependent on social interaction than Piaget hypothesised, leading towards theories described rather by Vygotsky (Case 1996, p. 2). Charlesworth and Lind (2013, p. 12) go on to describe Vygotsky's view of how learners learn and develop. Vygotsky had a view on cognitive development that recognises developmental and environmental forces. He theorised that mental tools are developed by people and that these tools assist people in mastering their own behaviour. Vygotsky referred to these mental tools as *signs*. In Vygotsky's theory three sign systems were established as important. The first and most important is speech as it frees one from distractions and allows for the internal (mental) solving of problems. The second and third important signs were writing and numbering. Vygotsky developed an alternative concept know as the *zone of proximal development* (ZPD). The ZPD, according to Vygotsky (1978, p. 86) "is the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers."

The assistance that is provided to the child through an adult or a more capable peer is coined "scaffolding". Scaffolding is provided to the learner until the concept is mastered and the child is able to perform the task unassisted. As a teacher it is important to establish learners' ZPD in order to provide instruction that is developmentally appropriate and stimulates the learners successfully. As discussed with regard to Piaget's theory, strengths and weaknesses for Vygotsky's theory also emerges through literature. Vygotsky placed great emphasis on social and cultural influences and how cognitive development is affected and the importance of language in his theory attributes to the teachers use of language as a facilitating method (Shayer, 2003; Bruner, 1997).

Following the discussion of the strengths of the theory above, several shortcomings emerged. Vygotsky's theory fails to account for the developmental stages of children. This attributes to less information about a child's developmental level, interests and age specific appropriateness. The role of the teacher as a facilitator could impact on the spontaneity of learners and through scaffolding, if assistance from others (adults and peers) occurs too frequently the learner may become too dependent and struggle to cope when the support is not available. Finally, there is no standard or assessment method that can measure ZDP (Van der Veer & Ijzendoorn 1985; Hua Liu & Matthews, 2005; Matusov & Hayes, 2000).

2.3.1.3 Piaget *versus* Vygotsky

Following the establishment of Piaget and Vygotsky's core theories and their corresponding strengths and weaknesses it is necessary to address their differences and similarities.

Table 2.4: A comparison between Piaget and Vygotsky's theories on development

Piaget	Vygotsky
Development precedes learning.	Learning precedes development.
Cognitive development is mostly common across cultures.	Assumption that cognitive development varies across cultures.
Underestimates the effect of social factors contributing to cognitive development. His opinion is that cognitive development stems from the isolated child where through his/her own explorations knowledge is constructed.	Cognitive development stems from social interaction through guidance in learning within the ZDP, knowledge is co-constructed. He further accredits the environment in which the child is raised and how that influences what and how a child thinks.
Lack of emphasis on language. Language is dependent on thought.	More influence is placed on the role of language in cognitive development. Thought and language are initially separate entities which eventually merge at approximately 3 years of age (verbal thought/ inner speech).
Importance of peers. Promotes social perspective taking.	Importance of adults. Cultural tools are transmitted to the child which are then internalised.
Minimal emphasis on make believe play.	More emphasis on make believe play. Believing it extends a child's behaviour beyond their actual age.
Role of teacher: Facilitator and guide. Opportunities are created by the teacher for the learners to interact with meaningful ideas and materials.	Role of teacher: Mediator and mentor. Opportunities are constructed with the learners for interaction with meaningful ideas and materials.
Role of learners: Active construction within their minds.	Role of learners: Active co-construction with others.

Cognitive development occurs through four distinct phases.	Assumed there are no set stages in cognitive development.

Note: From McLeod (2014); Vianna and Stetsenko (2006, p. 81-108)

In addition to the differences identified in Table 2.4, the prominent supposed fundamental difference between the theories of Piaget and Vygotsky will be discussed (Lourenço, 2012, p. 282).

The argument that emerges focuses on Piaget's theory that the construct of knowledge occurs within the individual in isolation (Bruner, 1997). Vygotsky on the other hand believed that one develops knowledge through participation in various forms of social interaction, this being attained through the use of tools (abacus, blocks etc.) and signs (language, mathematics formulae, pretend play etc.) (Lourenço, 2012, p. 282). This divide in the theories is rejected by various authors (Bickhard, 2004; Cole & Wertsch, 1996; Müller & Carpendale, 2000). The rejection of the division between the theories is based in the idea that Vygotsky's and Piaget's theories adopt, according to Lourenco (2012) "a relational perspective rather than a genetic or developmental individualism," (p. 282). This rejection of the fundamental difference between the theories establishes the foundation for secondary comparison between the theorists (Lourenço, 2012, p. 282). This secondary comparison between the theorists focuses on their similarities rather than their differences and points at the importance of utilising both theorists in teaching and learning strategies. The similarities of the theorists are as follows (Shayer 2003, p. 477-478):

- Both theorists are constructivists.
- Both believed societal influences set the limits of development.
- They focused on mechanisms through which higher cognitive development occurs.
- Both believed that learning is affected by:
    - context in which an idea is taught
    - learners' beliefs and attitudes

According to Cole and Wertsch (2000), in many instances the weaknesses of one theorist are complemented by the strengths of the other. Three authors support the decision to primarily view Piaget and Vygotsky rather as complimentary theorists with multiple similarities rather that two distinct opposing theorists where teachers must choose one or the other (De Vries, 2000; Lourenço, 2012; Shayer, 2003). According to Shayer (2003) "it is argued that by the early 30s they (Piaget and Vygotsky) had reached almost identical positions regarding child development, and that the work of each is complementary to that of the other" (p. 465). Utilising the two theorists' views establishes a solid foundation for instruction. By addressing the strengths of both Piaget and Vygotsky, learners can be targeted in a way that stimulates optimal learning. During the preschool years considerable development of aspects of informal mathematical knowledge takes place. These aspects include enumeration, arithmetic problem solving, spatial reasoning and geometric knowledge. This development lays the foundation for the acquisition of formal mathematics knowledge in school (Geary, 1994; Starkey et al., 2004, p. 100; Krajewski & Schneider, 2009).

2.3.2 TEACHING STRATEGIES

Following the establishment of Piaget and Vygotsky's theories on learning mathematics, it is necessary to acknowledge potential teaching strategies that can be utilised for the improvement of mathematics performance. Firstly, the constructivist view of teaching developmentally (in accordance with aims of CAPS) will be discussed and secondly, methods for preventative teaching will be elaborated upon.

2.3.2.1 Teaching developmentally

Teaching is viewed as a decision-making process, where the teacher plans what will be taught and decides what steps should be taken to ensure a concept is attained by the learner (Freeman 1989, p. 27). Decisions are not only long term but extremely short term, where constant decisions need to be made throughout the day with regards to responses to ever changing situations, including: specific assistance for a child struggling with a concept; discipline; and when one has to intervene in problem solving for example (Van de Walle et al., 2007, p. 31). The foundations for developmental teaching have been set out by Van de Walle et al. (2007, p. 31-32) and a teacher who utilises and is aware of these ideas/foundations is said to base his/her instruction on a constructivist view of learning. Each of these ideas will be listed and elaborated upon.

1. *Children construct their knowledge and understanding; we cannot transmit ideas to passive learners*

Every child is unique and, as a result, comes to a teacher with their own unique ideas. As discussed previously in this section, ideas are tools that a teacher utilises in order to build on a child's pre-existing knowledge and experiences. A child needs to be an active participant in their learning for a construct of ideas to occur (Kanuka & Anderson 2007, p. 57; Van de Walle et al., 2007, p. 31).

2. *Knowledge and understanding are unique for each learner*

Each child has their own 'network' of ideas, unique to them, following their individualised experiences and knowledge. When a new idea is formed it is incorporated into the individual child's network in a unique way. It is important to note that no child is the same and as a teacher one should not try to make all learners the same (Henderson 2003, p. 5; Van de Walle et al., 2007, p. 32).

3. *Reflective thinking is the single most important ingredient for effective learning*

A learner needs to be completely engaged in their learning process for them to create new ideas. A learner must find the relevant connections of their pre-existing ideas and apply them to develop ideas and to solve problems (Baron 1981, p. 291; Van de Walle et al., 2007, p. 32).

4. *Effective teaching is a child-centered activity*

The South African curriculum encourages the OBE way of teaching in that is to stimulate and engage learners, guiding them towards solutions rather that performing a rote role of 'downloading' information. Problems must be posed and an environment of exploration must be encouraged (Hmelo-Silver &

Barrows 2006, p. 37). According to Van de Walle et al. (2007), “the source of mathematical truth is found in the reasoning carried out by the class” (p. 32).

2.3.2.2 Importance of teaching through problem solving

Mathematics teaching should focus on problem solving and inquiry. There should not only be a focus on teacher developed problems but learners should also play an active part in their own generated problems (Michael 2006, p.165). According to Charlesworth and Lind (2013, p. 48) problem solving and inquiry are the major processes that underlie all instruction in mathematics. For the young child, problem solving strategies develop as they experience and interact with situations in their world. It is extremely important that learners are presented with problems that are not straightforward so that they can extend their minds (Charlesworth & Lind, 2013, p. 48).

The traditional method of teaching mathematics entails the teacher broadcasting information, the learners then practicing the concept for a while after which the learners are expected to use the new skills in problem solving. This process focuses on where the teacher is rather than where the learners are, this is attributed to the belief that all children possess the underlying ideas necessary to make sense of the information given by the teacher in the way the teacher feels best (Van de Walle et al., 2007, p. 37). It is not theoretically easy to teach through the medium of problem solving, a constant reflection on the curriculum as well as an understanding of the individual levels of the learners is necessary (Van de Walle et al., 2007, p. 37).

Van de Walle et al. (2007, p. 41-42) establish a three part lesson structure (before, during and after) for teaching through problem solving. When teaching problem solving it is the teachers responsibility to guide the class and establish the appropriate atmosphere. Each part of the lesson structure will be discussed:

1. Before

In this part of the lesson structure it is the teacher’s responsibility to mentally prepare the learners. This occurs through the establishment of ideas and concepts that will assist them in the problem solving process. In addition, the teacher needs to ensure that learners understand the task at hand as well as their associated responsibilities regarding the task and the expectations for the final product (Van de Walle et al., 2007, p. 41).

2. During

It is in this part of the lesson structure that the teacher withdraws constant guidance and lets the learners use the opportunity to work by themselves. Learners must be encouraged to explore and use their own ideas. It is the teacher’s responsibility to listen to how different learners/groups are thinking and approaching the problem at hand, hints may be provided if necessary (Van de Walle et al., 2007, p.41).

3. After

Once learners have been given the opportunity to work on their problems they must be brought together as a community to discuss their thought processes. There is no evaluation in this part of the lesson structure rather an exercise where all are encouraged to participate and contribute to the overall discussion. As a group the learners must work together to decide what worked and what didn't. Thought processes must not stop at the solution; learners must be encouraged to reflect on the solutions and methods used (Van de Walle et al., 2007, p. 42).

2.3.2.3 Preventative teaching

Fuchs and Fuchs (2001) and Forness, Kavale, MacMillan, Asarnow and Duncan (1996) discuss methods for preventative teaching methods and these will be elaborated upon. A preventative teaching approach focuses on prevention rather than cure and attempts to limit the chances of a child developing learning difficulties. Forness et al. (1996) conceptualise prevention defining three levels that will enhance the potential for success of a mathematics intervention. The model consists of three levels: primary, secondary and tertiary. Universal design is the focus of primary prevention. Within universal design, instructions given to learners incorporate principles that address the needs of those learners in need of specialised attention without hampering the other learners in the class. The goal of primary prevention is to preclude the development of difficulties but sometimes this fails. It is this potential failure that leads to need for secondary prevention. Secondary prevention (pre-referral intervention) is offered to arrest the seriousness of a difficulty or to reverse its course. General education is modified at this level in ways that are feasible for the teacher and unobtrusive to learners. Within this level the desired outcome is to attain better class performance, with minimal invasiveness to target learners and minimal disruption to others in the class. Tertiary prevention entails difficulties being targeted directly. It is reserved for those learners that do not respond to the lower levels of prevention. This level is synonymous with intensive intervention where individualised attention relating to the learner's specific difficulties is given.

Fuchs and Fuchs (2001, p. 86-88) utilise the conceptualisation outlined by Forness et al. (1996) and discuss instructional methods meeting three criteria. Firstly, the method shows success in mathematics; secondly, research illustrates the utility of the methods with learners displaying LD; and third, a synonymous link within a universal design framework. The principles are as follows: quick pace with varied instructional activities and a high level of engagement; challenging standards for achievement; self verbalisation methods; physical and visual representations of number concepts or problem solving situations. The main characteristics of each principle will be stated.

❖ **Quick pace with varied instructional activities and a high level of engagement**

Within this principle it was established that several variables distinguished teachers with a successful teaching strategy in terms of maintaining an effective learning environment. The effective teacher incorporated a dramatically quicker pace resulting in more activities each lesson, had more instructional activities and had a greater range of grouping arrangements. The instructional pacing and varied instructional formats utilised by the teacher leads to more active learner involvement (discussions, writing computing and problem solving). This type of teaching differed greatly from the typical scenario of learners sitting and listening and showed a distinct improvement in learning and results (Fuchs & Fuchs, 2001, p. 86).

❖ **Challenging achievement standards**

Another key variable in a successful teaching strategy involves the level and type of motivation provided to their learners. In this situation the teacher communicates high expectations of learners. Rather than enforcing "it will be fun," the teacher enforces the expectation that everyone will learn. Learners showed a distinct eagerness to learn following the expectations and were highly engaged in mathematical activities (Fuchs & Fuchs, 2001, p. 87).

❖ **Self verbalisation methods**

As discussed previously in this chapter, research in mathematics has specifically identified cognitive strategy instruction as an effective instructional tool. In this principle, learners are taught and must memorise explicit steps for approaching and solving problems and these steps are applied through verbalisation, first overtly and then less overtly over time.

Cognitive strategy instruction to enhance problem solving performance can be taught to learners through a strategy established by Montague, Applegate and Marquard (1993). LD learners were taught:

(1) Seven cognitive steps (read the problem, paraphrase, visualise with picture or diagram, hypothesis a plan to solve the problem, estimate the answer, compute and check).
(2) Methods for regulating their use of the above mentioned steps.
(3) Both.

Results of utilising the seven cognitive steps indicated that they were sufficient to effect change in the first seven days following implementation. Evidence has emerged according to Fuchs and Fuchs (2001) that "verbal rehearsal routines, which specify steps for approaching and solving mathematics problems, are an effective means for enhancing the performance of learners with LD." It is important to acknowledge that verbal rehearsal routines benefit all learners in the class regardless of their level of performance (Fuchs & Fuchs, 2001, p. 87).

❖ **Physical and visual representations of number concepts or problem solving situations**

Research on mathematics has long focused on procedures more than concepts, but studies indicate the importance of conceptual understanding in order to facilitate application of procedural knowledge and to accomplish long-term retention of procedural competence. The use of physical and visual representations to facilitate conceptual understanding assists learners in mastering and maintaining mathematical competence. A study by Harris et al. (1995) showed that Grade 3 learners with and without LD learned multiplication to high levels of competence through the use of physical and visual representations (Fuchs & Fuchs, 2001, p. 87-88).

Within the context of this study, the purpose of the designed intervention is to target possible mathematics learning difficulties and to improve the overall mathematics performance at the Grade 1 level. In the following section, the difference between mathematical learning difficulties and disabilities will be established.

Within the concept of mathematical learning difficulties (MLD), barriers to learning emerge. In the South African context barriers are a very prominent influence on the attainment of learning outcomes and need to be acknowledged in the designing of the intervention (Lomofsky & Lazarus, 2001, p. 311). Stemming from the identification of barriers to learning, the three systemic levels in the education system are elaborated upon in terms of the relevant barriers, this is represented in Figure 2.1. The final sub-section views a model of a normally performing learner *versus* a learner with MLD, this section is imperative to the intervention design as it allowed the researcher to adapt the intervention to target MLD specifically.

2.4 MATHEMATICAL LEARNING DIFFICULTIES

When acknowledging a child performing poorly, two categories emerge: the child with a learning *disability* and a child with a learning *difficulty* (scholastically impaired learner) (Course material, 2008, p. 2-3). Mathematics learning difficulties or more appropriately arithmetic difficulties (attributing to the relevance towards young children), according to Geary (2004, p. 4) “can result from deficits in the ability to represent or process information in one or all of the many mathematical domains (e.g., geometry) or in one or a set of individual competencies within each domain.” These deficits can be attributed to the intrinsic and/or extrinsic barriers affecting the child (Dowker, 2005). In this section the barriers to learning will be addressed as well as the difference between a “normally” performing learner *versus* a learner with MLD.

2.4.1 BARRIERS TO LEARNING

Intrinsic and extrinsic barriers will be discussed within the context of learning *disabilities* and *difficulties*. The term “learning disability” applies to the child that deviates from the normal development of other learners owing to an identifiable handicap or disability. The disability can manifest with varying degrees of severity and usually presents early on in the child’s development. Two scenarios present for a child with a learning disability: firstly, the child receives specialised education outside of a mainstream school and secondly, remedial education and additional attention is provided for the child from a teacher within the mainstream school system (Course material, 2008, p. 2-3).

Learning disabilities are associated with intrinsic barriers to learning. Intrinsic (personal) barriers are barriers that occur within the child and can be divided into three sub-categories: physical, general health and neurological. Physical disabilities can present as sensory deficits such as auditory or visual disability or a bodily deficit such as paraplegia. The second intrinsic barrier, the general health of a child, presents if a child is poorly nourished, does not get enough sleep, constantly struggles with an illness or has a chronic disease learning will not take a priority and the child will have difficulties in concentrating. Lastly, neurological impairment, where a particular neurological aspect is damaged within the child's brain, affecting for instance, the acquiring of mathematics skills where possibly logical thinking is impaired (a major prerequisite of problem solving) (Engelbrecht & Swanepoel, 2009).

Five neurological learning disabilities feature more frequently in diagnosis, and present as, attention deficit hyperactivity disorder (ADHD), dyslexia (reading disability), dyscalculia (mathematics disability), dysgraphia (writing disability) and dyspraxia (planning disability) (Bornman & Rose, 2010, p. 133). Whilst the researcher acknowledges that disabilities may be a factor in MLD this is not the focus of this study.

The term "learning difficulty" describes a child who develops a deficiency in their modes of learning actualisation, leading the child to experience problems with understanding spoken or written language. This manifests in their thought processes, laying a foundation for possible problems with speech, reading, spelling and mathematics (Geary, Hoard, Nugent & Byrd-Craven 2008, p. 277). A child with a learning difficulty has the full potential, given effective intervention, to reduce the gap between the level of achievement and his/her actual ability. Learning difficulties as a whole stem from a variety of environmental factors as acknowledged by Engelbrecht and Swanepoel (2009). Engelbrecht and Swanepoel (2009) have identified the main factors that lead to extrinsic barrier related learning difficulties.

2.4.1.1 Extrinsic barriers to learning

Extrinsic barriers to learning are barriers that occur outside the child as an entity and are imposed by society or the environment (macro and micro levels). These barriers present themselves as the following influences on the child: socio-economic status; home environment and circumstances; didactical situation including the education system; teacher qualification and the knowledge they possess in assisting learners who display learning difficulties; poor language acquisition and/or inadequate vocabulary (Engelbrecht & Swanepoel, 2009).

❖ **Socio-economic status (SES) and circumstances**

It has been shown that the socio-economic standing of a child has a great effect on their educational performance (Starkey et al., 2004, p. 99; Gersten et al., 2005, p. 297). Starkey et al. (2004, p. 99) have established that mathematical knowledge develops in early childhood and that evidence shows, children from an economically disadvantaged and language minority family receive less mathematics developmental support compared to their middle-class peers, resulting in a identifiable gap in knowledge and skills. This gap is further attributed to Wium and Louw's (2012, p. 8) research where very few learners from a low-SES receive a preschool education, this impacts on the above mentioned acquisition of mathematical skills and knowledge and affects their school readiness. Starkey et al. (2004, p. 99) acknowledge that, low-SES learners require more knowledge input relative to their starting point than their middle-class peers. Engelbrecht and Swanepoel (2009, p. 15) establish the detriments which hamper education for learners within the schools in poverty-stricken communities (poor socio-economic standing), they are as follows: poor language development, non-stimulating environment, poor orientation towards school, lack of order in communal structures, insecurity, short term orientation towards time, powerful negative peer groups, culture of vandalism and conflicting value orientation between family and school. Gersten et al. (2005, p. 297) further establish that a child from a low-SES has obvious disadvantages in the acquisition of mathematics skills, particularly discrimination skills (which is bigger 9 or 7?) as compared to their high-SES counterparts and this is attributed to the amount of informal instruction the child receives at home. The acquisition of number sense is pivotal in the mathematical development of the child and occurs in the child's early years beginning in the home situation (the concept of number sense will be discussed subsequently in the chapter) (Gersten et al., 2005, p. 297).

The circumstance of the child in their home environment is of additional notable importance in learning. Emotional stability plays a large part in the attention, observation, thinking and memorization a child displays. A problematic situation in the home situation (leading to the child feeling venerable, unsafe and insecure) can have significant detrimental effects on a child's learning ability (Van Vuuren, 2009, p. 6).

❖ **Didactical situation**

A poor didactical situation plays a large part in learners potentially acquiring mathematical learning difficulties. A poor education system accounts predominantly as the didactical stimulus for the potential development of MLD. Within this context, multiple government shortcomings have been identified including: poor service delivery (Alexander, 2010, p. 25), poor enforcement of school attendance (Sutila, 2009, p. 6), language of learning and teaching (addressed below), intervention failure (Meier 2011, p. 553) and teacher training and qualification (Steyn et al., 2011, p. 583).

The above mentioned shortcomings all attribute within the implementation phase of policy. Policy implementation issues have been identified as the South African government's primary shortcoming with the resultant outcome being poor mathematical achievement presented by learners on a universal scale (Anderson et al., 2001; Wittenberg, 2005). A further predominant problem arises from teacher qualification, enthusiasm and the knowledge they possess in assisting learners who display learning difficulties. A teacher is pivotal in the learner's developmental process and can establish whether the learning environment is positive, encouraging growth, support and confidence or negative, promoting insecurities and anxiety (Chuenyane, 2010; Van Vuuren, 2009, p. 6).

❖ **Poor language acquisition and/or inadequate vocabulary**

Within the South African educational context it has been established that multiple paradigm shifts have occurred. A prominent shift has been attributed to the language-in-education policy which is failing South African learners (Heugh, 1999). Wium and Louw (2012, p. 8) support this statement acknowledging that a primary factor in the poor performance of South African learners in benchmark testing attributes to learners' inadequate language capabilities, as many learners did not understand what was expected of them in the assessments. Language related barriers develop following two predominant influences: a milieu-deprived environment and the language of learning and teaching (LOLT). Firstly, reiterating the point established in the SES of a learner, often times, economically disadvantaged parents inadvertently create a milieu-deprived environment following a lack of education and resources, this leads to a lack of adequate foundation in the development of language, particularly mathematical language. Secondly, the language of learning and teaching (LOLT), whereby learners possibly develop academic barriers following the presentation of a lesson that is not in their mother tongue (Van Vuuren, 2009, p. 9). The above mentioned factors are attributed to the facilitation of language development for numeracy.

Numeracy is, as stated by Wium and Louw (2012, p. 8), "the ability to understand and reason with number." Mathematics in itself is a language comprising of verbs (<, =, //), nouns (3, three), expressions (2+5, 4X10), sentences (10+5=15) and grammar (order of operations) (Usiskin, 1996; Wium & Louw, 2012). According to Schleppegrell (2007, p. 140) "learning the language of a new discipline is part of learning the new discipline; in fact, the language and learning cannot be separated." Therefore, the acquisition of mathematical language (numeracy) is imperative in the development of mathematics skills and knowledge."

In terms of the possible language orientated barriers that may develop in learners it is important to acknowledge vocabulary and the role it plays in the potential development of MLD. A milieu-deprived learner will often times have inadequate concrete experiences as well as a poor vocabulary (Olivier, 2006). A poor vocabulary can have detrimental effects on mathematical development, owing to a learner having difficulty in understanding the words used by a teacher. The problem may not arise from understanding quantities but rather from understanding instructions and new concepts. A secondary reason why learners may not understand mathematical language emerges from the different meanings of certain words, for example as taken from Van Vuuren (2009, p. 7), a learner understands the meaning of left in the context of direction as left and right. In the Mathematical context when a teacher gives the learners a subtraction sum and asks in terms of the answer "How many are left?" the child may get confused and think what number is to the left within the sum and as a result give the wrong answer based on a misunderstanding of mathematical language. Examples of concept associated vocabulary the learner must acquire include understanding: comparative words (same/different; too many/not enough); opposites (smallest/biggest; shortest/tallest) and number words (four; ten) (Wium & Louw, 2012, p. 9). Following the established importance of language and numeracy in the development of mathematics skills and knowledge and that the South African curriculum includes numeracy at the

Foundation Phase as a basis for mathematics, it is imperative that all learners should be adequately linguistically stimulated from as early on as possible to limit language based MLD development (Wium & Louw, 2012).

2.4.1.2 Systemic levels

As discussed in Chapter 1, there are three systemic levels acknowledged in this study: the macro-level, micro-level and nano-level. It is important to understand the interconnectivity of these levels which entails the mutual relationships between people, communities and institutions leading to a system. The functioning of the system is dependent on the interactions between these levels (Steyn et al 2010, p. 171). It is within these levels that one can map a child's extrinsic influences (macro and micro-level), and therefore understand contributions to their potential individual learning difficulties (nano-level). The interrelationships of the levels will be illustrated in Figure 2.2, combining the macro factors identified in Chapter 1, Section 1.2, and the micro factors identified in Section 2.4.1 of this chapter, and how when interrelated can potentially lead to MLD in a learner. In addition an acknowledgement of the intended, implemented and attained curriculum is made linking to Chapter 1 as well as Section 2.1 (Curriculum design) of this chapter.

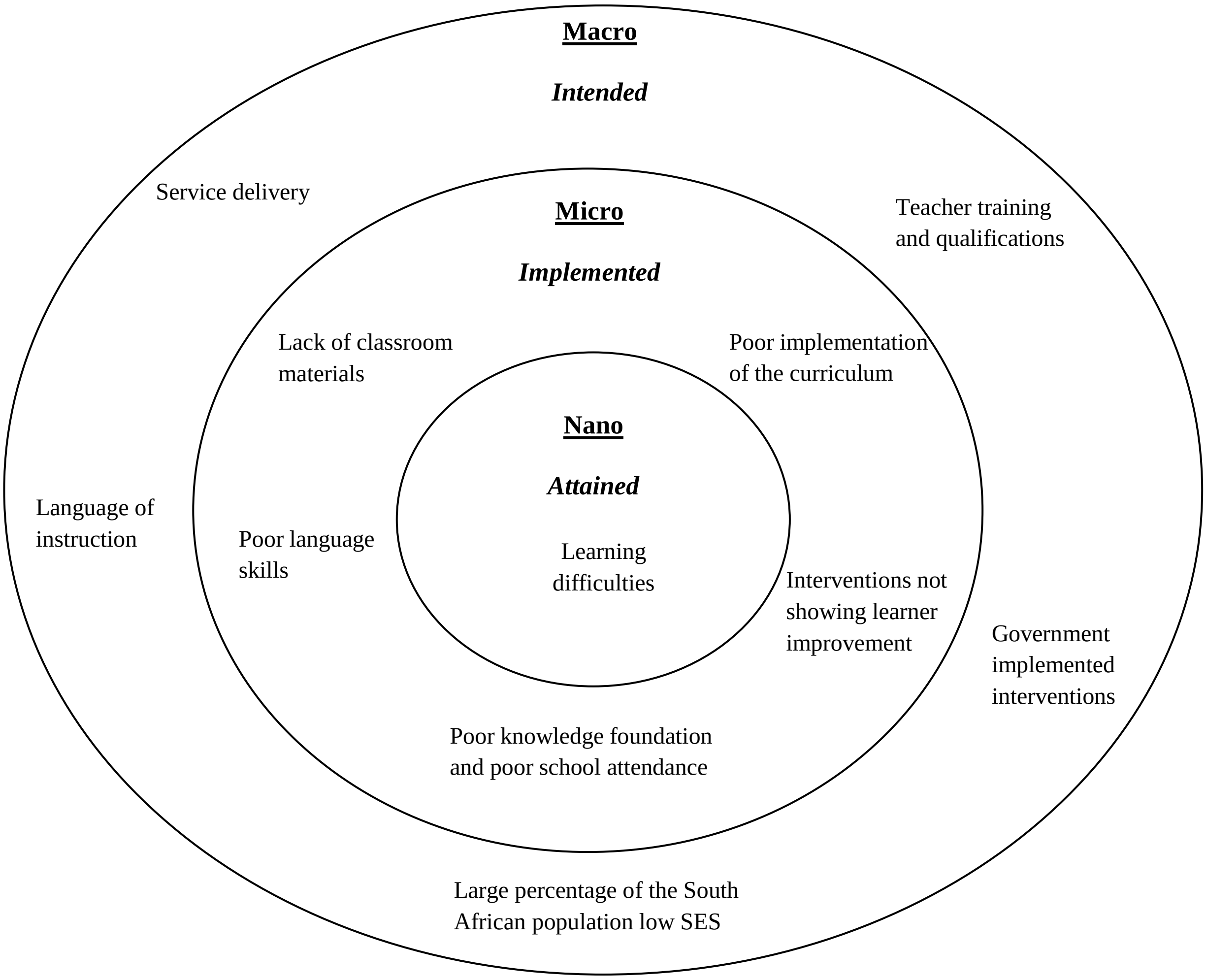

Figure 2.2: Schematic representation of the systemic levels influencing the potential development of learning difficulties (Adapted from A framework for understanding inclusion by Swart & Pettipher. In: E Landsberg (ed.) Addressing barriers to learning 2005, p. 11)

2.4.2 MODEL OF A NORMALLY PERFORMING LEARNER *VERSUS* A LEARNER WITH MLD

The previous section has established the causes of a learner potentially developing a mathematics learning difficulty and how to recognise specific extrinsic barrier-related difficulties. For the purpose of this study, specific problems that arise from MLD will be reviewed and will contribute to the foundation of the intervention design in Chapter 3. It has been established that learners with MLD present with poor performance in the mathematics learning area (Dowker, 2005; Geary, 2004). This poor performance can be attributed to difficulties within a single component in mathematics or multiple components (Dowker, 2004, p. ii). In order to further understand the development of a learner with MLD it is necessary to acknowledge the developmental path of a "typically performing child" in relation to a child with MLD. It is imperative to understand that each child is an individual and will develop and progress at their own rate and that theoretical models of typical development establish a general basis from which to understand the path of development a "typically performing learner" will take. Geary (2004, p. 6) has established a theoretical model of typical development for a "typically performing child" compared to a child with MLD.

2.4.2.1 Counting

It appears that a learner's understanding of the principles associated with counting emerges from a combination of inherent constraints and counting experience. Firstly, early inherent constraints can be mapped according to Gelmen and Gallistel's (1978, p. 136) five implicit counting principals. *One-to-one correspondence* (one word tag is assigned to each counted object for example "one", "two"); *stable order* (the order of word tags across counted sets must remain unchanged); *cardinality* (the value of the final word tag represents the final quantity of the counted objects in the set); *abstraction* (homogenous and heterogeneous objects can be collected and counted together); and *order irrelevance* (objects/items within any given set can be tagged in any sequence). One-to-one correspondence, stable order and cardinality form the scaffolding for a learner's development of counting skills.

Secondly, counting experience assists learners making deductions about the basic characteristics of counting through the observation of standard counting procedures and the associated outcomes of those procedures. These observations lead the child to establish the rules of counting subliminally as well as establishing features that are in fact not essential in counting. These unessential features are *standard direction* (counting must start at one of the end points of a set of objects) and *adjacency* (items must be counted consecutively). A child should attain these rules by 5 years of age. The unessential features of counting, when attained, can be attributed to the belief that young children's conception of counting is based on a rigid and immature platform, mainly influenced by an "observe" and "replicate" mentality.

It has been found that a child with MLD will have poor conceptual understanding with regard to certain aspects of counting. There is usually a general understanding of the counting principals, but learners particularly seem to find difficulty with aspects such as tasks that assess order irrelevance or adjacency. Learners with MLD are also found to have difficulties with the retention of information in working memory. These possible problems contribute to a delay in their competencies in the solving of arithmetic associated problems and may result in the detection and correcting of counting errors.

2.4.2.2 Arithmetic

Arithmetic competency and improvement can be attributed to the shift in the distribution of procedures/ strategies learners use during problem solving. Counting procedures used by young learners are often executed with the help of the fingers (finger counting strategy) or sometimes without the use of fingers (verbal counting strategy). There are two predominant procedures utilised by learners, the *counting on* and the *counting all* technique (Groen & Parkman, 1972). *Counting on* involves establishing the larger value and then counting up to the value of the added smaller number, for example 6+3 is solved by establishing the number of greater value (6) and then counting on to the value of three (7,8,9) to attain the answer of 9. *Counting all* involves the solving of the problem through counting both values from 1.

Procedural competency development is related partially to the shift in learners ability from *counting all* to *counting up* this shift encompasses the improvement of a learner's conceptual understanding of counting (Geary, Bow-Thomas & Yao, 1992). Additionally the effective use of counting strategies attributes to the development of memory representations of basic fact. These long-term memory representations eventually lead to memory-based problem solving processes, most commonly attributed to *direct arithmetic fact retrieval* and *decomposition*. *Direct retrieval* associates with the learner's ability to acquire the answer to a question based on an associated long-term memory. For example, a problem of 7+2 is automatically retrieved as 9. *Decomposition* involves construction of an answer based on the retrieval of a long-term memory focused on a sum. For example, given the problem of 4+5, the child may retrieve 4+4 from memory and merely add one to attain the answer. Retrieval-based processes are closely associated with the learner's level of confidence when answering a problem.

A learner's confidence can be related to two criteria: *rigorous* (only stating answers that are certain to be correct) and *lenient* (stating any retrieved answer whether correct or not) (Rittle-Johnson, 1998). As a child matures memory retrieval should become more effective and encompass a broader knowledge base, thus allowing for a more effective and faster retrieval and execution of strategies. The development of effective retrieval strategies allows the learner to use simple problems embedded in memory for more challenging problems (simple problems combined within a larger context, for example word problems) allowing the learner to be less error prone. A learner with MLD tends to use the same types of strategies as their better performing peers but differ in their strategy mix as well as their pattern of developmental change within the mix. MLD learners tend to make far more counting errors than their peers and often stick to using the immature *count all* procedure more frequently. MLD learners find a heavy reliance on finger counting compared to their peers who inevitably move to verbal counting and retrieval as they mature. The primary observation made attributes to MLD learners primarily presenting with difficulties in retrieval-based processes (with a higher level of errors) in the solving of problems and in the manipulation of mathematical information which is presented in a spatial form (number line) as compared to their typically achieving peers.

2.4.2.3 Cognitive mechanisms and deficits

According to Van de Walle et al. (2007), “all knowledge, mathematical or otherwise, consists of internal or mental representations of ideas that the mind has constructed,” (p. 27). Mathematics can be separated into two types of knowledge: procedural knowledge and conceptual knowledge (Van de Walle et al., 2007, p. 27). A learner’s proficiency in any given area of mathematics is dependent on conceptual understanding of the domain as well as procedural knowledge supportive of problem solving (Geary 2004, p. 9). According to Van de Walle et al. (2007), conceptual knowledge, “consists of logical relationships constructed internally and existing in the mind as a part of a network of ideas” (p. 27), and procedural knowledge is “knowledge of the rules and the procedures that one uses in carrying out routine mathematical tasks and also the symbolism that is used to represent mathematics” (p. 27).

MLD would manifest as a result of a deficit in conceptual or procedural abilities defined by the mathematical domain. Theoretically, this would be owing to possible underlying deficits in the central executive (responsible for the control and regulation of cognitive processes), or working memory systems of the language or visuospatial domains (Van de Walle et al., 2007, p. 9). In the following subsections procedural, semantic memory and visuospatial deficits will be discussed in terms of the characteristics associated with MLD learners.

❖ **Procedural deficits**

As acknowledged previously, learners with MLD display errors in terms of counting, strategies (e.g., finger counting) and problem solving procedures (e.g., counting all). Procedural deficits are displayed by learners in the following ways: relatively frequent use of developmentally immature procedures, frequent errors in the execution of procedures, poor understanding of the concepts underlying procedural use and difficulties sequencing the multiple steps in complex procedures (Geary, 1993, p. 362).

Below, procedural deficits displayed by MLD learners will be discussed in relation to three subcategories: working memory, conceptual knowledge and neural correlates. There has not been a formal relation established between working memory and difficulties in executing arithmetical procedures. It is, however, apparent that learners with MLD have a certain degree of working memory deficit (Passolunghi & Mammarella, p. 341). The deficit attributes to information representation and manipulation in the language system (representation and articulation of number words and the procedural competencies, for example counting). Deficits in working memory disrupt the execution of mathematical procedures, for example the use of finger counting is used primarily by MLD learners owing to the reduced need for working memory demands in the counting process. MLD learners are further prone to over and undercounting during the problem solving process (source of counting procedure error) (Geary, 1990). With regards to conceptual knowledge**,** poor understanding of the concepts underlying a procedure can lead a learner to a mathematical developmental delay in terms of the adoption of more sophisticated procedures and the reduction of ability in the detection of procedural errors (Ohlsson & Rees, 1991 p. 173).

The immature counting knowledge which MLD present could potentially also contribute to frequent counting errors, with emphasis on a lack of self correcting abilities. Finally, when addressing Neural correlates, similarity is found between deficits associated with MLD and acquired dyscalculia. This allows light to be cast on potential neural systems contributing to procedural deficits in learners with MLD, though a direct relation has not been fully established between dyscalculia and procedural deficits in learners. Individual learners with Dyscalculia (following damage to the right hemisphere of the brain) often have difficulty with the procedural component of counting, particularly with pointing to successive objects as they are enumerated.

❖ **Semantic memory deficits**

The arithmetical development of a MLD learner does not always follow the shift from procedure-based problem solving to memory-based problem solving that their typically achieving peers do. A MLD learner typically has difficulties in storing arithmetic facts and retrieving from long term memory. Semantic memory deficits are presented by learners in the following ways: Difficulties in retrieving mathematical fact (can be considered the primary defining feature of MLD); any fact retrieval is fraught with many errors; and regarding arithmetic, retrieval errors are often associates of numbers in the problem (for example: the learner retrieves the answer of 4 to the problem of 2+3, with the learner associating the counting string, in that 4 follows 2, 3) (Geary, 1993, p. 362).

Geary (1993, p. 362) hypothesises that deficits associated with semantic memory involve the information representation mechanisms of the language system. This hypothesis is founded in the formation of long term memory representations of arithmetic facts. Counting typically gauges phonetic and semantic representational systems within the language domain. Any disruption in ability to retrieve or represent information from the above mentioned system has the potential to affect and cause difficulties in the formation of problem-answer associations during counting (Geary, 1993). These disruptions would affect learning arithmetic and the storing of information for later retrieval.

❖ **Visuospatial deficits**

Visuospatial systems support many mathematical competencies (e.g., certain areas of geometry and the solving of word problems). If there happens to be a deficit in the system it could potentially result in a corresponding MLD. Learners that possibly have visuospatial deficits present with the following features: difficulties in spatially representing numerical and other forms of mathematical information and relationships; and frequent misinterpretation or misunderstanding of spatially represented information (Geary, 1993, p. 362).

In Chapter 1 (Section 1.2), the failure of previous and current government based interventions were represented. In the following section the shortcomings of the interventions will be discussed in order to establish the need for this study's intervention.

2.5 PREVIOUS INTERVENTIONS REVIEWED

In light of the disjuncture between the South African government's intended and implemented education policies, as discussed in Chapter 1, an *interstice* has emerged within the system; this highlights the necessity for the design of an intervention focused on the improvement of mathematics. To intervene is to "take part in something so as to prevent or alter a result or course of events," (Oxford Dictionary). An education-focused intervention has its basis in the targeting or prevention of possible learning difficulties displayed by learners. Howell (2009, p. 6) identifies five constituents of a successful intervention and they present as follows: it is *planned*, establishing a decision making process whereby data is utilised to ensure a solid foundation of theory; it is *sustained,* implementing the intervention over an extended period of time; it *targets* or *focuses* on a particular set of skills or knowledge (presented by a learner or group of learners) and the intervention must attribute to meet the particular needs of the intended audience; it is *goal orientated,* meaning the intervention is intended to make a change from the current towards the desired goal state; finally an intervention is a *set of procedures* rather than a singular instructional component/strategy. Within this study the five above mentioned constituents of an intervention will be addressed in the forthcoming chapters.

In Chapter 1, Section 1.2, the most prominent interventions implemented to address the shortcomings in mathematical performance, as well as the Education White Paper 6 which addresses learning difficulties, were acknowledged and their aims discussed. In this section the interventions will be reviewed in terms of their shortcomings, represented in Table 2.5.

Table 2.5: A representation of the interventions implemented by South African government and their relevant shortcomings in implementation

Intervention	Shortcomings
Education Quality Improvement Partnership Programme (EQUIP)	• Implemented in only 490 schools. • The intervention worked well in improving learner performance in high school but this was not mirrored in the lower grades. • Did not take the individual culture and environment of a school into consideration. It is not possible to develop a single blueprint for all schools, every school is different. • Challenges occurred in the use of service providers. • Fluctuating pattern of secondary school pass rates. (O'Connell, 2013, p. 138-145)
Foundations for Learning Campaign (FLC)	• Schools did not take the FLC seriously in terms of the way tests were administered • Teachers were underprepared and/or unprepared for implementation. • Teachers felt that the FLC increased their administrative duties and workload, taking away from their teaching time. • Poor support from district offices in terms of lesson plan implementation was additionally reported. (Meier, 2011, p. 552)

Systemic Evaluations	• Following implementation the Department of Education (2008) concluded there was an "urgent need to improve performance in these critical foundation skills" (p. 12) (reference to poor performance in literacy and mathematics). • According to Spaull (2013), there "are serious concerns around the comparability of these tests and thus they should not be used as a primary source for reporting changes over time" (p. 13).
Annual National Assessments (ANA)	• Negative trend in mathematics results from Grade 1 to Grade 9 (Department of Basic Education, 2014, p. 9). According to Nkosi (2015): • Teachers spend too much time teaching learners what will be in the tests rather than focusing on the curriculum. • Assessments have become a burden to teachers.
Education White Paper 6	• After a decade of the unveiling of the EWP6, most learners with disabilities are still in separate 'special schools'. • No structure on what should and should not be classified as a disability. • Many teachers have either been trained in general education or special needs not both, creating a lack of skills in ability to accommodate learners with disabilities. • Workload increases for a teacher that has to accommodate a special needs learner. • Training programmes for teachers have been found to be insufficient. • Lack of support provisions (financial and otherwise) from government makes implementation difficult for schools and teachers. • Education officials unsure of the EWP6 goals. • A cultural attitude dominates in South Africa, where learners with disabilities are believed to be unable to learn. • Lack of clarity, specificity and detail, it only has broad strategies that gives no guidance in terms of implementation. • According to Bornman and Rose (2010), "a general lack of support and resources, as well as the prevailing negative attitudes toward disability, all contribute to the general bewilderment in South African schools towards inclusion" (p. 7). (Donohue & Bornman 2014, p. 1-11)

Adapted from various sources as acknowledged.

It is important to note that the ANAs and the Education White Paper 6 are not, in fact, straight forward interventions. Both were included as interventions owing to the various attributes they display applicable to intervention design. The ANAs are an assessment tool implemented to gather data on the performance of learners in South Africa (Department of Basic Education, 2014, p. 14). The data attained from this assessment can be utilised for the foundations of intervention design (Department of Basic Education, 2014, p. 14). The EWP6 was intended to address learning difficulties in the South African context (Department of Basic Education, 2001). Weaknesses identified in the implementation of the

EWP6 assisted in understanding the limitations of implementation in the South African context (Donohue & Bornman 2014, p. 7). The shortcomings and poor performance data identified in the interventions acknowledged in Table 2.5, as well as the macro-level, extrinsic barriers to learning identified in Section 2.4.1.1, lay the foundation for the need for an effective mathematics intervention.

Section 2.6 aims to represent the methods for targeting mathematical learning difficulties. This is imperative to the intervention design as it lays an initial framework for assisting learners with MLD. The themes that emerge in this section are carried through throughout the intervention design process and culminate into the model utilised in the conceptual framework (Chapter 3).

2.6 TARGETING MATHEMATICS LEARNING DIFFICULTIES

Dowker (2005, p. 324) states that, "to study the nature of the arithmetical difficulties that learners experience and thus to understand the best ways to intervene to help them, it is important to remember one crucial thing: Arithmetic is not a single entity; it is made up of components, including knowledge of arithmetical facts; ability to carry out arithmetical procedures; understanding and using arithmetical principles, estimation; mathematical knowledge; applying arithmetic to the solution of word problems and practical problems; and so forth." Learning disabilities as compared to learning difficulties and the associated barriers that contribute to the development of the aforementioned have been discussed (Section 2.2), as well as the theoretical model of a "typically performing learner" as compared to a learner with MLD (Section 2.3). In addition, Piaget and Vygotsky's theories where acknowledged in terms of approaches to learning and teaching strategies to improve implementation on the micro-level.

Following the establishment of the deficits and their causes it is necessary to delve into the manner to which they can be addressed in the classroom environment by means of an intervention. A previous section (2.3) has already contributed the theories established by Piaget and Vygotsky towards the way a child acquires mathematical ability and the educational focus that should be implemented to optimise learning. In this section multiple mathematics intervention studies have been addressed. Within each of the studies, components emerged that have been shown to be successful in improving mathematics results. The components have been separated into prominent themes. In Chapter 3 a model that encompasses these themes will be discussed.

2.6.1 EARLY INTERVENTION

Early intervention finds its foundation in the principle of "prevention rather than cure" (Fuchs et al., 2007, p 14) and can be a major positive factor in altering the developmental course of high risk learners (Ramey & Ramey, 2004, p. 487). Two core areas are identified by Chard, Clarke, Baker, Otterstedt, Braun and Katz (2005, p. 4) and Fuchs and Fuchs (2001) in the development of a prevention based intervention system.

Firstly, the improvement of general education instruction in mathematics and, secondly, an approach to assessment that identifies learners who are likely to struggle with mathematics difficulties in later grades (whilst allowing teachers to monitor learner achievement over a prolonged period of time). The relation between poverty, sub-optimal cognitive development and academic failure has been well established (Welsh, Nix, Blair, Bierman & Nelson, 2010, p. 44) and early intervention's major benefit is its potential to partially offset (in the short and long term) the destructive impacts of poverty and inadequate learning environments on child development and school success (Barnett, 2011, p. 975; Bronfenbrenner, 1974, p. 14).

Early identification and treatment of learning disabilities may be the most effective means for reducing the incidence of these disorders (Taylor et al., 2000, p. 200). Following literature (Dowker, 2005; Fuchs et al., 2007) it has been established that the earlier a child is targeted for intervention, the more likely the learning difficulties the child will acquire / already display can be effectively addressed and possibly eliminated.

Early intervention is not without its pitfalls in terms of implementation. Ramey and Ramey (2004, p. 487) have identified four reasons attributed to potential failures in closing the achievement gap. Firstly, many interventions have not taken teacher qualification into account (regarding the level of instruction and the LOLT). Secondly, many interventions are not very intensive. Thirdly, many interventions focus more on remediation instead of prevention making it far more difficult to overcome the accumulated toll of limited learning. Finally, many programs find their basis in primarily supporting families and, indirectly, the learners, avoiding the imperative focus of teaching the learners cognitive and language concepts to assist in their scholastic development.

2.6.2 EARLY SCREENING

It has been established that sound academic screening can be done effectively in the early elementary years (Elliott, 2007, p. 137). Early screening measures for the prevention and identification of reading difficulties have been widely established and utilised but, similar valid measures for mathematics, is in its infancy (Chard et al., 2005, p. 3; Gersten et al., 2005, p. 293). It is, therefore, imperative to utilise existing literature in order to develop valid screening techniques for 'at risk' learners (Dowker, 2005, p. 330). Early screening of mathematics performance can be utilised to provide early predictors and support for interventions, before learners fall seriously behind in school (Jordan et al 2010, p. 82). Additionally early screening focuses on the process of the identification of the subset of learners who require early, intense and targeted instruction (Jenkins & O Connor, 2002) as well as evaluating the quality of the curriculum and how it is being taught (Ardoin, Connell, Koenig & Witt, 2005, p. 375). The importance of early screening cannot be overstated as supported by Compton, Fuchs, Fuchs, Bouton, Gilbert, Barquero, Cho and Crouch (2010, p. 327), who acknowledge that, the most important facet in the educational situation involves the use of early screening to gauge the response of the learners to the curriculum; establishing the success/failure of instruction; and establishing which learners show a distinct hindrance so as to intervene and provide remediation, allowing an address of achievement outcomes. Further, Torgesen, Alexander, Wagner, Rashotte, Voeller and Conway (2001) establish that, for most learners, the identification of learning difficulties usually occurs at an age where their academic problems are impermeable to even the most intensive remedial efforts, enforcing the need for early screening and intervention.

Early screening does have its disadvantages though and this requires acknowledgement in order to ensure a baseline of success in development of a screening tool. Taylor et al. (2000, p. 200) identify the predominant disadvantage associated with early screening. Firstly, screening administered before the first grade have shown to be frequently inaccurate in the prediction of future performance possibilities in learners and it is acknowledged that whilst it is best to screen learners in the first grade, certain difficulties may not present until later grades. Secondly, administering screening batteries to large numbers of learners can be very expensive as well as time consuming. Lastly, early screening measures have the potential to stigmatise learners based on future performance expectations, screening should find its focus in the establishment of whether a learners performance is satisfactory or not and provide the information necessary to assist the learner before difficulties emerge, a learner must not be aware that they have the potential for developing a LD.

2.6.3 Monitoring of Learners through Continuous Assessment

Assessment is the process of gathering information that enables teachers or relevant stakeholders to meet with a learner's current or future educational needs (Bornman & Rose, 2010, p. 37). Within this process one is able to gauge the quality of the instructional environment; learner response to this environment; and, therefore, inform instructional decision-making (Vaughn & Fuchs, 2003, p. 138; Coleman, Buysse & Nietzel., 2006). Assessment is identified as a core contributor towards an intervention in the fact that it allows the researcher/teacher to gain an understanding of the weaknesses, strengths and educational needs of the individual learner, as well as providing a basis for the determination of the efficiency of a particular intervention in the improvement of performance (Dowker, 2005, p. 325). Assessment relies on multiple methods and sources of information, in the form of: observation, checklists, work sampling and curriculum based assessments. These methods and sources are used to determine which learners are meeting key benchmarks/outcomes; which learners are in the process of developing these skills; and which learners are not making adequate progress (Coleman et al., 2006). Within the above mentioned categories refined objectives for the individual assessment of a learner are established by Westling and Fox (2004) in that assessments should reflect: who the learner is; what he knows (knowledge); what he understands (concepts and principles); what he is able to do (skills); how he learns; and how he shows what he has learnt. If the above mentioned categories and objectives are met effectively, the continuous assessment of learners as a monitoring function within an education system correlates with the success and effectiveness of said education system (Magrab & Dunst, 2003, p. 7).

2.6.4 Importance of the Development of Number Sense

Number sense, as stated by Case (1996), is difficult to define but easy to recognise. Markovits and Sowder (1994, p. 23) and Gersten et al. (2005, p. 297) have contributed encompassing similar definitions of the concept, whereby number sense is a conceptual structure described as a network made up of many links of organised number information. This number information consists of mathematical relationships, principles and procedures. The linkages serve as essential tools, enabling learners to cognitively relate numbers and operations to solve mathematical problems in creative and flexible ways, leading to the development of higher order insights when working on future mathematical problems. The number sense that is relevant to learning mathematics takes place in early life, well before a child enters school (Jordan et al., 2010, p. 82). Number sense can further be described as one's "feeling for number" (Ogletree, Rackauskas & Buergin, 1970, p. 13). It has been established that most learners entering pre-school have some degree of number sense, though this is variable depending on the individual and particularly the individual's socio-economic standing, as discussed earlier in this chapter (Jordan et al., 2007, p. 36).

Number sense lays the foundation for learning formal mathematical concepts and skills as well as being a reliable and powerful predictor of mathematics achievement (Jordan et al., 2007). Further, number sense reflects a child's early experiences with numbers as well as his/her cognitive facility (Jordan et al., 2007, p. 36). Following an established observation that Jordan et al. (2007) make about the correlation between certain aspects of number sense with mathematics achievement, and that the screening of early number sense development is a useful tool for the identification of at risk learners (mathematically speaking), measures for identifying levels of number sense emerge. Okamoto and Case (1996) establish the characteristics of good number sense, and these include: fluency in estimating and judging magnitude; the ability to recognise unreasonable results; flexibility when mentally computing and the ability to move among different representations, using the most appropriate representation. Jordan et al. (2007, p. 38-39) link onto Okamoto and Case's (1996) characteristics with a designed measure for predicting first grade mathematics achievement focused on counting, number patterns, magnitude comparisons, estimating and number transformations. The methods for determining number sense abilities will be discussed, using the designed measure by Jordan et al. (2007).

- **Counting.** Counting consists of three categories: counting sequence (learner counts to 10), counting principles (whether a 'puppet' is counting correctly or not) and number recognition (show a number and the learner must identify it).
- **Number knowledge.** Learner is given a number (e.g., 5) and asked, which number comes one after and two after the given number. Learner is given two numbers (e.g., 6 and 8) and asked which number is bigger or smaller. Learners are also shown a visual array of three numbers (e.g., 5, 2 and 4), each placed at the vertices of an equilateral triangle and asked to identify which number is closest to the target number (e.g., 5).
- **Nonverbal calculation.** The learner and tester sit opposite one another with twenty chips placed off to the side. A certain number of chips are placed in front of the learner in a horizontal line, the chips are then covered with a box lid and the learner is asked to tell the tester how many chips there were or to show the tester using the other chips provided. Secondly addition and subtraction abilities are gauged by asking the learner four of each set.

This is done by placing chips horizontally in front of the learner and the learner is told how many are in front of him/her. The chips are then covered and the tester either adds or subtracts chips through a hole in the side of the box lid and the learner was told simultaneously how many chips were added or taken away. The learner is then asked how many chips are hiding under the box. Addition is presented before subtraction.

- **Story problems.** Learners are given four addition and four subtraction story problems, presented orally. The same problems must be used with *nonverbal calculations*. For example the addition problems should be phrased in a similar manner to: "Jenny has *x* apples. John gives her *y* more apples. How many apples does Jenny have now?" Similarly, subtraction problems should be phrased: "Matt has *y* chocolates. Anna takes away *x* of his chocolates. How many does Matt have now?" The questions are presented in this manner with the relevant applicable language to maintain a level of understanding and for consistency in questions.
- **Number combinations.** Four addition and four subtraction problems are given to the learner. The same calculations used in *nonverbal calculations* and *story problems* are utilised. Items are phrased thusly, "How much is *x* and *y*?" and "How much is *y* take away *x*?"

The definition and recognition of number sense has been discussed, but the emerging question is "can number sense be developed?" Jordan et al. (2010) and Gersten et al. (2005, p. 297) believe this is very possible through continual experience and practice, particularly when provided with appropriate instruction in pre-school and first grade. Effective teaching of mathematics in the primary grades must have a focus, not only on the development of understanding of mathematics processes, but also the simultaneous endeavour to develop a feeling of number (Jordan et al., 2010, p. 14). Most learners that may potentially lack number sense from informal instruction in the home environment can quickly catch up with their peers once provided with adequate and dedicated instruction (Gersten et al., 2005, p. 297).

2.7 SYNTHESIS OF CHAPTER

This literature review was conducted to establish a solid theoretical foundation for this study. Multiple theoretical components were addressed in this chapter with the premise of assisting in the core foundational aspects of the intervention design process. In Chapter 1 the importance of the *intended*, *implemented* and *attained* curriculum was introduced. This concept was elaborated on and discussed in Section 2.2. Within this concept the curriculum aspects were linked with the systemic levels (macro, micro and nano). It was established in Chapter 1 that the problem with South Africa's education system is not in the intended but rather in the implemented curriculum. Through the need to adjust the implemented curriculum, a framework emerged. This framework, the curriculum spiderweb (van den Akker 2009, p. 39), presented nine components imperative to the design process and influenced classroom lesson design in the intervention (this process of intervention design is further discussed in Chapter 3). Further, with regards to design, the intended curriculum needed to be acknowledged and discussed to lay the foundation for the concepts that needed to be addressed in the intervention. The intervention was designed based on the current South African curriculum, therefore content areas and their relevant topics were presented. It is important to note the weighting of number sense (65%) in the curriculum (Department of Basic Education 2011, p. 10-35); as this was identified as imperatively important in literature (Section 2.6.4).

Theories about mathematics teaching and learning approaches were discussed in Section 2.3. The South African curriculum emphasises the importance of constructivism in Foundation Phase (Department of Education 2011, p. 3). The importance of using constructivism in learning was further emphasised by delving into the roots of the theory (cognitive school of psychology). The two primary constructivist theorists that were acknowledged were Jean Piaget and Lev Vygotsky; both theorists had their own theories on constructivist learning and the cognitive development of the child (Case, 1996; Charlesworth & Lind, 2013). These theories were discussed in detail in terms of their weaknesses, strengths and specific differences. Secondly teaching approaches were addressed in terms of teaching developmentally (following theories established from Piaget and Vygotsky), teaching through problem solving and methods for preventative teaching.

Mathematics learning difficulties (MLD) forms a core component of this study. In Section 2.4 the concept of MLD was introduced with emphasis on the extrinsic barriers, which are imposed by society or the environment (macro and micro levels). These barriers present themselves as the following influences on the child: socio-economic status, home environment and circumstances, didactical situation including the education system, teacher qualification and the knowledge they possess in assisting learners who display learning difficulties, poor language acquisition and/or inadequate vocabulary (Engelbrecht & Swanepoel, 2009). These barriers were discussed in the South African context and provided the researcher with an understanding of uncontrollable influences from outside the child that the designed intervention needed to accommodate. Following on barriers to learning, the systemic levels introduced in Chapter 1 were elaborated upon. The systemic framework of the macro, micro and nano levels was refined displaying the interrelationships of the levels and how a shortcoming on one of the levels can filter down to impede a learner on the nano level (Steyn et al 2010, p. 171). The final part of the section, presented a model of a ‘normally’ performing child versus a child with MLD. The subsection gave the researcher a foundation on key aspects that required attention in the designed intervention as well as a knowledge on characteristics to look out for during implementation.

As discussed in Chapter 1 (Section 1.2), there was an identified disjuncture between the intended and implemented curriculum and as a result learners were not performing as anticipated. Government acted on this evident shortcoming in the education system by implementing interventions with the aim of improving mathematics results. The five prominent government based interventions that were implemented in South Africa were presented in terms of their relevant shortcomings (Section 2.5). The presentation of the shortcomings of the government based interventions further supported the need for a designed intervention.

To conclude the chapter the methods for targeting MLD were addressed (Section 2.6). This section was pivotal for establishing core concepts/themes that need to be focused on in mathematics as well as successful emergent techniques in improving mathematics results. They included: early intervention; early screening; monitoring of learners through continuous assessment and the importance of the development of number sense. The above mentioned concepts established a framework of key themes in improving mathematics that lead to the selection of an appropriate model. The model was further refined through the attribution of the various foundational aspects perceived through the literature review of this chapter.

2.8 CONCLUSION

Through the established gap that the South African education system displays in terms of shortcomings in the implementation phase within the mathematics learning area, the viability for an intervention focused on targeting and improving the process has emerged, as discussed in Chapter 1. If a designed intervention proves to be successful, the outcomes of the mathematics education process should stimulate the resultant desired outcomes accordingly. In the design of an intervention that possesses a high potential for success, various literature sources have been consulted and discussed in this chapter to determine pathways of high viability for achievement of stipulated aims. Designing an intervention based on the themes, concepts and teaching strategies discussed in this chapter should have positive results, as they focus on a sound knowledge base, constant monitoring and the all important measures to be put in place to prevent Mathematical problems developing at a later stage. Further, through a review of the literature a foundational model has emerged that holds significant value for adaptation to include as well as refine the themes, concepts and teaching strategies discussed in this chapter. The response to intervention model (Fuchs & Fuchs, 1998) will be discussed in the subsequent chapter. In Chapter 3, the conceptual framework will be addressed where the relevant models will be discussed (Section 3.2). The intervention model has three phases/stages that will be discussed in detail, including: Phase/Stage I. Early universal screening; Phase II. A classroom intervention; Stage II. Rescreening and motivation and Phase/Stage III. Intensive remediation. Each phase/stage will be discussed in detail pertaining to the core themes and components identified through literature (Section 3.3).

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Chapter 3
Conceptual framework

3.1 INTRODUCTION

As stated in Chapter 1, this research aims to develop an intervention that will be focused on improving the mathematics performance and understanding of Grade 1 learners regardless of the average performance of the school. This aim is founded on the recognition that South African learners have shown to be performing poorly in Mathematical achievement at a universal level. As discussed in Chapter 1, interventions already put in place by government are not attaining desired outcomes owing to a process error in the implementation of intended policy (Sayed, 2002, p. 394).

A review of literature (Chapter 2), has established core themes that may possibly attribute to the improvement of the implementation of desired policy outcomes). In culminating the prominent themes identified through literature, a particular model presents itself that potentially lays the foundations for successful intervention design. In addition to this main model an adjoining model emerges, that further enforces the potential for a successful intervention. The two models were selected owing to their compatibility with the themes identified in Chapter 2, in that they allow the researcher to follow 3 distinct stages/phases whereby *screening, classroom influence and individualised attention* are addressed. In addition further identified aspects can be adjusted and implemented by the researcher within each phase.

The emergent themes from Chapter 2, as well as the relevant models will be discussed in the next section (3.2). In Section 3.2.1, the main model, response to intervention (RTI), is clarified by including its description and associated advantages and challenges. RTI's adjoining support model (STEEP) will be discussed (Section 3.2.2) in terms of its strong association with screening and continuous assessment, core themes identified in Chapter 2, Sections 2.6.2 and 2.6.3. A figure emerges by combining the two models creating a framework for the different phases/stages in the intervention design process. Section 3.3 discusses each phase/stage in detail addressing the core themes and components. An amalgamation of these core themes and relevant components will lead to a solid framework and as a result a potentially successful intervention design.

3.2 EMERGING FOUNDATIONAL MODELS

In Chapter 1, two problems emerge from literature in terms of the poor performance displayed by South African learners in mathematics. The first stems from curriculum implementation failure (Section 2.2) and the second, the failure of past interventions to address poor mathematics performance (Section 2.5). These two problems establish a niche for the designing of an intervention to improve mathematics results and, as a result, establish the aim of this study. Core concepts that contribute to the improvement of mathematics results were discussed in Chapter 2. These core concepts included teaching and learning approaches (Section 2.3) and how one should target MLD (Section 2.6). The addressing of MLD encompasses those learners who may have mild to severe levels of mathematics difficulties, whether a learner has difficulty with one concept or many, and should improve the entire class's results if implemented correctly.

When addressing MLD, four core themes emerged in the literature: *early intervention*, *early screening*, *monitoring through constant assessment* and the *importance of the development of number sense*. The emergent themes laid the foundation for an effective intervention and established the parameters in the search for a potential model/s to be used in this study. A model presented itself that encompasses the core themes and showed that through effective implementation, success in general and special needs education would potentially be possible. This model, in addition to the focus on core themes, allowed teaching (implementation) to be modified for the entire class as well as the ability to intensely focus on learners that were acutely struggling with maths (severe MLD). The conceptual framework for this study consists of the amalgamation of two aspects, the response to intervention model (RTI) and its adjoining 'sister' problem solving model screening to enhance equitable placement (STEEP). These two models will be discussed in detail pertaining to this study's intervention design.

3.2.1 RESPONSE TO INTERVENTION (RTI)

The response to intervention model (RTI) (Fuchs & Fuchs, 1998) establishes an innovative process focused on a paradigm shift. This shift entails a movement of focus from identifying learners with learning difficulties to the identification of learners at risk of developing future learning difficulties (Ardoin et al., 2005). According to Ardoin et al. (2005, p. 363) the RTI model is characterised by three successively more intensive phases of empirically based instruction/intervention. The two primary goals of the three phase process entail, firstly, early identification of risk so that learners can participate in prevention before severe deficits occur and secondly the identification of subsets of learners who are unresponsive to validated intervention (these learners will require individualised attention through special education). The two aforementioned goals will, therefore, contribute to an increase in the likelihood that the academic competence of at risk learners develops adequately (Fuchs, Fuchs, Compton, Bryant, Hamlett & Seethaler, 2007b, p. 312). Van der Heyden and Jimerson (2005, p. 22) have identified the probable advantages and challenges associated with the implementation of the RTI model.

3.2.1.1 Advantages of RTI

A model or intervention strategy can only be successful if implemented correctly and at the intended level. RTI has shown considerable promise in special needs and general education when implemented as stipulated above. As a result of correct implementation several probable advantages emerge in the RTI model (Van der Heyden & Jimerson, 2005, p. 22).

- **Improved treatment validity**

RTI identifies and provides assistance to those learners that potentially display LD, this leads to an articulation of the problem, an intervention to address the problem and an assessment to determine if the problem was adequately addressed. This process leads to a shift from a distanced "admiration" of the problem to a hands-on approach of problem solving. RTI creates an environment (within the classroom) in which potential learning difficulties are targeted and learners have the potential for "real improvement" in functionality and learning (Van der Heyden & Jimerson, 2005, p. 22).

- **Contextualised decision making**

The RTI model enforces that assessment must be contextualised and must appropriate to the level at which the child can attain educational outcomes in the main stream educational setting, separate from remediation. The above approach establishes the quantification of, firstly, the level of instruction within the child's educational environment and secondly, the child's response (potential learning) given optimal instruction. This leads to establishing either that a child presents with LD or is merely showing a poor response to curriculum following a poor instructional level within the classroom environment. The RTI model allows for a fast actualisation of instruction levels to allow for efficient amendment to instruction related deficits (Van der Heyden & Jimerson, 2005, p. 22).

- **Improved identification accuracy for LD**

When classifying learners, regarding the potential to be at risk of developing LD, certain errors need to be acknowledged. These errors are: firstly, *false positives* whereby learners who eventually become academically competent and sound, were deemed at risk following a poor score (below the cut-point) on a predictive instrument. False positives are mostly attributed to a poor level of instruction. Secondly, *false negatives*, whereby learners score above the cut-point but later develop academic problems (Fuchs et al., 2007b, p. 312). A classification process that produces a large percentage of false positives is not an effective measure as it deprives potentially at risk learners of an intervention that may potentially prevent academic difficulties. For the prevention system to implement successfully, the processes for identifying learners at risk needs to yield a high percentage of true positives, at the same time identifying a controllable group (at risk learners) by curbing false positives (Fuchs et al., 2007b, p. 312).

Owing to intervention becoming a specified, operationalised variable under RTI, false positives drastically decrease. This is because of the class-wide intervention that occurs in Phase II of the model. Within Phase II instruction is modified to ascertain the effect on learning within the classroom, adjoining improved instruction the core curriculum is implemented at the intended level. This allows one to distinguish whether a child is performing poorly owing to inadequate instruction as opposed to potentially having a learning difficulty. To target false positives and negatives it has been stipulated that the use of a universal screening tool (based on specific, curriculum based criteria), the implementation of sufficient intervention strategies and the judgement of remediation efforts can protect against over and under identification errors and these factors are encompassed (following literature based design) in the correctly implemented RTI model.

❖ **More effective intervention**

RTI lays the framework for more structured interventions which are, thus, more likely to be effective. According to Van der Heyden and Jimerson (2005), a structured intervention possesses four characteristics. Structured intervention:

(a) allows for some estimation of the likelihood of the intervention efficiency under specified stimulus conditions

(b) allows for some estimation of the degree of match between the stimulus conditions for an individual child and the intervention selected

(c) allows for estimation of the integrity with which the intervention is delivered and

(d) allows for sensitive ongoing progress monitoring data (p. 23).

3.2.1.2 Challenges of RTI

If incorrectly implemented, RTI will not show the desired level of success in the classroom and challenges relating to the model emerge. For maximum success of the RTI model, two possible challenges must be addressed (Van der Heyden & Jimerson, 2005, p. 22).

❖ **Decision-making criteria under RTI models must be operationalised and validated through research**

Determining the purpose of the RTI model correlates with how the intervention should proceed. In order to establish the purpose of RTI, validated literature needs to be consulted in the design process of the intervention. The purpose of the RTI model within the context of this study is the prevention of possible mathematics learning difficulties and the themes that will attribute to the success of prevention: early intervention, early screening, individualised attention for at risk learners and enforcing of number concepts/sense. The validity and success of the RTI model is directly dependent on the designed intervention (Van der Heyden & Jimerson, 2005, p. 23).

❖ **Effective intervention delivery poses new challenges for teams**

Within the RTI model it is imperative to have adequate control of relevant intervention variables. The intervention must be designed adequately so when implemented it attains the aims stipulated in the study, in other words effectively targeting and remediating the problem for which it was designed. For the intervention to be successful (once it is properly specified) it must, according to Van der Heyden and Jimerson (2005, p. 24), be implemented with integrity, sufficient frequency, intensity and duration to allow for adequate effectiveness. For a child to be deemed ‘unresponsive’ to RTI (in need of special education) the intervention should be implemented effectively, ruling out factors such as poor integrity or being insufficiently powered. Further attaining treatment validity under the RTI model is imperative to the success of the intervention. This can be achieved by constant monitoring (trend performance, level of performance, comparison with peer performance) of the individual learners within the study (Van der Heyden & Jimerson, 2005, p. 24).

3.2.2 SCREENING TO ENHANCE EQUITABLE PLACEMENT (STEEP)

Adjoining to the RTI model, a secondary model has been developed (Van der Heyden & Jimerson, 2005): Screening To Enhance Equitable Placement (STEEP). STEEP was developed to work in unison with the RTI model and uses its foundations as a framework. The monitoring of learners through continuous assessment was identified as a core theme in Chapter 2 (Section 2.6.3) and STEEP utilises this theme in its model. Relating to RTI's three stage process, STEEP requires a child to pass through three 'gates' (stages) when addressing identification of potential LD: poor performance relative to their same-class peers; poor performance given powerful incentives and poor performance given intensive remediation (Van der Heyden & Jimerson, 2005, p. 25-27). In addition to the emphasis on identifying learners that may have MLD, this assessment process allowed the researcher to determine the level of the learners and the efficiency of the implemented intervention. In addressing the two adjoining models, Figure 3.1 will be used to demonstrate interrelatedness for use of successful intervention design.

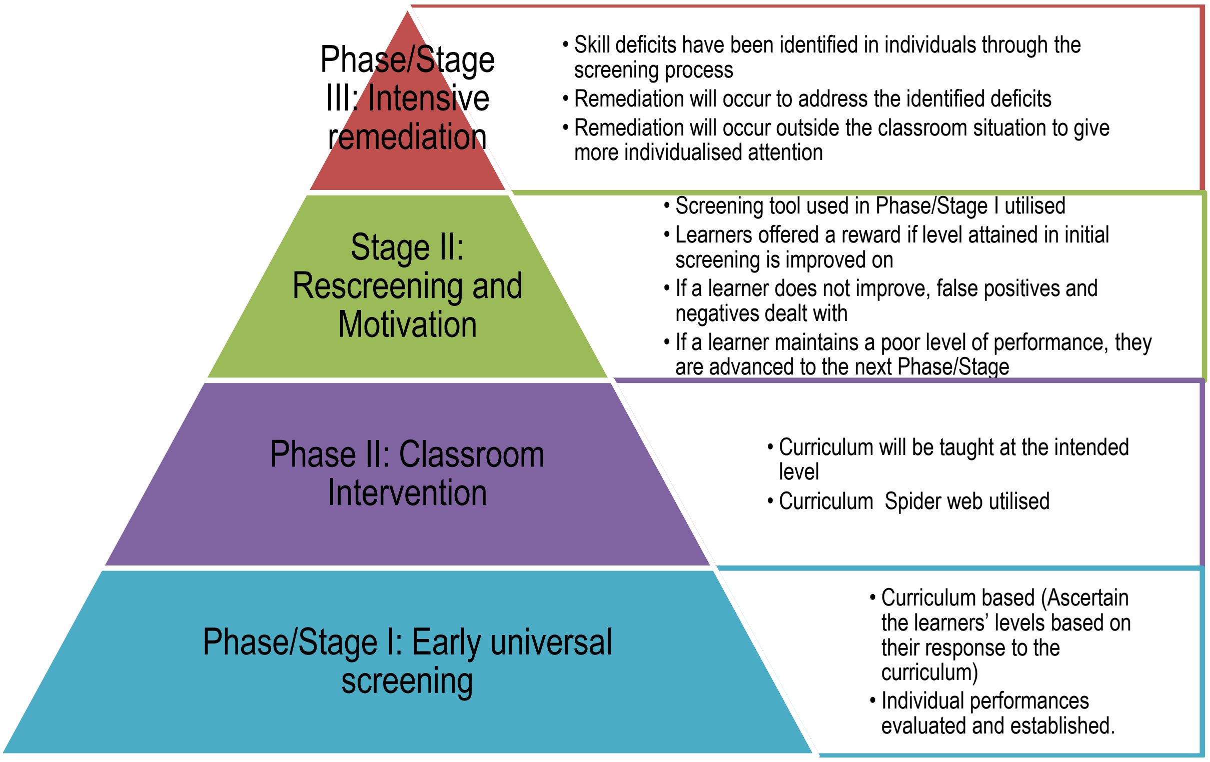

Figure 3.1: Representation and relationship of the response to intervention and system to enhance educational performance models

3.3 PHASES/STAGES OF THE RTI AND STEEP MODELS

Following the previous section and Figure 3.1, three phases/stages have come to light. In each phase/stage components are addressed and targeted to optimally influence the shortcomings identified in the mirco-level (discussed in Chapter 2). These three phases/stages additionally encompass the core themes identified through previous intervention studies acknowledged in Chapter 2 (Section 2.6): *early screening*, *monitoring learners through continuous assessment* and the *importance of number sense development*.

Whilst not acknowledged in the above figure, number sense development is a primary thread within the phases/stages, forming part of: screening (Section 3.3.1), lesson planning (Section 3.3.2) and remediation (Section 3.3.3). In addition to number sense (which is discussed in detail in Chapter 2, Section 2.6.4), four other mathematical areas emerge as important to the individual stage/phases of the intervention and improving mathematics results (elaborated on in Section 3.3.4). In stages/phases II and III, the classroom and remediation phase, core themes identified in the improvement of learning and teaching (that would potentially improve mathematics results) were brought forward in Chapter 2. The core themes were intended to work with the core curriculum not against it, as it was identified that the curriculum was not the reason for poor learner performance. The targeting of language in mathematics (Section 2.4.1.1) and the adjustment of teaching and learning techniques (Section 2.3) presented as a primary focus. The adjustment of learning and teaching focused on constructivism, problem solving and the prevention of MLD and, in addition to the curricular spiderweb (McKenney, Nieveen & Van den Akker 2006, p. 69), allowed for a multi faceted framework for effective lesson planning.

In the following sub-sections the individual phases/stages will be discussed in detail and the relevant design implications will be addressed (Section 3.3.1-3.3.3).

3.3.1 RTI Phase I & STEEP Stage I – Early Universal Screening

At this level of the intervention process, RTI phase I and STEEP stage I require the same processes. It has been established in Chapter 2 (Section 2.6.2) that early screening is a key theme in the identification of learners at risk of developing Mathematical learning difficulties. Within this phase/stage, learners were monitored (through a screening tool) in terms of their responses to the core curriculum; this allowed the evaluation and establishment of individual learner performance. Further, an imperative characteristic of this phase/stage manifested as an opportunity to gauge the level of instruction provided to learners and determine if in fact learners were receiving quality education (Ardoin et al., 2005). In this phase the primary screening tool was implemented in the two schools, following this implementation the data required to answer a sub-question of this study was attained. The sub-question addressed was: "What concepts present as most problematic for Grade 1 learners?"

The contextual foundation for the development of a screening tool for use in this study emerged as firstly, a method for the early identification and intervention for learners at risk of developing MLD, and secondly, with the possibility that one could identify specific concepts that are problematic for the individual as well as the class as a whole.

A trend has emerged from various literature on the successes of various techniques in assessing learners. The various successes of specific techniques have been found to associate with a large portion of the number knowledge test, developed by Case and Okamoto (1996) and correlations appeared stronger when the number knowledge test was used in previous studies. Owing to this it was utilized and adapted for the purpose of this study. Adaptations emerged through additional literature that showed successful techniques in the identification of learners with potential and existing learning difficulties but were not acknowledged in the number knowledge test (Gersten et al., 2005; Fuchs et al., 2007b; Baker, Braun, Chard, Katz & Otterstedt, 2005; Jordan, Kaplan, Locunaik & Ramineni, 2007). Theses adaptations where attained from: SAMP assessments (the South African Monitoring system for Primary Schools) and the importance of problem solving in mathematics learning and teaching (Chapter 2, Section 2.3.2.2). In Chapter 4 (Section 4.5.2.2.1) the description, framework and design of the screening tool will be presented.

3.3.2 RTI PHASE II – CLASSROOM INTERVENTION

Within phase II, a classroom-wide intervention was implemented. Within this phase, potential extrinsic barriers (Chapter 2, Section 2.4.1) affecting learners were addressed and targeted on the micro-level. It is important to acknowledge that, as establish in Chapter 1, the South African curriculum is well designed; it is the implementation of the curriculum that posed the problem. Therefore, the primary aim of this stage in the intervention process was to correct aspects of the implementation process in order to offset potential learning barriers. The secondary aim within this phase was that false positives in terms of identifying learners at risk were addressed and reduced. The above mentioned aims were attained through the curriculum being implemented to a satisfactory high level to ensure that learners at risk of developing learning difficulties were truly at risk and were not struggling with mathematics following poor curriculum implementation (Ardoin et al., 2005; Van der Heyden & Jimerson, 2005; Fuchs et al., 2007b).

In Chapter 2 (Section 2.2.1), Van den Akker's (2009, p. 41) curriculum spiderweb was introduced and discussed. The spiderweb established nine components (assessment; time; aims & objectives; content; learning activities; teacher role; materials & resources; grouping; and location) and how, when effective linkages are formed between the components, balance would be attained in the classroom system (micro-level) (Gravemeijer et al., 2006).

Lesson plans in this stage were designed through the use of Van den Akker's (2009) framework along with the knowledge framework and core themes established thus far through the chapters. Primary lesson plans were designed encompassing the above mentioned components and themes and were adjusted according to the average performance within the classrooms once implementation commenced. In the design of lesson plans, teaching aids were developed based on the core themes identified in the literature. These teaching aids were divided into the mathematical areas that were shown to be imperative for mathematics improvement: basic concepts, number concept, basic operations, number knowledge and vocabulary (Section 3.3.6). These areas all culminated towards the improvement of number sense as discussed in Chapter 2 (Section 2.6.4).

Lesson plans found their foundation in CAPS but utilised the designed teaching aids in order to enhance the learning experience. The teaching aids fit into the curriculum without causing an additional work load for teachers, assisting in ensuring that aims and objectives are achieved. These teaching aids aim at targeting the potential shortcomings displayed by learners through the screening tool and are represented in Appendix H. The formal teaching aids will appear in Appendix H with their corresponding codes represented in a table in Appendix G. The multiple teaching aids have been adapted from Van Vuuren (2009) and Case and Okamoto (2006).

3.3.3 STEEP STAGE II – MOTIVATION

Stage II in STEEP was implemented after RTI phase II. In this stage the screening tool used in phase/stage I was be administered again after a select amount of time dedicated to phase II (two week period). Learners were offered a reward if they could improve upon their previous results; the reward acted as motivation. This process established if a learner's poor performance was a result of a learning difficulty or rather an exposure to poor quality instruction, thus addressing false positives effectively. After false positives were addressed, learners that showed a lack of improvement were isolated for advancement to the next phase/stage: intensive remediation (Van der Heyden & Jimerson, 2005, p. 27).

3.3.4 RTI PHASE III & STEEP STAGE III – INTENSIVE INTERVENTION (REMEDIATION)

Learners who did not respond to the classroom intervention and who had been identified as being at risk following screening and monitoring, were subjected to intensive remedial intervention, whereby they were given additional time and attention focused on their particular weaknesses in the Mathematical learning area (Section 3.3.6) (Ardoin et al., 2005; Van der Heyden & Jimerson, 2005; Fuchs et al., 2007b). This occurred outside classroom time in small groups. For the remediation of the learners the main mathematical areas were focused on, utilising the teaching aids mentioned in the previous section and found in Appendix H. The learners were guided through every activity and were assisted until the task was completed successfully. The remediation was directly related to the areas the learners struggled with (identified through the assessment) and the areas targeted in the classroom during the intervention period so as to assist in maximum retention of concepts.

3.3.5 MATHEMATICAL AREAS RELEVANT TO THE STAGES

Improvement in mathematics ability can be attributed to enhanced attention to five mathematical areas including, *basic concepts, number concept, counting and place value, basic operations and number sense. Number sense* development is of primary importance in the previously discussed phases/stages of the intervention, but owing to the concept being discussed in-depth within the previous chapter (Chapter 2, Section 2.6.4) it will not be elaborated upon here. The remaining mathematical areas, as established by McIntosh, Reys, & Reys (1992, p. 4) & Van Vuuren (2009), will be discussed below.

3.3.6.1 Basic concepts

A child needs the ability to do certain operations in order to master specific mathematical concepts. The ability to master the following skills is primarily necessary as preparation for mathematical reasoning: *classification*, *arranging and sequencing*, *one-to-one pairing* and *conservation of number, length, volume, mass, area, etc.* (Van Vuuren 2009, p. 77 – 104).

❖ **Classification**

Classification is the ability to organise, in classes and sub-classes, certain objects (concrete), schemes or pictures (semi-concrete) and ideas (abstract) based on the grounds of similarities and differences. This process is attained by means of inclusion, exclusion and grouping. Classification and the thinking process associated with it is an essential basis of developing number concepts. The process leads a child to become aware of grouping strategies in which associations on whether certain groups have more or less elements than others and the potential of establishing relationships between said groups.

For classification ability to develop effectively a child must, firstly, be able to classify the simplest concrete objects and put the same types together, then more difficult exercises can be introduced. A child needs to be able to verbalise his/her activities all the time. Reasoning is imperative and words such as “and”, “or”, “not” and “except” must be utilised.

Once the child can communicate his actions he/she will begin to abstract and generalise certain valid deductions. Initially the learner must classify according to differences and then later according to similarities. Firstly learners can classify according to physical characteristics (texture, colour, shape, size), at a later stage classification should occur based on function. The ultimate goal in terms of classifying objects emerges when they are grouped according to a general category (food, mammals, transport). Lastly, classification-based activities always start on a three-dimensional concrete level, this progresses to the use of pictures or schemes and only once this concept is grasped can the process move to and abstract level where categories may be used (Van Vuuren 2009, p. 77-86).

❖ **Arranging and sequencing**

In the formation of a series, a child has the ability to observe the sequence of objects, symbols and events and relate them in a meaningful way. In mathematics, an understanding of the concept of ordinal numbers (first, second, third, etc.) is built by understanding the sequence of digits and the formation of series. A child will not have a logical understanding of number if he cannot see a particular number, for example 6, as an element within a series: 1,2,3,4,5,6,7,8 and the ability to work with and understand relationships such as $6<7$ and $6>5$ and $6 = (3+3) = (2+2+2) =(7-1) = (2+4)$ and so on. Attention must be paid to vocabulary and ordering of forms according to shape colour, position and size; numbers: smaller, bigger and equal to and quantities: less, more and equal to (Van Vuuren 2009, p. 86-93).

❖ **One-to-one-correspondence**

This denotes the ability to pair off objects, counters, digits, words etc. One-to-one correspondence is the prelude to the development of concepts like equal to, 1 more and 1 less. The making of sets is a result of this skill and the skill is a prerequisite for counting meaningfully leading to the conservation of number (Van Vuuren 2009, 93-95).

❖ **Conservation of number, length, volume, mass, area, etc.**

The conservation of number is an imperative concept for the child; it is the understanding that the number of objects in a set stays the same, even if the objects in the set are arranged in different ways. Learners must be taught to count objects in a group to understand their magnitude as owing to an experiment by Piaget, children have the tendency to think that if presented with two groups of equal amounts in a row, if the second row is arranged differently (further apart), that the second row now has a greater magnitude (Van Vuuren 2009, p. 95-104).

3.3.6.2 Number concept, counting and place value

Number concept is a culmination of the above mentioned skills and it plays a key role in number sense (McIntosh et al., 1992, p. 5). Children play and are observant of their surroundings, differences and similarities become evident to the child in his/her environment and this allows them to make conclusions about what belongs where. Additionally, physical laws and relationships between the characteristics of various objects become apparent to the child and this is deduced through colour, shape, function, size, and so on, allowing the child to give objects names and place them into categories. This naming and categorisation leads to an important phase in the process of conceptualisation (moving away from the concrete).

Generalisation begins to develop as a result. A child, being able to distinguish one category from another, is then able to observe new objects and features qualitatively, placing new information into a frame of reference that he/she has created from his/her basic set of concepts. Constructivism occurs within the child using newly attained information/knowledge and building on previous experiences. The more established and broader a child's experiences the easier it is for a child to think on an abstract level. It is important to understand that a child's conceptualisation is strengthened by each experience.

Succession and sequencing can be mastered if a child is able to name, sort and classify objects as mentioned above. Series can form from certain characteristics such as longest/shortest and fattest/thinnest, for example. From the above mentioned observation the child learns that an object must have a specific place on a number line or in a row to have any meaning within that context.

A simultaneous learning curve occurs whilst the child arranges objects from biggest to smallest; this is the learning of the concept of one-to-one correspondence. This learning occurs in simple daily situations where, for instance, the child has sweets, wants to give each of his friends one and suddenly realises he is one short or has one too many. As mentioned previously, one-to-one correspondence prepares a learner for the skill of conservation of number. One-to-one correspondence allows a child to count meaningfully and the comparison of objects in different sets should precede the typical counting activity to ensure meaningful counting and therefore increased experience with numbers.

In addition, a further result of practical experience is for the child to understand the difference between ordinal and cardinal numbers. This is attained through arranging and pairing off for an understanding of cardinal numbers (one, three, eight) whilst seriation and sequencing lead to an understanding of the ordinal number concept (last, third, first). Verbalisation of a child's own actions is pivotal in the organisation of thought and therefore the understanding of a concept.

It is important to understand that number concept cannot be taught it must be achieved. A teacher is there to create a stimulating environment that optimises learning and allows the learners to attain new information to build on their pre-existing knowledge and experiences. The primary view for a teacher must be to allow conceptualisation to take place and keep in touch with the level of development of the child's thinking processes. Mathematical experiences must be guided from motor actions to concrete apparatus, then semi-concrete schemes and pictures and finally abstract symbols (McIntosh et al., 1992, p. 5-6 & Van Vuuren 2009, p. 119-120).

3.3.6.3 Basic operations

Effective counting skills attribute to the ability to solve many mathematical problems, but as a child matures, and the numbers become larger, the process of counting becomes tedious. It is owing to this that a child needs to attain the skills of knowing when and how to add, subtract, multiply or divide. For a learner that displays difficulties in mathematics, particular emphasis needs to be placed on: concrete apparatus to enhance the learner's experience of a concept or process through experimentation; and verbal expression of his/her thinking processes to encourage generalisations that can be replaced by semi-concrete and abstract functioning. Vocabulary is important and must be meaningfully and thoroughly inculcated during the oral and concrete phase, for example: *how many together*, *add*, *groups of*, *take away* etc. (McIntosh et al., 1992, p. 6).

3.4 CONCLUSION

The intervention design discussed in this chapter made use of two distinct models, a primary foundational model (RTI) and an adjoining 'sister' model (STEEP). These two models were chosen owing to their correspondence with essential themes identified in Chapter 2. In addition to the 3 phases/stages established in the models, personalised adaptation on the researcher's part was possible owing to various additional themes attained through literature. This allowed for the design of individual components integrated within the two models' framework, including the design of an effective assessment tool, classroom lesson plans and remedial lesson plans. The models created a solid and valid foundation following previous successes and secondly, the identified themes and concepts addressed in the literature review and within this chapter contributed to a solid knowledge basis from which to garner successful methods and techniques that showed success in improving mathematics results. Of great importance, lastly, is that the intervention adhered to the constituents established by Howell (2009, p. 6) discussed in Section 2.5 of the previous chapter.

In the following chapter the research design and methodological undertakings will be outlined and discussed. The philosophical underpinnings will be addressed stemming from a pragmatic approach (Section 4.2). As part of this approach, the methodology of the mixed methods (Section 4.3) approach as well as the design research method (Section 4.4) will be utilised. Specific methodological processes will be addressed according to phase and included discussions on: sample (Section 4.5.2.1), instruments (Sections 4.5.2.2 & 4.5.3.1), data collection (Sections 4.5.2.4 & 4.5.3.3) and data analysis (Sections 4.5.2.5 & 4.5.3.4). Finally, methodological norms (Section 4.6), ethical considerations (Section 4.7) and methodological constraints (Section 4.8) were addressed.

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Chapter 4
Methodology

4.1 INTRODUCTION

The ultimate aim of this study was to develop an intervention that was focused on improving the mathematics performance and understanding of Grade 1 learners regardless of the average performance of the school. Certain methodological processes and concepts needed to be consulted and applied for the realisation of design and implementation success. A pragmatic approach (Section 4.2) was utilised in this study, which incorporated the methodology of the mixed methods approach (Section 4.3) as well as the design research method (Section 4.4). Specific methodological processes were addressed according to phase and included discussions on: sample (Section 4.5.2.1), instruments (Section 4.5.2.2 & 4.5.3.1), data collection (Section 4.5.2.4 & 4.5.3.3) and data analysis (Section 4.5.2.5 & 4.5.3.4). Participants included: subject experts, class teachers and Grade 1 learners. Qualitative data was collected through various strategies including: expert appraisal, a walk-through and interviews. Quantitative data was attained through the implementation of an assessment instrument. Data analysis took two forms, firstly as a strategy for intervention improvement and secondly as a means to determine the intervention's efficiency. Data analysis strategies included thematic content analysis and the Wilcoxon signed-ranked test. Finally, methodological norms (Section 4.6), ethical considerations (Section 4.7) and methodological constraints (Section 4.8) were addressed.

Data had a twofold purpose in this study, firstly it was collected and analysed as a means to improve intervention design and, secondly, it was utilised as a means to determine the efficiency of the designed intervention. Owing to this twofold purpose the research questions acted as a means to address the needs of the intervention design process. This study has one main research question and four sub-questions. Within the three phases of Design Research the characteristic of a successful intervention emerged and this attributed to the answering the main research question.

The relevant Phases are as follows: Phase I: Problem identification and needs analysis; Phase II: Design development and implementation and Phase III: Semi-summative evaluation. The Phases and their relevant cycles will be discussed in Section 4.5. Certain methodologies were specifically chosen in order to answer the research questions listed in Chapter 1 and will be described in Table 4.1.

Table 4.1: How the research questions were addressed methodologically

Research Question	Sources and Participants				Relevant Phase			Data Strategies and Instruments	
	Literature	**Experts**	**Learners**	**Teachers**	**1**	**2**	**3**	**Assessment**	**Interview**
What are the characteristics of an intervention for the purpose of improving Grade 1 learners' mathematics in the South African context?	X	X	X	X	X	X	X	X	X
• What concepts in mathematics present as most problematic for Grade 1 learners?	X			X	X	X			X
• How do Grade 1 teachers assist learners with learning difficulties?	X			X	X	X			X
• What are the challenges of designing and implementing an intervention in the South African context?	X	X		X	X	X	X		X
• How effective was the intervention in the improvement of Mathematics achievement in the Foundation Phase?	X			X		X	X		X

4.2 RESEARCH PARADIGM

Establishing lucidity in terms of the philosophical underpinnings of research allows one to connect said research to intellectual traditions. In doing so, judgement can be made on the research based on certain emerging standards (Rossman & Rallis, 2011, p. 35). Although philosophical ideas are largely hidden in research, their identification is important as they influence the actual practice of research (Creswell 2013, p.5). These philosophical underpinnings form the foundation of the methodological framework and establish the research paradigm. A set of assumptions about the world and the actions that occur within it (worldview) is referred to as a paradigm (Rossman & Rallis, 2011, p. 35). Each paradigm has its own set of assumptions which differ based on reality and knowledge. These particular assumptions underpin their particular research approach (Scotland 2012, p. 9). A pragmatic approach was utilised in this study and will be discussed (4.2.1) in terms of a brief overview and rationale for use in this study.

4.2.1 PRAGMATISM

Pragmatism originated in the 19th century in the United States (Rylander 2012, p. 3). It finds its foundations in the works of Charles Sanders Pierce, William James, John Dewey, and George Herbert Mead (Creswell 2013, p. 10). Pragmatism is inspired through an evolutionary perspective whereby emphasis is placed on interaction and integration (Rylander 2012, p. 3). As stated by Creswell (2013), "pragmatism as a worldview arises out of actions, situations, and consequences rather than antecedent conditions," (p. 10). It is this statement that enforces the pragmatic notion of the researcher focusing on the research problem rather than on the method. This is not to say that method is unimportant but rather that multiple methods are addressed and tested for inquiry to establish effectiveness in attaining a specific goal (Maxcy, 2003, p. 81). It is this characteristic that attributes to the neglect of the pragmatic paradigm to any particular system of philosophy and reality (Creswell 2013, p. 10). Within this notion the suitability of pragmatism as applicable to mixed methods research emerges, in that the researcher can draw from both quantitative and qualitative assumptions to attain the specified goal in their research (Creswell 2013, p. 10). Additionally, according to Creswell (2013, p.10-11), pragmatism is an effective underpinning for mixed methods research in the following ways:

- A researcher is free to choose the methods, techniques and procedures that will be utilised to achieve their goals;
- Multiple approaches are addressed for the collection and analysis of data in mixed methods. This adheres to the pragmatic view of not viewing the world as an absolute unity;
- Qualitative and quantitative data are used in unison for the researcher to gain the best understanding of the research problem which adheres to the pragmatic paradigm;
- In mixed methods research, the researcher must find purpose for mixing methods, this corresponds with the pragmatic view point of looking into the "what" and "how" in the specific research.

Through the underpinning of pragmatism as the paradigm for this study it is expected that the researcher is provided access to multiple methods, different world views, different assumptions and different forms of data collection and analysis. In addressing assumptions, the ontological, epistemological and axiological philosophical assumptions associated with pragmatism will be acknowledged in Table 4.2.

Table 4.2: Philosophical assumptions associated with Pragmatism

Methods	Qualitative and quantitative. (Creswell, 2013, p. 10)
Logic	Abduction (moves between inductive and deductive reasoning). (Morgan, 2007, p. 71)
Epistemology	Inter-subjectivity (both an objective and subjective view). (Morgan, 2007, p.71)
Axiology	Value plays and important part in conducting research and interpreting results. (Teddlie & Tashakkori, 2009)
Ontology	Occurrences exist independent of any observers. Emphasis is placed on reason and thought as the creators of elements in the external world. Both positivist and interpretivist ontologies are taken as a middle/duel perspective for pragmatism. (Goldkuhl, 2012, p. 10)

Adapted from various sources as acknowledged

In the following two sections the Mixed Methods, methodology (Section 4.3) and the Design Research, method (Section 4.4) will be discussed. Within each section the two methodological approaches will be addressed in relation to the rationale for the use of pragmatism and its relevant assumptions. Both methodological approaches attribute to pragmatism as a philosophical underpinning and afford the researcher the best opportunity to obtain useful answers to the research questions identified in Chapter 1 (Johnson & Onwuegbuzie, 2004, p. 17-18). Following on from the aforementioned topic the section will continue with a thorough discussion on the different approaches as well as their application to this study.

4.2.2 RATIONALE FOR A PRAGMATIC APPROACH IN MIXED METHODS

Following the characteristics and investigative nature of the aims and research questions identified in Chapter 1, complimentary research methods would be utilised for the purpose of this research. The mixed methods approach applies to data collection and analysis in this study. A mixed methods approach supports the utilisation of multiple worldviews (paradigms) instead of the typically utilised paradigms associated with qualitative or quantitative research (Creswell, 2003 p. 9). This leads one to think about a specific paradigm that encompasses qualitative and quantitative research as a whole.

The specific paradigm that underpins this study is *pragmatism*. According to Creswell (2003, p. 15), calls have been made to embrace pragmatism as the best philosophical foundation for mixed methods research. In mixed methods research the research problem and questions form the foundation of the research design, this determines the philosophical underpinning of pragmatism in that, according to Creswell (2003, p. 60) "the notion of "what works" applies well to selecting the methods that "work" best to address a study's problem and questions." Within mixed methods research, quantitative and qualitative data are merged. This can cause problems philosophically as one might be forced to mix various paradigms. It is therefore recommended by Creswell (2003, p. 78) that a researcher utilise pragmatism as an "umbrella paradigm" as this paradigm is appropriate for assisting the researcher in the merging of qualitative and quantitative data into a broader understanding offering the best opportunity to answer the study's relevant research questions (Creswell, 2003).

Ontology or "the nature of reality" finds foundation in mixed methods research through its two embedded methods: qualitative and quantitative research. Johnson and Onwuegbusie (2004, p. 15) assert that epistemology should be emphasised in educational research so that a researcher becomes informed about the various epistemological possibilities leading to more effective research being carried out. Onwuegbuzie and Teddlie (2003) point out that a debate often had amongst individuals pertaining towards qualitative *versus* quantitative paradigms tend to confuse the "logic of justification" with regards to the research methods. This leads to synonymous conjunction between epistemology and method which should not be the case as the logic of justification (an important aspect of epistemology) does not force the researcher into using specific data collection and data analysis strategies (Onwuegbuzie & Teddlie, 2003). For example, epistemological beliefs, should not hinder a researcher who, primarily utilises quantitative data from gaining validity from methods primarily associated with qualitative research and vice versa (Onwuegbuzie & Teddlie, 2003 p. 15).

4.4.3 RATIONALE FOR A PRAGMATIC APPROACH IN DESIGN RESEARCH

Design research is rooted in pragmatism (Cole et al., 2005 p. 3). Pragmatism is a worldview that assesses and evaluates theories (truth) based on the success of those theories in practical application (Oxford Dictionary; Rylander, 2012*).* According to Cole et al. (2005, p. 3) “for the pragmatist, truth and utility are indistinguishable – truth lies in utility”. Therefore, during the design process of developing the artefact (in this study the intervention), theory should be incorporated in the development as well as ensuring a theory-building contribution (Cole et al., 2005 p. 4). Rylander (2012, p. 36-37) establishes two factors for a pragmatic basis in design research. Firstly, pragmatism seeks out the “truth”; within this context scientific enquiry is based on the pursuit of truth by the constant experimenting and testing of ideas. Within the process of searching for truth, new ideas emerge through inquiry that allows one to advance. Secondly, inquiry is grounded in experience, and experience develops from our previous memories and future ideas interacting with our current social and natural environments. This process establishes our experiences as being integrative. Within the design research process ontological and epistemological viewpoints shift as the research moves through its respective cycles (Carlsson, 2006, p. 199). This attributes to a notion that the researcher’s assumptions about how the “world is constructed” should change during the research (Carlsson, 2006, p. 199). When advocating towards ontology (assumptions about the nature of reality), Creswell (2007, p. 238) establishes that phenomena remain in an active state constantly changing and adjusting throughout the research process (Cole, Purao, Rossi & Sein, 2005). In the case of design research an artefact emerges through implementation of the research process (Cole et al., 2005 p. 199). Next, Crotty (1998, p. 3) describes epistemology as “a way of understanding and explaining how we know what we know.” Design research advocates towards epistemology in that there is a method of knowing attributed to causing change through intervention. More specifically, the intervention was designed through envisioning and construction in order to theoretically bring about the desired changes to the contextual situation (improvement of Grade 1 Mathematics results) (Cole et al, 2005, p. 14).

4.3 METHODOLOGY - MIXED METHODS

In the following section a description of the mixed methods methodology as well as its application to this study will be discussed (4.3.1). The section is concluded with the mixed methods notation (4.3.2).

4.3.1 MIXED METHOD APPROACH

It is important to understand that within this study mixed methods research is utilised as an approach to the collection and analysis of data within the design research method (which will be discussed in the following section). In other words it forms part of the cyclical processes involved in the development of the prototypes discussed in the following section. Morgan (as stated in Tashakkori & Creswell, 2007, p. 5) stipulates that the strength of the mixed methods approach is “its emphasis on the connection between philosophical concerns about the nature of knowledge and the technical concerns about the methods that we use to generate that knowledge.” The mixed methods design approach can be viewed as the collection, analysis and integration of findings from qualitative and quantitative data, within a single study or inquiry (Tashakkori & Creswell, 2007, p. 4).

Quantitative data involves close-ended information including, for example, information garnered from attitude, behaviour or performance instruments. It is numerical in nature and is attained in a systemic and objective way (Maree, 2007, p. 145). The data involves scores that are collected on instruments, checklists or public documents. These scores are then analyzed through statistical methods in order to answer research questions or test hypotheses (Creswell & Plano-Clark, 2006, p. 6). Qualitative data on the other hand involves open-ended information that is attained through interviews with participants. Answers garnered from these interviews allow the participants leeway in terms of answering in their own words. Qualitative data can also be attained through observation of participants, gathering documents or through the collection of audiovisual materials. So, put simplistically, qualitative data is the collection of 'words' and is obtained through an inquiry process of understanding (Maree, 2007, p. 257).

A mixed method approach usually includes two or more stages and these stages are combined at varying points, depending on the methodological needs of the study or inquiry (Ivancova, Creswell & Stick, 2006). A mixed method design combines the two types of data so as to achieve the best understanding of the phenomenon of interest and allows for an in-depth and complete conclusion from the data increasing validity of the study (Maree, 2007). It is not enough to simply collect and analyze qualitative and quantitative data; it has to be combined (mixed) in a particular way so as to form a more complete picture of the studies problem rather than when they are viewed alone (Creswell & Plano-Clark, 2006, p. 7). According to Creswell and Plano-Clark (2006, p. 7) there are three ways of mixing datasets: *merging* the two datasets by actually bring them together, *connecting* the two datasets by having one build on the other, or *embedding* one dataset in the other so that one type of data provides a supportive role for the other dataset.

This study's main aim is to develop an intervention that is focused on improving the mathematics performance and understanding of Grade 1 learners regardless of the average performance of the school. An embedded mixed method design will be utilised, the decision to adopt this design follows on the premise of one data set providing a supportive secondary role in this study which is based primarily on another data set. The primary purpose of this study will make use of quantitative data attained through pre-, intermediate and post-tests implemented before, during and after the intervention process. This data will be used to test the theory of whether the designed intervention has a positive effect on Grade 1 learners' mathematics results. The secondary purpose will be to gather qualitative data through the use of interviews (expert appraisers and Grade 1 teachers) that will explore the central phenomenon of this study being, mathematic improvement in Grade 1 learners. The rationale for collecting secondary qualitative data is to provide support for the primary purpose as well as to address the different sub questions of this study (Creswell, 2008, p. 36). Figure 4.1 illustrates the embedded mixed methods design. In the following section (4.4) the embedded design will be elaborated on further in terms of its place in the cyclical process of this study.

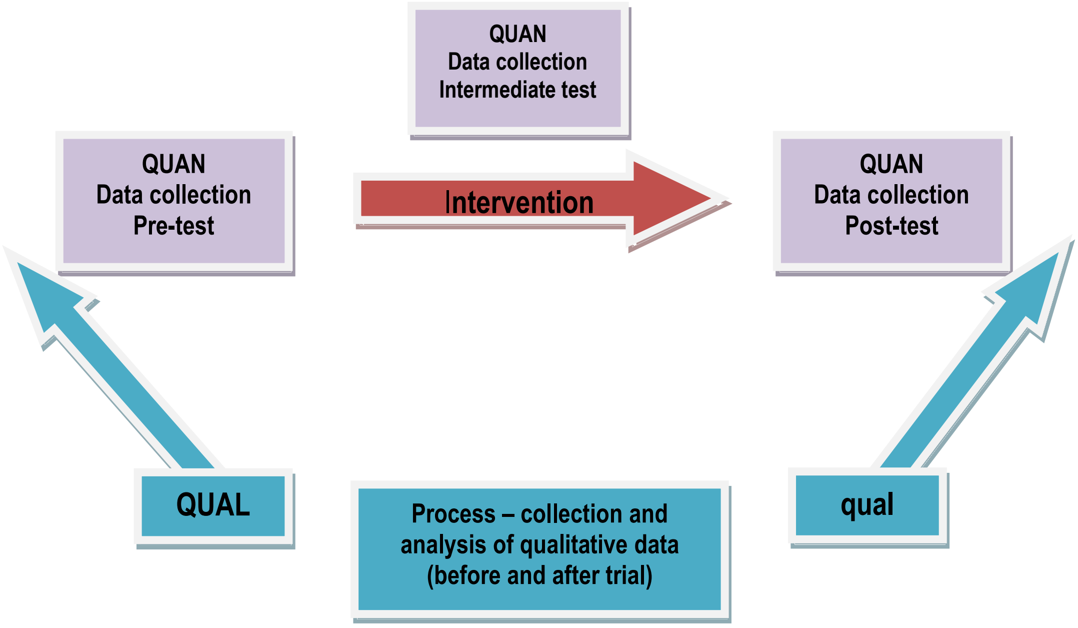

Figure 4.1: Visual model illustrating the mixed methods embedded design (Adapted from *Mixed Methods Research: Design and Procedures* by J.W. Creswell 2008, p. 32)

4.3.2 NOTATION

The Morse (1991) notation system indicates whether a study has a qualitative (QUAL) or quantitative (QUAN) orientation and specifically which aspect is more dominant (QUAL or QUAN) or less dominant (qual or quan). In addition, it shows how a study was carried out, simultaneously (QUAL + quan) or sequentially (QUAN.....qual) (Graff, 2013, p. 50). One is required to understand that this study is predominantly founded in design research and owing to this there are various phases with certain focuses and ways of doing that tend to be more dominant than others. In Table 4.3 the mixed methods notation is presented in terms of the relevant phases. In Phase II the qualitative aspect is more dominant (QUAL), following the sequential embedded design the QUAL data attained before intervention implementation contributes to the design of the intervention. In Phase III the designed intervention was implemented and a semi-summative evaluation occurred, in this phase the quantitative aspect is more dominant (QUAN) with the qualitative aspect being less dominant (qual).

Table 4.3: Mixed methods notation for Phase II and III

Phase	II		III		
Description	Design development and implementation		Semi-summative evaluation		
Notation	QUAL	➡	QUAN	➡	qual

4.4 METHOD – DESIGN RESEARCH

Design research has a twofold purpose, it is viewed as a research design aimed at the development of research based solutions to complex educational problems (*development studies*) or it can be utilised as a method to validate theories about learning processes, learning environments and similar concepts (*validation studies).* Plomp (2007), defines *developmental studies* as, “the systematic analysis, design and evaluation of educational interventions with the dual aim of generating research-based solutions for complex problems in educational practice, and advancing our knowledge about the characteristics of these interventions and the process of designing and developing them” (p. 6). Additionally *validation studies* are defined as “the study of educational interventions (such as learning processes, learning environments and the like) with the purpose to develop or validate theories about such processes and how these can be designed” (p. 6). Regardless of the above mentioned purposes, design research is founded in its systematic nature and establishes its success through the use of iterations which likens it to the systemic variations in experiments (Gravemeijer et al., 2009, p. 13; Cobb, Confrey, Lehrer & Schauble, 2003, p.9). The systemic educational design process is illustrated in Figure 4.2.

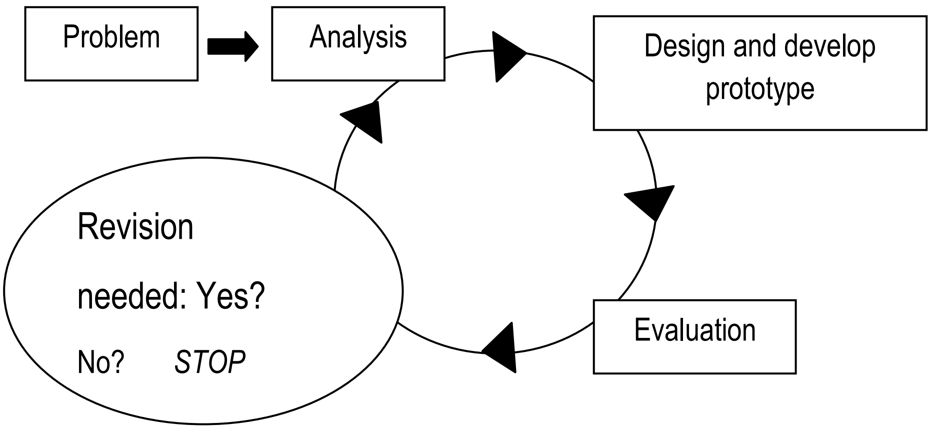

Figure 4.2: **Iterations of systemic design cycles** (Reprinted from Educational Design Research p. 6, by T. Plomp, in *An introduction to educational design research* by T. Plomp & N. Nieveen, 2007, Netzodruk: Enschede)

4.4.1 PHASES AND CYCLES OF DESIGN RESEARCH

The cyclical process of design research involves: analysis, design, evaluation and revision. This process continually ‘repeats’ until balance is achieved between the ‘ideals/intended’ and ‘realization’ (Plomp, 2007, p. 7). Plomp (2007, p.15) establishes a ‘picture’ of design research, which (following the agreement of multiple authors) consists of stages or phases.

Research for this study will function in three phases: Preliminary research, Prototyping and Assessment. Within these stages, either qualitative, quantitative or both approaches are employed depending on the identified research question in stages, mini-cycles (iterations) will occur where the design or phase will be appraised by experts, tried out or implemented and/or evaluated. Throughout these activities the researcher will perform systematic reflection and documentation. If the phase is lacking in any manner, then there will be a reversion to the previous iteration in the design/development phase. In Table 4.4 the three phases applicable to design research are discussed.

Table 4.4: Three phases applicable to design research

Phase	Description
Preliminary Research	Needs and content analysis will be performed by means of a thorough literature review and concept validation whereby the study's research questions and target themes will be addressed and utilised for use in the intervention design.
Prototyping	The study's conceptual framework, developed in the previous iteration will be utilised. The second phase will create three main prototypes of the intervention. Each prototype will be the subject of formative evaluation through the use of appraisal or trail. The purpose of the appraisals and trails will be to gauge weaknesses within the intervention allowing for the enhancement and refining of the intervention for use in the subsequent prototype. This is the most important research activity. By the stage's third main iteration, the intervention should obtain the study's desired outcomes.
Assessment	Implementation of the developed intervention will take place in the chosen environments (a high performance and a low performance school). This will be the final (summative) evaluation of the intervention in terms of fluidity of implementation and success of outcomes.

Note: Adapted from Plomp, 2009, p.15.

In Figure 4.3 the cyclical process of this study is illustrated within the three stages previously discussed. The processes that occur within each iteration will be elaborated on in Section 4.5 of this chapter.

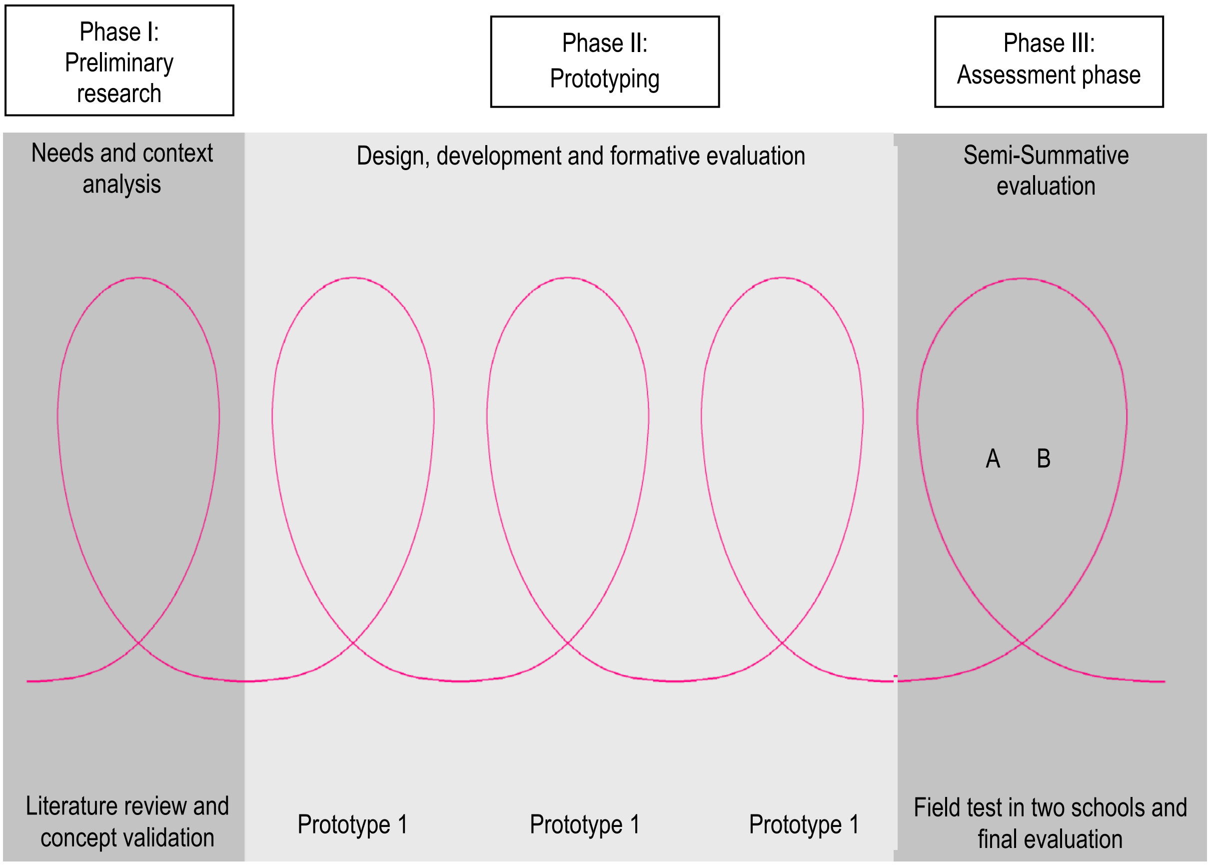

Figure 4.3: Design research models showing the cyclical processes of this study (Adapted from McKenney, 2001)

4.5 METHODOLOGY ACCORDING TO PHASE

The issues pertaining to the methodology are discussed in terms of the relevant phases and cycles that were addressed in the previous section. Sample, instruments, data collection and data analysis are discussed. In Figure 4.4 the Design research model for the development of an intervention aimed at the improvement of Grade 1 learners' mathematics results is illustrated to provide clarity in regards to the methodological processes associated with the relevant phases and cycles.

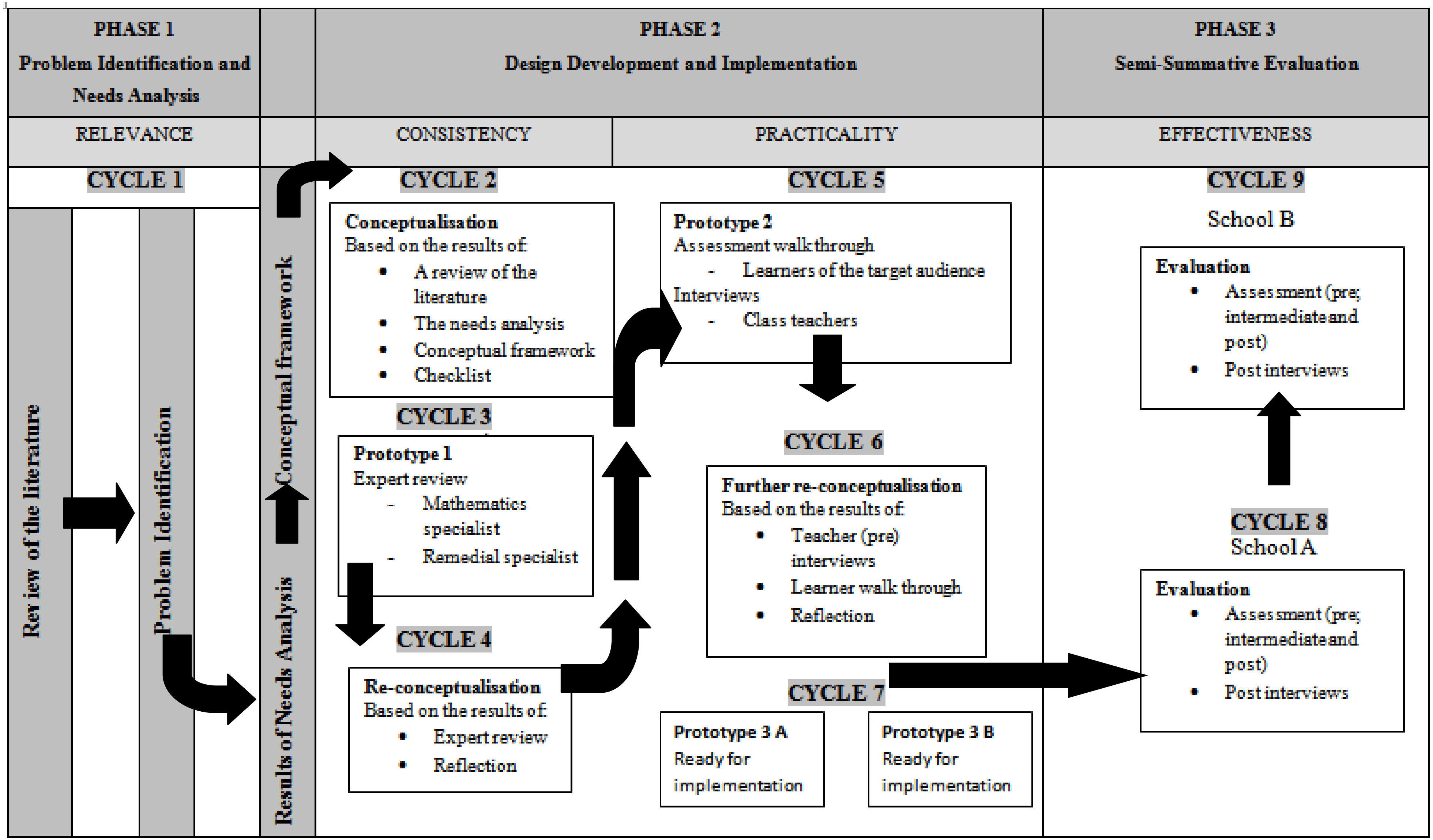

Figure 4.4: Design research model for the development of an intervention aimed at the improvement of grade 1 learners' mathematics results
(Adapted from: Dowse, in press; also Dowse and Howie (2013); see Chapter 40, Part B of this book).

4.5.1 Phase I – Problem Identification and Needs Analysis

❖ **Cycle 1**

Within Cycle 1 a thorough literature review was conducted leading to an educational problem being identified and discussed (Chapter 1). In the case of this study the problem identified, through a substantial literature review and from the researcher's personal experience, is the poor performance of South African learners in mathematics. Once the problem was identified the researcher proceeded with a thorough needs and content analysis delving into the literature to support the designing of the intervention and grasping the knowledge of what will make the intervention potentially successful (Chapter 2). The outcome of this cycle is a conceptual/theoretical framework (Chapter 3) (Plomp, 2007, p. 8).

4.5.2 Phase II – Design, Development and Implementation

Phase II (Cycle 2-7), is aimed at the development of prototypes within the intervention. The development of prototypes occurs through various iterations each being a micro-cycle of research. The research activity that occurs primarily is formative evaluation whereby the researcher aims to improve and refine the intervention (Plomp, 2007, p.8). Each cycle within this phase will be discussed with regards to methodological processes involved in the development of the intervention. It is important to note that certain cycles were conceptual (2, 4 & 6) whereas some were empirical in nature (3, 5 & 7) in nature. In Table 4.5 the conceptualisations of the three prototypes are presented relevant to Cycles 2, 4 and 6. Following on Table 4.5 the methodological processes and the relevant cycles within them will be addressed

Table: 4.5: Conceptualisations of the prototypes of Phase II according to cycle

Cycle	Description	Conceptualisation through:							
		Literature review	Needs and content analysis	Conceptual framework	Checklist	Expert appraisal	Reflection	Teacher interview	Learner walk-through
2	In Prototype 1, as discussed in the previous chapter, an assessment tool, classroom lessons and remedial teaching aids were designed as part of the intervention. At this point in the design process the researcher created a checklist through the knowledge attained in the literature review (Appendix I). The supervisor of this study worked through the checklist, made recommendations and the prototype was adjusted accordingly.	X	X	X	X				

4	Data gathered in Cycle 4 allowed for the re-conceptualisation of Prototype 1. The outcome of this cycle was Prototype 2	X	X		
6	Data gathered in Cycle 5 allowed for the re-conceptualisation of Prototype 2. The outcome of this cycle was prototype 3.		X	X	X
7	Prototype 3 was adjusted specifically for each school. Result 3A and 3B.				

4.5.2.1 Sample

Purposive sampling is utilised when units (individuals, groups, institutions) are selected based on a set of certain criteria, these criteria are associated with the answering of a study's specific research questions (Teddlie & Yu, 2007, p.77). Purposive sampling is a type of non probability sampling that involves particular settings, persons or events that are selected owing to the important information that they provide which cannot be obtained alternatively (Dolores & Tongco, 2007, p. 147). This sampling process is viewed as one with purpose rather than being random in nature (Tashakkori & Teddlie, 2003, p. 713). There are three instances of purposive sampling utilised in this study and they will be discussed based on their relevant cycle.

❖ **Cycle 3 – Expert Appraisers**

Following the development of a primary intervention prototype in Cycle 2 whereby lesson plans, teaching aids and an assessment tool was developed a further iteration came to light. This iteration/cycle involved expert review to improve the consistency and validity of the prototype. For the purpose of this study two experts where consulted. Their selection for participation in this study was based on certain pre-selected criteria (Maree, 2007, p.79). These criteria were selected based on their relevance to answering the research question of this study. An expert reviewer would need one if not more of the following characteristics for selection as a participant in this study: Foundation Phase experience, mathematics experience and or remedial experience. These three criteria form the foundation of this study and would assist in the refinement of intervention design. The reviewers were purposefully selected based on their experience, their field of expertise and their location. The first expert appraiser is highly experienced in Foundation Phase and associated Foundation Phase mathematics, whilst the second is a highly experienced remedial specialist. Both of these experts contributed greatly to the purpose of this study owing to the foundational core aspects of the intervention.

❖ **Cycle 5 – Schools and Teachers**

Two schools were purposively selected for this study. The researcher selected these two schools from a list of participating schools originally part of the SAMP project. The two schools were selected based certain criteria including the LOLT; being dual medium schools teaching in both English and Afrikaans;

having a similar demographic; and both being government schools. Of high importance was location and this was decided upon based on convenience for the researcher, so that access to the schools to implement the intervention everyday for a month would be straightforward. The aim of this study was to develop an intervention that improves mathematics results regardless of the average performance of the school, it was, therefore, imperative to select two schools of differing average performance as the final criteria of selection. The schools where sampled for maximum variation whereby a high performance and a low performance school were selected to allow for a greater understanding of intervention success (Patton, 2005). Other SAMP schools were not considered due to a lack of appropriate variation in terms of high performance and low performance incorporating the appropriate LOLT, demographic and location.

Within each of the selected schools, two Grade 1 classes were included for the sample, a control group (did not receive the intervention) and an experimental group (received the intervention). The two participating classes, within each school, were selected based on convenience for the school. The choice on which class would receive the intervention was random, in that once the researcher received the class lists one class was chosen without knowledge of individuals or average scores in mathematics. Once classes were selected, the learners selected for participation were chosen based on their ethical clearance to participate in this study (refer to Section 4.6 for ethical guidelines). The selected number of participants did not present as originally predicted and a discrepancy occurred. The original number of participants selected for School A was, experimental group: 31 and control group: 31. For School B, experimental group: 42 and control group: 42. A discrepancy in terms of the number of participants occurred owing to two reasons; the first was the stipulation of participants unwilling to participate and the second a lack of response following ethics forms being sent out. The teachers followed up with the participants but owing to time constraints and a set period that the schools agreed upon for intervention implementation, the researcher had to continue with the participants that had stipulated a willingness to participate. This resulted in the discrepancy of numbers between experimental and control groups. The resulting participants were as follows, School A experimental group: 28 and control group: 15. For School B, experimental group: 22 and control group: 19. Data analysis was affected as a result of the discrepancy in participants between the experimental and control groups. This will be elaborated upon in Section 4.5.3.3.

In addition, all 4 teachers from the two schools (four selected classes) were asked to participate in interviews to aid, firstly, in the design process of the intervention (Phase II – pre-interviews) and secondly, to provide the supportive qualitative data required for answering the primary research question (Phase III – Post-interviews).

4.5.2.2 Instruments

Two types of research instruments are utilised in this phase: an assessment and interview schedules. In this section the instruments will be discussed. With regards to the assessment, the full design process for the assessment tool framework will be acknowledged in terms of the sections and items included.

The interview schedules included two separate data collections the first from expert appraisers and the second from the Grade 1 class teachers.

4.5.2.2.1 Assessment instrument

The assessment instrument consisted of 3 sections, namely: Number knowledge, SAMP and Problem solving (See Appendix B). The assessment was designed to incorporate core themes identified through literature (Chapter 2) and as a result pre-existing successful instruments where consulted and merged for the final product. In this sub-section the test components and the framework for the assessment design will be discussed. Firstly, the central numerical structure development model (Case 1996, p. 6 & 7) will be discussed owing to its foundational basis for the number knowledge test linking to a discussion of said test developed by Okamoto and Case (1996). Secondly, additional screening techniques including problem solving are discussed. Thirdly, the SAMP assessment and the chosen components will be addressed. Concluding this section the relevant techniques and parameters from various literature that address the shortcomings of the number knowledge test will be addressed.

Central numerical structure development model. A comprehensive figure (Figure 4.5) has been developed by Case (1996, p. 6 & 7) to illustrate the hypothesised process of central numerical structure (the mental number line) development, emerging in a child at roughly 6 years of age. This process is used as a basis for the number knowledge test and will be discussed.

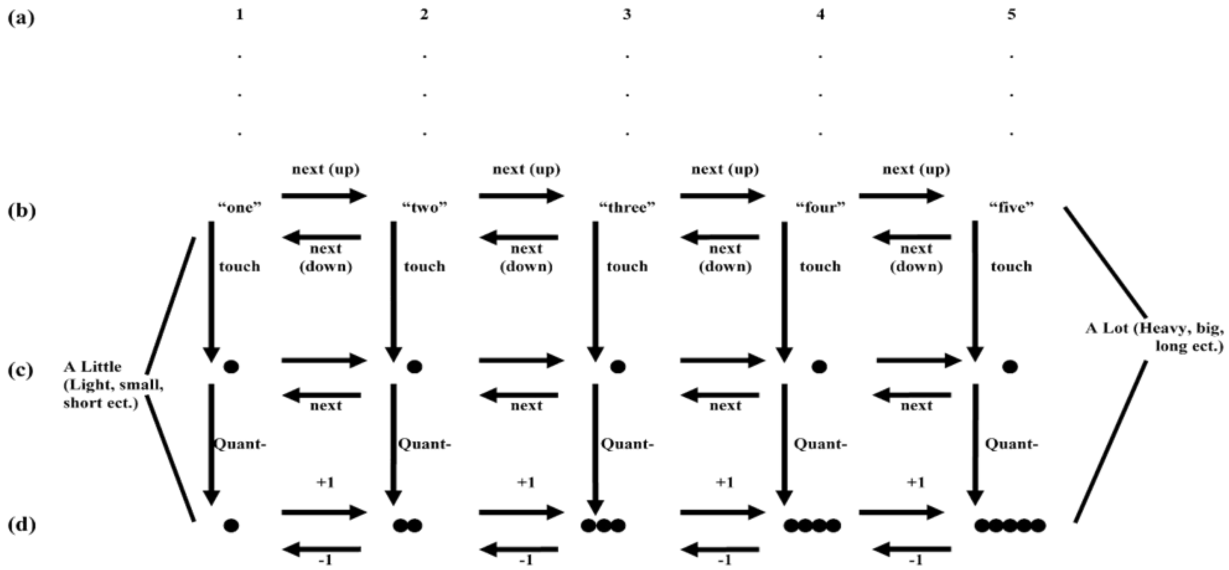

Figure 4.5: Adaptation of Case (1996) hypothesised central numerical structure development model

- *Row A- Knowledge of written numeral.* In the figure row (a) is indicative of a child's ability to recognise written numerals (according to the South African curriculum the ability to recognise numbers from 1-50 by completion of Grade 1). These numbers are then grafted upon to form a structure that is more fundamental (which can be seen at the bottom of the dotted lines) based on three basic components, interconnected in the rows from (b) to (d).

- *Row B- Knowledge of number words.* The first of the components reflects as the "verbal labelling" line. This row indicates the child's ability to recognise and generated the number words, for example *one; two; three* etc.
- *Row C – Mental action.* This row is indicative of a child's ability to routinely 'point to' or 'tag' a set of objects as they say the number words (done in a way that the child tags the object once and only once in the process). The process primarily begins as sensorimotor but eventually manifests to be fully cognitive, simulating the primitive sensorimotor activity.
- *Row D – Conceptual interpretation.* Children understand, at this point in the model, that each act of 'tagging' an object equates to the formation of sets that consist of a certain number of objects and that these sets perpetuate a certain characteristic perceptual form. Finally, a child understands that a movement whether forwards or backwards involves addition or subtraction of 1 unit.
- *Horizontal arrows.* Horizontal arrows in the figure indicate transformations that allow the child to move from one item to the next in any row and then back again. Additionally the brackets on the opposing ends of the figure signify a child's understanding that movement forward and backward along the four rows is simultaneous with movement toward the concept of "more" or "less".
- *Vertical arrows.* The vertical arrows indicate a child's understanding of the process of a one-to-one mapping between each row and the next. Therefore, when moving from one item to the next in any row, a necessary accompaniment in movement in all other rows must be made as well. The mental counting line, once formed, presents to the child as a tool that can be used to build new knowledge and concepts. Allowing for improved understanding in future mathematical theory.

Number knowledge test. Following on the central numerical structure development model, the number knowledge test will be discussed. Case and Okamoto (1996, p. 30-35) divided the number knowledge test into three distinct categories: items reflecting unidimensional thought (designed to search for the presence of the "mental number line" structure); items reflecting bidimensional thought (in this sub-stage learners are expected to be capable of coordinating two number lines in order to reason about a variety of new problems presented to them) and items reflecting integrated bidimensional thought (the final sub-stage where learners should become capable of constructing and comparing two sums or differences rather than just one). For the purpose of this study (with regard to targeting Grade 1 learners), the category of 'items reflecting unidimensional thought' will be utilized as relevant to this study as the subsequent categories focus on an older more experienced learner. The items will be discussed below and adapted for the screening tool design.

Item 1: One and two numbers after 7. Learners are asked, "What number comes after 7?" and then "What number comes two after 7?" The purpose of this item is to test for the child's ability to associate the "next arrows" of row (b) in Figure 2. It is important to understand that a child able to count may, in some instances, not have the ability to understand the representation of what number comes before or after another number, it is this concept that is addressed by this items assessment.

- *Item 2: Forward counting.* A card with several numbers displayed is presented to the learners (8, 5, 2, 6). The learner is asked, "Which number comes first when you are counting?" and "Which number comes last when you are counting?" This adheres to Figure 2's top two rows a correct response from the learner indicates their understanding of written numerals and their position in the counting sequence. There is also a mental counting sequence that occurs that allows the learner to see which numbers are and are not on the card presented to them.
- *Item 3: Backward counting.* Similar to item 2, learners are presented with a card with several numbers on it (6, 4, 2, 9). The learner is asked "Which number comes first when counting backwards?" and which *last*? The rationale is synonymous with the previous item.
- *Item 4: Bigger/smaller.* Learners are asked, "Which of these two numbers is bigger, 5 or 4?" and then, "Which of these two numbers is bigger, 7 or 9?" The same questions are given, but in the place of "bigger", "smaller" is now used and the number sets are exchanged for "8 or 6" and "5 and 7". The child's use of ordinal information depicted in row (b) is gauged in terms of how the child processes in order to make cardinal judgments of the sort indicated in row (d).
- *Item 5: Which number is closer?* Learners are presented with a card depicting three numerals arranged so that each number is at the point of an equilateral triangle: 5 (at the top); 6 (bottom left) and 2 (bottom right). The child is asked "Which number is closer to 5, 6 or 2?" The rationale behind this item stems from the assessment of a child's knowledge of numerical adjacency in a novel context. If a child is able to gauge that 6 comes after 5, they should possesses the knowledge to infer that 6 is therefore closer to 5 than 2. Two questions are asked in this item, the second being "Which number is closer to 7, 4 or 9?"

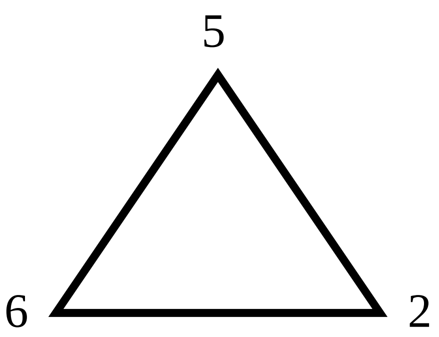

Figure 4.6: Example to depict Case (1996) equilateral triangle used as item 5 in the number knowledge test

Additional screening techniques. Gersten et al. (2005, p. 295), stipulate that the sophistication of a child's counting strategies correlates with number combination mastery and therefore efficiency in mathematics. There are three levels of counting ability that Gersten et al. (2005, p. 295) have identified: *simple* (the child depends on concrete objects); *intermediate* (the child begins at the smaller number and counts up, 3+8); *mature* (the child begins at the larger number and counts up, 8+3) and lastly, *very mature* (Child simply has the combination stored in memory). The levels that have been established allow one to understand the counting ability of the child whilst assessing. In addition to counting ability, Gersten, Jordan and Flojo (2005, p. 302) enforce that early screening measures should examine the learners' calculation strategies across different types of problems, to establish whether each learner is making the transition from concrete to mental representations effectively. As a child approaches the transition into concrete operations, structured problem solving becomes an activity that is more easily engaged in (Charlesworth & Lind, 2013, p. 41). Teaching through problem solving and the importance of the development of problem solving in learners was discussed in Chapter 2 (Section 2.3.2.2).

Chard, Clarke, Baker, Otterstedt, Braun and Katz (2005, p. 4); Gersten et al. (2007), argue the importance of number sense in early screening and state that learners who demonstrate later difficulties in mathematics lack a strong sense of number. Following the importance of number sense and the established fact that it is powerful predictor of mathematics achievement, it is an important aspect to include in mathematical screening. Chard et al. (2005, p. 4), establish core aspects necessary for a numbers sense battery and include rote counting; object counting; sequencing numbers; determining which of two numbers is larger/smaller; identifying a missing number in a sequence; determining which of two numbers is closer to a third (equilateral triangle method); and counting on from a given number. There are a few techniques referred to above that are synonymous with the number knowledge test but it is important to acknowledge those techniques that have proven success and are missing from the number knowledge test.

Lastly in terms of parameters for the designing of a screening tool, Gersten et al. (2005) establish three key points in the design of a successful (identifying at risk learners) screening tool: it must be based on the core curriculum; the test must be divided into sections to ensure all areas of mathematics are targeted and learners who attain less than 35% or lower are identified as being 'at risk'. The established techniques addressed above (excluding problem solving) have been found to culminate in a pre-existing assessment tool specifically designed for the South African learner (Scherman, Howie & Archer, 2013). Certain items specific to the above discussed techniques were extracted and adapted for the purpose of this study. In addition a single item was added to this study's screening tool focused on problem solving as neither the number knowledge test, nor the SAMP assessment targeted this concept deemed important by Charlesworth and Lind (2013 p. 48).

South African Monitoring system for Primary Schools (SAMP). According to Scherman, Howie and Archer (2013, p. 5), the SAMP assessment was designed to provide schools and teachers with information regarding Grade 1 learner performance. It utilises the PIPS (Performance Indicators in Primary School) assessment and adapts it to the South African context focusing on the country's current curriculum. The SAMP assessment consists of four sections: handwriting, early phonics, early reading and early mathematics, the initial three sections of which are not relevant to this study. The early mathematics section consists of four subtests: ideas about maths, counting, sums A and numbers. The subtests adhere to the mathematical areas relevant to the stages discussed in Section 3.3.5. These include: *basic concepts, number concept, counting and place value, basic operations and number sense.* The subtests are described (according to Scherman et al., 2013 p. 11-13) and their adaptations for this study are discussed below. The subtests have been utilised in this study owing to the literature foundation from Chapters 2 and 3.

- *Ideas about maths.* Learners are presented with different quantities, sizes and concepts in this sub test. The learner is expected to be able to differentiate between terms such as “biggest” and “smallest”, “more” and “less” and “tallest’ and “shortest” The inclusion of this subtest in this study’s designed screening tool aims at addressing basic number concepts including, visual discrimination and conservation of mass, capacity and length. In addition vocabulary is ascertained.
- *Counting subtest*. In this subtest the learner is, firstly, required to count a specific number of objects presented to them and then secondly, short term memory is addressed by asking he learner to recall the amount they have just counted (the objects having been covered). Counting ability and number concept have been established as being of core importance in determining mathematics ability (Chapter 2 and 3) and it is, therefore, that this subtest will be included. In addition one to one correspondence is acknowledged in this subtest (basic concepts).
- *Sums A subtest*. Basic addition and subtraction skills are addressed in this subtest addressing number sense. The learner is shown a certain amount of objects, then told how many objects are presents followed by asking “if I take *x* away, how many would there be?” This subtest adheres to the importance of number sense (nonverbal calculation, story problems and number combinations) addressed in Chapter 2 and basic operations discussed in Section 3.3.1 and, therefore, included in the designed screening tool.
- *Number subtest.* Number recognition is addressed in this subtest. Numbers are presented to the learner ranging from single digit to double digit (1 to 20). The SAMP assessment progresses to three digit numbers but in this study’s screening tool only numbers up to 20 will be targeted owing to the literature emphasising the paramount importance of ensuring that learners have an in depth understanding of numbers 1 to 20 and their combinations. This subtest addresses number knowledge, visual discrimination and long term memory.

Assessment tool framework. In the previous subsections, items have been established for the optimum gauging of Grade 1 learners mathematics results with the primary focus being on number sense (See Appendix A). This subsection addresses the formal framework that will utilise the items attained in the previous subsections and combine them into a successful assessment design. An educational assessment provides an assessor with important information about levels of instructions and learner abilities (DiDonato & Fives, 2013, p. 1). A table of specifications (TOS) or a 'test blueprint' assists an assessor in the design process and allows for an improvement of the assessment's validity (DiDonato & Fives, 2013, p. 4). Long, Dunne and De Kock (2014) has designed a framework for the planning of a summative assessment instrument. This adheres to the principal of a TOS but focuses less on instructional objectives. Within Long et al.'s (2014) framework the assessment's difficulty and cognitive skills levels are addressed. The difficulty of the assessment will range between items that are: easy, moderate and difficult. The ability and age level of the learners will be addressed so as to gauge the assessment's difficulty level. Three cognitive skills levels will be utilised in the choice of the assessment's questions. Questions are classified to either be *conceptual knowledge*, *comprehension and application* or *analysis and problem solving*. Long et al. (2014) defines the above mentioned cognitive skills as follows: *Conceptual knowledge* or 'recall of information' involves the ability of reproducing learnt knowledge. It is a rote learning skill that involves memorisation of work that can be given back in the exact form it was attained. *Comprehension and application* or 'application of knowledge and understanding' entails a reproduction of answers that are comparable to those experienced in the classroom. Familiarity in the type of question occurs but unfamiliarity in the specifics of the question arises. Finally, *analysis and problem solving* involves the learners ability to take learnt information, in the form of knowledge, experiences and strategies, and apply them to the solving of unfamiliar questions. The items established in the previous sections are categorised into their relevant specifications within a table in Appendix A.

4.5.2.2.2 Interview Schedules

Expert appraisers. The aim of the interview schedule with the expert appraisers was to collect information on the appropriateness and potential efficiency of the designed intervention prototype. The schedule took the appearance of being open-ended in that it was a review process where the sole question involved asking the appraisers for recommendations on improving the intervention presented to them (see Appendix C.1). The responses from the appraisers were recorded through taping by the interviewer (Merriam & Tisdell, 2015, p. 149).

Grade 1 teachers. The aim of the interview schedule for the Grade 1 teachers (four participants) in Cycle 5 was to collect information for further refinement of the intervention prototype. A semi-structured 'pre-interview' was conducted to attain qualitative data. This method of interviewing was utilised owing to the need to attain specified information but also allowing for probing and clarification of answers if needed (Maree, 2007, p. 87). Participants were expected to answer a set of predetermined questions to garner how best to implement the intervention in their specific class/grade as well as providing data that can contribute to the answering of research sub-questions (see Appendix C.2). Importantly one must be aware that the data gathered from school A was viewed separately from school B this is so that the intervention was designed optimally for each class. The responses from the interviews were recorded through taping by the interviewer (Peräkylä, 2008, p.351).

4.5.2.4 Data Collection

The data collection in Phase II of this study entails two forms of verification. The first being interviews and the second, assessment (refer to Section 4.5.2.2.1). The data collection conducted in this phase serves to improve validity of the intervention as established in the previous sub-section. It is important to point out that in this phase the assessment tool is merely implemented as a walk-through for the target audience to ensure practicality in the overall design and will be discussed as such. In the following phase the assessment tool was implemented in its full capacity to gauge effectiveness through the collection of quantitative data.

Appraisal data collection. The purpose of this data collection was to ascertain the appropriateness and potential efficiency of the primary prototype of the designed intervention. The two appraisers were contacted via email to establish their willingness to participate in this study. Following confirmation, an appointment was made to present the complete prototype to them and background information on the project was provided. An appropriate time period for response was established for the review process and the follow up appointment was made. In the follow-up, an open-ended interview was conducted where the prototype was discussed in terms of successes, shortcomings and recommendations (see Appendix C.1).

Assessment instrument walk-through/pilot. A walk-through was conducted with the target audience of this study (Grade 1 learners) to establish if the assessment tool was age appropriate, time effective and easily administered. The learners selected were from the participating schools (two from each school). Further selection involved requesting a high performance learner and low performance learner based on their current level as established by the class teacher. This was done to enhance the validity of the instrument to ensure it was effective in determining ability in mathematics. An observation was conducted by the researcher to determine the efficiency of the assessment tool based on the three important criteria. The relevant observations about the learner interaction with the assessment, as well as the time it took each learner to complete the assessment were recorded through learner data from completing the assessment and notes taken by the researcher.

Grade 1 Teacher interview data collection. The purpose of this data collection was to further refine the intervention prototype. Participants were expected to answer a set of predetermined questions to garner how best to implement the intervention in their specific class/grade as well as providing data that can contribute to the answering of research sub-questions "**What concepts in mathematics present as most problematic for Grade 1 learners?"** and "**How do Grade 1 teachers assist learners with learning difficulties?"** Importantly one must be aware that the data gathered from school A was viewed separately from school B. This is so that the intervention was designed optimally for each class (see Appendix C.2). The interview was recorded and transcribed.

4.5.2.5 Data Analysis

Data analysis involves the process of examining data to reveal relationships, patterns and/or trends allowing the researcher to, as stated by Scherman (2007, p. 147): validate interpretations, formulate inferences, and draw conclusions. For the interviews thematic content analysis was utilised. For the assessment walk-through a simple check list analysis was conducted.

Interview schedules. Thematic content analysis is a qualitative method used for minimally organising and describing a data set in ample detail through the identification, analysis and reporting of patterns found (Braun & Clarke, 2006, p. 79). It is systematic (inductive and iterative) and flexible in nature and allows the researcher to identify and summarise message content (Braun & Clarke, 2006, p. 78; Neuendorf, 2002). It is a process whereby information is viewed from various angles in order for raw data to be interpreted and understood (Maree, 2007, p. 101). Thematic content analysis adheres to a process of coding the data. Once the data is coded, themes emerge allowing the researcher to establish recurrent patterns (Braun & Clarke, 2006). It is the process of chunking and synthesising of the data for the purpose of creating a new meaningful whole that lead to the decision to utilise this analysis method in this study (Braun & Clarke, 2006, p.79). This method has six phases of analysis and Braun and Clarke (2006, p. 87) represent them in Table 4.6.

Table 4.6: Phases of thematic analysis

Phase	Description of process
1. Familiarizing yourself with your data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Note: From *Using thematic analysis in psychology* by V. Braun and V. Clarke, 2006, *Qualitative Research in Psychology*, 3(2), p. 77-101.

When coding the interviews from the expert appraisers and class teachers, the extent to which the data contributed to the specific research objective was addressed. In this Phase the research objective was clean cut in that the purpose of the data collection was to improve the overall designed intervention before Phase III implementation. Therefore the specific analysis question asked was: what does the data mean for intervention improvement?

To answer this question the interview transcripts were initially read through twice. During the third time reading through the transcripts the researcher performed a first layer of coding, a deductive approach was employed to analyse the data. This approach was utilised owing to the need to improve the intervention and the researcher already having ideas as to what specific categories were important for mathematics improvement, established from preconceived frames made evident through a thorough literature review (Fereday, 2006, p. 82-83). The second layer of coding involved the attaching of working labels (codes) onto blocks of text. The labels stimulated the formation of certain categories that encapsulated specific thoughts and ideas, formulated from themes already founded in literature (Gay, Mills & Airasian, 2011, p. 469-470). These categories emerged as the formal themes presented in the forthcoming chapter. Data attained from the expert appraisers was refined through coding according to themes of *applicability (level appropriateness)*, *age appropriateness* and *the importance of basic concepts in a mathematics intervention*. The data attained from the class teachers, was refined through coding according to themes of *mathematical difficulties* and *accommodation*. The themes and their relevant codes were utilised to further refine the intervention adapting the single intervention into two learner-level appropriate interventions.

Walk-through. For the assessment walk-through with the target audience (two Grade 1 learners), the researcher conducted and observed the assessment process. Records were taken from observation with regards to three set criteria including: time efficiency; age and level appropriateness; and whether the assessment was easily administered. To attain clarification on the aforementioned criteria analysis occurred in the following ways:

(1) The younger a child, the shorter their attention span (Cowan, Nugent, Elliott, Ponomarev & Saults, 1999, p. 1092). When conducting the walk-through the individual learners were timed on how long they took to complete the entire assessment. Times were recorded and reflected upon in terms of appropriateness.

(2) For age and level appropriateness the test scores attained by the two learners were compared to their grade average as established by the class teachers.

(3) With regard to the assessment being easily administered the researcher took note of the learners asking questions regards concept clarification and reflected on the assessment based on fluidity of administration.

4.5.3 PHASE III – SEMI-SUMMATIVE EVALUATION

Phase III (Cycle 8 & 9) is the final phase of the intervention design model and within this phase the effectiveness of the designed intervention was established. As discussed in Chapter 3 the intervention is a three phase approach involving a pre, intermediate and post assessment; classroom lessons and remediation for learners who are shown to be weak in the intermediate tests. To evaluate the efficiency of the intervention, "post" interviews were conducted with the teachers of the experimental groups to ascertain whether they found the intervention successful. The intervention cycles are viewed separately owing to prototype 3 A and B being implemented in the corresponding schools. It is in this phase that this study's research method comes to light utilising quantitative and qualitative data in a mixed methods embedded design. Instruments, data collection and data analysis are the same for both cycles and will be discussed in the following sub-sections.

4.5.3.1 Instruments

In Phase III two instruments were utilised, the assessment tool designed and discussed in Phase II and interview schedules conducted with the two experimental class teachers. The assessment tool has already been discussed in detail and will be further acknowledged in the further sub-sections in terms of data collection and analysis. Within this section the relevant interview schedules will be discussed.

Interview Schedules with Grade 1 teachers. The aim of the interview schedule for the Grade 1 teachers (two participants) in Cycle 8 and 9 was to collect information about the effectiveness of the intervention as implemented within their classrooms at the end of the intervention process. The interview was conducted with the experimental group's class teachers from both schools. A semi-structured 'post-interview' was conducted to attain qualitative data. This method of interviewing was utilised owing to its corroborative nature when data emerges from other sources (quantitative data from the assessment instrument) and as discussed in the previous phase, specific information was needed but the nature of the interview allowed for probing and clarification if required (Maree, 2007, p. 87). Participants were expected to answer a set of pre-determined questions to ascertain their feelings on the efficiency and success/failure of the intervention. The responses from the interviews were recorded through taping by the interviewer (Peräkylä, 2005, p.34).

4.5.3.3 Data collection

The data collection in Phase III of this study entails two forms of verification. The first being assessment and the second, interviews. The data collection conducted in this phase serves to determine the efficiency of the designed intervention. The mixed methods approach becomes prominent in this phase as qualitative data (interviews) will be utilised to build on the attained quantitative data (assessment instrument). In the following section the data collection process for the two instruments will be described.

Assessment instrument. The assessment instrument was implemented at three intervals within the intervention period to attain pre, intermediate and post data. The assessment was administered to both the control and experimental groups as a means of comparing data. It was divided into three sections and each section revealed the learner's ability in a sub-set of skills. The sections were: the number knowledge test, SAMP and problem solving (see Appendix B). In Cycle 8 the intervention was implemented in school A and in Cycle 9 the intervention was implemented in School B. The data attained from the two schools were viewed separately and not compared to one another.

Grade 1 teacher interviews. The purpose of this data collection was to attain qualitative data in order better understand the phenomenon of interest (efficiency of the designed intervention) (Maree, 2007, p. 266). Participants (two teachers from the experimental group) were expected to answer a set of predetermined questions to ascertain their views on the successes/failures of the implemented intervention. This was done owing to them observing the intervention and observing their learners in additional maths “practice” lessons. Through the mixed methods approach the data attained in these interviews was used to build on the results of the quantitative data (see Appendix C.3). The interview was recorded and transcribed.

4.5.3.3 Data Analysis

In Phase III, quantitative and qualitative data were collected. In this phase 'mixed methods' was utilised; specifically, an embedded mixed method design. The primary focus of this study in its final phase was the collection and analysis of quantitative data and then once the intervention was complete to collect qualitative data. In this section the data analysis is discussed separately owing to the nature of the embedded mixed method design acknowledging qualitative data as support for the primary purpose, strengthening the understanding of the central phenomenon of the study.

4.5.3.3.1 Quantitative data analysis

Quantitative data analysis is discussed in terms of descriptive statistics and inferential statistics. Within these two topics the relevant processes applicable to the data attained from the assessment instrument are discussed.

Descriptive Statistics. The initial step in quantitative data analysis is the description, organisation and condensation of data (Fowler, Cohen & Jarvis, 1998, p. 7). Descriptive statistics, according to Creswell (2012), "indicates general tendencies in the data (mean, mode, median), the spread of scores (variance, standard deviation and range) or a comparison of how one score relates to all others (z-scores, percentile rank) (p. 181). Further, a descriptive statistic is a number or collection of numbers that coveys the characteristic of a sample (Wilson & MacLean, 2011, p. 283). There are no inferences or predictions made in descriptive statistics and there is always a level of uncertainty about the samples. It is inferential statistics that allows the data to go further to arrive at conclusions about populations.

The initial process employed for the data attained from the assessment instrument was to tabulate the scores according to the experimental group and separately the control group. Two main things were considered to provide a better understanding of the data set: central tendency and spread. Central tendency establishes information about the score that the data centres around (Wilson & MacLean, 2011, p. 286). This included the calculation of the mean, median and mode. For a complete picture of the data the spread was addressed and calculated. The spread is often referred to as the dispersion or variability of scores and include the range, variance and standard deviation (Wilson & MacLean, 2011, p. 290).

Inferential statistics. Inferential statistics encompasses a variety of techniques that allows one to draw conclusions regarding populations based on data obtained from a sample (Wilson & McLean, 2011, p. 317). In addition, when comparing groups or when relating two or more variables, inferential statistics becomes applicable (Creswell, 2012, p.186). Some inferential statistical tests make specific assumptions about the data (Wilson & MacLean, 2011, p. 340). In order to meet the assumptions of the various statistical tests one needs to check for normality to determine if the statistical test will be parametric or non-parametric. Normally distributed data are symmetrical around the mean and would follow a bell shaped distribution curve (Wilson & MacLean, 2011, p. 302). The distribution of the data plays an important role in inferential statistics and the data attained for this study was checked for normality using the Shapiro Wilk Test (Shapiro & Wilk, 1965, p.591). The Shapiro Wilk Test utilises the null hypothesis (discussed further in this section) to determine if a sample comes from a normally distributed population (Shapiro & Wilk, 1965, p.602). In addition to checking the data for normality, the discrepancy of the sample identified in Section 4.5.2.1 needs to be addressed in terms of how it was dealt with methodologically. As previously mentioned the control and experimental groups of both schools held different numbers of participants (School A, experimental group: 28 and control group: 15. For School B, experimental group: 22 and control group: 19). The analysis implications of this discrepancy that emerged attributed to the inability to compare the experimental and control groups directly but rather to compare assessment intervals (pre-int; int-post; pre-post) between the various assessment tests and the overall averages of each group individually. This adjustment to data analysis stems from one of the assumptions of the significance test utilised in this study. The need arose to compare matched pairs within each sample of learners. In Figure 4.7 the various statistical methods are presented according to stipulated criteria. The pathway employed for the choice of appropriate statistical tests is highlighted in green.

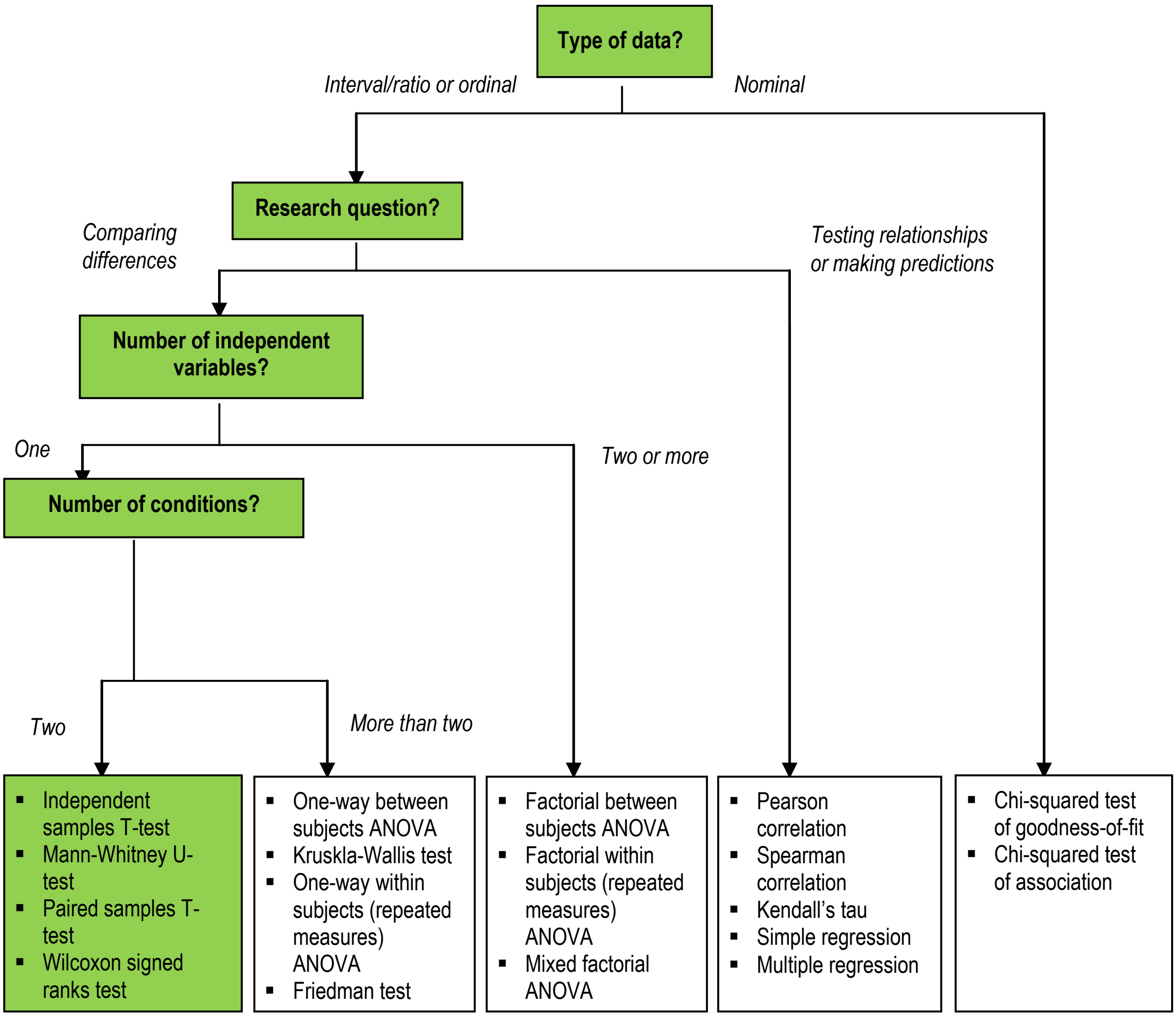

Figure 4.7: Overview of statistical tests and the relevant pathway utilised for this study (Adapted from *Research methods and data analysis for psychology* by S. Wilson & R. MacLean, 2011, McGraw-Hill Higher Education)

Following the pathway of reasoning presented in Figure 4.8 and the finding that the data followed a non-normal distribution, a parametric and non-parametric statistical test choice emerged. If the sample size was greater than or equal to (≥) 30 then the arcsine transformation would be applied to the percentage scores. Transformed data from two samples would be compared using a parametric T-test (Fowler et al., 1998, p. 176). In this study the sample size was less than (>) 30 necessitating the use of a non-parametric test (Maree, 2007, p.231-233). According to Figure 4.8 two tests emerge from the non-parametric category, the Mann-Whitney U-test and the Wilcoxon signed-ranked test. For the purpose of this study the Wilcoxon signed-rank test (two-tailed) was performed on untransformed data owing to the following data characteristics, firstly, the parametric assumptions haven't been met but data analysis involves a study with paired samples (the samples were matched pairs comparing either: pre-int; int-post or pre-post scores from the same set of learners) and secondly, the test is performed based on a single variable namely the difference between two scores (Maree, 2007, p. 231). The final stage of the quantitative data analysis involved null hypothesis significance testing. Creswell (2012, p. 186) identifies five steps in hypothesis testing namely:

(i) ***Identification of the study's null and alternative hypotheses:*** Two samples were compared under the null hypothesis, H_0: The learner performance (pre-int; int-post; pre-post) did not change with implementation of the intervention and the alternate hypothesis, H_A: Learner performance (pre-int; int-post; pre-post) changed with implementation of the intervention. A change between the two samples was deemed positive or negative according to the difference between the mean test scores achieved by the learners.

(ii) ***Set the level of significance or alpha level:*** The significance of the change was evaluated by the p value of the Wilcoxon test with an alpha of 0.05. A test result using the methods described earlier was considered significant if the significance was based on a 95% confidence interval.

(iii) ***Collect the data:*** As previously discussed the data was collected by means of a designed assessment instrument. It was then analysed by means of descriptive statistics, checked for normality and an appropriate statistical test was decided upon.

(iv) ***Compute the sample statistic:*** A computer program (XLSTAT) was used to compute the *p value*. A p value, according to Creswell (2012), "is the probability (*p*) that a result could have been produced by chance if the null hypothesis were true," (p. 188). The statistical test as discussed previously utilised for the computation was the Wilcoxon signed-rank test.

(v) ***Make a decision about rejecting or failing to reject:*** The level of significance is the probability that one decides on to indicate whether an outcome is statistically significant (Wilson & MacLean 2011, p. 290). The significance of the outcome in this study was evaluated by the p value of the Wilcoxon test with an alpha of 0.05. According to Creswell (2012, p. 191) The decision to reject or fail to reject the null hypothesis falls on two primary rules:

- **Rule 1:** If the *p value* is less than or equal to (≤) 0.05 the H_0 can be rejected owing to a statistically significant result.

- **Rule 2:** If the *p value* is greater than (>) 0.05 then fail to reject the H_0 owing to the research finding not being statistically significant.

In research, if something is significant, it shows that the null hypothesis was rejected and the rejection of the null hypothesis finds foundation in probabilities rather than certainties, it is this degree of uncertainty that sometimes leads to errors (Wilson & MacLean 2011, p. 334). There are two types of errors that may occur in hypothesis testing, Type I and Type II errors. A Type I error rejects the H_0 even though it is true and the Type II error retains the H_0 when actually false (Creswell 2012, p. 193). It is the aim of this research to limit the probability of committing Type I errors. As the probability of making Type I errors is decreased, the probability of making Type II errors increases (Fowler et al. 1998, p108). It is generally accepted that committing a Type II error is far less problematic than committing a Type I error and in educational research one has to be very cautious of saying that a difference has occurred when it in fact has not (Creswell 2012, p. 193). In practice however, according to Fowler et al. (1998) "the calculated value of a test statistic often exceeds the tabulated critical value at $P = 0.05$ in which case we can reject H_0 at $P<0.05$ and the risk of error is accordingly reduced" (p. 108).

4.5.3.3.2 Qualitative data analysis

When coding the interviews from the experimental group's class teachers, the extent to which the data contributed to the specific research objective was addressed. In this Phase the research objective was to determine the effectiveness of the implemented intervention. To determine the effectiveness of the intervention the specific analysis question asked was: what does the data mean for the success of the designed intervention? To answer this question the interview transcripts were initially read through twice. During the third read-through of the transcripts, the researcher performed a first layer of coding; a deductive approach was employed to analyse the data. This approach was utilised owing to the need to determine the efficiency of the intervention and the researcher asked three specific questions in order to determine this: *"In your opinion do you feel the intervention was successful?"; "Would you change anything about the intervention?"* and *"Do you feel that this intervention would be easy to implement in your classroom without causing you inconvenience?"* The answers to these questions provided the qualitative data support needed in the embedded mixed methods approach (Creswell, 2008, p. 32). The second layer of coding involved the attaching of working labels (codes) onto blocks of text. The labels stimulated the formation of certain categories that encapsulated specific thoughts and ideas (Gay, Mills & Airasian, 2011, p. 469-470). These categories emerged as the formal themes presented in the forthcoming chapter (Sections 5.4.1.2 & 5.4.2.2). Data attained from the experimental group's class teachers was refined through coding according to themes of i*ntervention successes, intervention failures* and *implementation potential*.

4.6 METHODOLOGICAL NORMS

Multiple methodological norms need to be addressed in terms of ensuring validity and reliability in this research. Within this section the methodological norms applicable to the instruments (Section 4.6.1) as well as those associated with design research (Section 4.6.2) will be addressed.

4.6.1 INSTRUMENT RELIABILITY AND VALIDITY

Reliability and validity are important aspects of research (Maree, 2007, p. 80). Within quantitative research reliability and validity are common place and it has been found to be important in qualitative research as well (Golafshani, 2003, p. 597). In quantitative research, reliability in an instrument refers to the ability of the instrument to be used at different times or administered to different subjects whilst still providing the same findings/results. This shows that the instrument is repeatable and consistent (Maree, 2007, p.215). In qualitative research, reliability is utilised as a method of determining the quality of research by enhancing quantitative findings, it has a purpose of explaining and generating understanding (Golafshani, 2003, p. 601). According to Golafshani (2003), “the quality of a study in each paradigm should be judged by its own paradigm's terms” (p. 106). It is owing to this that rather than being referred to as reliability and validity, in qualitative research one refers to trustworthiness and credibility (Maree, 2007, p. 81).

In research, multiple definitions emerge for the term ‘validity’ (Winter, 2000, p. 4). An emerging trend emerges through two definitions: the first, whether the means of measurement are accurate; and the second, whether an instrument is measuring what it is supposed to measure (Winter, 2000, p. 4). In this section the reliability and validity of the instruments utilised in Phase II will be discussed. Instruments fall into two categories: researcher-completed instruments and subject-completed instruments (Denzin & Lincoln, 2005). The assessment instrument falls into the subject-completed category and interview schedules fall into the researcher-completed category.

4.6.1.1 Assessment instrument

The assessment instrument was administered initially in the walk-through in Cycle 5, followed by the effective data collection process of pre, intermediate and post-testing during the intervention implementation (Phase III). For the walk-through, the researcher requested a high performing learner and a low performing learner according to classroom monitoring and assessment (two learners per school) from the relevant principals who arranged with the class teachers. The assessment instrument was administered and results were compared to those attained from the teachers. Reliability of the instrument was determined through it accurately showing the determined level of the learners. In addition to this, particular mathematics concepts the learners struggled with were also adequately identified and corresponded with the result attained through the assessment.

For the context of this study, in terms of validating the assessment instrument, the different types of test validity will be addressed. Test validity indicates that significance can be placed on a set of assessment results (Messick, 1979, p. 1).

Table 4.7: Types of validity and the application to the assessment instrument

Type of validity	Description	Application to assessment instrument
Face	The point to which an instrument 'appears' valid. This measure is unquantifiable but requires scrutiny from experts to enhance face validity (Maree, 2007, p. 217).	Face validity was established through the appraisal by the two experts.
Content	Refers to the level to which the instrument addresses and covers the content of the construct it is intended to measure. Emphasis placed on: • content areas and objectives • types of items included • number of items included • appropriate difficulty level of items (Thorndike & Thorndike, 1997)	Experts were consulted and the important aspects of establishing content validity were addressed. In addition, when assessment design was taking place the content corresponded closely with the Grade 1 Mathematics curriculum. This enabled the researcher to gauge a valid result in terms of what learners had been previously exposed to in terms of curricular domains. (Thorndike & Thorndike, 1997)
Criterion	The most proficient way of determining if an instrument measures what it is supposed to measure. Two categories of criterion validity are: *Concurrent validity* – Measures an instruments degree of validity against that of a benchmark test. A high correlation indicates high criterion validity *Predictive validity* – The level to which the instrument predicts ability. (Maree, 2007, p. 217; Riazi, 2014, p. 1)	For the purpose of this study *predictive validity* was established through the walk-through where the two learners were selected based on their established performance. The results attained through the assessment corresponded with the average performance established through classroom assessment administered by the class teachers.
Construct	The purpose of construct validity is to enhance standardisation. It determines how proficiently the focused construct(s) of the instrument are measured by dissimilar groups of related items. According to Guion (1977) "all validity is at its base some form of construct validity…It is the basic meaning of validity" (p. 410). Construct validity incorporates both criterion and content validity into one common framework (Messick, 1979, p. 10).	The purpose of the assessment instrument was to determine mathematics ability (construct) through the assessment of core concepts that were identified through literature. Two existing tests (NKT and SAMP) were utilised and adapted in correspondence with the Grade 1 curriculum to improve construct validity (Biddix, 2009). Both tests had been implemented prior to this study and were determined valid (Case & Okamoto, 1996; Scherman et al., 2013).

Adapted from various sources as acknowledged

4.6.1.2 Interview schedules Phase II

There have been arguments from researchers that the term validity does not find applicability in qualitative research but at the same time understand that there is a need for a form of a 'quality check' in the research (Winter, 2000). Validity has more appropriate terms when referring to qualitative research: 'trustworthiness', 'worthy', 'relevant', 'plausible', 'confirmable', 'credible' or 'representative' (Winter, 2000). Within qualitative research, the researcher is viewed as the data collecting instrument (Maree, 2007, p. 80). In qualitative research the nature of the research is decided and modified by the research itself. Within the research the concept of validity stems from the representation of participants, the purpose of the research and the suitability of the processes (Winter, 2000). Within Phase II, two interviews were conducted both with the purpose of improving the designed intervention. The expert appraisal enhanced the overall construct of the intervention improving suitability and content and the interviews conducted with the Grade 1 class teachers allowed the intervention to be adapted for the specific needs of the target audience (high level and low level schools).

4.6.1.3 Interview schedules Phase III

Lincoln and Guba (1985) state that "Since there can be no validity without reliability, a demonstration of the former [validity] is sufficient to establish the latter [reliability]" (p. 316). Therefore the validity of the interview conducted in this phase will be discussed based on the premise that validity will establish reliability. A method utilised to enhance validity in research emerges as triangulation. Patton (2001) believes in the use of triangulation stating that "triangulation strengthens a study by combining methods. This can mean using several kinds of methods or data, including using both quantitative and qualitative approaches" (p. 247). The combination of methods in this study stems from attaining quantitative data through the assessment instrument and then attaining qualitative data from the interviews to strengthen findings, thus enhancing validity.

4.6.2 METHODOLOGICAL NORMS ASSOCIATED WITH DESIGN RESEARCH

By utilising design research and the mixed methods approach in this study, multiple methodological norms need to be addressed. The methodological norms applicable to mixed methods research have been discussed in this phase and will be further discussed in Phase III relating to reliability and validity. In this section the methodological norms applicable to Design Research will be discussed.

For a high quality intervention, Nieveen (2007, p. 94) establishes four main criteria to adhere to during a design research project. Firstly, *relevance* or *content validity*; which establishes whether there is a need for the intervention based on 'state-of-the-art scientific knowledge. *Consistency* is the second criterion, which focuses on the logicality of the design of the intervention. Thirdly, there is *practicality*, which separates into two categories: expected and actual. It needs to be understood that the expected is, in effect, assumed before practical experience of the intervention and the actual occurs once the target users experience the intervention. The intervention is expected to be usable in the context for which it was designed, and the actual accomplishment will be realised when the intervention proves to be usable in the context it was designed for. The final criterion established for the insurance of a high quality intervention is *effectiveness*. This too has the same two categories as practicality. Firstly the intervention is expected to attain the desired outcomes established at commencement of the study and secondly, once implemented, the intervention results in desired outcomes (actual).

Table 4.8: Criteria for high quality interventions

Criterion	
Relevance (also referred to as **content validity**)	There is a need for the intervention and its design is based on state-of-the-art (scientific) knowledge.
Consistency (also referred to as **construct validity**)	The intervention is logically designed.
Practicality	**Expected** The intervention is expected to be usable in the settings for which it has been designed and developed. **Actual** The intervention is usable in the settings for which it has been designed and developed.
Effectiveness	**Expected** Using the intervention is expected to result in desired outcomes. **Actual** Using the intervention results in desired outcomes.

Note. From *An Introduction to educational design research* edited by N.Nieveen & T.Plomp 2009, p. 26.

Design Research, as previously mentioned, is iterative in nature and the criteria discussed may attain different emphasis depending on the stage of research and the specific needs in terms of the research questions (Plomp, 2007, p. 26). In the preliminary research phase, emphasis is primarily placed on *content validity*. It is in this phase that a framework is established for the intervention using solid theories applicable to the research question. In Phase II, *consistency* (construct validity) and *practicality* form the initial focus, as the prototype progresses, the focus shifts to mainly *practicality* and eventually *efficiency*. It is in this phase that formative evaluation takes place through expert judgement, trials and revisions. In the final phase, assessment takes place to determine the overall *efficiency* of the designed intervention; therefore focus is placed on *practicality* and *efficiency* (Plomp, 2007, p. 27).

There are various methods of formative evaluation that can be chosen, in this research the following methods were utilised:

- Expert review (Cycle 3)
- Walk-through (Cycle 5)
- Teacher Interviews (Cycle 5, 8 & 9)
- Field test (Cycle 8 & 9)

In Figure 4.8, the various formative evaluation methods that were used for the respective prototypes are illustrated.

Cycle		3	5	5	8 A		9 B	
Prototype		1	2					
Participants		Experts (n=2)	Users (n=2)	Teachers (n=4)	Users (exp n= 28) (con n=15)	Teacher (n= 1)	Users (exp n= 22) (con n=19)	Teachers (n=1)
Validity	Content	√ea						
	Construct	√ea						
Practicality	Content		√wt	√id	√ft	√id	√ft	√id
Effectiveness	Entire intervention				√ft	√id	√ft	√id
√ = primary attention of prototype and of formative evaluation Methods of formative evaluation: wt= walk-through; ea= expert appraisal; id= interview data; ft= field test								

Figure 4.8: Focus of design and formative evaluation of the prototypes for an intervention to improve mathematics results (adapted from Nieveen, 1999)

4.7 ETHICAL CONSIDERATIONS

Ethical clearance to undertake this study was received from the Ethics Committee of the Faculty of Education at the University of Pretoria. Ethics are an imperative part of the research process, from the foundation through to the conclusion. Within the ethical considerations of this study, there is a clear understanding that participants may withdraw from the study at any time. When conducting research using animal or human subjects it is imperative to ensure that ethical guidelines are attended and adhered to (Maree, 2007, p. 298). Various pieces of literature establish three main principles to follow when working with human subjects (Fraenkel, Wallen & Hyun, 1993; Maree, 2007). Firstly, informed consent and voluntary participation (all participants will be made aware of all aspects of the study and must be willing to participate). Secondly, protection from harm and privacy: participants must not be exposed to anything that can cause physical or psychological harm, whilst honesty, respect and sympathy are key. In the context of this study, a further acknowledgement of this principle will be made in the insurance that the control group receives the designed intervention once the implementation phase is complete and relevant data is collected from the experimental group. Lastly, confidentiality where the participants' information and identities will remain anonymous and private (only known to the researcher). Any audio recordings will be destroyed following the study's completion (Fraenkel et al., 1993; Maree, 2007). Along with adherence to the above mentioned guidelines, constant reference will be made to the Faculty of Education's Ethics and Research Statement.

4.8 METHODOLOGICAL CONSTRAINTS

In this chapter the research method and methodology were elaborated on in detail. It is however, necessary to address the methodological constraints that presented in the research process.

- Sample sizes at the classroom and school level were small. This was impacted by ethical clearance forms not being sent back by parents even after regular requests from the class teacher.
- Once the researcher visited the schools before implementation it occurred that there were highly evident differences in learner level and language levels. In addition implementation of the intervention couldn't occur at the same time in the same term and this influenced the understanding of content and the levels of learners. A full prototype was designed but as discussed in Section 4.5.2.2.2, this constraint lead to the design of two separate prototypes to ensure the intervention was adapted to accommodate the specific learners.
- Only two schools participated in this study and although selected based on their performance, both were urban schools. Therefore, this research cannot be generalised to the full extent in the South African context, as a large percentage of schools are situated in rural areas.

4.9 CONCLUSION

In this chapter information pertaining to research design and methodology was discussed in detail. The purpose of the research was to design an intervention with the aim of improving mathematics results. In order for this purpose to be realised the research found its foundation in a pragmatic approach encompassing the use of qualitative and quantitative methods of inquiry (mixed methods). Mixed methods as the research methodology was introduced and discussed and the specific focus emerged as the embedded mixed methods approach. The qualitative data was viewed as being embedded within the quantitative data acting as a means to enhance understanding of the data set. The research method of Design Research was described and the methodological processes relevant to the specific phases was acknowledged and discussed. A description of the sample, instruments, data collection and data analysis was provided. In addition methodological norms relevant to the process of research were discussed. Lastly, the ethical considerations and the methodological constraints were addressed.

In the following chapter the data attained through the design and implementation phase will be represented through the analysis procedures discussed in this chapter, within them the imperative focus on the addressing of the research questions outlined in Chapter 1. The forthcoming chapter will be conceptualised in terms of the empirical cycles. Within the relevant cycles the analysis findings applicable to qualitative or quantitative data will be presented. Cycle 3 (Section 5.2) will attribute to qualitative data attained from the expert appraisers, which functioned to enhance *consistency* in the intervention. Cycle 5 (Section 5.3) focuses on enforcing *practicality* of the designed intervention and entailed the analysis of two means of data collection: a walk-through for the assessment and interviews with the class teachers (qualitative data). The final section (5.4) focuses on the final stage of the intervention process where the intervention was tested for effectiveness, quantitative data attained through pre, intermediate and post tests with the learners of the experimental group, and post interviews with the class teachers is presented. The presentation of data will be utilised in the final chapter where the research questions will be formally answered.

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Chapter 5
Data Analysis and Findings

5.1 INTRODUCTION

In the previous chapter, a framework was established that represented the intervention design process of this study. Within this framework the various cycles and phases where outlined and the methodological processes within them explained. In this chapter, the data will be analysed and presented based on the previous chapters stipulated processes, including within them the imperative focus on the addressing of the research questions outlined in Chapter 1. Qualitative data collected in Phase II and III of the research process were analysed through a thematic content analysis (Chapter 4, Sections 4.5.2.5 & 4.5.3.3.2) and quantitative data attained in Phase III were analysed through the utilisation of the Wilcoxon sign-ranked test (Chapter 4, Section 4.5.3.3.1).

The way in which this chapter has been conceptualised is in terms of cycles. Therefore every cycle, as outlined in the previous chapter, will have its own unique aspects with regarding data analysis. Sections in this chapter will have headings appropriate to the empirical cycle being discussed. Only cycles relevant to the function of data analysis will be included in this chapter. Cycle 2, 4, 6 & 7 will not be included in this chapter as the conceptualisation of the intervention did not involve conventional data collection. The checklist given to the supervisor of this study was based on discussion and appropriate deliberation and reflection on the normal learner supervisor relationship whereby guidance is provided and acted upon. As represented by Figure 4.6 in the previous chapter each cycle falls into a particular phase and function within the design process and this will be adhered to in the analysis process within each section/cycle.

Section 5.2 will focus on Cycle 3. Within this cycle experts in remedial education and Foundation Phase mathematics reviewed the intervention and provided a critical reflection utilised to improve the intervention prototype. Qualitative data attained from the experts through an interview will be analysed according to its function, which is to enforce *consistency*. The two following sections will be divided into subsections which will represent the two schools utilised in this study (School A and B). Section 5.3, Cycle 5, will attribute to a function of enhancing *practicality*. A walk-through with two Grade 1 learners for the assessment component of the intervention and interviews with the class teachers will yield qualitative data utilised to attain the above mentioned function. In Section 5.4, the *effectiveness* of the intervention will be determined through data collection and analysis processes occurring in Cycles 8 and 9. These two cycles are the final phase in the design process of the study's intervention and through pre, intermediate and post tests with the learners of the experimental and control groups, and post interviews with the class teachers; quantitative and qualitative data was attained. The experimental group received the assessment and intervention whereas the control group received the assessment but not Phase II and III of the intervention.

5.2 CYCLE 3

Within this cycle the prototype was appraised by two experts with the aim of improving the intervention. An open-ended interview was utilised as the data collection method. The qualitative data analysis took the form of a thematic content analysis in the conventional sense where the interview was coded and themes where established from the codes. It is important to understand, however, that because of the nature of this interview within the design process, the data is utilised in a different manner. It addresses validity issues focusing on consistency, strengthening the intervention ensuring foundations are covered. Through the analysis of the data three prominent themes emerged: *age appropriateness* (Section 5.2.1), *importance of basic concepts in mathematics* (Section 5.2.2) and *level appropriateness* (Section 5.2.3). The themes will be discussed in terms of the data that supports them and will be broken down into their relevant contributing codes. Figure 5.1 presents a graphical representation of the codes and themes for this cycle. This section concludes with a full presentation of the themes, results, supporting literature and the adaptations to the intervention according to findings.

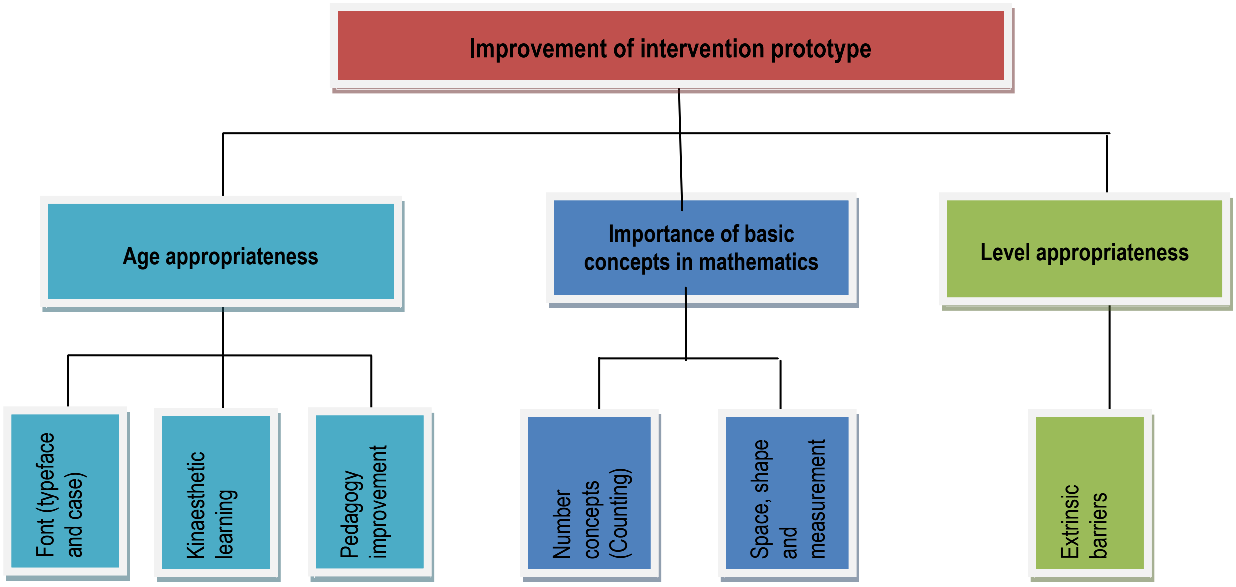

Figure 5.1: Theme and code representation for Cycle 3

5.2.1 AGE APPROPRIATENESS

According to Cassidy (2013) "age appropriate refers to a developmental concept whereby certain activities may be deemed appropriate or inappropriate to a child's 'stage' or level of development," (p. 83). This statement ties in with the developmental stages introduced and discussed in Chapter 2 (Section 2.3.1.1). Piaget hypothesised that the form of children's operational structures is different at different stages of their development and that this gives their thought at each stage a unique character (Case 1996, p.1). Further, when observing a child's functional development it is necessary to acknowledge whether or not the child has mastered certain developmental targets and expectations appropriate for his or her age (Cassidy, 2013, p. 83). During the interview with the expert appraisers (EA) age appropriateness was emphasised.

The expert appraisers said:

EA1: *"… the first thing with the activities is the Grade 1 font that you have used because this is not the appropriate font which they use in the schools. We usually write these words with small letters with Grade 1 font. We never write things in capital letters in Grade 1, that is a very important thing. The other thing that really concerns me about the activities is that the lessons are worksheet driven. Um so at this stage in Grade 1 when you enter the school most of their activities, happen, especially if you want to go into an intervention program, you have to work kinaesthetically and also using 3 dimension with real apparatus so that is the biggest thing, I mean you can do the test to understand where they are, what I would recommend is you go and sit in a Grade 1 class for a week and see where they are now."*

EA2: *"… especially since it's Grade 1s they might not know the capital letters so if you use small letters and if you can also use the school font that will also be nice."*

The three codes that emerged through the interviews were: Font (typeface and case); kinaesthetic learning and pedagogy improvement. The codes will be discussed further in Table 5.1.

5.2.2 IMPORTANCE OF BASIC CONCEPTS IN MATHEMATICS

Concepts are the fundamental and foundational building blocks of knowledge (Charlesworth & Lind, 2013, p.2). Exploratory activities begin in infancy during the sensory motor period (See Piaget's theory, Chapter 2, Section 2.3.1.1) and acts as the foundation for later success. As a child develops so do their concepts; in the concrete operations phase the child attains the ability, with guidance, to apply abstract information to their concrete knowledge applicable to mathematics and it concepts (Van Vuuren, 2009, p. 56). The construction of knowledge manifests in a child's everyday life through activities, exploration and problem solving (Charlesworth & Lind, 2013, p.2). Examples of basic concepts in mathematics include: one-to-one correspondence; counting; classifying and measuring (Charlesworth & Lind, 2013, p.2). During the interview with the expert appraisers (EA) the importance of basic concepts in mathematics is emphasised.

They said:

EA1: *"… if children have a problem and you have to do an intervention programme you have to start with counting because number concept development is a very important part. The other things that's a concern to me is you don't really go into the other content areas like measurement and shape and space which is very important so those are the main things and I've got some activities here with measurement and shape and space."*

EA2: *"… I had my interviews for my masters last year at two schools also Grade 1 teachers and I think it was in June after the holidays. Those teachers were so upset about this curriculum and they said that the children just didn't cope there were some children who still couldn't count, they had no number concept, they were supposed to be through all of those things."*

5.2.3 LEVEL APPROPRIATENESS

In the context of this study, "level appropriateness" refers to the level of the schools utilised in this study. The schools' levels (higher and lower performing) were influenced by extrinsic barriers. Extrinsic barriers, as discussed in Chapter 2 (Section 2.4.1.1), are barriers that occur outside the child as an entity and are imposed by society or the environment (macro and micro levels). They manifest from the following conditions: socio-economic status; home environment and circumstances; didactical situation including the education system; teacher qualification and the knowledge they possess in assisting learners who display learning difficulties; poor language acquisition and/or inadequate vocabulary (Van Vuuren, 2009; Engelbrecht & Swanepoel, 2009).

The expert appraiser said:

EA2: *"… so I thought at the beginning of Grade 1 even March it's so early and especially the children, you might find it at the low performance school, that have children from a rural background, I'm sure you'll find they are not ready for it. I think it will be very interesting to see the differences between the two schools even though you're not going to compare them data wise. It's unthinkable to think that they want all schools to implement the same curriculum at the same time, it just doesn't work."*

The statement made by the expert appraiser held true during implementation of the intervention. There was a distinct difference between the schools in terms of their levels and the extrinsic barriers that influenced the learners. This will be discussed further in Section 5.3.

Table 5.1: Interview with expert appraisers: Presentation of the themes, results, literature and the adaptations to the intervention according to findings

Theme	Results	Literature	Prototype adaptations according to findings
Theme 1: **Age appropriateness**	The appraisers believed that three categories needed to be addressed in order to make the designed intervention more age appropriate these included: *font*, *kinaesthetic learning* and *improved pedagogy*.	*Font*: In terms of typeface and case, it is an important contributor to learner comprehension of material presented to them, particularly in Grade 1 when learners are just starting to acquire the skills to decipher meaning from written words (Soleimani & Mohammedi, 2012). *Kinaesthetic learning*: Every learner learns differently, some are visual learners, some are auditory and some kinaesthetic learners (Gilakjani 2011, p. 104). Kinaesthetic learning is 'learning by doing' and for grade 1 learners this is an imperative method as it targets those that have short attention spans and allows for a more concrete understanding of concepts	*Font*: The intervention worksheets and teaching aids where adapted by removing capital letters and by using the accepted "Grade 1 font". *Kinaesthetic learning*: The intervention was found to be in need more kinaesthetic aspects as it seemed to be based primarily on visual and auditory stimuli. The intervention was adapted by including more kinaesthetic activities in the classroom and remedial lessons. *Improved pedagogy*: Literature was consulted on the pedagogy appropriate for

		(Gilakjani 2011, p. 106). *Improved pedagogy*: Teaching Foundation Phase learners, as with the different phases, requires a unique set of skills applicable to the specific phase that can be attained through appropriate theory or practical experience. Skills involve teaching techniques that address the Foundation Phase learner, focusing on: age appropriateness and gauging the best way to address a concept that need to be taught (Cochran, 1991).	Foundation Phase as well a practical influence of attending a few Grade 1 lessons. The lesson plans were adapted accordingly following the pedagogical influence.
Theme 2: Importance of basic concepts in mathematics	Two specific categories emerged from the appraisers regarding this theme: *number concepts (specifically counting)* and *space, shape and measurement.* Within the interview the importance of number concept with specific emphasis on counting was reiterated.	*Number* concepts: Number concept development and counting form an integral part of the intervention and are referred to regularly in Chapter 2 and 3. Fuch & Fuch (2001) discuss the importance of conceptual understanding in order to facilitate application of procedural knowledge, and to accomplish long-term retention of procedural competence. Counting is a foundational component in mathematics and effective counting skills attribute to the ability to solve many mathematical problems (Van Vuuren, 2009). *Space, shape and measurement*: Van Vuuren (2009) emphasises that physical laws and relationships between the characteristics of various objects become apparent to the child through deductions made about colour, shape, function, size etc.	*Number* concepts: In the prototype's lesson plans additional emphasis was placed on number concepts and counting skills to ensure that all learners had a formal understanding of counting to at least until ten and the number concepts associated with the skills. *Space, shape and measurement*: Space and measurement formed a small part of the intervention, whereas shape was not included. The reason for the exclusion and minimal inclusion of the above mentioned concepts were decided upon in terms of time constraints and prioritising the importance of attaining certain concepts in the time period.
Theme 3: **Level appropriateness**	It was found in the interviews that careful attention needed to be paid to the individual school performance levels as the learners would most likely come from different backgrounds and therefore the low performance school's learners may potentially have experienced probable extrinsic barriers.	*Extrinsic barriers*: Extrinsic barriers were discussed in detail in Chapter 2 (Section 2.4.1) and refer to learning influences that occur outside the child as an entity and that are imposed by society or the environment (Engelbrecht & Swanepoel, 2009).	For the prototype a class observation prior to implementation was performed by the researcher in order to ascertain the level of the classes' ability. In addition, information attained through data collection in cycle 5 (interviews with class teachers) was utilised to further garner the level of the learners. Once the information was attained the prototype was adjusted for each individual school based on the learners' levels and abilities.

5.3 CYCLE 5

In Cycle 5, two means of data collection were utilised in order to improve the intervention prototype. Firstly, an assessment walk-through with two learners of the target audience to determine if the assessment was age, level and time appropriate. In addition administration ease was noted. A higher performing and a lower performing learner where selected for the walk-through; this information was attained from the class teacher following the learners' performance from the beginning of the school year through to the time of the intervention implementation. Data was attained by means of observation and a checklist, in addition the assessment was timed for each learner in order to determine the average time expected per learner when conducting the assessment.

The second means of data collection was attained through pre-interviews with the class teachers of the relevant Grade 1 classes (control and experimental classes). School A and B's interview data will be discussed independently as data garnered from each individual school will be utilised to enhance the prototype for each school respectively. As discussed in the introduction, improvement of practicality is focused on in this cycle and once the cycle was completed the prototypes emerged ready for implementation in the two schools.

5.3.1 ASSESSMENT INSTRUMENT WALK-THROUGH

The researcher observed and timed the two learners from the target population to determine time appropriateness, administration ease and level/age appropriateness of the assessment instrument. Data and findings for the walk-through are represented in Table 5.2.

Table 5.2: Data and findings for assessment instrument walk-through

	Detail	Data	Findings
Time appropriate	Both tests were timed to establish an average	Learner A: 8min12 sec Learner B: 9min52sec	Time taken to complete the assessment was appropriate.
Administration	The researcher read the questions out to the learners. Observations were noted in terms of learner pauses owing to misunderstanding and how often a question would have to be repeated.	Recurrent misunderstanding occurred with the item "Which number is closer?" This concept presented as foreign to the learners and they used their fingers to try and measure the distance between the numbers on the triangle rather than understanding which number is closer on a number line. This was a higher order thinking question and was intended to challenge learners.	The administration of the assessment instrument ran smoothly with minimal pauses owing to misunderstanding and few instances where questions needed to be repeated.
Age appropriate and level	Learners utilised for the trial run were selected as a higher performing	The results that learner A and B attained were within the same percentile benchmarks relevant to	The results of the walk-through determined the assessment tool to be

appropriate	and lower performing individual.	mathematics ability (higher *versus* lower performing) that had been established by the teacher from the start of the academic year through to the time of implementation. ***Learner A percentile benchmark:*** 80-90% ***Learner A assessment score:*** 86% ***Learner B percentile benchmark***: 60-70% ***Learner B assessment score***: 69% Neither child lost interest in the assessment showing that it engaged them successfully.	effective in age and level appropriateness. Learners responded adequately to questions, instructions and what was expected of them.

Following the walk-through with the Grade 1 learners to improve *practicality*, the intervention's assessment tool was deemed appropriate for implementation in Phase III of the design process.

5.3.2 Pre-interview with Class teachers

The purpose of the pre-interviews with the Grade 1 class teachers was to further refine the intervention to adapt it specifically for the particular school in which it was to be implemented. The schools were established to be of different performance levels as identified by the SAMP project (Scherman et al., 2013). School A was a high performance school and School B a low performance school.

5.3.2.1 School A

In the analysis of the interview data, attained from the two class teachers of school A, two main themes emerged: *mathematical learning difficulties* and *accommodation.* These two themes emerged owing to the focus of the questions posed to the teachers in that the researcher needed detailed information about what learning difficulties arise most often in that specific school as well as what accommodation measures are put in place by the teachers in order to counter act said learning difficulties. This allowed for sufficient adjustment of the prototype for the specific school in order to ensure enhanced practicality and potentially improved effectiveness in Phase III of the intervention design. In Figure 5.2, the codes and sub-codes that make up the themes are represented. Following the figure, the themes and their supporting data will be discussed and broken down into their relevant contributing codes. This section concludes with a full presentation of the themes, results, supporting literature and the adaptations to the intervention according to findings.

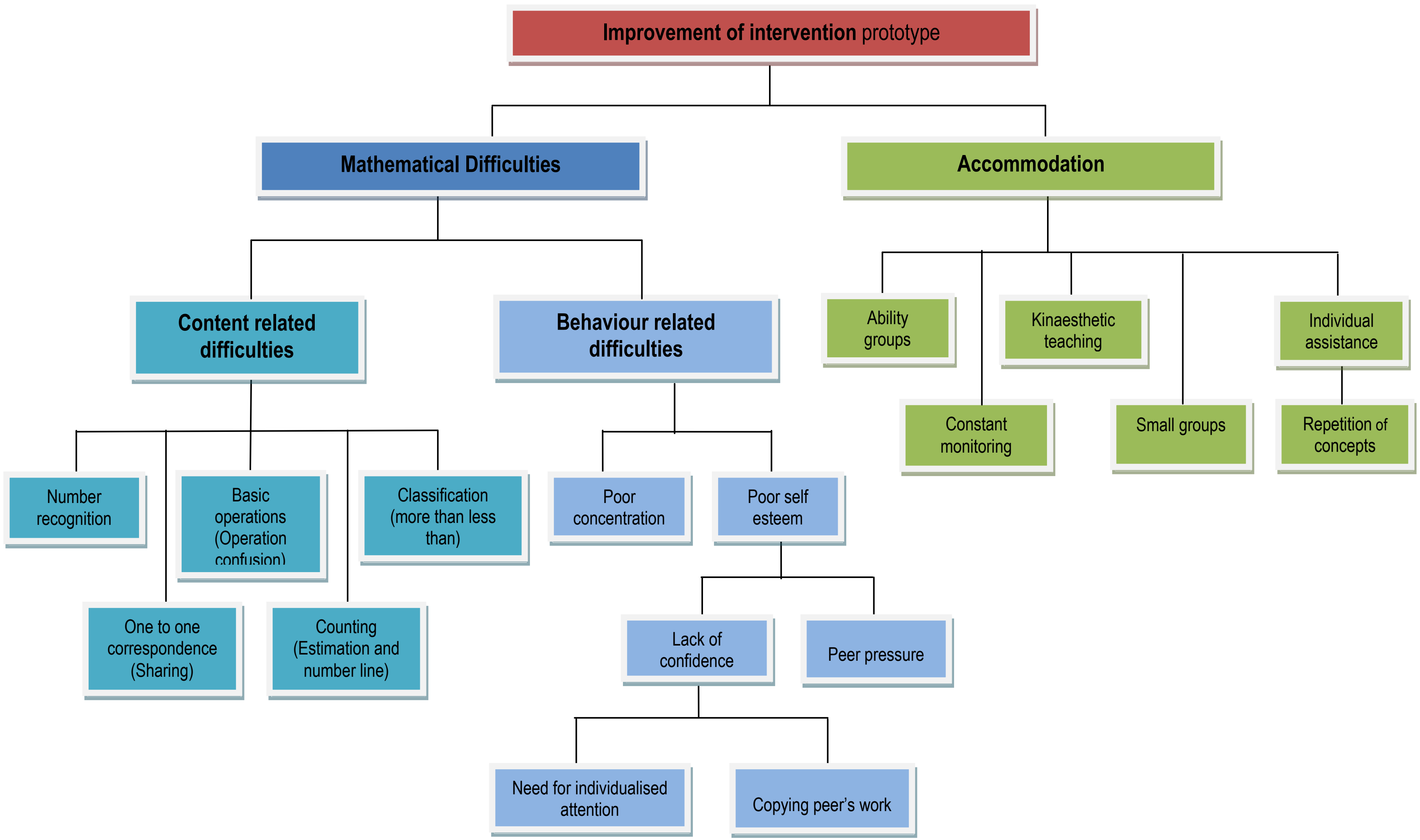

Figure 5.2: Theme and code representation for Cycle 5 (School A)

Mathematical learning difficulties. The concept of mathematical learning difficulties is discussed extensively in Chapter 2 (Section 2.4). MLD according to Geary (2004, p. 4) "can result from deficits in the ability to represent or process information in one or all of the many mathematical domains (e.g., geometry) or in one or a set of individual competencies within each domain." Within the theme of MLD two sub-themes emerged including: Content related difficulties and Behaviour related difficulties. In Table 5.3 the sub-themes and supporting data from the interview with the teachers (T1 & T2) will be represented.

Table 5.3: Representation of the codes and supporting data relevant to the themes of Content related difficulties and Behaviour related difficulties: School A

Content related difficulties	
Code	**Data**
Number recognition	**T1:** "I think the basics most of them can grasp up until about five and then it gets a bit more tricky and then sort of after ten I find it's just really difficult for them even though it's the same concept, they struggle with the bigger numbers."
One-to-one correspondence (Sharing)	**T1:** "Sharing, I find my kids are grasping it better than my kids last year, there is a problem when there is one left over, they can do it if its equal but then they don't realise when there is one left over at the end that it must be halved, they tend to put it with the first one and then the second one gets less. They don't realise it at the end."
Basic operations (Operation confusion)	**T1:** "I find subtraction is very difficult for them to grasp, they get addition fairly quickly but then if you do addition and subtraction on the same day, they get completely confused. I find that you have to do them on different days otherwise they just don't understand." **T2:** "… also especially when we start addition and subtraction then they get confused and they lose confidence." "Mostly subtraction for some reason. Subtraction confuses them for some reason."
Counting (Estimation and number line)	**T1:** "And I find that estimating, they have no idea, they can't tell you how much they think it is they have to count otherwise their estimation is completely off, say if there is five they will say twelve because they just have no concept of ja, estimating."
Classification (More than, less than)	**T1:** "They struggle with more and less a lot."
Behaviour related difficulties	
Code	**Data**
Poor concentration	**T2:** "… but I would say concentration. I find that they can't concentrate and can't finish tasks."
Poor self esteem	**T1:** "They get very shy and um they tend to sort of, I'd rather not ask my teacher in case she shouts at me. Which I would never do, unless they are not listening or paying attention which is a different story but that's a big thing for me, that the kids just don't ask me if they don't understand." "… I find also that the other kids can be very cruel to a kid that struggles. Lots of teasing, lots of laughing and pointing fingers and it's really not nice and I try and encourage that even if your answer is wrong it doesn't matter as long as you tried."

	T2: "Um, ok also, confidence. They lose confidence if they don't get it immediately and they get scared of maths, even at an early age and also especially when we start addition and subtraction then they get confused and they lose confidence. "… the kids that are slower, um, they don't finish a task and if you don't give them individual attention they won't finish it or they lose focus and complete it just to get it done."

Accommodation. Focused on the methods employed by the teachers to assist learners displaying mathematical difficulties (regardless of whether constant or periodical) (National Center for Learning Disabilities 2006, para. 1). In Table 5.4 the codes and supporting data from the interview with the teachers (T1 & T2) will be represented.

Table 5.4: Representation of the codes and supporting data relevant to the theme of Accommodation: School A

Code	Data
Ability groups	**T2:** "Well I usually divide them into groups and then I work with the group alone and give the other groups that go faster something more advanced and then I focus on the basic again in the weak group. I divide my learners from the beginning of the year into groups, the weak learners are put together and the strong learners are put together so I can help the weak learners."
Constant monitoring	**T1: "**When I teach a concept then I walk around the whole time and if I see that they are struggling then I show them again with the specific problem we're busy with because we do a lot of it with our whiteboards."
Kinaesthetic teaching	**T1:** "Oh something else I do is I try to show them practically. I try to use blocks or something to help them."
Small groups	**T1:** "I also take them in small groups onto the carpet with their whiteboards to help them."
Individual assistance	**T1:** "If I still find that they are struggling then I call them to my table at another time and explain it again and again and we just repeat it over and over."

Table 5.5: Pre-Interview with teachers School A: Presentation of the themes, results, literature and the adaptations to the intervention according to findings

Theme	Results	Literature	Prototype adaptations according to findings
Theme 1: **Mathematical learning difficulties**	The questions "What difficulties have you faced with regards to learners grasping new material?" and "What area/s of mathematics do you find your learners have the most problems with grasping?" were presented to the teachers. Both teachers acknowledged that certain learners often display difficulties and these difficulties culminated into two sub-themes: *Content related* and *Behaviour related difficulties.*	Mathematical learning difficulties are discussed in detail in Chapter 2 (Section 2.4). MLD or more appropriately arithmetic difficulties (attributing to the relevance towards young children) (Geary 2004, p. 4) can be attributed to intrinsic and/or extrinsic barriers affecting the child (Van Vuuren, 2009).	MLD is a core theme of this study. The interviews with the teachers isolated the relevant themes applicable to MLD that were specific to the individual school including the relevant barriers effecting said school and allowed the intervention to be adapted accordingly.

Sub-theme 1.1: *Content related difficulties*	The teachers identified various codes that culminated in the theme of content related difficulties. The codes included: number recognition, one-to-one correspondence, basic operations (operation confusion), Counting (Estimation and number lines) and classification (more than and less than).	As discussed at length in Chapter 3 (Section 3.3.6) the isolated concepts identified by the teachers, form part of the primary concepts a learner needs in order to improve their mathematics ability (Van Vuuren, 2009).	The prototype was adjusted to ensure that the above mentioned concepts received more emphasis in order to counteract the learners' specific difficulties.
Sub-theme 1.2: *Behaviour related difficulties*	The second sub-theme that emerged from the interview with the teachers was behaviour related difficulties. These difficulties are a result of: environmental influences which result in internal behaviours exhibited by the child and normal age expected behaviour. The codes that emerged were: poor self esteem and poor concentration. *Poor self esteem:* Two contributions emerged. Firstly, *peer pressure*, whereby peers would mock weaker learners when a question was answered incorrectly. Secondly, *lack of confidence* which manifested in the constant need for individualised attention from the teacher and further in the copying of a peers work, with the child desperate to impress the teacher and their peers by getting the answer correct. *Poor concentration:* One of the teachers mentioned that learner concentration is a large problem in trying to get them to grasp new concepts and to finish tasks.	*Poor self esteem:* According to Furrer, Skinner and Pitzer (2014, p. 101), learners perform better in academics when they feel accepted and encouraged particularly by their peers. Whilst Dowker (2005) enforces the need for individualised attention in order to benefit a learner in improving mathematics results, learners who are too dependent on assistance and approval from a teacher (or peer) usually have low self esteem owing to the fear of not performing well (Caldwell et al. 2005). *Poor concentration:* Learners need to be taught how to learn and how to pay attention. There are a large amount of learners that have not learnt the skill of paying attention (Whitehead 2013, p. 1). According to a study conducted by, Ialongo, Werthamer, Kellam, Brown, Wang and Lin (1999, p. 634) it is suggested that the early risk of poor concentration skills are malleable in Grade 1, especially for boys.	*Poor self esteem:* Prototype modification in this regard would be addressed on a behavioural level with the researcher enforcing in every lesson the importance of acceptance and encouragement regardless of each learner's ability. The constant fear and insecurity displayed by certain learners needed to be abated in a similar manner to the fear of peer opinions, learners were encouraged in their individual abilities to teach them that they do not need constant affirmation and that making a mistake is not frowned upon. In addition to the behavioural modification of the researcher a reliance on modifications in terms of concept focus of the intervention was enhanced. *Poor concentration:* Activities were kept short and fun. Lessons were made more kinaesthetic to get the learners up and active.
Theme 2: **Accommodation of learners with LD**	Techniques identified through the interview that the teachers employed to accommodate learners with mathematical difficulties included: *learners being divided into ability groups*, *kinaesthetic learning*, *constant monitoring* and *individual assistance.*	*Learners being divided into ability groups:* Dividing learners into ability groups, whilst assisting the teacher in accommodating learning (Engelbrecht & Swanepoel, 2009, p. 83), has shown to not be the best means of accommodation for learners. A study by Butler (2008), showed that learners labelled high performing and allocated to said group where less likely to seek help. Equally, ability grouping does not increase the willingness of low performing learners to	*Learners being divided into ability groups:* In prototype adjustment, the method of ability grouping will not be utilised in the classroom. The only 'grouping' that occurred was the remedial group that was given extra attention outside of class time and learners were not made aware of their ability level. *Kinaesthetic learning:* The use of kinaesthetic learning to improve concept

		seek help. In addition to the lack of seeking help and ensuring a concept is understood, learners are very self aware with regard to differentiating characteristics and labelling them at an early age can be detrimental, this links to previous statements about the influence of peer opinions (pressure) and lack of confidence in abilities. *Kinaesthetic learning*: As discussed in Section 5.2, every learner learns differently, some are visual learners, some are auditory and some kinaesthetic learners (Gilakjani, 2011, p. 104). *Constant monitoring*: Chapter 3 (Section 3.2) described the importance of constant monitoring of learners and how it plays a vital aspect of the RTI model (Van der Heyden & Jimerson, 2005, p. 24). *Individualised attention*: Individualised attention for a learner with difficulties is of great importance as discussed in Chapter 2 with regards to preventative teaching. Further emphasising the importance of the concept, Dowker's (2005) conducted a study where two interventions were identified stemming from an individualised basis of addressing MD's, the Mathematics Recovery program and the Numeracy Recovery program. Both interventions were shown to be successful in improving learners Mathematics skills.	attainment has already been discussed in Section 5.2. *Constant monitoring*: The prototype did not require adaptation as this was implemented in terms of the periodic assessment (pre, intermediate and post) as well as in the classroom situation where the researcher monitored learner progress through observations and worksheet informal assessments. *Individualised attention*: Within the intervention prototype individualised attention was given to the learners identified as having mathematics learning difficulties.

5.3.2.2 School B

Owing to the same aims for garnering information as the pre-interviews performed at school A, an analysis of data for the pre interview with the teachers from school B yielded the same two themes: *mathematical learning difficulties* and *accommodation*. The school specific codes that emerged and contributed to the themes will be discussed as they were in the previous section. In Figure 5.3, the codes and sub-codes that make up the themes are represented. Following the figure, the themes and their supporting data will be discussed and broken down into their relevant contributing codes. This section concludes with a full presentation of the themes, results, supporting literature and the adaptations to the intervention according to findings.

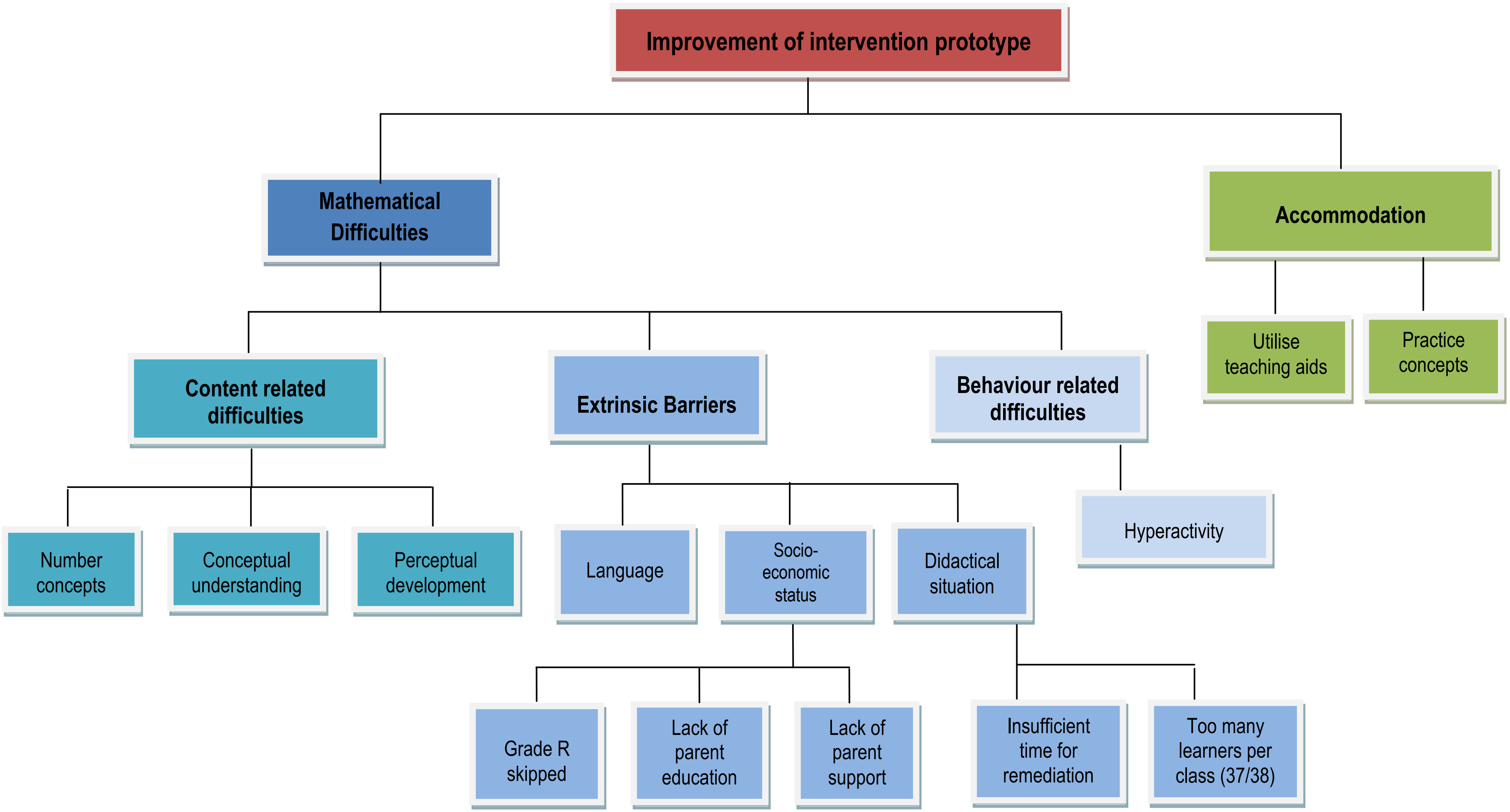

Figure 5.3: Theme and code representation for cycle 5 (School B)

Mathematical learning difficulties. This theme coincides with that of school A and as a result will not be defined again. Within the theme of MLD three sub-themes emerged including: Content related difficulties, Extrinsic Barriers and Behaviour related difficulties. In Table 5.6 the sub-themes and supporting data from the interview with the teachers (T1 & T2) will be represented.

Table 5.6: Representation of the codes and supporting data relevant to the themes of Content related difficulties and Behaviour related difficulties: School B

Content related difficulties	
Code	**Data**
Number concepts	**T1:** "Um, definitely basic number concepts. Counting, number concepts, number values and that all adds to they don't know what is more they don't know what is less so basic number concepts that they had to teach in Grade R basically and that is Grade R work." "They can't have basic, um, under, up, underneath, that basic concepts then they struggle to do basic maths." **T2: "**I think the number concepts."
Conceptual understanding	**T1:** "Um, definitely basic number concepts. Counting, number concepts, number values and that all adds to they don't know what is more they don't know what is less so basic number concepts that they had to teach in Grade R basically and that is Grade R work." **T2:** "it becomes very difficult for them to understand a concept especially in the first term."
Perceptual development	**T1:** "…not all of the children attended Grade R so they do not have the perceptual development that is needed and with CAPS they took away the whole perceptual program from Grade 1 and they gave it to Grade R but Grade R is not compulsory and a lot of the children did not attend it and that is my big problem." "… they don't have the perceptual skills needed because mathematics relies a lot on perceptual development. They can't have basic, um, under, up, underneath, that basic concepts then they struggle to do basic maths."
Extrinsic barriers	
Code	**Data**
Language	**T1:** "Um, I think in our school environment it's language problems, it's the biggest problem that they don't always understand because English is not their first language…" **T2: "**I think the most difficult part, the most difficult thing is the language, because most of them, their language is the mother tongue and then when they come to school it's English first language, so it becomes very difficult for them to understand a concept especially in the first term."
Socio-economic status	**T1:** "… the problem is that not all of the children attended Grade R so they do not have the perceptual development that is needed and with CAPS they took away the whole perceptual program from Grade 1 and they gave it to Grade R but Grade R is not compulsory and a lot of the children did not attend it and that is my big problem." **T2:** "the other difficult part is we also don't have home support, we have parents that by the time they come back home it's already late in order for them to help their poor kids. We also have parents who can't afford…but you know with

	affordability, I don't believe that I think maybe we just have parents who are not well exposed, ja they are not yet exposed to the remedial world. Ja basically I think, ja, we do have so many problems.
Didactical situation	**T1: "…** I mean we have 37/38 Grade 1s in each class that it's difficult to get to each learner and to help that one learner because then you have a lot that is not part of the whole remedial process." **T2: "…** the large number that we have is also a huge problem because you will find that you have more children that don't understand and very few that understand and for you to give that individual remedial attention it is very, very difficult no matter how hard you can try or became very difficult for you as a teacher and most of our learners use public transport and even if you can say that you'll compromise and stay at school to teach the group that is really lacking up until maybe 4oclock but you won't have that time because at 13:45 they have to go. So no matter if you as a teacher have time to say I'm prepared to stay behind with group 1 and 2 but you won't have that chance."
Behaviour related difficulties	
Code	**Data**
Hyperactivity	**T2:** "I shall say the main part the most difficult part is the ignorance because they tend to be very much playful"

Accommodation. As stipulated with the theme of MLD, accommodation has been defined in the previous section regarding School A. In Table 5.4 the codes and supporting data from the interview with the teachers (T1 & T2) will be represented.

Table 5.7: Representation of the codes and supporting data relevant to the theme of Accommodation: School B

Code	Data
Practice concepts	**T1: "**What I do is I usually give a lot of work for home and our grade 1's stay in school until 1:30 but we stop working at 13:00 because then our day program is over and the last half an hour I usually use practise. I have a hundred card and I let them count for me and we do basic work, reading work and basic plus minus, counting, number values." **T2: "**So from 12:30 to I think for about an hour I can take the learners who struggled to my table and I can show them. Also if there are a group of kids at a table I also have the opportunity of taking one child away from the table and helping them, but I can tell you it's so… it's not easy but that is the method I use. For me it's working."
Utilise teaching aids	**T2: "**When they see things things like when you give them "one plus one" and you show them the object then they understand much, much easier. But if you don't have teaching aids it becomes very difficult explaining things especially because the language is still the problem.

Table 5.8: Pre-Interview with teachers School B: Presentation of the themes, results, literature and the adaptations to the intervention according to findings

Theme	Results	Literature	Prototype adaptations according to findings
Theme 1: **Mathematical learning difficulties**	The questions "What difficulties have you faced with regards to learners grasping new material?" and "What area/s of mathematics do you find your learners have the most problems with grasping?" were presented to the teachers. Both teachers acknowledged that certain learners often display difficulties and these difficulties culminated into two sub-themes: *Content related, Extrinsic barriers* and *Behaviour related difficulties.*	Mathematical learning difficulties are discussed in detail in Chapter 2 (Section 2.4). MLD or more appropriately arithmetic difficulties (attributing to the relevance towards young children) (Geary (2004, p. 4) can be attributed to intrinsic and/or extrinsic barriers affecting the child (Van Vuuren, 2009).	MLD is a core theme of this study. The interviews with the teachers isolated the relevant themes applicable to MLD that were specific to the individual school including the relevant barriers effecting said school and allowed the intervention to be adapted accordingly.
Sub-theme 1.1: *Content related difficulties*	The teachers identified various codes that culminated in the theme of content related difficulties. The codes included: *Number concepts*, *conceptual understanding* and *perceptual development.* The above mentioned difficulties reveal as more foundation based especially when viewing the conceptual and procedural development of the child. Through the data analysis it was revealed that many learners in the classes did not attend Grade R, this is of primary concern for lack of particularly procedural knowledge (this will be elaborated upon further in the appropriate theme).	*Number concepts:* The literature supporting the importance of number concepts was already presented in Section 5.2. *Conceptual and procedural knowledge:* Mathematics competency involves the child's attainment of both conceptual and procedural knowledge (Rittle-Johnson & Schneider, 2014). DeCaro and Rittle-Johnson (2012, p. 552) identifies three methods to enhance conceptual and procedural knowledge: promoting comparison of alternative solution methods, prompting for self-explanation and providing opportunities for exploration before instruction.	*Number concepts:* The importance of number concepts was discussed in Section 5.2 and as a result of the data attained in cycle 3; the prototype was already adjusted to include more activities based on improving number concepts. *Conceptual and procedural knowledge:* With regard to the mentioned components featuring as primary difficulties in the learners of School B, an adjustment of the prototype involved a redesigning of lesson plans to focus on foundational maths, starting at the "beginning" in order to rectify problems to improve mathematics ability as a whole.
Sub-theme 1.2: *Extrinsic barriers*	Extrinsic barriers to learning that were identified through the data analysis were: *language*, *socio-economic status* and *didactical situation.*	The barriers affecting learners identified through the interview were discussed in detail in Chapter 2 (Section 2.4.1) but to reiterate extrinsic barriers are barriers that occur outside	*Language:* The prototype was adjusted to have more activities focused on mathematics vocabulary, practicing high frequency maths

	Language: The language barrier within School B occurred owing to the learners' first language not being English. The learners therefore struggled with new concepts owing to the language barrier, not understanding terms such as "how many altogether?" and "how many more are there?" for example. *SES:* The socio-economic status of learners was that of low income households where parents worked long hours leaving little to no support from home. In addition to the above mentioned, many parents had a poor education level thus not having the ability to assist learners even if they wanted to (less mathematics development support). A significant problem that arose from the low SES is that many learners did not attend Grade R (as it is an expense and not compulsory) and it is within this phase that procedural development on the curriculum level begins. *Didactical situation:* In the case of this school classes are very large, approximately 38 learners per class. This diminishes the chance for teachers to address learners who display difficulties. As determined from the interview data there are too many learners who perform poorly and not enough time is available to address them (they have to leave on a bus at 13:00 everyday).	the child as an entity and are imposed by society or the environment (macro and micro levels) (Van Vuuren, 2009). *Language:* A prominent shift has been attributed to the language-in-education policy which is failing South African learners (Heugh, 1999). Wium and Louw (2012, p. 8) support this statement acknowledging that a primary factor in the poor performance of South African learners in benchmark testing attributes to learners' inadequate language capabilities, as many learners did not understand what was expected of them in the assessments. *SES:* It has been shown that the socio-economic standing of a child has a great effect on their educational performance (Starkey et al., 2004, p. 99; Gersten et al., 2005, p. 297). *Didactical situation:* A general consensus exists that the amount of learners in a class affects the quality of education given to those learners (Hornsby, Osman & De Matos-Ala 2013, p. 8). However, class size does not stand in isolation as a determinant of poor performance additional didactical situation barriers contribute to the overall educational experience (Hornsby et al., 2013, p.8).	"words". *SES:* This barrier would be addressed (as discussed in Sub-theme 1.1) by focusing more intently on conceptual and procedural development. *Didactical situation:* This was unfortunately a difficult barrier to be addressed by the intervention. The classroom aspect of the intervention may show promise but the remedial phase would be difficult for teachers to implement.
Sub-theme 1.3: *Behaviour related difficulties*	The third sub-theme that emerged from the interview with the teachers was behaviour related difficulties. These difficulties are a result of: environmental influences which result in internal behaviours exhibited by the	Grade 1 learners are predisposed to energetic behaviour owing to their age; it is when the behaviour escalates to a disruptive level that behaviour influences learning negatively. Grade 1 learners that display negative	Prototype modification involved an adaptation for the researcher's teaching method. Discipline was a priority and the amount of kinaesthetic activities was lessened owing to

	child and normal age expected behaviour. The code that emerged was: Hyperactivity.	behaviour in terms of hyperactivity need as much structure as possible in the lesson (Toohey 1998, p. 67).	the potential of the class situation getting out of control.
Theme 2: Accommodation of learners with LD	Accommodation presented with only two methods and included: practising of concepts and utilising teaching aids. Firstly, concepts were practised for thirty minutes at the end of the day with learners who struggled; the time for practising would then additionally be divided between English and Mathematics giving learners inadequate time for sufficient concept understanding. This once again displays the teachers' inability to perform remediation with learners owing to time constraints and numbers of learners. Secondly, the teacher would utilise a teaching aid to demonstrate a concept to a learner who struggles owing to a language barrier using a teaching aid. For example showing the learner one pencil to emphasise the number one.	Individualised attention for a learner with difficulties is of great importance as discussed in Chapter 2 with regards to preventative teaching. Further emphasising the importance of the concept, Dowker's (2005) conducted a study where two interventions were identified stemming from an individualised basis of addressing MD's, the Mathematics Recovery program and the Numeracy Recovery program. Both interventions were shown to be successful in improving learners Mathematics skills. A study conducted by Ahmed, Clark-Jeavons and Oldknow, (2004) emphasises the importance of how utilising teaching aids in mathematics can improve performance.	Compounded with the didactical situation the data showed that the teachers simply do not have enough time to individually address all the learners effectively. The prototype was not modified in this regard as time was allocated for selected learners to receive remediation form the researcher as part of the intervention process. This will be discussed further in recommendations section in the final chapter of this study. In terms of teaching aids each learner was provided with Unifix cubes in addition to the teaching aids provided in the lesson to further assist learners in the conceptualisation of numbers.

5.4 PHASE III

Cycle 8 (School A) and 9 (School B) are within the final phase of the intervention process. Within Phase III the effectiveness of the intervention was tested. In this section School A and B's data will be analysed separately as in the previous section, in addition data analysis will be divided into qualitative and quantitative sections. The quantitative data (Section 5.4.1) was attained through the designed assessment tool. The assessment was administered at three intervals: pre-intervention, mid-intervention (intermediate) and post-intervention. The quantitative data section will be divided into two sub-sections. The first sub-section will address the overall comparison of tests between experimental and control groups throughout the intervention period (all three intervals). The second sub-section focuses on the remedial group, within this group the learners that where shown to have little to no improvement in the class room intervention where isolated and received intensive remediation. Quantitative data was analysed using the Wilcoxon sign-ranked test. Data (mean, mode, standard deviation, the V-value and p value) will be represented in tabular format and statistical significance will be represented graphically. The p value represented in the graphs has been converted to percentages to allow for clearer representation in the graphs. A percentage of 95% and higher represents a statistically significant result where it is the equivalent significance of $P \leq 0.05$. The qualitative data was attained from a post interview with the class teachers of the experimental groups. Within the qualitative data three categories where focused on in order to determine intervention effectiveness: intervention successes; intervention failures and implementation potential.

5.4.1 SCHOOL A

Through data attained from the SAMP project, School A was identified as a high performing school. According to the Phase II data analysis, learners' primarily presented with difficulties in content and behaviour. Extrinsic barriers were not identified as seriously affecting learners. The experimental group received the assessment and intervention whereas the control group received the assessment but not Phase II and III of the intervention.

5.4.1.1 Quantitative data

In this section the quantitative data attained from the assessment tool from School A will be discussed in terms of findings according to the Wilcoxon sign-ranked test. The overall comparison of tests between the experimental and control groups throughout the intervention period (all three intervals) will be discussed. This will be addressed by, firstly, presenting two tables (Table 5.6 and 5.3) displaying the comparison of the experimental group and control groups' mean, mode, standard deviation, V value and the significance (as alpha = 0.05) throughout the intervention period. Secondly, all of the sections (all three intervals) of the assessment tool (Number Knowledge Test; SAMP; Problem Solving) and the overall average of the assessment will be presented in terms of a comparison between the control and experimental groups. Lastly, the results of learners that received remedial support are isolated and the findings presented. It is important to remember that the experimental and control groups are viewed separately owing to sample discrepancy (See Chapter 4, Section 4.5.2.1). Further, if the computed p value is lower than the significance level alpha=0.05, one should reject the null hypothesis H_0, and accept the alternative hypothesis H_a.

5.4.1.1.1 Overall comparison of tests between experimental and control groups throughout the intervention period (all three intervals)

Table 5.9 displays the comparison of the experimental group's mean, mode, standard deviation, V-value and the significance (as alpha =0.05) throughout the intervention period, and Table 5.10 display the comparison of the control group's mean, mode, standard deviation, V-value and the significance (as alpha = 0.05) throughout the intervention period

Table 5.9: Comparison of the experimental group's mean, mode, standard deviation, V-value and the significance (as alpha =0.05) throughout the intervention period

Assessment	Interval Comparison	PRE			INT			POST			V value	Significance (p value)
		mean	mode	SD	mean	mode	SD	Mean	mode	SD		
Number Knowledge	PRE - INT	71.4	61.5	15.4	85.4	100	14.6	-	-	-	25	0.001
	INT-POST	-	-	-	85.4	100	14.6	94.2	100	10.6	21	0.005
	PRE - POST	71.4	61.5	15.4	-	-	-	94.2	100	10.6	0	<0.0001
SAMP	PRE - INT	92	100	8.197	94.3	100	6.1	-	-	-	64	0.211
	INT-POST	-	-	-	94.3	100	6.1	93.7	100	8.3	54.5	0.924
	PRE - POST	92	100	8.197	-	-	-	93.7	100	8.3	33	0.127
Problem Solving	PRE - INT	76.4	100	32.2	86.4	100	25.6	-	-	-	16	0.071
	INT-POST	-	-	-	86.4	100	25.6	95.7	100	15.8	0	0.020
	PRE - POST	76.4	100	32.2	-	-	-	95.7	100	15.8	0	0.005
Average	PRE - INT	82.1	77.143	9.6	89.9	100	8.9	-	-	-	19	0.0001
	INT-POST	-	-	-	89.9	100	8.9	94.2	100	6.9	18.5	0.001
	PRE – POST	82.1	77.143	9.6	-	-	-	94.2	100	6.9	0	<0.0001

Table 5.10: Table displaying the comparison of the control group's mean, mode, standard deviation, V-value and the significance (as alpha = 0.05) throughout the intervention period

Assessment	Interval Comparison	PRE			INT			POST			V value	Significance (p value)
		mean	mode	SD	mean	mode	SD	mean	mode	SD		
Number Knowledge	PRE - INT	73.3	76.9	18.6	74.4	76.9	18.8	-	-	-	16.5	0.888
	INT-POST	-	-	-	74.4	76.9	18.8	73.3	53.9	16.4	40	0.561
	PRE - POST	73.3	76.9	18.6	-	-	-	73.3	53.9	16.4	43	0.783
SAMP	PRE - INT	92.9	100	7.5	91.8	94.1	7.1	-	-	-	64	0.605
	INT-POST	-	-	-	91.8	94.1	7.1	90.9	100	9.3	54.5	0.858
	PRE - POST	92.9	100	7.5	-	-	-	90.9	100	9.3	33	0.721
Problem Solving	PRE - INT	81.3	100	28.7	88	100	27.1	-	-	-	6	0.395
	INT-POST	-	-	-	88	100	27.1	82.7	100	26.2	15	0.387
	PRE - POST	81.3	100	28.7	-	-	-	82.7	100	26.2	20.5	0.858
Average	PRE - INT	84	88.6	11.9	84.8	88.6	12.2	-	-	-	23.5	0.721
	INT-POST	-	-	-	84.8	88.6	12.2	83.2	88.6	11.7	73	0.205
	PRE - POST	84	88.6	11.9	-	-	-	83.2	88.6	11.7	46	0.609

Number knowledge. There was a statistically significant improvement (V = 25, p= 0.001) in the number knowledge test results of experimental group learners between the pre ($\bar{x}$ 71.4%, mode 61.5%, SD 15.4) and intermediate ($\bar{x}$ 85.4%, mode 100%, SD 14.6) assessment intervals. There was no significant improvement (V=16.5, P=0.888) in the number knowledge test results of the control group learners between the pre ($\bar{x}$ 73.3%, mode 76.9%, SD 18.6) and intermediate ($\bar{x}$ 74.4%, mode 76.9%, SD 18.8) assessment intervals.

There was a statistically highly significant improvement (V=21, p = 0.005) in the Number Knowledge test results of the experimental group between the intermediate ($\bar{x}$ 85.4, mode 100%, SD 14.6) and post ($\bar{x}$ 94.2%, mode 100%, SD 10.6) assessment intervals. There was no significant improvement (V= 40, p= 0.561) in the number knowledge test results of the control group learners between the intermediate ($\bar{x}$ 74.4%, mode 76.9%, SD 18.6) and post ($\bar{x}$ 73.3%, mode 53.9%, SD 16.4) assessment intervals.

There was a statistically very highly significant improvement (V= 0, p <0.0001) in the number knowledge test results of experimental group learners between the pre ($\bar{x}$ 71.4%, mode 61.5%, SD 15.4) and post ($\bar{x}$ 94.2%, mode 100%, SD 10.6) assessment intervals. There was no significant improvement (V= 43, p= 0.783) in the number knowledge test results of the control group learners between the pre ($\bar{x}$ 73.3%, mode 76.9%, SD 18.6) and post ($\bar{x}$ 73.3%, mode 53.9%, SD 16.4) assessment intervals. Refer to Figure 5.4.

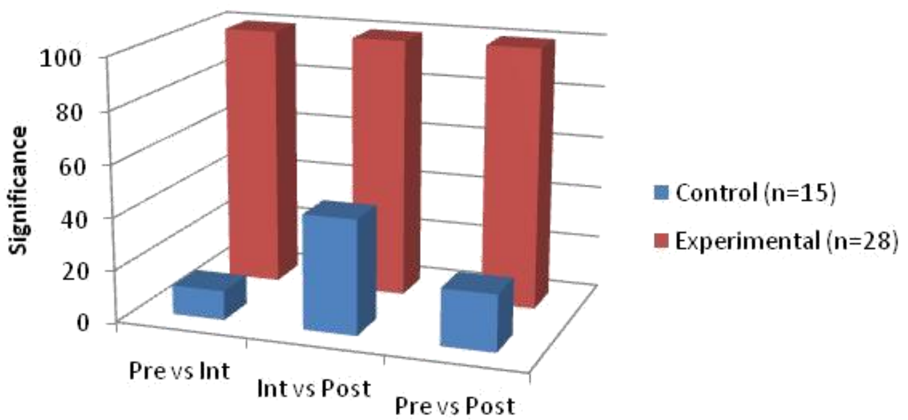

Figure 5.4: Overall comparison of Number Knowledge test (all three intervals) between experimental and control groups (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of p≤0.05)

SAMP. There was no significant improvement (V= 64, p= 0.211) in the SAMP test results of the experimental group learners between the pre ($\bar{x}$ 92%, mode 100%, SD 18.6) and intermediate ($\bar{x}$ 94.3%, mode 100%, SD 6.1) assessment intervals. There was no significant improvement (V= 17.5, p= 0.605) in the SAMP test results of the control group learners between the pre ($\bar{x}$ 92.9%, mode 100%, SD 7.5) and intermediate ($\bar{x}$ 91.8%, mode 94.1%, SD 7.1) assessment intervals.

There was no significant improvement (V= 54.5, p= 0.924) in the SAMP test results of the experimental group learners between the intermediate ($\bar{x}$ 94.3%, mode 100%, SD 6.1) assessment intervals and post

($\bar{x}$ 93.7%, mode 100%, SD 8.3) assessment intervals. There was no significant improvement (V= 24.5, p= 0.858) in the SAMP test results of the control group learners between the intermediate ($\bar{x}$ 91.8%, mode 94.1%, SD 7.059) and post ($\bar{x}$ 90.9%, mode 100%, SD 9.3) assessment intervals.

There was no significant improvement (V= 33, p= 0.127) in the SAMP test results of the experimental group learners between the pre ($\bar{x}$ 92%, mode 100%, SD 18.6) and post ($\bar{x}$ 93.7%, mode 100%, SD 8.3) assessment intervals. There was no significant improvement (V= 26, p=0.721) in the SAMP test results of the control group learners between the pre ($\bar{x}$ 92.9%, mode 100%, SD 7.5) and post ($\bar{x}$ 90.9%, mode 100%, SD 9.3) assessment intervals. Refer to Figure 5.5.

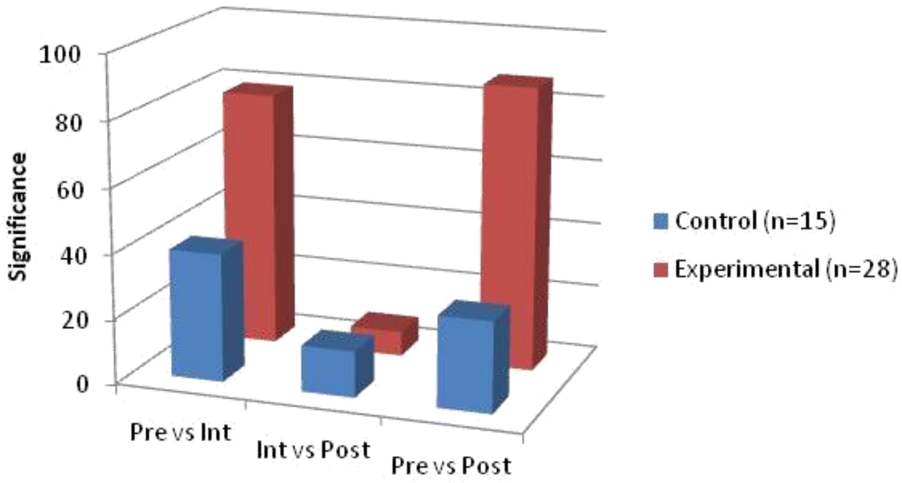

Figure 5.5: Overall comparison of SAMP test (all three intervals) between experimental and control groups (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

Problem Solving. There was no significant improvement (V= 16, p=0.071) in the Problem solving test results of the experimental group learners between the pre ($\bar{x}$ 76.4%, mode 100%, SD 32.2) and intermediate ($\bar{x}$ 86.4%, mode 100%, SD 25.6) assessment intervals. There was no significant improvement (V= 6, p=0.395) in the Problem solving test results of the control group learners between the pre ($\bar{x}$ 81.3%, mode 100%, SD 28.7) and intermediate ($\bar{x}$ 88%, mode 100%, SD 27.1) assessment intervals.

There was a statistically significant improvement (V= 0, p = 0.020) in the Problem solving test results of the experimental group between the intermediate ($\bar{x}$ 86.4, mode 100%, SD 25.6) and post ($\bar{x}$ 95.7%, mode 100%, SD 15.7) assessment intervals. There was no significant improvement (V= 15, p=0.387) in the Problem solving test results of the control group learners between the intermediate ($\bar{x}$ 88%, mode 100%, SD 27.1) and post ($\bar{x}$ 82.7%, mode 100%, SD 26.2) assessment intervals.

There was a statistically significant improvement (V= 0, p= 0.005) in the Problem solving test results of the experimental group between the pre ($\bar{x}$ 76.4%, mode 100%, SD 32.2) and post ($\bar{x}$ 95.7%, mode 100%, SD 15.7) assessment intervals. There was no significant improvement (V= 20.5, p= 0.858) in the

Problem solving test results of the control group learners between the pre ($\bar{x}$ 81.3%, mode 100%, SD 28.7) and post ($\bar{x}$ 82.7%, mode 100%, SD 26.2) assessment intervals. Refer to Figure 5.6.

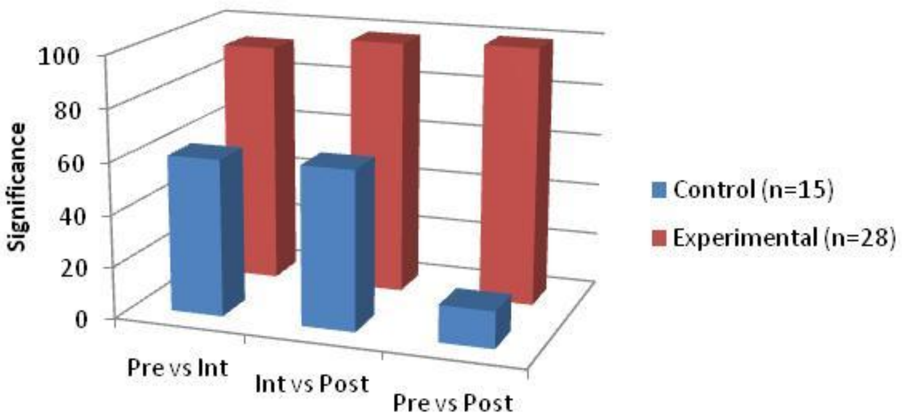

Figure 5.6: **Overall comparison of the Problem solving test (all three intervals) between experimental and control groups (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of *P*≤0.05)**

Combined Average. There was a statistically highly significant improvement (V= 19, p= 0.001) in the combined average of the test results of experimental group learners between the pre ($\bar{x}$ 82.1%, mode 77.1%, SD 9.6) and intermediate (x-bar 89.9%, mode 100%, SD 8.9) assessment intervals. There was no significant improvement (V= 23.5, p= 0.721) in the combined average of test results of the control group learners between the pre ($\bar{x}$ 84%, mode 88.6%, SD 11.9) and intermediate ($\bar{x}$ 84.8%, mode 88.6%, SD 12.2) assessment intervals.

There was a statistically highly significant improvement (V= 18.5, p= 0.001) in the combined average of test results of the experimental group between the intermediate (x-bar 89.9, mode 100%, SD 8.9) and post ($\bar{x}$ 94.2%, mode 100%, SD 6.9) assessment intervals. There was no significant improvement (V= 73, p= 0.205) in the Combined average of test results of the control group learners between the intermediate ($\bar{x}$ 84.8%, mode 88.6%, SD 12.2) and post ($\bar{x}$ 83.2%, mode 88.6%, SD 11.7) assessment intervals.

There was a statistically very highly significant improvement (V= 0, P<0.0001) in the combined average of the test results of experimental group learners between the pre ($\bar{x}$ 82.1%, mode 77.1%, SD 9.6) and post ($\bar{x}$ 94.2%, mode 100%, SD 6.9) assessment intervals. There was no significant improvement (V= 46, p= 0.609) in the combined average of test results of the control group learners between the pre ($\bar{x}$ 84%, mode 88.6%, SD 11.9) and post ($\bar{x}$ 83.2%, mode 88.6%, SD 11.7) assessment intervals. Refer to Figure 5.7.

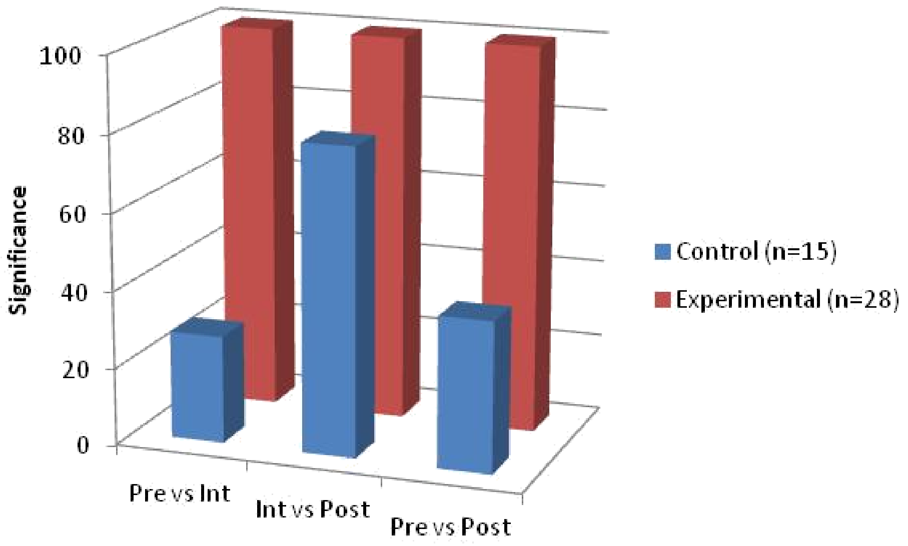

Figure 5.7: Overall comparison of the Combined average of all tests (all three intervals) between experimental and control groups (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

5.4.1.1.2 Remedial Group

Table 5.11 display the comparison of the remedial group's mean, mode, standard deviation and the significance (as alpha = 0.05) throughout the intervention period.

Table 5.11: Comparison of the remedial group's mean, mode, standard deviation and the significance (as alpha = 0.05) throughout the intervention period

Assessment	Interval Comparison	PRE			INT			POST			V value	Significance (p value)
		Mean	Mode	SD	mean	mode	SD	mean	mode	SD		
Number Knowledge	PRE – INT	67.9	69.2	10.2	62.8	61.5	5.8	-	-	-	3	0.371
	INT-POST	-	-	-	62.8	61.5	5.8	85.9	92.3	11.3	0	0.058
	PRE – POST	67.9	69.2	10.2	-	-	-	85.9	92.3	11.3	0	0.059
SAMP	PRE – INT	84.3	88.2	4.8	91.2	94.1	6.2	-	-	-	3	0.138
	INT-POST	-	-	-	91.2	94.1	6.2	92.2	100	7.1	4	0.854
	PRE – POST	84.3	88.2	4.8	-	-	-	92.2	100	7.1	0	0.054
Problem Solving	PRE – INT	76.7	100	40.8	86.7	100	20.7	-	-	-	1.5	0.586
	INT-POST	-	-	-	86.7	100	20.7	100	100	0	0	0.346
	PRE – POST	76.7	100	40.8	-	-	-	100	100	0	0	0.371
Average	PRE – INT	77.1	82.9	7.5	80	80	4.8	-	-	-	5	0.292
	INT-POST	-	-	-	80	80	4.8	90.9	88.6	4.9	0	0.058
	PRE - POST	77.1	82.9	7.5	-	-	-	90.9	88.6	4.9	0	0.036

Number Knowledge. The remedial group obtained scores that were not significant (V= 3, p= 0.371) in the Number knowledge test results between the pre ($\bar{x}$ 67.9%, mode 69.2%, SD 10.2) and the intermediate ($\bar{x}$ 62.8%, mode 61.5%, SD 5.8) assessment intervals.

The remedial group obtained scores that were not significant (V= 0, p= 0.058) in the Number knowledge test results between the intermediate ($\bar{x}$ 62.820%, mode 61.538, SD 5.790) and the post ($\bar{x}$ 85.897, mode 92.307%, SD 11.322) assessment intervals.

The remedial group obtained scores that were not significant (V= 0, p= 0.059) in the Number knowledge test results between the pre ($\bar{x}$ 67.9%, mode 69.2%, SD 10.2) and the post ($\bar{x}$ 85.9, mode 92.3%, SD 11.3) assessment intervals. Refer to Figure 5.8.

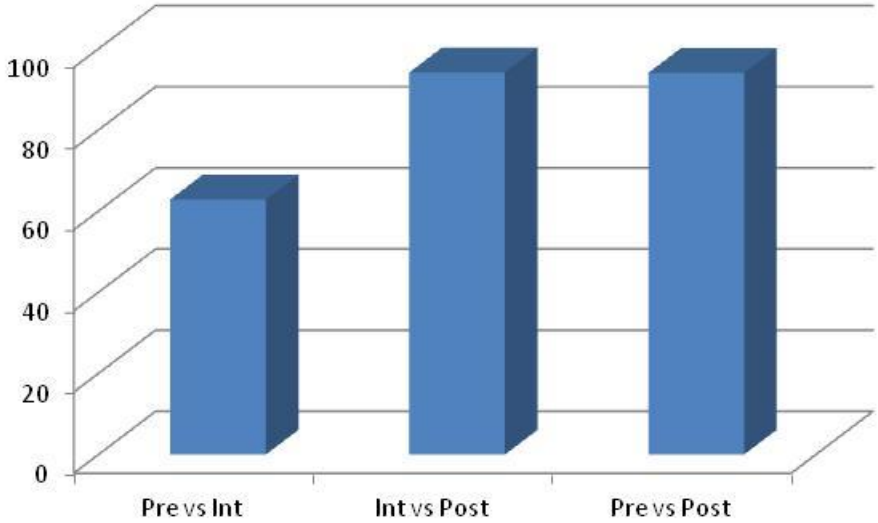

Figure 5.8: Number knowledge test interval comparison for remedial group (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

SAMP. The remedial group obtained scores that were not significant (V= 3, p= 0.138) in the SAMP test results between the pre ($\bar{x}$ 84.3%, mode 88.2%, SD 4.8) and the intermediate ($\bar{x}$ 91.2%, mode 94.1%, SD 6.2) assessment intervals.

The remedial group obtained scores that were not significant (V= 4, p= 0.854) in the SAMP test results between the intermediate ($\bar{x}$ 91.2%, mode 94.1%, SD 6.2) and the post ($\bar{x}$ 92.2%, mode 100%, SD 7.1) assessment intervals.

The remedial group obtained scores that were not significant (V= 0, p= 0.054) in the SAMP test results between the pre ($\bar{x}$ 84.314%, mode 88.235%, SD 4.803) and the post ($\bar{x}$ 92.157%, mode 100%, SD 7.1) assessment intervals. Refer to Figure 5.8.

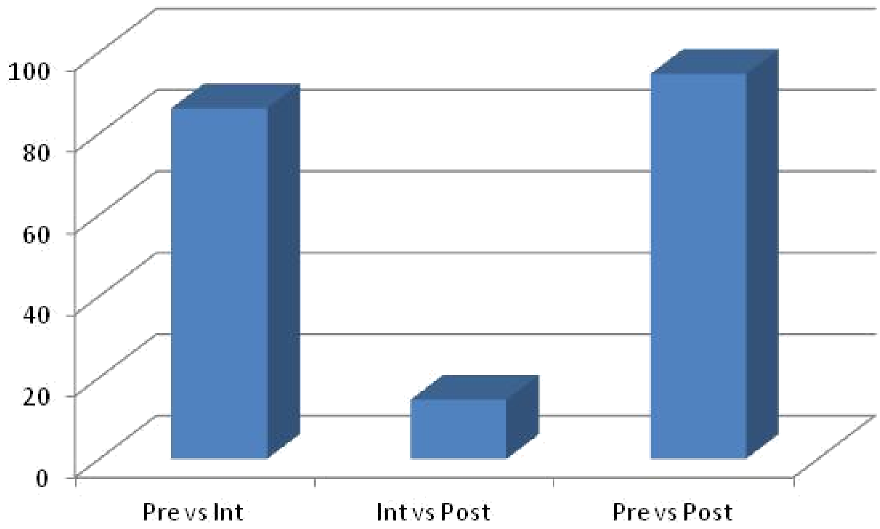

Figure 5.9: SAMP test interval comparison for remedial group (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

Problem solving. The remedial group obtained scores that were not significant (V= 1.5, p= 0.586) in the Problem solving test results between the pre ($\bar{x}$ 76.7%, mode 100%, SD 40.8) and the intermediate ($\bar{x}$ 86.7%, mode 100%, SD 20.7) assessment intervals.

The remedial group obtained scores that were not significant (V= 0, p= 0.346) in the Problem solving test results between the intermediate ($\bar{x}$ 86.7%, mode 100%, SD 20.7) and the post ($\bar{x}$ 100%, mode 100%, SD 0) assessment intervals.

The remedial group obtained scores that were not significant (V=0, p= 0.371) in the Problem solving test results between the pre ($\bar{x}$ 76.7%, mode 100%, SD 40.8) and the post ($\bar{x}$ 100%, mode 100%, SD 0) assessment intervals. Refer to Figure 5.9.

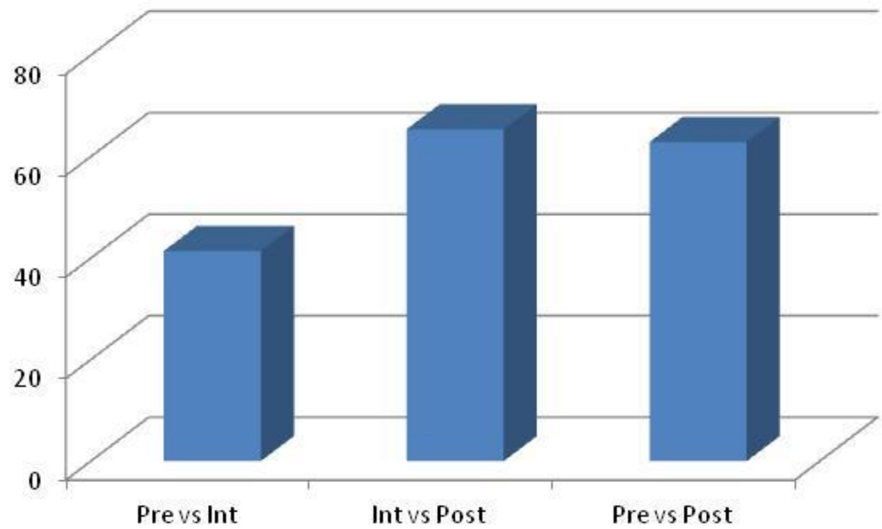

Figure 5.10: Problem solving test interval comparison for remedial group (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

Combined average. The remedial group obtained scores that were not significant (V= 0, p= 0.292) in the Combined average of all tests between the pre ($\bar{x}$ 77.1%, mode 82.9%, SD 7.5) and the intermediate ($\bar{x}$ 80%, mode 80%, SD 4.8) assessment intervals.

The remedial group obtained scores that were not significant (V=0, p= 0.058) in the Combined average of all tests between the intermediate ($\bar{x}$ 80%, mode 80%, SD 4.8) the post ($\bar{x}$ 90.9%, mode 88.6%, SD 4.9) assessment intervals.

The remedial group obtained scores that were significant (V= 0, p= 0.036) in the Combined average of all tests between the pre ($\bar{x}$ 77.1%, mode 82.9%, SD 7.451) the post ($\bar{x}$ 90.9%, mode 88.6%, SD 4.921) assessment intervals. Refer to Figure 5.11.

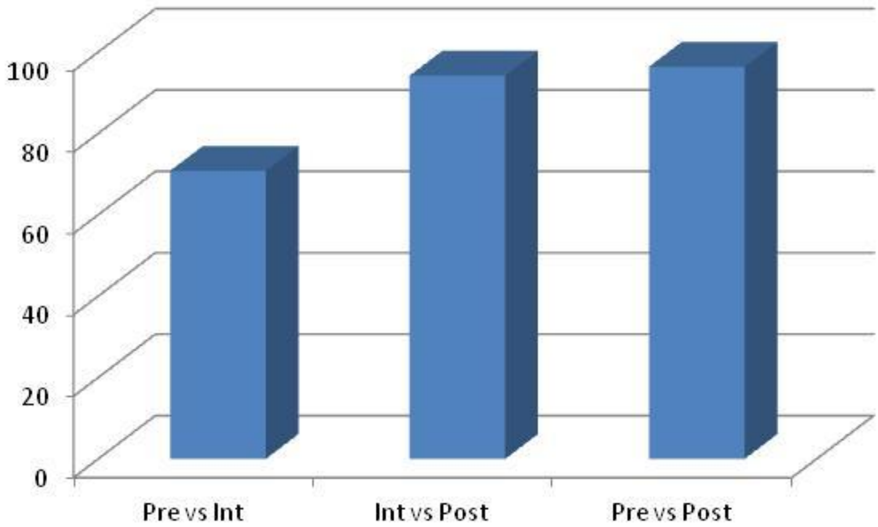

Figure 5.11: Combined average across all test intervals for remedial group (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

5.4.1.2 Qualitative data

The qualitative data attained through the interview with the experimental group teacher will be discussed in terms of findings following a thematic content analysis. The post interview with the experimental group teacher revealed data that is represented in Table 5.12.

Table 5.12: Themes and findings for post-interview with experimental group class teacher

Theme	Data	Findings
Intervention successes	"I must say I did notice that there was some improvement in some of the kids." "I was quite surprised when I did some plus sums with them and I was very surprised to see how many of them actually got the answers right."	1. Noticed improvement in some learners 2. Basic operations improved: Addition 3. Conceptual understanding (grasp concepts easier) 4. Learner enjoyment (Interactive and different)

	"I really do feel like they are grasping concepts easier." "I found it was really good, I found it very interactive and different from what we usually do in class and it was really nice for them."	
Intervention failures	"The only thing was the one exercise which we did speak about, where I found the task a bit too difficult for them. The one with the hidden words."	Age appropriateness in one activity (week x day x): Find the numbers
Implementation potential	"It was simple lessons where you used things that I could easily get a hold of." "The worksheets were also not complicated I would easily be able to replicate them. So I feel like it would be really easy to implement in my class as well." "Definitely! Especially after seeing the results then I feel it's definitely worth it."	1. Simple lessons 2. Teaching aids are easy to replicate 3. Worksheets not complicated 4. Easy to implement 5. Teacher would definitely implement if given the materials

In the post-interview with the class teacher from School A the intervention showed successful results. The teacher noticed an improvement in some learners overall as well as class-wide improvement in addition (basic operations), conceptual understanding and during the intervention the level of enjoyment. The teacher found the lessons simple, the teaching aids easy to replicate and the worksheets uncomplicated. The intervention was attributed as easy to implement especially if given the materials. The only negative comment was that relating to one activity within a lesson that was found to be a bit challenging for learners. The activity was aimed at challenging the learners but was found to be just outside their level of capabilities.

5.4.1.3 Synthesis of section

In the number knowledge test there was a statistically significant improvement throughout all the test intervals in the experimental group, where as there was no statistical significance for the results of the control group throughout the test intervals (Section 5.4.1.1). The learners were shown to have the lowest average for the Number Knowledge test showing great efficiency in the intervention of improving learner mathematics results in this particular section. The SAMP test did not show statistical significance in improving learners' marks in both the experimental and control groups and can be attested to the average high score the learners attained in the pre-test (Experimental: 92%, Control: 93%). This showed that the learners had a sound understanding of the content within the SAMP test (Section 5.4.1.1). The final test, Problem solving, did not show statistical significance in the pre-int interval with both the experimental and control groups. Statistical significance emerged with the int-post interval of the experimental group (improvement) with the control group showing no significance (Section 5.4.1.1). The final interval (pre-post) showed a statistical improvement in the experimental group, but not in the control. For the combined average of the tests, the experimental group showed a statistically significant result (improved), whereas the control group showed no significance (Section 5.4.1.1).

The remedial group was isolated to receive intensive support following the pre-int interval. The selected learners' score did not change between the first and second intervals. Therefore in the first interval, of all the tests, including the combined average there was no statistical significance. In the second interval (int-post), all the tests, including the combined average there was no statistical significance. In the final interval (pre-post), there was no statistical significance in all the tests, but the combined average did show a significant improvement (Section 5.4.1.1.2).

Following on the quantitative data analysis, the experimental group's teacher was interviewed to determine her opinions on the interventions successes, failures and potential for implementation. In terms of successes data revealed that: there was a noticed improvement in some learners; basic operations improved, specifically in addition; conceptual understanding improved (grasped concepts easier) and that learners enjoyed the intervention (interactive and different). A single failure was brought to the researcher's attention with regards to a specific lesson that was implemented that was too challenging for the learners. This was a lesson that was specifically designed to challenge learners' critical thinking and was adjusted in the class to make it easier. The final theme of implementation potential was met with positive results with acknowledgements made to: simple lessons, teaching aids are easy to replicate, worksheets not complicated, the intervention being easy to implement and that the teacher would definitely implement the intervention if given the materials (Section 5.4.1.2).

Results from the implemented intervention in School A showed great promise in terms of quantitative and qualitative data. A noticed inconsistency was that the remedial group did not show statistical significance in the test intervals barring the final combined average interval. This will be discussed further in the following chapter.

5.4.2 SCHOOL B

Through data attained from the SAMP project, School B was identified as a low performing school. According to the Phase II data analysis, learners' primarily presented with difficulties in content and behaviour. Extrinsic barriers were identified as seriously affecting learners. The experimental group received the assessment and intervention whereas the control group received the assessment but not Phase II and III of the intervention.

5.4.2.1 Quantitative data

In this section the quantitative data attained from the assessment tool from School B will be discussed in terms of findings according to the Wilcoxon sign-ranked test. As in the previous section, the overall comparison of tests between the experimental and control groups throughout the intervention period (all three intervals) will be discussed. This will be addressed by, firstly, presenting two tables (Table 5.6 and 5.7) displaying the comparison of the experimental group and control groups' mean, mode, standard deviation, V-value and the significance (as alpha = 0.05) throughout the intervention period. Secondly, all of the sections (all three intervals) of the assessment tool (Number Knowledge Test; SAMP; Problem Solving) and the overall average of the assessment will be presented in terms of a comparison between the control and experimental groups. Lastly, the results of learners that received remedial support are isolated and the findings presented. It is important to remember that the experimental and control groups are viewed separately owing to sample discrepancy (See Chapter 4, Section 4.5.2.1). Further, if the computed p value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0, and accept the alternative hypothesis Ha.

5.4.2.1.1 Overall comparison of tests between experimental and control groups throughout the intervention period (all three intervals)

The following Table 5.13 display the comparison of the experimental group's mean, mode, standard deviation, V-value and the significance (as alpha =0.05) throughout the intervention period, and Table 5.14 display the comparison of the control group's mean, mode, standard deviation, V-value and the significance (as alpha =0.05) throughout the intervention period.

Table 5.13: Table displaying the comparison of the experimental group's mean, mode, standard deviation, V-value and the significance (as alpha =0.05) throughout the intervention period

Assessment	Interval Comparison	PRE			INT			POST			V value	Significance (p value)
		Mean	mode	SD	mean	Mode	SD	mean	mode	SD		
Number Knowledge	PRE – INT	55.6	53.9	19.1	63.6	38.5	23.8	-	-	-	55.5	0.038
	INT-POST	-	-	-	63.6	38.5	23.8	68.5	100	24.8	67.5	0.166
	PRE – POST	55.6	53.9	19.1	-	-	-	68.5	100	24.8	3.5	0.001
SAMP	PRE - INT	78.9	100	16.9	81.6	100	13.8	-	-	-	25	0.159
	INT-POST	-	-	-	81.6	100	13.8	85.3	100	12.8	9	0.020
	PRE - POST	78.9	100	16.9	-	-	-	85.3	100	12.8	11.5	0.006
Problem Solving	PRE - INT	73.7	100	39.2	90	100	27.4	-	-	-	3.5	0.047
	INT-POST	-	-	-	90	100	27.4	92.7	100	20	6	0.784
	PRE - POST	73.7	100	39.2	-	-	-	92.7	100	20	0	0.021
Average	PRE - INT	69.5	77.1	15.4	76.1	65.7	16.4	-	-	-	20	0.002
	INT-POST	-	-	-	76.1	65.7	16.4	80.1	100	16.1	39.5	0.015
	PRE - POST	69.5	77.1	15.4	-	-	-	80.1	100	16.1	0	<0.0001

Table 5.14: Comparison of the control group's mean, mode, standard deviation, V-value and the significance (as alpha =0.05) throughout the intervention period

Assessment	Interval Comparison	PRE			INT			POST			V value	Significance (p value)
		Mean	mode	SD	mean	mode	SD	mean	mode	SD		
Number Knowledge	PRE - INT	51.8	46.2	18.6	55.9	76.9	21.4	-	-	-	46.5	0.277
	INT-POST	-	-	-	55.9	76.9	21.4	59.9	53.9	17.5	19	0.125
	PRE - POST	51.8	46.2	18.6	-	-	-	59.9	53.9	17.5	43.5	0.040
SAMP	PRE - INT	78.9	100	16.9	81.6	100	13.7	-	-	-	18.5	0.210
	INT-POST	-	-	-	81.6	100	13.7	85.3	100	12.8	81	0.849
	PRE - POST	78.9	100	16.9	-	-	-	85.3	100	12.8	41	0.459
Problem Solving	PRE - INT	73.6	100	39.2	90	100	27.4	-	-	-	35	0.468
	INT-POST	-	-	-	90	100	27.4	92.7	100	20	3	0.139
	PRE - POST	73.6	100	39.2	-	-	-	92.7	100	20	4.5	0.480
Average	PRE - INT	69.5	77.1	15.4	76.1	65.7	16.4	-	-	-	35.5	0.300
	INT-POST	-	-	-	76.1	65.7	16.4	80.130	100	16.1	21.5	0.031
	PRE - POST	69.5	77.1	15.4	-	-	-	80.130	100	16.1	34	0.026

Number Knowledge. There was a statistically significant improvement (V= 55.5, p= 0.038) in the Number knowledge test results of experimental group learners between the pre ($\bar{x}$ 55.6%, mode 53.9%, SD 19.1) and intermediate ($\bar{x}$ 63.6%, mode 38.5%, SD 23.8) assessment intervals. There was no significant improvement (V= 46.5, p= 0.277) in the Number knowledge test results of the control group learners between the pre ($\bar{x}$ 51.8%, mode 46.2%, SD 18.6) and intermediate ($\bar{x}$ 55.9%, mode 76.9%, SD 21.4) assessment intervals.

There was no significant improvement (V= 67.5, p= 0.166) in the Number Knowledge test results of the experimental group between the intermediate ($\bar{x}$ 63.636%, mode 38.462%, SD 23.8) and post ($\bar{x}$ 68.5%, mode 100%, SD 24.8) assessment intervals. There was no significant improvement (V= 19, P= 0.277) in the Number knowledge test results of the control group learners between the intermediate ($\bar{x}$ 55.9%, mode 76.9%, SD 21.4) and post ($\bar{x}$ 59.9%, mode 53.9%, SD 17.5) assessment intervals.

There was a statistically very highly significant improvement (V= 3.5, p< 0.001) in the Number knowledge test results of experimental group learners between the pre ($\bar{x}$ 55.6%, mode 53.9%, SD 19.129) and post ($\bar{x}$ 68.5%, mode 100%, SD 24.8) assessment intervals. There was a significant improvement (V= 43.5, p= 0.040) in the Number knowledge test results of the control group learners between the pre ($\bar{x}$ 51.8%, mode 46.2%, SD 18.6) and post ($\bar{x}$ 59.9%, mode 53.9%, SD 17.5) assessment intervals. Refer to Figure 5.12.

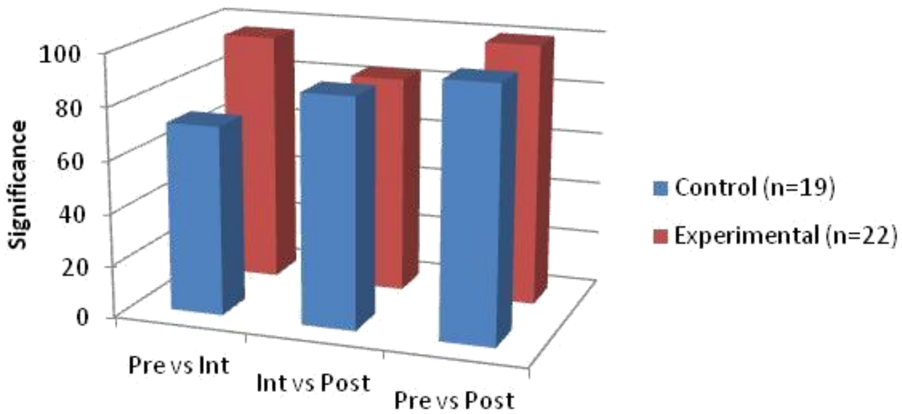

Figure 5.12: Overall comparison of Number Knowledge test (all three intervals) between experimental and control groups (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

SAMP. There was no significant improvement (V= 25, p= 0.159) in the SAMP test results of the experimental group learners between the pre ($\bar{x}$ 78.9%, mode 100%, SD 16.9) and intermediate ($\bar{x}$ 81.6%, mode 100%, SD 13.7) assessment intervals. There was no significant improvement (V= 18.5, p= 0.210) in the SAMP test results of the control group learners between the pre ($\bar{x}$ 74.923%, mode 76.471%, SD 10.889) and intermediate ($\bar{x}$ 77.090%, mode 88.235%, SD 12.991) assessment intervals.

There was a statistically significant improvement (V= 9, p= 0,020) in the SAMP test results of experimental group learners between the intermediate ($\bar{x}$ 81.6%, mode 100%, SD 13.7) and post ($\bar{x}$

85.3%, mode 100%, SD 12.8) assessment intervals. There was no significant improvement (V= 81, p= 0.849) in the SAMP test results of the control group learners between the intermediate ($\bar{x}$ 77%, mode 88%, SD 12.9) and post ($\bar{x}$ 77.7%, mode 82.4%, SD 13.7) assessment intervals.

There was a statistically significant improvement (V= 11.5, p= 0.006) in the SAMP test results of experimental group learners between the pre ($\bar{x}$ 78.9%, mode 100%, SD 16.9) and post ($\bar{x}$ 85.3%, mode 100%, SD 12.8) assessment intervals. There was no significant improvement (V= 41, p= 0.459) in the SAMP test results of the control group learners between the pre ($\bar{x}$ 74.9%, mode 76.5%, SD 10.9) and post ($\bar{x}$ 77.7%, mode 82.4%, SD 13.7) assessment intervals. Refer to Figure 5.13.

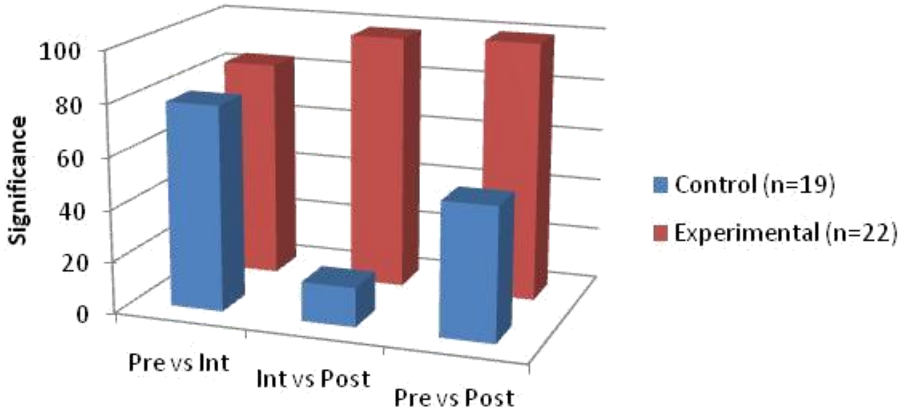

Figure 5.13: Overall comparison of SAMP test (all three intervals) between experimental and control groups (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

Problem Solving. There was a statistically significant improvement (V= 3.5, p= 0.047) in the Problem solving test results of experimental group learners between the pre ($\bar{x}$ 73.6%, mode 100%, SD 39.2) and intermediate ($\bar{x}$ 90%, mode 100%, SD 27.4) assessment intervals. There was no significant improvement (V= 35, p= 0.468) in the Problem solving test results of the control group learners between the pre ($\bar{x}$ 84.2%, mode 100%, SD 25.5) and intermediate ($\bar{x}$ 78.9%, mode 100%, SD 30.9) assessment intervals.

There was no significant improvement (V= 6, p=0.784) in the Problem solving test results of the experimental group learners between the intermediate ($\bar{x}$ 90%, mode 100%, SD 27.4) and post ($\bar{x}$ 92.7%, mode 100%, SD 20) assessment intervals. There was no significant improvement (V= 3, p= 0.139) in the Problem solving test results of the control group learners between the intermediate ($\bar{x}$ 78.9%, mode 100%, SD 30.9) and post ($\bar{x}$ 87.4%, mode 100%, SD 30.7) assessment intervals.

There was a statistically significant improvement (V= 0, p= 0.021) in the Problem solving test results of experimental group learners between the pre ($\bar{x}$ 73.6%, mode 100%, SD 39.2) and post ($\bar{x}$ 92.7%, mode 100%, SD 20) assessment intervals. There was no significant improvement (V= 4.5, p= 0.480) in the Problem solving test results of the control group learners between the pre ($\bar{x}$ 84.2%, mode 100%, SD 25.5) and post ($\bar{x}$ 87.4%, mode 100%, SD 30.7) assessment intervals. Refer to Figure 5.14.

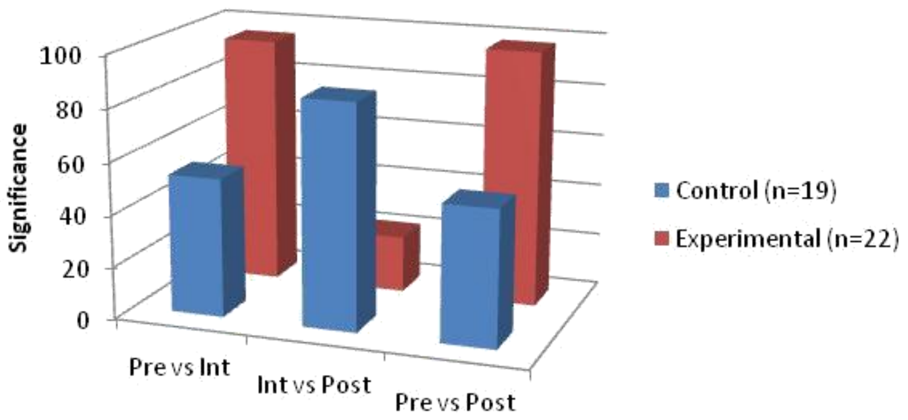

Figure 5.14: Overall comparison of Problem solving test (all three intervals) between experimental and control groups (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

Combined Average. There was a statistically highly significant improvement (V= 20, p= 0.002) in the Combined average of the test results of experimental group learners between the pre ($\bar{x}$ 69.5%, mode 77.1%, SD 15.4) and intermediate ($\bar{x}$ 76.1%, mode 65.7%, SD 16.4) assessment intervals. There was no significant improvement (V= 35.5, p= 0.300) in the Combined average of the test results of the control group learners between the pre ($\bar{x}$ 67.7%, mode 65.7%, SD 11.4) and intermediate ($\bar{x}$ 69.5%, mode 65.7%, SD 14.6) assessment intervals.

There was a statistically significant improvement (V= 39.5, p=0.015) in the Combined average of the test results of experimental group learners between the intermediate ($\bar{x}$ 76.1%, mode 65.7%, SD 16.4) and post ($\bar{x}$ 80.1%, mode 100%, SD 16.1) assessment intervals. There was a statistically significant improvement (V= 21.5, p= 0.031) in the Combined average of the test results of control group learners between the intermediate ($\bar{x}$ 69.5%, mode 65.7%, SD 14.6) and post ($\bar{x}$ 72.5%, mode 77.1%, SD 15.1) assessment intervals.

There was a statistically very highly significant improvement (V= 0, p< 0.0001) in the Combined average of the test results of experimental group learners between the pre ($\bar{x}$ 69.5%, mode 77.1%, SD 15.4) and post ($\bar{x}$ 80.1%, mode 100%, SD 16.1) assessment intervals. There was a statistically significant improvement (V= 34, p= 0.026) in the Combined average of the test results of experimental group learners between the pre ($\bar{x}$ 67.7%, mode 65.7%, SD 11.4) and post ($\bar{x}$ 72.5%, mode 77.1%, SD 15.1) assessment intervals. Refer to Figure 5.15.

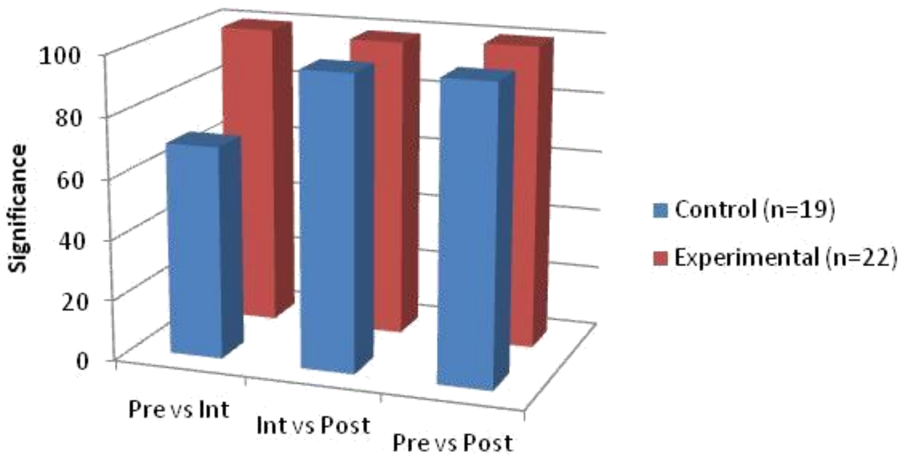

Figure 5.15: Overall comparison of the Combined average of all tests (all three intervals) between experimental and control groups (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

5.4.2.1.2 Remedial Group

Table 5.12 display the comparison of the remedial group's mean, mode, standard deviation and the significance (as alpha = 0.05) throughout the intervention period.

Table 5.15: Comparison of the remedial group's mean, mode, standard deviation and the significance (as alpha = 0.05) throughout the intervention period

Assessment	Interval Comparison	PRE			INT			POST			V value	Significance (p value)
		mean	mode	SD	mean	mode	SD	mean	mode	SD		
Number Knowledge	PRE - INT	38.5	38.5	15.4	38.5	38.5	11.8	-	-	-	9.5	0.916
	INT-POST	-	-	-	38.5	38.5	11.8	42.9	53.9	15.9	10.5	0.611
	PRE - POST	38.5	38.5	15.4	-	-	-	42.9	53.9	15.9	0	0.371
SAMP	PRE - INT	68.1	64.7	14.8	70.6	64.7	8.3	-	-	-	8	0.672
	INT-POST	-	-	-	70.6	64.7	8.3	73.9	82.4	8.2	4.5	0.498
	PRE - POST	68.1	64.7	14.8	-	-	-	73.9	82.4	8.2	0	0.022
Problem Solving	PRE - INT	74.3	100	37.8	80	100	38.3	-	-	-	2	0.773
	INT-POST	-	-	-	80	100	38.3	82.9	100	31.5	2.5	1
	PRE - POST	74.3	100	37.8	-	-	-	82.9	100	31.5	0	0.371
Average	PRE - INT	57.9	57.1	14.3	60	65.7	12.9	-	-	-	5	0.588
	INT-POST	-	-	-	60	65.7	12.9	63.7	N/A	11.9	6	0.402
	PRE - POST	57.9	57.1	14.3	-	-	-	64.7	N/A	11.9	0	0.034

Number knowledge. The remedial group obtained scores that were not significant (V= 9.5, p= 0.916) in the Number knowledge test results between the pre ($\bar{x}$ 38.5%, mode 38.5%, SD 15.4) and the intermediate ($\bar{x}$ 38.5%, mode 38.5%, SD 11.8) assessment intervals.

The remedial group obtained scores that were not significant (V= 10.5, p= 0.611) in the Number knowledge test results between the intermediate ($\bar{x}$ 38.5%, mode 38.5%, SD 11.8) and the post ($\bar{x}$ 42.9%, mode 53.9%, SD 15.9) assessment intervals.

The remedial group obtained scores that were not significant (V= 0, p= 0.371) in the Number knowledge test results between the pre ($\bar{x}$ 38.5%, mode 38.5%, SD 15.4) and the post ($\bar{x}$ 42.9%, mode 53.9%, SD 15.9) assessment intervals. Refer to Figure 5.16.

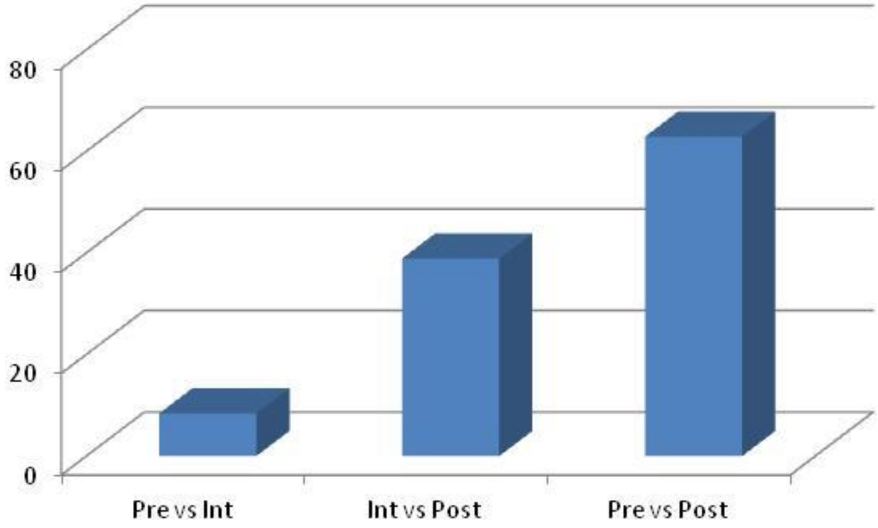

Figure 5.16: Number knowledge test interval comparison for remedial group (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

SAMP. The remedial group obtained scores that were not significant (V= 8, p= 0.672) in the SAMP test results between the pre ($\bar{x}$ 68.1%, mode 64.7%, SD 14.8) and the intermediate ($\bar{x}$ 70.6%, mode 64.7%, SD 8.3) assessment intervals.

The remedial group obtained scores that were not significant (V= 4.5, p= 0.672) in the SAMP test results between the intermediate ($\bar{x}$ 70.6%, mode 64.7%, SD 8.3) and the post ($\bar{x}$ 73.9%, mode 82.4%, SD 8.2) assessment intervals.

The remedial group obtained scores that were statistically significant (V=0, p= 0.022) in the SAMP test results between the pre ($\bar{x}$ 68.1%, mode 64.7%, SD 14.8) and the post ($\bar{x}$ 73.9%, mode 82.4%, SD 8.2) assessment intervals. Refer to Figure 5.17.

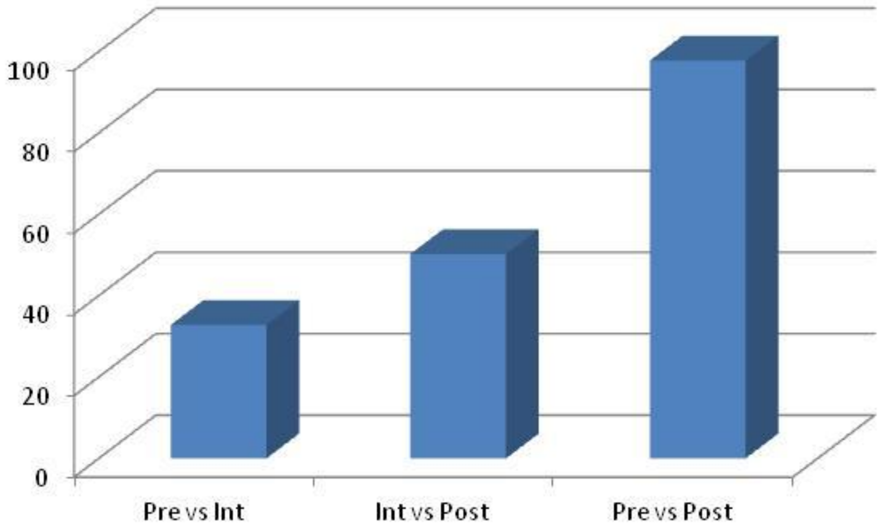

Figure 5.17: SAMP test interval comparison for remedial group (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

Problem solving. The remedial group obtained scores that were not significant (V= 2, p= 0.773) in the Problem solving test results between the pre ($\bar{x}$ 74.3%, mode 100%, SD 37.8) and the intermediate ($\bar{x}$ 80%, mode 100%, SD 82.9) assessment intervals.

The remedial group obtained scores that were not significant (V= 2.5, p= 0.588) in the Problem solving test results between the intermediate ($\bar{x}$ 80%, mode 100%, SD 38.3) and the post ($\bar{x}$ 82.9%, mode 100%, SD 31.5) assessment intervals.

The remedial group obtained scores that were not significant (V= 0, p= 0.371) in the Problem solving test results between the pre ($\bar{x}$ 74.3%, mode 100%, SD 37.8) and the post ($\bar{x}$ 82.9%, mode 100%, SD 31.5) assessment intervals. Refer to Figure 5.18.

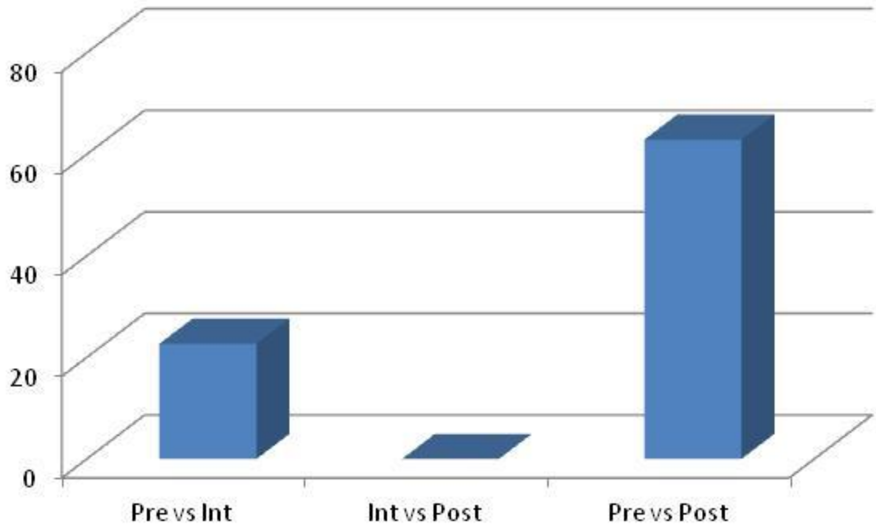

Figure 5.18: Problem solving test interval comparison for remedial group (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

Combined average. The remedial group obtained scores that were not significant (V= 5, p= 0.588) in the Combined average of test results between the pre ($\bar{x}$ 57.9%, mode 57.1%, SD 14.3) and the intermediate ($\bar{x}$ 60%, mode 65.7%, SD 12.9) assessment intervals.

The remedial group obtained scores that were not significant (V= 6, p= 0.402) in the Combined average of test results between the intermediate ($\bar{x}$ 60%, mode 65.7%, SD 12.9) and the post ($\bar{x}$ 63.7%, no mode, SD 11.9) assessment intervals.

The remedial group obtained scores that were significant (V= 0, p= 0.034) in the Combined average of all tests between the pre ($\bar{x}$ 57.9%, mode 57.1%, SD 14.3) and the post ($\bar{x}$ 63.673%, no mode, SD 11.863) assessment intervals. Refer to Figure 5.19.

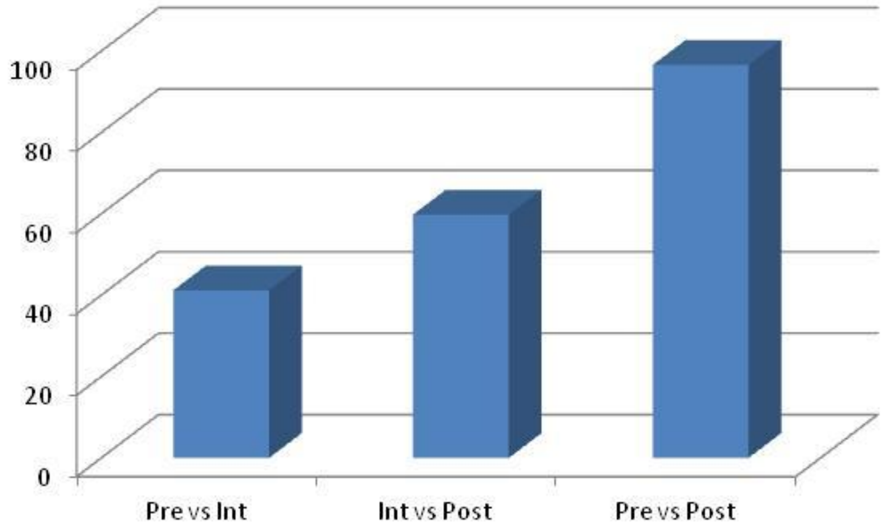

Figure 5.19: Combined average comparison between experimental and control groups (represented on a scale of 0 to 100% where ≥95% is the equivalent significance of P≤0.05)

5.4.2.2 Qualitative data

The qualitative data attained through the interview with the experimental group teacher will be discussed in terms of findings following a thematic content analysis. The post interview with the experimental group teacher revealed data that is represented in Table 5.13.

Table 5.16: Themes and findings for post-interview with experimental group class teacher

Intervention successes	"Um, it's difficult to say now because we are still busy with the final assessment. Um, I did pick up, I would say about two learners that showed a little bit more improvement in number knowledge and number recognition, they usually didn't have. Um, so I think it was successful. Any extra learning for them is a plus point."	1. Noticed improvement in 2 learners 2. Number knowledge improved 3. Number recognition improved

Intervention failures	"No not at all."	None identified.
Implementation potential	"We just don't have time for remedial unfortunately and we know it would help the children. But other than that, we don't have unifix blocks and I actually saw the importance of them so I asked the deputy principal because I see we desperately need it because we can just use an abacus. I think some of the worksheets we can definitely use yes, anything will help." "Yes definitely, for sure."	1. No time to implement remedial for learners 2. Buying Unifix cubes following the success of using them in intervention 3. Worksheets good and would be utilised 4. Teacher would definitely implement classroom intervention if given the materials

In the post-interview with the class teacher from School B the intervention showed multiple successes in the results. A definite improvement was noticed in two learners. Their improvement was noticed in number knowledge and number recognition. No failures or weaknesses where identified in the intervention. The implementation potential showed difficulties with regards to the implementation of the remediation. This was not a weakness on the part of the intervention but rather a result of problem affecting the school (low SES, poor didactical situation and no time in school hours or after school for the teacher to give remedial attention to learners). Outside of the lack of ability to implement the remedial aspect of the intervention, the interventions implementation potential was good. The teacher saw the value of concrete learning in mathematics and as a result ordered Unifix cubes for all the Grade 1 classes. The worksheets were viewed as good and the teacher would definitely implement the classroom intervention if given the materials.

5.4.2.3 Synthesis of section

There was a statistically significant improvement in the first interval (pre-int) of the Number knowledge test for the experimental group but no statistical significance for the control group. The second interval (int-post) showed no statistical significance for both the experimental and control groups. The final interval showed a statistically significant result for the experimental group and no statistical significance for the control group. As mentioned in School A's data the learners were shown to have the lowest average for the Number Knowledge test showing great efficiency in the intervention of improving learner mathematics results in this particular section (Section 5.4.2.1). The SAMP test did not show statistical significance in improving learners' marks in both the experimental and control groups in the first interval (pre-int). In the second interval (int-post), the experimental group showed a statistically significant improvement and the control did not. In the last interval (pre-int), the experimental group showed a statistically significant improvement whereas the control showed no significance (Section 5.4.2.1). The final test, Problem solving, showed statistical significance in the pre-int interval with the experimental group and no significance with the control group. No statistical significance emerged with the int-post interval of the experimental group and with the control group (Section 5.4.2.1). The final interval (pre-post) showed a statistical improvement in the experimental group, but not in the control group. For the combined average of the tests, the experimental group showed a statistically significant result (improved) and the control group did not show significance in the first (pre-int). In the second and final intervals, the experimental and control groups showed a statistically significant improvement in results (Section 5.4.2.1).

The remedial group was isolated to receive intensive support following the pre-int interval. The selected learners' score did not change between the first and second intervals. Therefore, in the first interval, of all the tests, including the combined average there was no statistical significance. In the second and final intervals for Number knowledge there was no statistical significance. In the second interval for SAMP scores were not significant. In the final interval results were significant. For the Problem solving test all intervals were not significant. In the combined average the first and second intervals showed no statistical significance but the final interval did show a significant improvement (Section 5.4.2.1.2).

Following on the quantitative data analysis, the experimental group's teacher was interviewed to determine her opinions on the interventions successes, failures and potential for implementation. In terms of successes, data revealed that: there was a noticed improvement in two learners, number knowledge improved and number recognition improved. No failures were identified by the teacher. The final theme of implementation potential was met with mixed results. A negative aspect with regards to implementation emerged owing to the teacher just not having time to give remedial assistance to learners therefore the third phase of RTI could not be implemented in their normal school environment. Positive aspects included: the teacher buying Unifix cubes for the learners following the success of using them in the intervention; worksheets would be utilised if given by the researcher and the teacher would definitely implement the intervention if given the materials (Section 5.4.2.2).

During the implementation of the intervention, it was noted that there was a greater change in the experimental group ($p<0.0001$) than the control ($p=0.026$) even though both groups attained a statistically significant result in the combined average in the final interval (Section 5.4.2.1). In addition the experimental group showed statistical significance in all of the tests in the final interval (pre-post) where the control group showed no significance in any of the intervals of any of the tests. An inconsistency that presented in the remedial group data was that there was no statistical significance in the test intervals with exception to the final combined average interval.

5.5 CONCLUSION

Various data (qualitative and quantitative) were utilised in order to: (1) improve validity of the intervention by focusing on consistency and practicality and (2) to determine the effectiveness of the intervention once implemented in a high performance and low performance school. It is through the analysis of the data and the resultant findings thereof that the research questions are to be answered in the following chapter (Section 6.3). A summary of the research (Section 6.2) and reflections on the conceptual framework (Section 6.4) and the methodology (Section 6.5) will be presented. In addition, recommendations on policy (Section 6.6) and practice (Section 6.7) will be provided to address future research.

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Chapter 6
Conclusion and Recommendations

6.1 INTRODUCTION

In the previous chapter, data was analysed and findings presented. In this chapter, conclusions are drawn from the findings presented in Chapter 5. The conclusions are presented in relation to evidence attained throughout this study. The evidence is attained through foundational literature (Chapter 2), the conceptual framework (Chapter 3) and the analysed data (Chapter 5). In addition a summary of the research is provided (Section 6.2), findings according to research question (Section 6.3), reflections on the conceptual framework (Section 6.4) and the methodology (Section 6.5) and in conclusion, recommendations on policy (Section 6.6) and practice (Section 6.7) will be provided. The main feature of this chapter is to establish the characteristics of a successful intervention with the purpose of improving mathematics results.

6.2 SUMMARY OF THE RESEARCH

The purpose of this dissertation was to develop a supportive intervention with the aim of improving Grade 1 learner's mathematics results through specific targeting and preventative measures. The rationale for undertaking this research is that South African learners were shown to be performing poorly in mathematics on the national and universal level (Department of Basic Education, 2011 & 2012; Foy, Martin & Mullis, 2003; Moloi & Strauss, 2005; Moloi & Chetty, 2010; Cappelle & Saito, 2010).

Specific shortcomings in the South African education system were identified and presented in the rationale (Chapter 1, Section 1.3). The shortcomings included those mentioned in the problem statement (Chapter 1, Section 1.2), barring SES (as this is not something that can be addressed directly, only possibly managing the resultant effects) and including the lack of learner performance in mathematics identified in the first section. When discussing the need for an intervention, addressing the shortcomings of the education system is an imperative part of the process. Owing to the disjuncture between policy intention and outcome three further refined focal points for the study emerged. These included: the identification of learners at the Grade 1 level who display indicators of developing learning difficulties with specific focus on potential barriers to learning affecting the learner, the implementation of a classroom intervention focused at improving the attainment level of the class as a whole and the tutoring of the identified learners after school (Fuchs et al., 2007a). Further an imperative driving factor of this study emerged as previous and current government based interventions not achieving the desired outcomes (Chapter 2, Section 2.5).

The main research question which guided the study is, *"**what are the characteristics of an intervention for the purpose of improving Grade 1 learners' mathematics in the South African context?**"* The characteristics implied in the question incorporate all contributing concepts and theories that influenced the intervention design and this is attributed to the three phase design research process. The main research question is operationalised by the means of four sub-questions namely:

1.1 *What concepts in mathematics present as most problematic for Grade 1 learners?*

1.2 *How do Grade 1 teachers assist learners with learning difficulties?*

1.3 *What are the challenges of designing and implementing an intervention in the South African context?*

1.4 *How effective was the intervention in the improvement of Mathematics achievement in the Foundation Phase?*

A pragmatic approach was adopted in this study. In a pragmatic approach the researcher focuses on the research problem rather than on the method. This is not to say that method is unimportant but rather that multiple methods are addressed and tested for inquiry to establish effectiveness in attaining a specific goal (Maxcy, 2003, p. 81). The suitability of pragmatism as applicable to mixed methods research emerges, in that the researcher can draw from both quantitative and qualitative assumptions to attain the specified goal in their research (Creswell, 2013, p. 10). It was shown in Chapter 4, Section 4.2 that pragmatism is an effective underpinning for mixed methods. Through this underpinning it emerged that the researcher had access to multiple methods, different world views, different assumptions and different forms of data collection and analysis.

With regard to design, the intended curriculum needed to be acknowledged and discussed to lay the foundation for the concepts that needed to be addressed in the intervention. The utilisation of the emergent models were stimulated by the four core themes of targeting MLD, identified in the literature: *early intervention*, *early screening*, *monitoring through constant assessment* and the *importance of the development of number sense*. The conceptual framework for this study consists of the amalgamation of two aspects, the response to intervention model (RTI) and its adjoining 'sister' problem solving model screening to enhance equitable placement (STEEP). According to Ardoin et al. (2005, p. 363) the RTI model is characterised by three successively more intensive phases of empirically based instruction/intervention. The two primary goals of the three phase process entail, firstly, early identification of risk so that learners can participate in prevention before severe deficits occur and secondly the identification of subsets of learners who are unresponsive to validated intervention (these learners will require individualised attention through special education). Further, the advantages and disadvantages of the model were discussed. The adjoining STEEP model was developed to work in unison with the RTI model and uses its foundations as a framework. The monitoring of learners through continuous assessment was identified as a core theme in Chapter 2 (Section 2.6.3) and STEEP utilises this theme in its model. In a similar manner to RTI, the STEEP model has three stages or "gates" that the learners need to pass through when addressing MLD. A figure was presented demonstrating the interrelatedness of the two models (Figure 3.1).

The methodology employed for this study was the mixed methods approach (Chapter 4, Section 4.3). The selection of this methodology was made owing to its applicability to the aims and research questions outlined by this study in Chapter 1. The methodological foundation of this study involved the design of an intervention which was investigative in nature. The cyclical nature of the design process benefited from the utilisation of both qualitative and quantitative data, with qualitative data being dominant in Phase II leading to quantitative data being more dominant in Phase III (Tashakkori & Creswell, 2007, p. 4). The foundational mixed methods approach was further enhanced through the use of the embedded mixed methods design where one data set provided a supportive secondary role Figure 4.1 illustrates the above mentioned process.

Design research was utilised as the primary research method for this study (Chapter 4, Section 4.4). Design research is systemic in nature with the aim, in the context of this study, of developing research based solutions to complex educational problems. It utilises iterations to enhance its success comparative to that of systemic variations in an experiment (Gravemeijer et al., 2009, p. 13). As discussed in previous chapters the research was divided into three phases: Phase I – Preliminary research; Phase II – Prototyping and Phase III – Assessment (Plomp, 2007, p. 7). Majority of the iterations in the research occurred within Phase II involving the design of the intervention where a prototype was appraised and adjusted according to data collected at three separate intervals.

The methodological processes relevant to each phase and cycle of the research design were discussed in Chapter 4, Section 4.5. Sampling, instruments, validity issues, data collection and data analysis are all elaborated upon within the relevant phases of the design research process. The specific methodological processes applicable to each phase/cycle will be presented in Table 6.1, refer to Chapter 4 for elaboration.

Table: 6.1: Nature of cycle, sampling, instruments, data collection and data analysis utilised in this study according to phase and cycle

Phase	Cycle	Nature of cycle		Sample			Instrument		Data collection strategy			Data analysis method		
		Conceptual	Empirical	Expert Appraisers	Grade 1 Teachers	Grade 1 Learners	Interview schedules	Assessment tool	Interview	Walk-through	Assessment	Thematic content analysis	Observation	Wilcoxon sign-ranked test
Phase I	Cycle 1	X												
Phase II	Cycle 2	X												
	Cycle 3		X	X			X		X			X		
	Cycle 4	X												
	Cycle 5		X		X	X	X	X		X	X	X	X	
	Cycle 6	X												
	Cycle 7	X												
Phase III	Cycle 8 & 9		X		X	X	X	X	X		X	X		X

6.3 RESEARCH FINDINGS BY RESEARCH QUESTION

In the following section, results established in Chapter 5 will be interpreted in relation to the research questions. As mentioned in Section 6.2 the main research question is operationalised by the means of four sub-questions. This statement formulates the structure of this section.

6.3.1 WHAT CONCEPTS IN MATHEMATICS PRESENT AS MOST PROBLEMATIC FOR GRADE 1 LEARNERS?

This research question was addressed through data collected in two ways. Qualitative data was attained from pre-interviews with Grade 1 teachers from the participating classes in the participating schools (Phase II). Quantitative data was attained from the assessment tool implemented with both the control and experimental groups from the participating schools (Phase III). A thematic content analysis of the qualitative data from the interview with School A's teachers revealed several contributing codes applicable to content related difficulties namely: number recognition, basic operations, one-to-one correspondence, counting and classification. The following codes were identified through the interviews with School B's teachers: number concepts, conceptual understanding and procedural development. Quantitative data in the form of percentile scores in the various tests contributes to the theme of content related difficulties. Each mathematical concept identified through the qualitative data will be discussed in terms of supporting literature. Once the qualitative data is presented the sub-section will be concluded with the supporting quantitative data.

The following concepts identified through data culminate into the core concept of number sense: number concepts, number recognition, basic operations, counting (including one-to-one correspondence) and classification. Basic number sense development can be attributed to the ability of the learners to compare, classify and understand one-to-one correspondence, to understand the concept of number magnitude and how this magnitude affects counting sequence and place value (Bryant, Bryant, Gersten, Scammacca, Funk, Winter, Shih & Pool, 2008, p. 48; Geary, Bailey, Littlefield, Wood, Hoard & Nugent, 2009, p. 413). Various literature supports the notion that number sense is a core, innate skill that forms the foundation for learning formal mathematical concepts and skills as well as being a reliable and powerful predictor of mathematics achievement (Jordan et al., 2007, Chard et al., 2005) (discussed in Chapter 2, Section 2.6.4). It has been established that most learners entering pre-school, have some degree of number sense, though this is variable depending on the individual and particularly the individual's socio-economic standing (discussed further in Chapter 2, Section 2.4.1.1) (Jordan et al., 2007, p. 36). It has been found that learners with a weak number sense will experience difficulties in: counting, number sequencing, quantity discrimination and in counting on from a given number (Chard et al., 2005, p.4). The main recurrent problems present in Foundation Phase learners that have been presented by researchers regarding MLD include: underdeveloped counting strategies when attempting to solve a mathematics problem and difficulty in understanding counting concepts (Geary et al., 2009, p. 143; Geary, 2011 p. 255; Mazzocco & Myers, 2003, p. 143).

In addition to the concept of number sense, Geary (2004, p. 6) established a theoretical model of typical development for a "typically performing child" compared to a child with MLD. Within this model counting, arithmetic and cognitive memory deficits were acknowledged. Whilst procedural development and conceptual understanding can be attributed to arithmetic, they more appropriately fall under the concept of cognitive mechanisms and deficits (refer to Chapter 2, Section 2.4.2). According to Van de Walle (2007, p. 9) MLD has the potential of manifesting as a result of a deficit in conceptual or procedural abilities defined by the mathematical domain this, theoretically, would be owing to possible underlying deficits in the central executive (responsible for the control and regulation of cognitive processes), or working memory systems of the language or visuospatial domains.

With regard to the quantitative data, the assessment tool was designed with number sense as its primary foundation. It was possible to observe discrepancies in concepts that learners struggled with owing to their relevant scores in the particular tests (Number Knowledge, SAMP Problem solving). In School A, learners showed a lower average performance in the number knowledge pre-test than in the other tests (Experimental: 71%; Control: 73%). These were in comparison in School B Experimental: 56%; Control: 52%. The components that made up the Number Knowledge test included: counting (what number comes after 4?), forward counting; backward counting; which number is closer?), number magnitude (which number is bigger/smaller?) and sequence (identification of a missing number in a sequence).

Whilst not all the specific concepts identified through the qualitative data could be isolated in the quantitative data the underlying trend still emerges, with the lack of number sense being the underlying cause of MLD in Grade 1 learners. In addition, it is important to understand that number sense cannot develop if the correct cognitive mechanisms are not in place. A learner's proficiency in any given area of mathematics is dependent on conceptual understanding of the domain as well as procedural knowledge supportive of problem solving (Geary, 2004, p. 9).

6.3.2 How do Grade 1 teachers assist learners with learning difficulties?

This research question was addressed by means of qualitative data attained through interviews with the Grade 1 class teachers (experimental and control) from both schools (Phase II). A thematic content analysis of the qualitative data from the interview with School A's teachers revealed several contributing codes applicable to accommodation: *learners divided into ability groups*, *kinaesthetic learning*, *constant monitoring* and individualised *attention*. The following code was identified through the interviews with School B's teachers: *practice concepts*. Quantitative data in the form of percentile scores in the various tests contributes to the theme of content related difficulties. Each mathematical concept identified through the qualitative data will be discussed in terms of supporting literature.

In every classroom there are diverse learners with diverse needs. A challenge emerges for teachers to accommodate these diverse needs which range in abilities, disabilities and socio-economic circumstances (Van de Walle, 2007, p. 91). Methods for assisting Grade 1 learners materialised from the data and allowed the researcher to modify the intervention appropriately through understanding the techniques employed by Grade 1 teachers. Through attaining insight into the techniques employed by the teachers the researcher was able to identify shortcomings or strengths and incorporate them into the prototype design.

Learners being divided into ability groups: Dividing learners into ability groups, whilst assisting the teacher in accommodating learning (Engelbrecht & Swanepoel, 2009, p. 83), has been shown to not be the best means of accommodation for learners. A study by Butler (2008) showed that learners labelled high performing and allocated to said group were less likely to seek help as well as ability grouping not increasing the willingness of low performing learners to seek help. In addition to the lack of seeking help and ensuring a concept is understood, learners are very self aware with regards to differentiating characteristics. It has been shown that labelling a learner at an early age can be detrimental, this links to previous statements about the influence of peer opinions (pressure) and lack of confidence in abilities.

Kinaesthetic l*earning*: Every learner learns differently, some are visual learners, some are auditory and some kinaesthetic learners (Gilakjani, 2011, p. 104). Kinaesthetic learning is 'learning by doing' and for Grade 1 learners this is an imperative method as it targets those that have short attention spans and allows for a more concrete understanding of concepts (Gilakjani, 2011, p. 106). This method for accommodating learners additionally emerged from the Cycle 3 expert appraiser interviews where an expert appraiser referred to making the intervention prototype more age appropriate.

Constant monitoring: Chapter 3 (Section 3.2) described the importance of constant monitoring of learners and how it plays a vital aspect of the RTI model (Van der Heyden & Jimerson, 2005, p. 24). Monitoring finds its foundation in assessment where learner abilities are tested to determine their levels of competency and has been found to be an essential component of high-quality education (Jacobson, 1998, p.579; Cotton, 1996). Monitoring takes various forms including, formal and informal assessments and observation (Cotton, 1996, p. 2).Cotton (1996) goes on to further state the importance of constant monitoring as, "activities pursued by teachers to keep track of learner learning for purposes of making instructional decisions and providing feedback to learners on their progress" (p. 1).

The final method that the Grade 1 teachers employed to assist learners with their mathematical difficulties emerged as *individualised attention*. *Individualised attention* for a learner with difficulties is of great importance as discussed in Chapter 2 with regards to preventative teaching. Further emphasising the importance of the concept, Dowker's (2005) conducted a study where two interventions were identified stemming from an individualised basis of addressing MD's, the Mathematics Recovery program and the Numeracy Recovery program. Both interventions were shown to be successful in improving learners Mathematics skills.

6.3.3 WHAT ARE THE CHALLENGES OF DESIGNING AND IMPLEMENTING AN INTERVENTION IN THE SOUTH AFRICAN CONTEXT?

Qualitative data from the research applicable to the answering of this research question emerged from the interview with an expert appraiser as well as the pre-interviews with the Grade 1 teachers from School B. A thematic content analysis of the qualitative data from the interview with the expert appraisers and School B's teachers revealed contributing codes applicable to (i) level appropriateness and (ii) mathematical difficulties. The codes culminated in the sub-theme of extrinsic barriers to learning. The specific codes that emerged from the interviews with the class teachers included: *language*, *socio-economic status* and *didactical situation*. Extrinsic barriers to learning were discussed extensively in Chapter 1 (Section 1.2) and Chapter 2 (Section 2.4.1.1), and formed part of the problem statement of this study.

Before the intervention was implemented in the schools one of the expert appraisers mentioned her experience with a school that she conducted interviews with for a Masters project. She stated that the Grade 1 learners were half way through the year and had no number concept. In addition she voiced her concerns that the low performance school's learners in this study may not be ready for a high level of curriculum implementation owing to their potential backgrounds. The appraiser's thoughts held truth owing to the evident data that emerged from the class teacher interviews. School B was selected based on the SAMP data that showed it to be a low performance school. The researcher's observations showed a large number of learners per class in Grade 1 (37/38) and that the learners had an inadequate level of English (reading, writing and comprehension). As mentioned above three specific extrinsic barriers emerged from the pre-interviews with the class teachers from School B. Literature supporting the specific findings from data will be presented.

Extrinsic barriers refer to learning influences that occur outside the child as an entity and that are imposed by society or the environment (macro and micro levels) (Engelbrecht & Swanepoel, 2009, Van Vuuren, 2009). The first extrinsic barrier stipulated as affecting learners was a *language barrier,* this manifested in their learners not understanding an instruction or mathematical concept owing to their mother tongue not being English. A prominent shift has been attributed to the language-in-education policy which is failing South African learners (Heugh, 1999). Wium and Louw (2012, p. 8) support this statement acknowledging that a primary factor in the poor performance of South African learners in benchmark testing attributes to learners' inadequate language capabilities, as many learners did not understand what was expected of them in the assessments.

Secondly, *SES*, or socio-economic status of learners was that of low income households where parents worked long hours leaving little to no support from home. In addition to the above mentioned, many parents had a poor education level thus not having the ability to assist learners even if they wanted to (less mathematics development support). A significant problem that arose from the low SES is that many learners did not attend Grade R (as it is an expense and not compulsory) and it is within this phase that procedural development on the curriculum level begins. It has been shown through literature that the socio-economic standing of a child has a great effect on their educational performance (Starkey et al., 2004, p. 99; Gersten et al., 2005, p. 297).

Lastly, the *didactical situation* of the learners, was noted. In the case of this school classes are very large, approximately 38 learners per class. This diminishes the chance for teachers to address learners who display difficulties. As determined from the interview data there are too many learners who perform poorly and not enough time is available to address them (they have to leave on a bus at 13:00 everyday). A general consensus exists that the amount of learners in a class affects the quality of education given to those learners (Hornsby, Osman & De Matos-Ala, 2013, p. 8). However, class size does not stand in isolation as a determinant of poor performance additional didactical situation barriers contribute to the overall educational experience (Hornsby et al., 2013, p.8).

The challenges of designing and implementing an intervention in the South African context are evident in literature and in practice. These challenges manifest particularly as the extrinsic barriers experienced by learners. An intervention needs to be responsive and accommodating to the barriers a child may experience on both the macro and micro level for it to be potentially successful on the nano level. This is no small feat as evident in the failure of government based interventions that have been implemented since 1995 (refer to Chapter 1, Section 1.2).

6.3.4 HOW EFFECTIVE WAS THE INTERVENTION IN THE IMPROVEMENT OF MATHEMATICS ACHIEVEMENT IN THE FOUNDATION PHASE?

Phase III in the design research process contributes to the answering of this research question. It is in Phase III that quantitative data presents as dominant where the implemented intervention is evaluated by means of an assessment tool. The Wilcoxon signed-ranked test was utilised to analyse the data, determining whether there was statistical significance between the intervals of the tests (Number Knowledge, SAMP, Problem solving) of the control (did not receive the intervention) and experimental groups (received the intervention). Statistical significance was determined for each interval (pre-int, int-post and pre-post) and the overall average. Whilst all intervals are acknowledged the interval of importance for the determining of intervention success is the *pre-post* as this demonstrates the scores before and after intervention implementation. Following on from the quantitative data, a post-interview with the experimental group's teachers was conducted to ascertain their experience of the implemented intervention. A thematic content analysis was conducted to address intervention successes, failures and implementation potential. Findings will be presented according to school as the results were viewed separately throughout the study with a conclusion on both at the end of this section. In addition the findings of the isolated remedial group will be discussed.

- **School A**

The results of the analysis of School A's data presents the following findings in terms of the successes and shortcomings of the design intervention. Overall the designed intervention showed great promise following the results (quantitative) attained from the screening tool. The successes of the intervention were attributed to: learner improvement throughout the test intervals of the Number Knowledge Test (the control group showed no improvement); improvement in problem solving (the control group showing no improvement) and the combined average of all the tests showing overall result improvements with the remedial group. The learners responded well to the intervention, actively engaging with the researcher and showed enjoyment with the altered style of teaching (more interactive). The learners had substantial foundation on which to build new mathematical concepts attributed to the positive influence of the macro level where the learners had access to resources, came from higher SES background, their LOLT had been English since pre-primary school and they attended Grade R, where procedural and conceptual knowledge was introduced. The qualitative data attained from the class teacher of the experimental group further established the interventions success, some learners were observed as showing improvement with basic operations (specifically addition) and conceptual understanding (grasped concepts with greater ease). In addition, positive results were attained in the implementation potential of the intervention with the teacher acknowledging the simplicity of the lessons, the ease of replicating teaching aids, the worksheets noted as not complicated and the ease of implementation being noted.

The experimental group learners did not show an improvement in their SAMP results throughout the intervention. This could be attributed to their macro level influence discussed above where learners had a sound foundational understanding of the basic concepts presented to them in the evaluation. A single shortcoming in the intervention was identified by the class teacher of the experimental group with regards to a specific lesson. The researcher wanted to challenge the learners' critical thinking but they displayed difficulties. The lesson was immediately adjusted once it was evident the learners weren't coping and the lesson was made easier. A noticed inconsistency was that the remedial group did not show statistical significance in the test intervals barring the final combined average interval. Remedial assistance is a process and as will be discussed in the recommendations of this chapter, one cannot expect a child with specific MLD to show drastic improvement with only a month's intervention; understanding a child's individual needs takes time (Johnson, 2000, para. 1). What was encouraging is that through evident data, the intervention was beginning to work for the remedial learners. Following the analysed data, the results for School A showed efficiency in improving Grade 1 learners' mathematics results.

- **School B**

School B portrayed a vast contrast to School A with regards to the SES of the learners. Challenges became immediately evident with regards to class size, available resources, LOLT and the level parental support. The intervention was adjusted to accommodate the level of the learners but the learners would have definitely benefited more with the intervention period being extended. As with the previous section, the strengths and shortcomings of the designed intervention will be discussed.

The experimental group's learners showed an improvement in their Number Knowledge test results with the control group not showing any improvement. In addition there was an improvement in the SAMP results (control showed no improvement), the SAMP section of the screening tool was founded on basic mathematical concepts and it was evident through the implementation of the intervention that the children received a level of foundational knowledge. Through the interview with the class teachers the researcher was made aware of the fact that majority of the learners did not attend Grade R where foundational procedural knowledge is introduced. It is positive that the intervention showed a level of efficiency in building up the "missing" foundational concepts. Problem solving result improved overall in the experimental group. Interestingly in the combined average of the tests both groups showed significance in an improvement of results though there was a greater improvement in the experimental group's results (Chapter 5, Section 5.4.2.1).

For the combined average results of the isolated remedial group there was only an improvement in the combined average of the final interval (Chapter 5, Section 5.4.2.1.2). As discussed in School A's section remedial assistance requires substantial time and as evident with School A an inconsistency presented as the learners only showing improvement in the combined average in the final test interval.

Further intervention success was established through the interview with the experimental group's teacher. She noted an improvement in some learners and acknowledged an improvement in number knowledge and number recognition. The implementation potential of the intervention was met with mixed results. Negatively the teacher stipulated that there was no time available to implement the remedial phase of the intervention. Positive aspects included the keenness to utilise the interventions worksheets if provided by the researcher and the acknowledgement of the the importance of kinaesthetic learning following the success of using Unifix cubes.

During the intervention period the researcher noticed certain learners improving and then suddenly falling back in their results, following an enquiry the researcher was made aware of emotional problems experienced by some learners after enquiring with the teacher, this further contributes to extrinsic barriers and was out of the researcher's control. In addition, based on the researcher's experience, lessons that required activities away from the learners' desks resulted in ill discipline with learners not following instructions and fighting with one another. Implementation was far more challenging in School B than in school A and lessons had to be regularly adjusted to maintain discipline. Regardless of the identified shortcomings in implementation the intervention showed efficiency in improving Grade 1 learners' mathematics results.

6.4 REFLECTION ON THE CONCEPTUAL FRAMEWORK

South Africa's main method for identifying learners with MLD, involves an emergent discrepancy between a learner's intelligence capacity and academic achievement (Moors, Weisenburgh-Snyder & Robbins, 2010, p. 224). This identification of MLD learners often happens too late in a learner's development and the child misses out on a critical period where an intervention would be most effective (Fuchs & Fuchs, 2007, p.14). This is where the need for the RTI model emerges, in that it is preventative rather than a "cure" for MLD (Chard et al., 2005, p. 3). The RTI model is characterised by an intervention framework that grows more intense as it moves up the levels (Phases). The three phases of RTI are characterised by, early screening, classroom based intervention and intensive remediation. A core theme established in Chapter 2 (Section 2.6.3) is the continuous monitoring of learners and this gave rise to the need of RTI's adjoining model, STEEP. Relating to RTI's three stage process, STEEP requires a child to pass through three 'gates' (stages) when addressing identification of potential LD: poor performance relative to their same-class peers; poor performance given powerful incentives and poor performance given intensive remediation (Van der Heyden & Jimerson, 2005, p. 25-27). Figure 3.1 presented in Chapter 3, depicts the two models merged as one and displays the intended intervention process.

For the purpose of this study the implementation of the RTI/STEEP model showed success. The researcher was able to monitor learners effectively and the intervention was shown to improve mathematics results. Of great importance was that the learners who showed potential for developing MLD were identified efficiently and without difficulty. In addition the researcher was able to further identify if other learners were presenting problems with specific concepts (through the main assessment tool as well as through classroom activities), which allowed for a more intensive focus on said concepts in the lessons. This reflection adheres to the aim of the model, where one is able to constantly monitor learners allowing for the possible identification of changes in learner performance and to act upon it by means of additional support (Ketterlin-Geller et al., 2008, p.34).

In the classroom lessons, specific core concepts could be taught, discussed and practised allowing learners the opportunity to grasp/master a new/previously taught concept. It was in this phase that the Foundation Phase mathematics curriculum was combined with the important concepts attained through literature and data that created a solid and stimulated class experience. The learners enjoyed the lessons and data showed in many instances that results improved between the pre-int intervals (refer to Tables 5.6 & 5.10) in the experimental group meaning the class lessons had a positive effect on learning.

In the final phase of the three phase RTI model intensive remediation was to be provided for the learners that were found to be at risk of developing MLD. Learners enjoyed the lessons and showed improvement in the final interval of the combined average of the tests (both Schools A & B). More time is needed to truly make a difference in learner performance; this will be discussed further in the recommendations for practice (Section 6.7).

Through the qualitative data attained from the class teachers it was evident that in the low performance school teachers did not have time to implement the third phase of the RTI model. Although this has a negative influence on the full potential of the RTI model, a teaching method can be implemented to still attain a level of the main outcomes of the third phase. Multi-level teaching is a possible option for those teachers who are under time constraints but really want to help those learners in their class with MLD. There was a period where the concept of multi-level teaching was overwhelming to teachers, but, according to literature, instead of increasing the workload of a teacher there are now teacher editions for learner textbooks and ready-made reproducible materials for the teachers to use and implement (Roberts, 2007, p.1). The method for implementing multi-level teaching in a lesson will be discussed further in the section on recommendations for practice (Section 6.7).

6.5 REFLECTION ON THE METHODOLOGY

In this research a mixed methods approach was utilised for the research method and design research was employed for the methodology. This research is rooted in pragmatism and from this philosophical underpinning it was found that both mixed methods and design research were appropriate for the research process. The philosophical underpinnings of mixed methods research still requires further effort with regards to designs and data analysis, validity strategies and rationale for mixing and integration procedures (Johnson & Onwuegbuzie, 2004).

This research was investigative in nature as presented in the cyclical process of the design research conducted. The main research question **"what are the characteristics of an intervention for the purpose of improving Grade 1 learners' mathematics in the South African context?"** provides insight into the type of mathematics intervention that could possibly be suited to the South African context. The research has shown that the intervention has the potential for improving Grade 1 learners' mathematics results, but that is not to say that there weren't any flaws in the methodological processes of the study:

- The intervention was implemented over a month at each school. The duration of the intervention was decided upon by the schools as they were uncomfortable with the intervention being for a longer period. This potentially affected the influence of the intervention especially with the remedial learners as it was previously stipulated that understanding a child's individual needs takes time (Johnson, 2000, para. 1).
- Within the design process in Phase II it was found that the intervention needed to be adapted for the specific schools. This resulted in two separate prototypes being developed to accommodate the levels of the learners at each school. Owing to this realization the interventions received by the two schools were different and prevented the researcher from comparing the schools directly.
- The sample was a specific concern in this study as it was very restrictive. This was applicable to the size as well as the demographic characteristics of the schools within the South African context. In terms of the size of the sample, statistical testing was influenced through (i) size of overall sample and (ii) discrepancies between the sizes of the control and experimental groups. Within this study's sample only urban schools from Pretoria were included, even though they presented different levels, peri-urban and rural schools were not included as well as schools from other provinces. This emerged as a limitation to this study.
- A further flaw in the methodology emerged in terms of reliability and validity. Owing to the small sample size of learners and the limitation of using only urban schools the potential to generalise the result was influenced. In addition, one would need to perform several replicates using a larger sample to account for random variation in order to improve reliability.
- The assessment tool was designed for the first half of the year excluding concepts (according to the Foundation Phase mathematics curriculum) the learners would learn in the second half

of the year. The assessment tool would need to be adapted accordingly to conduct this intervention in the second half of the year even though the core concepts identified as crucial for mathematics development were tested.

6.6 RECOMMENDATIONS FOR POLICY

In this section recommendations for policy will be addressed.

Recommendation 1: Extrinsic barriers on the macro level need to be addressed to improve the subsequent levels affecting learner performance.

The macro (intended), micro (implemented) and nano (attained) systemic levels have shown to be intricately interlinked. Negative aspects that affect a level filter down to the subsequent level/s impacting the learner and learning (Chapter 2, Section 2.4.1.2). It is evident through data analysis that the low performance school struggled with extrinsic barriers affecting the learners (Chapter 5, Section 5.3.2.2). Shortcomings on the macro level that need to be addressed include: teacher training and qualification; the high percentage of the population that is low SES; LOLT and the failure of previous and current government based interventions. Though not all of the shortcomings can be eliminated, education policy should attempt to accommodate the weaknesses in the system with well designed interventions that achieve the aims they intend to. The weaknesses that should be addressed are as follows: service delivery, teacher training and qualification, language of instruction, large portion of South African learners from a low SES and government implemented interventions.

Recommendation 2: Government needs to ensure teachers understand the curriculum for implementation and that outcomes are clear.

An emerging trend at the implemented phase of the curriculum showed that teacher understanding, training and qualification was a prominent, evident shortcoming (Chapter 1, Section 1.1). The teacher is crucial in the implementation of policies and curriculum goals and if not adequately qualified to implement, hinders the child in attaining the concepts, skills and understanding necessary to achieve in mathematics (Van den Akker, 2009, p. 38; Machaba, 2013). Government needs to ensure that only qualified teachers teach Foundation Phase and that a support structure is provided in terms of compulsory updated training on curriculum use and implementation. In addition, the support structure needs to offer what it purports to offer by not causing an inconvenience to teachers and by not increasing their workloads.

Recommendation 3: Inclusive education needs to be accommodated to be effective in large classes.

Government implemented a policy in the form of the Education White Paper 6 and its aim was to change the education system to be more inclusive where all learners can access education and training no matter what their individual needs are (Department of Basic Education, 2001). Whilst the intervention had adequate aims, various shortcomings were identified in Table 2.5 (Chapter 2, Section 2.5), of particular interest (from literature) in terms of this study is the acknowledgement of workload increase for teachers who have to accommodate learners with special needs as well as a lack of government support in terms of provisions, which makes implementation difficult. It emerged from data that the class teacher's of School B did not have the time to implement the intensive remediation aspect for learners that showed potential for developing MLD. They commented on the size of their classes and the difficulty of giving individualised attention to each learner. A method needs to be designed that will allow the classroom teacher to accommodate all levels of learners without impeding them or overloading them (discussed further in the following section). Government needs to be more supportive in providing the necessary provisions and adequate guidelines for teachers to be able to assist learners with difficulties and disabilities.

6.7 RECOMMENDATION FOR PRACTICE

The following section contributes to the recommendations for practice. Although the intervention's foundation has been established through the research and its successes stipulated in this chapter, there are important considerations if the intervention is to be implemented on a wider scale.

Recommendation 4. Increasing sample size on all levels

Owing to the exploratory nature of this study the sample size utilised (experts, Grade 1 teachers and learners) was sufficient. However, if one wants to truly gauge the efficiency of the intervention in South African context, multiple schools from all provinces and all demographics need to receive the intervention and as a result the sample size of schools and classes needs to increase substantially. While it is advantageous to have a small class size for the intervention implementation and for individualised attention, it would be preferable to have used a similar larger sized sample for a better comparison in the data analysis.

Recommendation 5. The intervention needs to be implemented over a longer period

The intervention was implemented for a month at each school. For a holistic understanding of the intervention's efficiency it would be ideally implemented over a full year. In this way the intended curriculum could be implemented at a high level to determine the effect on learner achievement without foreign influence from the beginning to the end of Grade 1. The researcher could be in control of all aspects of the mathematics teaching and learning and this would truly present the influence on mathematics performance.

Recommendation 6. Develop a method for accommodating MLD learners in a classroom situation where teachers have no time for the intensive remediation required by RTI model

A prominent shortcoming in terms of the designed intervention's implementation potential was that a teacher from School B stated that they would not have the time to implement the intensive remediation phase of the RTI model as they simply do not have enough time in the school day. The teachers stated that they would stay behind at school to assist learners in the afternoon but that the learners used public transport and left promptly after school ended. The intervention would need to be adapted to accommodate schools that have this problem by developing a method for assisting MLD learners within the mathematics lesson. A technique that comes to light and that would possibly be an effective option would be multi-level teaching approach (introduced in Section 6.4). Roberts (2007, p. 2-3) stipulates the recommended lesson plan to accommodate all learners:

(i) **Begin the lesson with the whole class together.** When beginning the class with all the learners together it provides a foundation on the appropriately levelled (according to individual learner abilities) tasks that would follow. The teacher introduces the lesson (in a traditional teaching manner) and the concepts that will be taught and varies instruction to accommodate all. Vocabulary usually forms the basis of a lesson introduction so it is fairly easy for the teacher to start the lesson thusly.

(ii) **Assign levelled tasks using a variety of groupings.** During this phase of the lesson concepts are practiced and evaluated. It is in this stage that tasks must be levelled according to proficiency and language ability. Based on learner proficiency certain tasks are adapted to be of a lower level and higher level.

(iii) **End the lesson with the whole class together.** When concluding the lesson the whole class must be brought back together for a review of the concepts learnt and for a formal class activity.

This is merely a recommendation and research needs to be conducted to determine the most effective methods for supporting MLD learners in the classroom and only in the classroom. Additionally, as stipulated previously, government needs to provide supportive measures to teachers in terms of resources otherwise the macro level will present with repercussions in terms of teaching and learning.

Recommendation 7. Intervention adapted for the Foundation Phase to ensure outcomes for foundational development

It would be ideal to extend the intervention, adapting it to be adequately implemented in Grade 2 and 3, promoting a high level of mathematics learning and teaching in the critical foundation years. The intervention would have to be adapted to the specific Foundation Phase mathematics curriculum applicable to the relevant grades.

Recommendation 8. Monitoring over consecutive grades to determine success of intervention on at risk learners

A further extension of the intervention would be to monitor learners throughout the Foundation Phase and possibly into the Intermediate Phase (Grade 4-6) to determine the intervention's success at preventing mathematics learning difficulties. It would be ideal to combine this recommendation with Recommendation 7 to fully gauge the intervention's efficiency in the Foundation Phase.

6.8 CONCLUSION

This chapter combined the literature, conceptual framework and data into a sequential whole in order to answer the research questions and to provide recommendations on policy and practice. The aim of this Masters dissertation was to develop an intervention that is focused on improving the mathematics performance and understanding of Grade 1 learners regardless of the average performance of the school. As the research progressed, the need for such an intervention in the South African context emerged.

The designed intervention showed effective results in the improvement of mathematics results in both a high performance and low performance school. Results were far more significant for School A (high performance) with learners responding well to all levels of the RTI model. School B however proved a challenge for the researcher with learners displaying poor discipline, very short attention spans and difficulties with English as a language of instruction. This resulted in the intervention not being implemented to its full potential. The control and experimental groups both attained statistically significant results but the experimental group did present with a greater change. The recommendation to address this shortcoming is to increase the duration of the intervention as the outcomes that were achieved in School A were not attained as desired in the time with School B. Far more attention was paid to vocabulary and basic concepts like counting which left little time for the development of the core components of the curriculum. In addition to School B, the remedial group from both schools required more time for the intensive remediation to improve performance. The intervention proved to be well received by the teachers and the learners enjoyed the lessons. The assessment tool and class assessments gave a good indication of progress and it was an efficient means of monitoring. Although the intervention was found to be successful, more research is required to truly gauge its effectiveness in the South African context.

In conclusion, regardless of what micro level intervention is developed its success will very much be dependent on an improvement of the macro level. The levels are so interconnected through attrition that any failure in the macro or micro level will affect the child on the nano level. The government needs to provide efficient support structures, training and materials to target the shortcomings of the macro level. It is once a change on the macro level occurs that one can begin to anticipate intervention success.

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