The acquisition of the Language of Mathematics

by

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Submitted in partial fulfilment of the requirements for the degree

MAGISTER EDUCATIONIS

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the 100 Languages

No Way.
The Hundred is there.
The Child
Is made of one hundred.
The child has
A hundred languages
A hundred hands
A hundred thoughts
A hundred ways of thinking
Of playing, of speaking.
A hundred always a hundred
Ways of listening
Of marveling, of loving
A hundred joys
For singing and understanding
A hundred worlds
To discover
A hundred worlds
To invent
A hundred worlds
To dream.
The child has
A hundred languages
(and a hundred hundred
hundred more)
But they steal ninety-nine.
The school and the culture
Separate the head from the
body.
They tell the child:
To think without hands
To do without head
To listen and not to speak
To understand without joy
To love and to marvel.
They tell the child:
To discover the world already
there
And of the hundred
They steal ninety-nine.
They tell the child:
That work and play
Reality and fantasy
Science and imagination
Sky and earth
Reason and dream
Are things
That do not belong together.
And thus they tell the child
That the hundred is not there.
The child says:
No way. The hundred is there.

Loris Malaguzzi, Founder of the Reggio Emilia Approach

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- My friends and colleagues who have always cheered me on.

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ABSTRACT

Why do so many learners fail to learn Mathematics, and experience severe anxiety and confusion in their Mathematics classes? It seems that the answer is that these learners have not cracked the code of Mathematics - in other words they have not mastered the Language of Mathematics. Many of these learners are capable, succeeding in other aspects of their education, but they experience the Language of Mathematics as if it was a foreign language, without meaning or relevance. However, not being able to understand nor communicate Mathematically is a major disadvantage for many learners, not only at school, but also in their future careers.

The rationale of this qualitative research was to explore how learners, particularly in Grade 3, acquire the Language of Mathematics through facilitation. The primary research question was: How is the Language of Mathematics facilitated in Grade 3 classes? This research sought to integrate the facilitation process, the teacher's pedagogy and the learners' acquisition of the Language of Mathematics.

What is the Language of Mathematics? It was the premise of this research that Mathematics is indeed a language in which combinations of Mathematical symbols and Mathematical terminology are placed in a specific order to form Mathematical expressions (equivalent to sentences) that communicate meaning. In school, Mathematical symbols seem to be carefully defined and taught. The problem arises with English Mathematical terminology, particularly as so many South African learners use English as their second or third language. Many of the words used in this subject have totally different meanings in colloquial English, which can lead to confusion in the mind of the learner. Examples of this terminology are 'bigger', 'smaller', 'equal', 'multiply', 'field', 'greater', and 'lesser'. The learner often has no conceptual framework within which to place Mathematical terms. The role of the teacher becomes pivotal in facilitating the acquisition of the correct meanings of both Mathematical symbols and terminology so that the learner acquires the Language of Mathematics.

Grade 3, (the fourth year of formal schooling), is a crucial stage in the learning of the Language of Mathematics; learners move from the concrete to the more abstract Mathematical concepts and there is a greater emphasis on story sums and problem solving. According to Slabbert, De Kock and Hattingh, (2011), the facilitation of learning has four aspects, namely: transmission, transaction, transformation, and transcendence. In order to encourage learners' active participation in the learning process, the educator's facilitation processes are different from those of previous grades, because more emphasis is placed on the learner's mastery of the Language of Mathematics. For this reason, this research focused on Grade 3 teachers rather than learners.

Mathematics in South Africa, as in other parts of the world, is experienced by many learners as a difficult and complicated subject, and many only master the most basic concepts in Mathematics. If Mathematics could be facilitated effectively, the acquisition of the Language of Mathematics could become easier and more enjoyable for learners, thereby impacting their lives positively. Therefore, in relation to the Language of Mathematics, the teacher's pedagogy is a crucial aspect of this qualitative research. There was one exploratory and descriptive case study within three schools where the participating teachers had the opportunity of explaining, (through semi-structured interviews) their perceptions and experiences in terms of the Language of Mathematics. Learners were observed to determine their response to the facilitation of the Language of Mathematics. The relevant documentation was also analysed.

From the data collected in this research, three themes were identified. These themes were explored and related to current research and theory so that the research could contribute to the body of knowledge. There appears to be almost no research on the facilitation of the acquisition of the Language of Mathematics by young learners and it is hoped that this research will be the catalyst for further research, which will benefit many learners globally.

KEY WORDS:

The Language of Mathematics; Facilitation; Language; Mathematics; Grade 3 learner; Foundation Phase; Acquisition; Appreciative Inquiry.

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➢	ANA	Annual National Assessment
➢	CAPS	Curriculum Assessment Policy Statements
➢	DBE	Department of Basic Education
➢	DoE	Department of Education
➢	HSRC	Human Sciences Research Council
➢	LoLT	Language of Learning and Teaching
➢	LiEP	Language in Education Policy
➢	OECD	Organization for Economic Co-operation and Development
➢	PCK	Pedagogic Content Knowledge
➢	PRAESA	Project for the study of Alternative Education in South Africa
➢	SAPA	South African Press Association
➢	SAQMEC	South African Consortium for Monitoring Educational Quality
➢	TIMSS	Trends In Mathematics and Science Study
➢	UN	United Nations
➢	UNESCO	United Nations Educational, Scientific and Cultural Organization
➢	WEF	World Economic Forum

CHAPTER 1: ORIENTATION TO THE RESEARCH

1.1 INTRODUCTION

In Mathematics, as in other fields of learning, there is a language which every newcomer has to master before any proficiency in Mathematics can be achieved. Therefore, proficiency in Mathematics requires an in-depth knowledge of the Language of Mathematics, i.e. both the symbolic and verbal aspects of Mathematics and their inter-relationship or grammar (Barnet–Lamb & Ganeslingam, 2009).

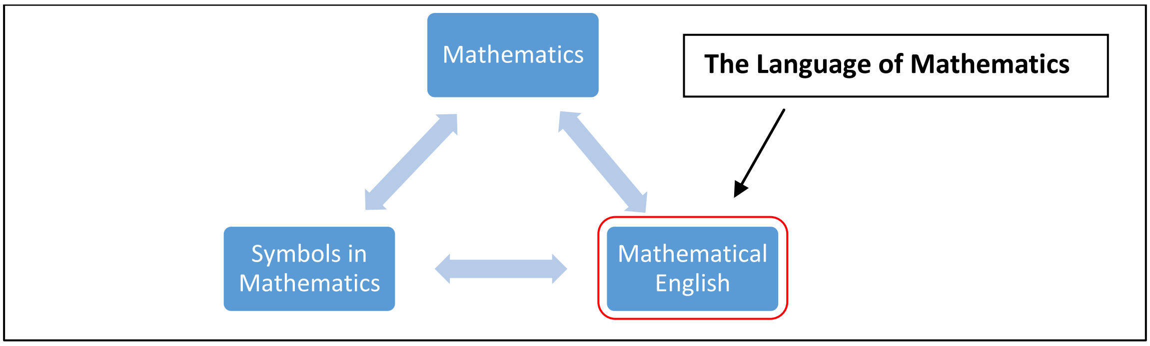


Figure 1.1: The components of Mathematics

In this research, I focused on the teachers' facilitation by using the terminology of Mathematics, namely, the Language of Mathematics, i.e. the role of the teacher in facilitating the acquisition of the Language of Mathematics through their pedagogy.

1.1.1 Rationale for the research

South African learners are underperforming in Mathematics, as shown by the results of the TIMSS and ANA assessments, which are discussed in Section 1.2. Therefore, the rationale for this research was to investigate, through a qualitative research study, how Grade 3 teachers facilitate the acquisition of the Language of Mathematics. The term 'acquisition' refers not only to gaining, but also to a full understanding of a Mathematical concept. The term "the Language of Mathematics" refers to the English terms that are used in Mathematics. Mastery of the Language of Mathematics by any learner would have long term benefits for both that individual's career choice, and in the longer term, for the economy. The serious situation in South Africa regarding Mathematics is highlighted in the following excerpt from the

2009 report of the Organization for Economic Co-operation and Development (OECD),

> “The national labour statistics reveal that only 9% of employed South Africans aged 15 to 65 are in occupations requiring some Mathematical competence. This is too weak a base to sustain South Africa’s rapid economic growth” (OECD, 2009:205).
>
> The Matriculation examination determines where Grade 12 learners will go in South African society. Learners who fail are largely destined for unskilled jobs” (OECD, 2009:202).

In both 1999 and 2003, South Africa (S.A) participated in the international Trends in Mathematics and Science Study (abbreviated as TIMSS) in which more than 50 countries participated. The purpose of the assessment was to determine how South African learners measured up against other countries in terms of their proficiency in Mathematics, and the results showed that South African learners performed very poorly in comparison to other countries. In 2003 and 2011, the highest scores were achieved by the Asian countries of Singapore, the Republic of Korea, Hong Kong, and Chinese Taipei.

Table 1.1: A summary of the TIMSS scores for South Africa in Mathematics in 1999 and 2003

TIMSS	**TIMSS 1999**	**TIMSS 2003**
Average score for South Africa	264	275
International average score	467	487

According to the Human Sciences Research Council (HSRC) media release on TIMSS (2003), the results could be “linked to multiple, complex and connected sets of issues including low overlap with the international curriculum; poverty; resources in schools; low teacher qualifications; language proficiencies; conceptual/cognitive demands in the classroom” (HSRC, 2003:1).The data in Table 1.2 shows a large discrepancy between the TIMSS national average and the TIMSS international average. It is possible that South Africa’s poor performance in Mathematics could be linked to language acquisition because the South African population is diverse and speaks many different languages. South Africa has eleven official language groups, although the two most common Languages of Learning and Teaching (LoLT) in South African schools are English and Afrikaans.

Table 1.2: TIMSS scores for South Africa in Mathematics per language group

Category	**Average score**
Afrikaans average	370
English average	263
National average (all language groups)	264
International average	467

In addition to the TIMSS assessment, the South African Department of Basic Education (DBE) has, since 2011, annually assessed over six million South African learners between Grade 2 and Grade 7 in numeracy (Mathematics) in all schools, namely public, private, and special-needs schools. This assessment is known as the Annual National Assessment (abbreviated as ANA). The ANA scores were low and, as illustrated in Table 1.3 and Figure 1.2, in the higher grades there was a marked and progressive decrease in the scores. This may indicate that learners have not acquired the Language of Mathematics. The comparative scores per grade of learners achieving more than 50% in Mathematics in the ANA are tabulated in Table 1.3, and are illustrated in Figure 1.2.

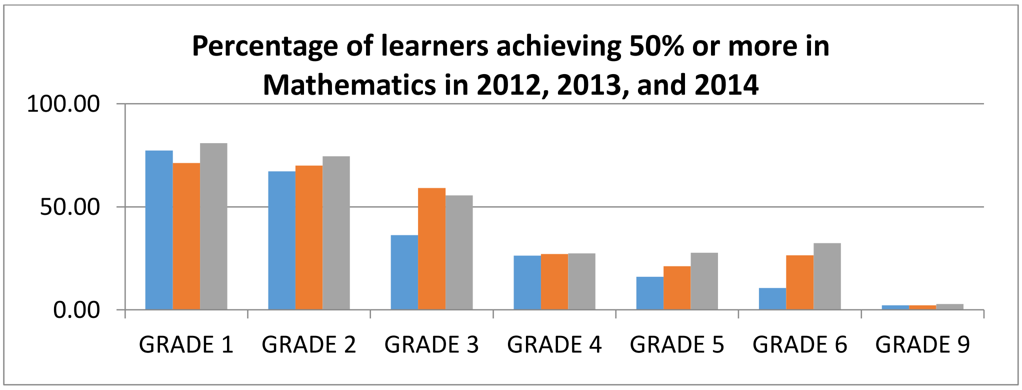


Figure 1.2: The comparative scores per grade of South African learners achieving more than 50% in Mathematics in the ANA

Table 1.3: The comparative scores per grade of South African learners achieving more than 50% in Mathematics in the ANA.

Grade	2012	2013	2014
Grade 1	77.4	71.3	80.9
Grade 2	67.8	70.0	74.5
Grade 3	36.3	59.1	55.6
Grade4	26.3	27.1	27.4
Grade 5	16.1	21.2	27.8
Grade 6	10.6	26.5	32.4

This research project focused only on the facilitation of Mathematics, and specifically the acquisition of the Language of Mathematics in Grade 3 classes. This grade marks a pivotal point for learners who are mastering the basics of the Language of Mathematics because they move from concrete to abstract Mathematical concepts.

Table 1.4: The breakdown of Mathematics scores achieved in the ANA for 2014 by Grade 3 learners nationally.

Level	Marks	Percentage of learners
Level 1	0-29	13.2
Level 2	30-39	9.7
Level 3	40-49	12.6
Level 4	50-59	17.0
Level 5	60-69	16.8
Level 6	70-79	15.2
Level 7	80-100	15.4

The statistics in Table 1.4 reveal that 35.5% of the Grade 3 learners assessed in the ANA assessment did not achieve 50% in Mathematics. From this, one can deduce that a solid foundation for Mathematical achievement must be laid in elementary/primary school; one can also deduce from these statistics that the facilitation of the acquisition of the Language of Mathematics must commence in the Foundation Phase of schooling. There appears to have been very little research done in South Africa on the facilitation and learning of the Language of Mathematics by learners at the primary school level. Therefore, the rationale for this research is to investigate the various facets of the facilitation of the Language of Mathematics.

1.2 PURPOSE STATEMENT

The purpose of this study was to explore how Mathematics teachers in the Foundation Phase of school (who have an understanding of the Language of Mathematics) facilitate the acquisition of the Language of Mathematics in their Grade 3 classes.

1.3 RESEARCH QUESTIONS

The central research question was:

> How is the Language of Mathematics facilitated in Grade3 classes?

The research sub questions were:

- What is the Language of Mathematics?
- What strategies are teachers using to facilitate the acquisition of the Language of Mathematics in Grade 3 classes?

These research questions were the bedrock of this research.

1.4 THEORETICAL FRAMEWORK

In this research, the teacher was viewed as playing a pivotal role in facilitating authentic learning. Slabbert, de Kock and Hattingh (2011:71) describe authentic learning as the process that engages the whole learner – when the learner is involved spiritually, emotionally, mentally and physically. In relation to the successful acquisition of the Language of Mathematics, two components or threads that are interdependent and intertwined are required. Together, these two components create the representation of the learner. It is vital that the teacher understands these components so that facilitation of the acquisition of the Language of Mathematics is optimised. The first component (or strand) focuses on the individual learner's attributes. The learner needs to have the characteristics of the four domains of intelligence, as described by Slabbert et al. (2011). The learner must have both the inner emotional drive and the will to learn; the intellectual capacity for learning; the physical stamina and attentiveness; as well as the spiritual resources of morality and respect for others (Slabbert et al., 2011).

The second component, or strand, looks beyond the learner to the ecology or environment, which is in line with Bronfenbrenner's eco-biological model of early childhood intervention. In terms of the acquisition of the Language of Mathematics, the learner is influenced by his immediate family, his teacher and peers in the classroom, the school atmosphere, and also by the country and international influences. Ryan and Paquette (2000:1) state that "Bronfenbrenner's theory of systems development is a cognitive map of the layers of influence in a learner's environment". According to Ryan and Paquette (2000:1), "The theory has been renamed Bronfenbrenner's bio-ecological systems theory to show the important influence of the internal factors within a learner". According to this theory, there are three layers of influence, namely, the micro-system (the learner's internal influences), the meso-system (the family and/or community influences) and the exo-system (national/global influences).

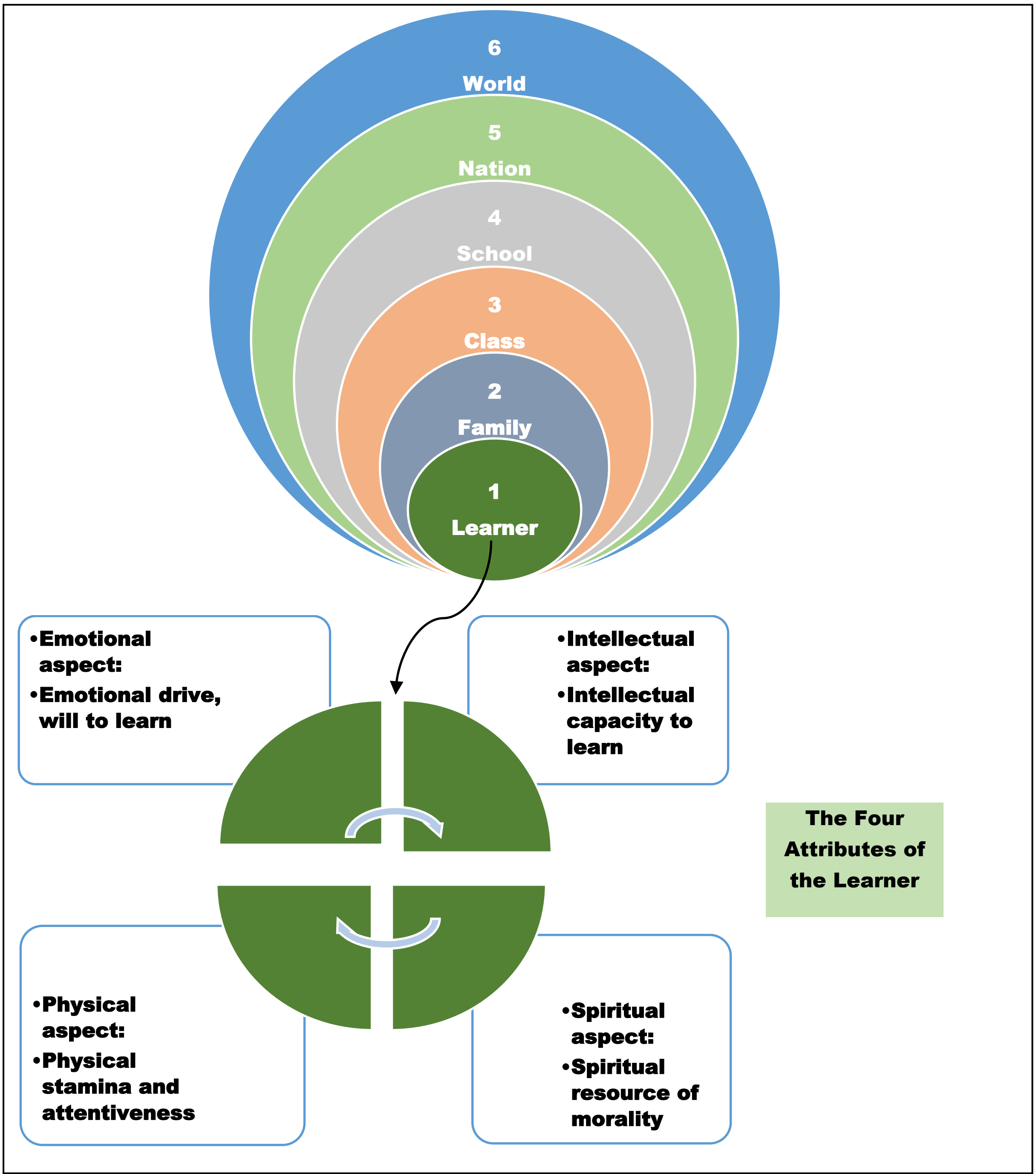


Figure 1.3: Adaptation of Bronfenbrenner's bio-ecological model of early childhood intervention (Ryan & Paquette, 2000) to the acquisition of the Language of Mathematics

Furthermore, the role of the teacher-facilitator must be considered. The contexts within which the teacher-facilitator operates have a bearing upon the way that the acquisition of the Language of Mathematics takes place. The teacher, just like the learner, has many emotional, intellectual, physical and spiritual facets. However, from the perspective of the Language of Mathematics, the focus is on the teacher's pedagogy and knowledge – in other words, the teacher's attitudes and beliefs; content knowledge (theoretical and practical); pedagogic skills; and rapport with the learner. From the perspective of the teacher as a professional, the contexts within which the teacher operates can be considered in the following hierarchy:

1. As professional facilitator and pedagogue.
2. As a member of the team which makes up the Foundation Phase, usually led by the Head of the Foundation Phase.
3. As a member of the staff of the school.
4. As a recipient of policy and curricula from the National Department of Education.
5. As a member of the community of Mathematics teachers globally.

These contexts are incorporated in a model which I developed of the attributes of the professional teacher-facilitator, as related to the acquisition of the Language of Mathematics. These attributes are the result of a number of environmental and pedagogic influences (Figure 1.4).

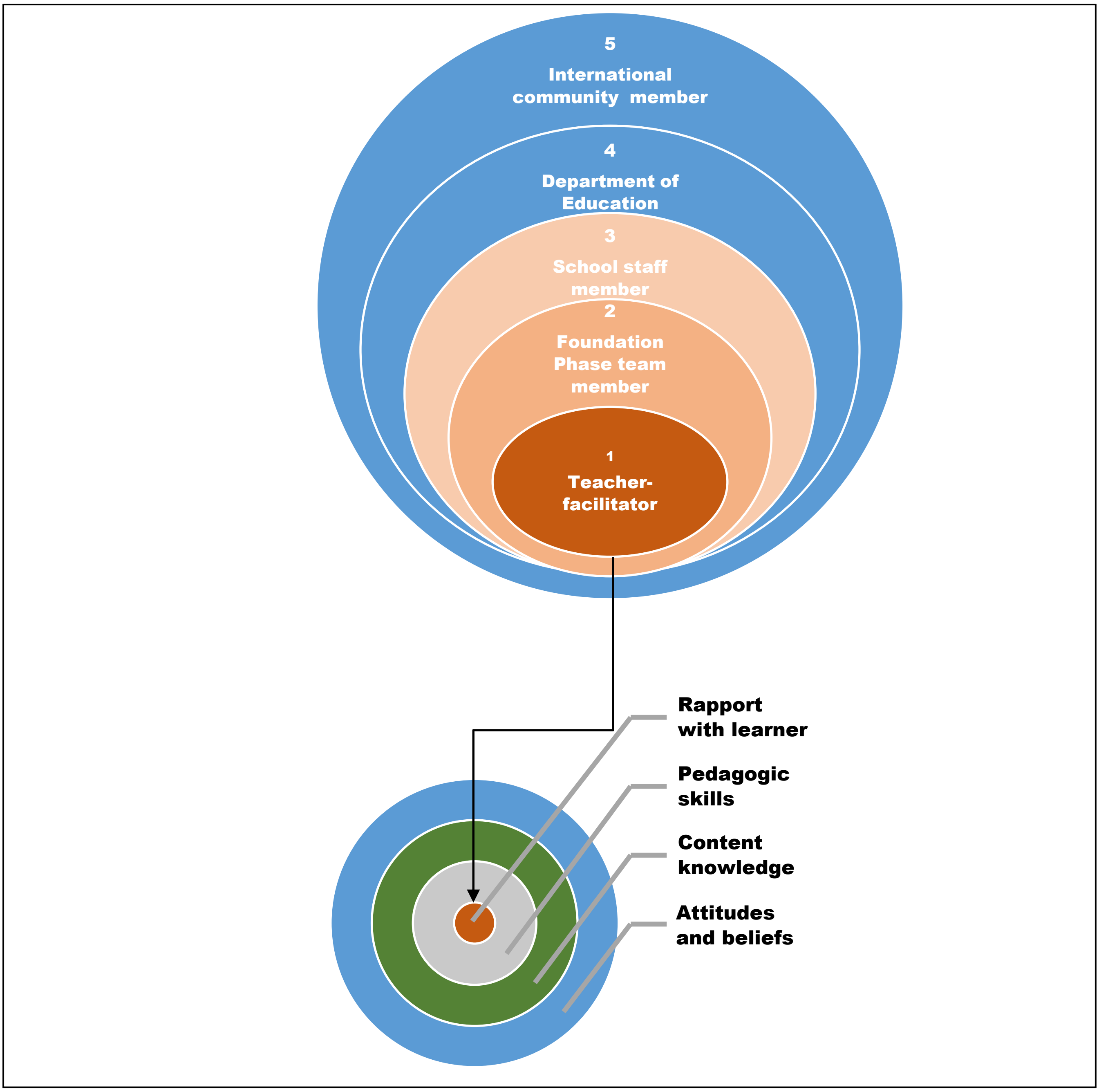


Figure 1.4: The attributes of the professional teacher-facilitator according to Bronfenbrenner's bio-ecological model (Ryan & Paquette, 2000), as related to the acquisition of the Language of Mathematics

1. The contexts within which the teacher facilitator operates have a bearing upon the way that the facilitation of the acquisition of the Language of Mathematics takes place. The teacher's beliefs about, and knowledge of, the Language of Mathematics forms the first and most important layer of the teacher's pedagogy.
2. The second layer influencing the teacher's pedagogy is the resources available to the teacher. These include the physical equipment and furniture in the classroom and the Mathematical charts, visual aids, worksheets, and Mathematics textbooks available to the teacher and learners.
3. The next layer of influence on the teacher's pedagogy relates to the school, namely: the school's culture, the school's value systems, and the school organisation. This layer influences the teacher's context and, in turn, impacts the facilitation of the acquisition of the Language of Mathematics. Generally, it has less force than the previous two layers on the teacher's pedagogy.
4. The final layer consists of the influence of cultural norms of the local community in combination with international influences (such as globalisation) on the teacher's pedagogy.
5. The circle in the centre of the (Figure 1.7) represents the four attributes of the learner, which were illustrated in Figure 1.3. These attributes are adapted from the model by Slabbert et al. (2011).

From the perspective of the teacher as a professional, the contexts within which the teacher facilitates can be considered in a structured way. The educational facilitation process of Slabbert et al. (2011:137) embodies four elements, which are considered to be interdependent. The elements of an educational facilitation paradigm are: Transmission, Transaction, Transformation and Transcendence, according to the model of Slabbert et al (2011:137).

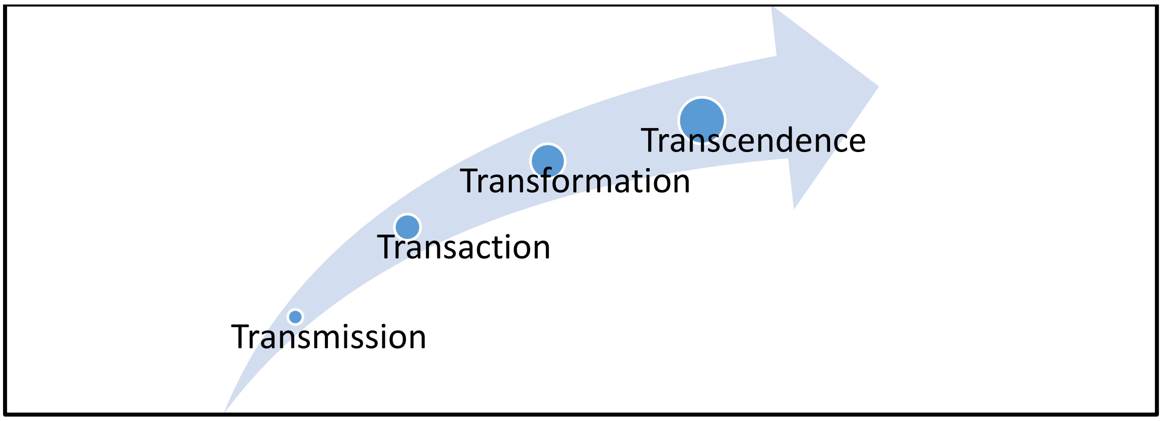


Figure 1.5: The four elements of the educational facilitation process (Slabbert et al., 2011)

Table 1.5: Definitions of each of the four elements of the educational paradigm, as proposed by Slabbert et al. (2011).

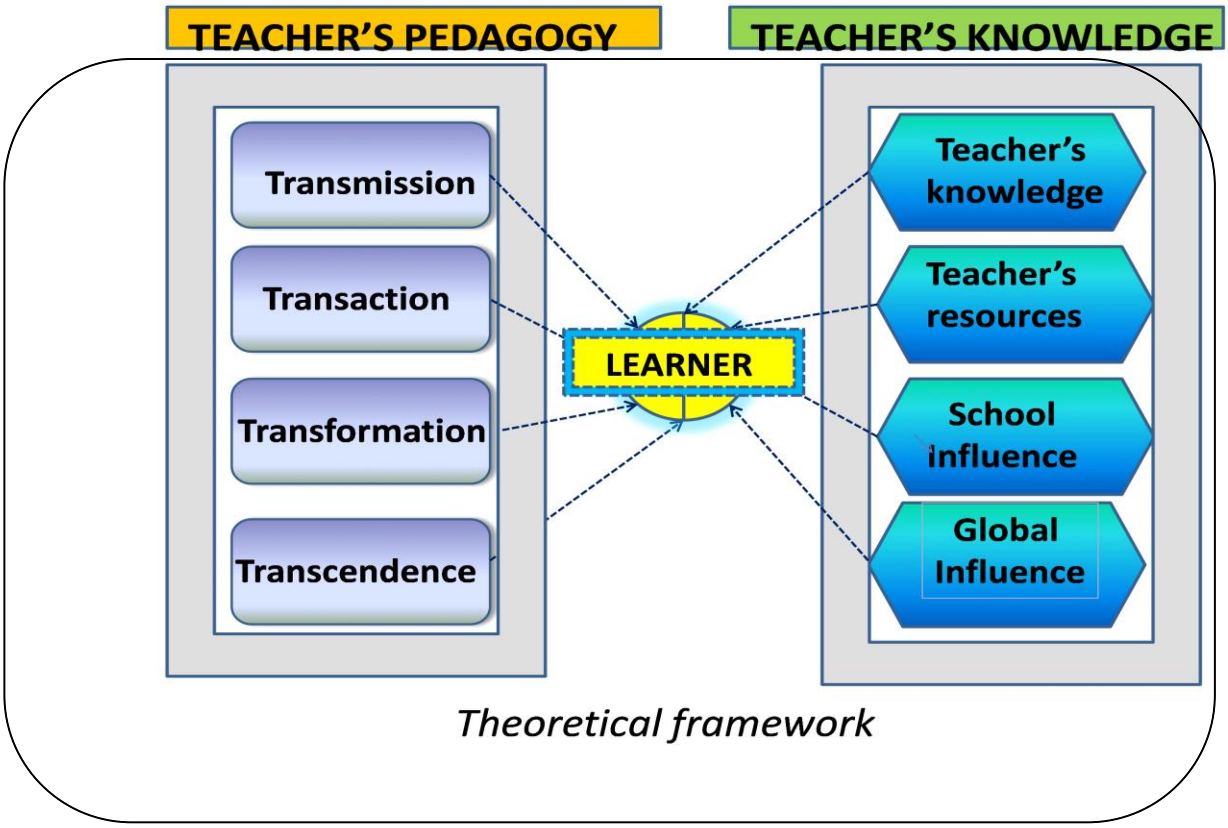
Elements of the educational paradigm	Definition and description of each element
Transmission:	The pedagogy in the acquisition of the Language of Mathematics.
Transaction:	Transaction: Grade 3 learners' number sense and their number sentences.
Transformation:	The teacher's facilitation of the Language of Mathematics learning experiences.
Transcendence:	The thinking and concepts acquired by the learner as they become visible, and to communicable these to others.

Facilitation of the acquisition of the Language of Mathematics by the teacher is supported by two pillars: firstly, the pedagogy of the teacher; and secondly, the teacher's knowledge of Mathematical concepts and words. The learner is the focus of all facilitation efforts; in the theoretical framework, the learner is the composite of the four aspects depicted in Figure 1.3. However, the theoretical framework rests on the twin pillars of firstly, the teacher's pedagogy, and secondly, the teacher's knowledge, as depicted in Figure 1.5. The teacher's pedagogy is comprised of the facilitation strategies of Slabbert et al. (2011), which are considered to be progressively more important with transmission being at the lowest level. These facilitation strategies are discussed in more detail in Chapter 2 (Section 2.1).

According to Bronfenbrenner's bio-ecological model (Ryan et al., 2000), the teacher's knowledge is the result of a number of influences. These influences are:

- The teacher's knowledge, which is a culmination of the individual's formal and informal education, as well as practical experience in the classroom setting.
- The teacher's resources, which represent both the physical resources available to the teacher (such as textbooks, visual aids, and technology) and the intellectual resources available (such as mentors, teacher's manuals, and libraries).
- The school influence, as the teacher forms part of a team. The support of the team is a positive influence, whereas the demeaning and critical attitude of the school team is a negative influence.
- Global influence, which encapsulates diverse educational trends and philosophies that have a bearing on the teacher.

Table 1.6: The theoretical framework underpinning this research



1.5 RESEARCH METHODOLOGY

1.5.1 Research design

This was a qualitative case study to explore the strategies used by the participating teachers to facilitate the acquisition of the Language of Mathematics in Grade 3 classes.

1.5.1.1.Research paradigm

The philosophical viewpoint of this research on the acquisition of the Language of Mathematics (i.e. the ontology) is within the phenomenological paradigm. Cohen, Manion and Morrison (2007:12) describe the phenomenological approach as "the point of view that advocates the study of direct experience in which behaviour is determined by the phenomena of experience." Cohen et al. (2007:12) also state that the "phenomenological perspective fit[s] naturally to the kind of concentrated action found in classrooms and schools."

The approach to this research was qualitative. Denzin and Lincoln (2005:4) explain that "qualitative researchers deploy a wide range of interconnected interpretive practices, hoping to get a better understanding of the subject matter". Mays and Hendricks (2010:18) describe qualitative research as providing "field-focused, interpretive, detailed descriptions and interpretations of participants and their settings". In this research, a number of data collection methods were used in order to understand the facilitation of the acquisition of the Language of Mathematics. The theoretical basis of this research was constructivist and interpretivist. Merriam (2012:3) describes the epistemological perspective of constructivism and interpretivism as an attempt to "describe, understand and interpret a phenomenon". Seale (1999) emphasises that a concern with validity and reliability is that it should be shared by all social researchers. Seale (1999:157) is fairly critical of the concept of constructivism being multiple realities, and suggests that relevance and truth should be the criteria on which research is judged.

1.5.1.2. Research approach

In this research, the data was collected in the natural setting of the phenomenon (i.e. the Grade 3 classrooms). Cohen et al. (2007:12) state that “the researcher sets out to understand the individual’s interpretation of the world around them.” Waters (2015) explains that “the goal of qualitative phenomenological research is to describe a lived experience of a phenomenon. Any way the participant can describe their lived phenomenal experience can be used to gather data in a phenomenological study. You can use an interview to gather the participants' descriptions of their experience”. In this research, the aim was to understand each of the participating teachers’ perspective of the acquisition of the Language of Mathematics and the resultant facilitation strategies. MacMillan and Schumacher(2010) advise that the researcher should “devise a questionnaire to help you answer your research question and make sure all the research questions are relevant. Try to have a sequence to your questions by grouping them into themes that follow a logical sequence. Make sure the questions are clear and easy to understand.” These principles were observed in the design of the interview questions for this research.

The research adopted the Appreciative Inquiry philosophical stance, wherein the focus is on the best practices of Mathematics teachers. Kessel (2013:1) maintains that “Appreciative Inquiry is a method for studying and changing social systems that advocates enquiry into the best of what is in order to imagine what could be”. For this reason, I purposefully chose to study the facilitation strategies used by experienced Mathematics teachers. “Case study research is useful in the early stages of a topic” (Huberman & Miles, 2002:28). Van Wyk (2004:3) finds that research design can be “an exploration, description, explanation, prediction, evaluation, or history. Exploratory research design is most appropriate when there is very little existing research on the subject matter.”This research can be considered as an exploratory case study because there seems to be very little research on the acquisition of the Language of Mathematics in Foundation Phase classes.

1.5.1.3 Research strategy

Willig (2008) explains that “Case study research is not characterised by the methods used to collect and analyse data but rather by its focus on a particular unit of analysis: a case”. Huberman and Miles. (2002:24) maintain that “Case study research involves viewing evidence from diverse perspectives.”

1.5.2 Research methods

1.5.2.1. Introduction

Research methods encompass procedures, tools and techniques used to gather and analyse data. The selection of participants, data collection, data analysis, trustworthiness and ethical considerations are all components of the research method. These will be discussed in detail.

1.5.2.3. Data collection strategies

Observation was one of the primary data collection techniques used. In terms of the Grade 3 learners, I was the sole researcher and, as the researcher, I consciously chose to observe and not participate in the classroom activities.

Semi-structured interviews with the participating teachers provided triangulation of the data collected during the observations. I interviewed each of the Grade 3 teachers outside of school hours. MacMillan et al. (2010:349) illustrate the range of the researcher’s role on a continuum from complete insider to complete outsider, and state that “the researcher role may vary with the degree and intensity of the interaction”. The researcher must be as objective as possible. Huberman and Miles. (2002:24) emphasise that “the researcher must judge the strength and consistency of relationships within and across cases.”

Analysis of documentation was the third techniques of data collection which was applied. The document which was analysed during this research was the national South African Mathematics curriculum which is applicable in all Grade 3 classrooms.

1.5.3 Research strategy

1.5.3.1 Case study:

The research design of this research was that of a single case study. A case study has been defined as "a research design which examines a bounded system, over time, in depth employing multiple sources of data found in the setting" (MacMillan et al., 2010:24; Merriam, 2012)."Qualitative case studies afford researchers opportunities to explore and describe a phenomenon in context using a variety of data sources. This ensures that the issue is not explored through one lens, but rather a variety of lenses which allows for multiple facets of the phenomenon to be revealed and understood" (Baxter & Jack, 2008:544); Merriam (2012) agrees with this viewpoint. In order to minimise bias, this research had multiple methods of data collection. This case study was focused on the elements pertaining to the Language of Mathematics, and examining these elements within the contexts of three Grade 3 classes. In summary, the following aspects of the research were the:

1.5.3.1.1 Participants

The three Grade 3 Mathematics teachers were from three different schools. The teachers were of diverse backgrounds, but were all experienced and qualified professional teachers. They were all within reasonably close proximity to me, the researcher, namely, within the greater Johannesburg district, which is an urban setting.

1.5.3.1.2 Interviews

The interviews were guided by the Appreciative Inquiry approach and therefore, the strengths and best practices of the teachers regarding the Language of Mathematics were sought. The interviews with the participating teachers were semi-structured as the interviews had a mixture of open-ended and closed questions. All the teachers were asked the same questions, in the prearranged order. These can be found in the Addenda.

1.5.3.1.3 Observation

Each of the classes was observed by me, in my role as the researcher. In this research, the responses to the interviewer (particularly the open-ended questions) were analysed in order to create categories, which enabled me as the researcher to discover interdependencies between the various categories (Hussey and Hussey, 1997). The Observation checklist is in the Addenda.

1.5.3.2 Data collection strategies

By employing multiple data collection methods, it was hoped that rich and detailed data would be collected. The multiple methods of data collection were observation, interviews with the participating teachers, and evaluation of the official curriculum documents of the Department of Basic Education. The interviews with each participating teacher were transcribed. The data are stored in a safe place. I wrote detailed descriptions of the classroom settings and lessons, as they related to the acquisition of the Language of Mathematics.

1.5.3.3 Data analysis strategies

On completion of the data collection phase, the data was categorised thematically to determine common themes and categories. This data analysis highlighted significant findings, which are described in Chapter 5.

1.5.3.4 Trustworthiness

The research was qualitative in nature and, as very little research exists on this research topic, there were, to my knowledge, no norms as yet. The trustworthiness and validity of this qualitative research was an extremely important consideration. The small sample size could mean that transferability may not be possible until further research has been conducted. The Open University (2013) advises that “Validity of qualitative designs has been improved by using multi-method strategies which were implemented within the same time frame as a type of triangulation.” This is a complex, multi-faceted research problem; hence this was an exploratory case study. In order to enhance the validity and credibility of this research, as has been mentioned, there were multiple methods of data collection, using semi-structured interviews and observation. During the interviews, the researcher probed for explanations whenever it was not clear what the participant meant. Precise and detailed descriptions were provided, and transcripts of each interview were made. This research provided detailed contextual summaries of the facilitation of the Language of Mathematics to ensure that this research was trustworthy.

1.6 ADHERENCE TO ETHICAL CONSIDERATIONS

The ethics of this research were thoughtfully considered and adhered to. Mouton (2001:243) highlights the importance of protecting the participant's rights and interests. This research was subject to approval by the University of Pretoria's Faculty of Education Ethical Committee. This research adhered to ethical principles, in particular, that participation was voluntary and that the teacher-participants had the right to withdraw from the research programme at any time; happily, this did not happen, and all the teacher-participants were committed to the research goal. Thereafter, permission from the school governing body and the principal was sought before the teachers were approached. The teachers' written consent to participate in this research was obtained before commencement of the research. The teachers were encouraged to participate fully in the research, but were made aware of their right of refusal to participate in the research and their right to anonymity (Mouton, 2001: 243). The identities of the teachers were not disclosed at any time. At all times, the rights of the participants (both teachers and learners) were kept in mind. The participants were treated with the utmost respect.

1.7 PROPOSED CHAPTER OUTLINE

Chapter 1	Orientation to the research
Chapter 2	Literature review
Chapter 3	Language development in the South African context
Chapter 4	Research design and methodology
Chapter 5	Data analysis
Chapter 6	Synthesis of the research

1.8 CONCLUSION

This introductory chapter leads us to consider the literature on this topic, which is contained in Chapter 2, the literature review. "Mathematics and Science are basic to human development and the functioning of society. The rich tradition of knowledge and understanding which they offer, belong to everybody" (Wilcox, 2006).In Mathematics, as in other fields of learning, there is a language which every newcomer has to master before any proficiency therein can be acquired. Therefore, proficiency in Mathematics requires an in-depth knowledge of the Language of Mathematics, i.e. both the symbolic and verbal aspects of Mathematics and their inter-relationship or grammar (Barnet–Lamb & Ganeslingam, 2009).

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

In examining the Language of Mathematics, many components must be taken into account. This research project focuses primarily on the role of the teacher in facilitating the learner's knowledge and application of the Language of Mathematics. A learner is not a passive object upon which the Language of Mathematics is imprinted through repetition or rote learning. Each learner is the sum of the interdependence of these dimensions: emotional, physical, socio-economic, cultural, psychological and spiritual dimensions, as described by Slabbert et al. (2011). In other words, every learner is multi-dimensional, and therefore an exploration of the learner's acquisition of the Language of Mathematics must also be multi-dimensional and must take important themes within the pedagogical environment into account. I have designed a model of the themes within the pedagogical environment of challenges faced by every Mathematics teacher, which is a meta-structure (teacher's facilitation strategies) enclosing a pyramid structure (home languages and the Language of Mathematics).

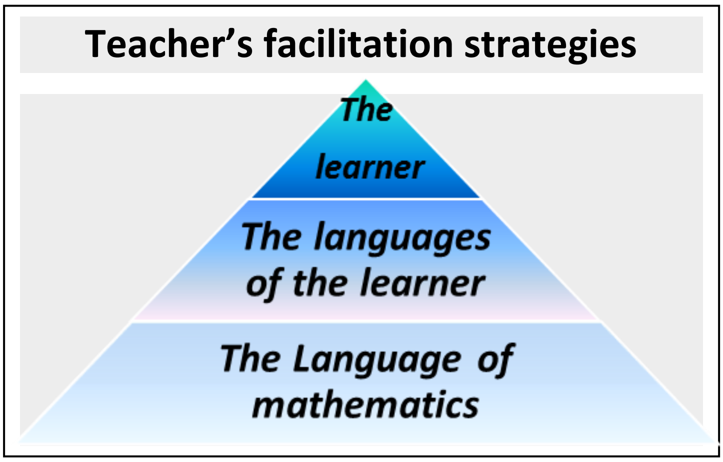


Figure 2.1: The three themes within the pedagogical environment of Mathematics

The first theme, which is metaphorically at the central and highest point of the pyramid, consists of the facilitation strategies that influence the individual learner. In many Mathematics classes, the teacher seems to disregard the individual learner, particularly if that learner is struggling to grasp the concepts of the Language of

Mathematics. Ideally, the teacher should facilitate by creating opportunities to acquire the Language of Mathematic sat the learners' own pace. This means that, as far as is practical, teachers must adapt Mathematics education and the facilitation strategies to meet the needs of the individual learner, and build on existing knowledge of the Language of Mathematics.

The premise of the second theme is that the acquisition of the home language leads naturally into an acquisition of the Language of Mathematics. Learners develop an understanding of the components that form Mathematical expressions (or sentences) using the Mathematical registers of their home language. This theme includes the pedagogy of the teacher in respect to both the home language and the Language of Mathematics. The final outcome of the teacher's facilitation should be that every learner can communicate meaningfully using the Language of Mathematics.

The third theme focuses on the international nature of the Language of Mathematics, whereby Mathematical terms, rules and syntax are universally accepted and understood. Mathematicians everywhere, regardless of which home language the learners and teachers speak, communicate clearly and easily with each other through the Language of Mathematics.

The themes which that were highlighted in Figure 2.1 undergird the structure of this literature review. My primary goal in this literature review is to report and analyse the relevant literature and research on teachers' facilitation of the acquisition of the Language of Mathematics. This was done in order to identify strategies that promote the effective acquisition of the Language of Mathematics. The chapter is structured in such a way that it progresses from the global elements of the Language of Mathematics to the local South African context.

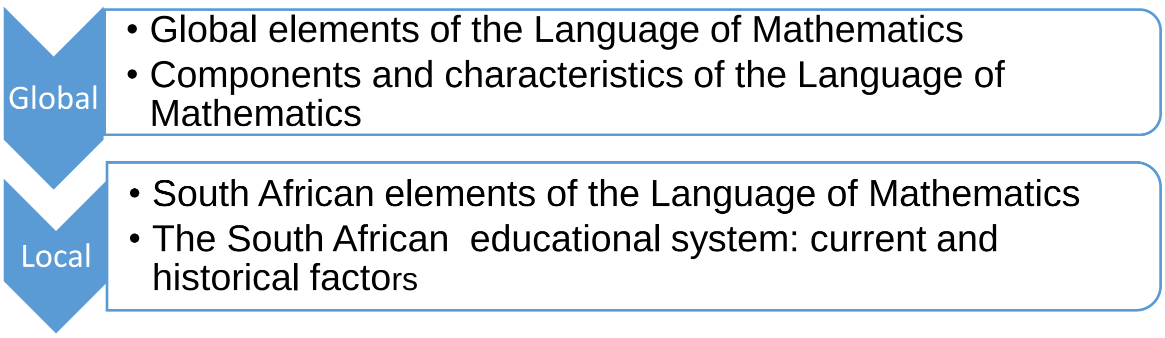


Figure2.2: The representation of the progression from global to local themes

The literature review begins with a clarification of what is meant by the term 'the Language of Mathematics', and a brief overview of the components and characteristics of the Language of Mathematics, which are universal. Any discussion of the acquisition of the Language of Mathematics would not be complete without analysing the role of the individual learner. Ryan (2000:1) writes that "Bronfenbrenner's systems theory suggests that the interaction between factors in the child's maturing biology, his immediate family/community environment and societal landscape fuels and steers his development". These factors were considered in the research design. For this research, Grade 3 learners were chosen as the participants alongside their teachers. It was assumed that most of the major developmental milestones would have been reached by this stage, although each learner would have reached a different point on the continuum of development in the Language of Mathematics.

The positive outcomes of the successful acquisition of the Language of Mathematics for the future of the individual learner are also probed in this literature review. Within the literature review, I have adopted an approach that starts with an exploration of the macro-elements and then moves to the micro-level elements. This approach includes the dimensions mentioned previously, and is grounded in the conceptual framework of this research. After discussing the facets of the multi-dimensional conceptual framework in terms of the acquisition of the Language of Mathematics, these facets are combined and summarised in the conclusion of the literature review.

2.2 CHARACTERISTICS OF THE LANGUAGE OF MATHEMATICS

2.2.1 Analysis of the Language of Mathematics

The term 'Language of Mathematics' has not been widely used in Mathematics circles and therefore, a starting point would be an analysis of the components of this concept. Very little research has been done on the Language of Mathematics. Researchers differ regarding the idea that Mathematics is a language (Ganesalingam, 2013). It is obvious that no-one speaks only in the Language of Mathematics. Nevertheless, there is a set of rules, terms and syntax that uphold the Language of Mathematics. Ganesalingam(2013:3) clarifies the concept of the Language of Mathematics in explaining that, in Mathematical texts, "the interaction between words and symbols is unlike anything found in any other language natural or artificial; although the two are entirely dissimilar, they are remarkably independent", while Kersaint (2014:1) finds that the Language of Mathematics "includes its own vocabulary; syntax (sentence structure); semantic properties (truth conditions) and discourse (oral and written)". The following statement by Usiskin (2014:8) echoes this belief; he declares: "Mathematics is a language of discourse: it is both a written and spoken language. We have words for virtually all the symbols. Familiarity with the Language of Mathematics is a pre-cursor to all understanding". I resolutely maintain that Mathematics is indeed an international language, and this belief forms the foundation of this research.

It is a fundamental tenet of this research that the Language of Mathematics uses a unique vocabulary, which is communicated through written and oral expressions in a similar way to the communication of vocabulary in conventional languages. In conventional languages, for instance, an example of a simple sentence is when there is a noun (i.e. an object or concept) and a verb (i.e.an action performed which involves the noun). An example of a simple sentence could be: *The boy runs,* or *the cat sits*. When we consider the equivalent in a number sentence, for example, *finding the square root of 36*, the object (i.e. the noun) is 36, and the action (i.e. the verb) is "find the square root of". In this example, the number 36 can be considered as the object and the operation or action is that of finding the square root. Just as one has sentences in conventional languages, so, in Mathematics, one has a number sentence in the Language of Mathematics, which can be compared to a written sentence in a conventional language. Bell (1998:56) proposes that "Writing number sentences has strong links to language arts. Just as word choice, commas, periods and other punctuation marks clarify verbal sentences so do numbers (nouns), operations symbols (prepositions), relation symbols (verbs) and parenthesis (punctuation marks) clarify number sentences."

Table2.1: Conventional sentences and number sentences compared (Bell, 1998:56).

Conventional sentences	Nouns	Prepositions	Verbs	Punctuation marks
Number sentences	Numbers	operations symbols e.g. + - * /	relation symbols e.g. <> =	Parenthesis ( )

This leads us to an examination of the most important components that make up the Language of Mathematics. According to Ganeslingam (2013:2), the Language of Mathematics has *two* primary and equally important components:

- Mathematical symbols; and
- Mathematical English or terminology.

Ganesalingam (2013:2) expresses this thought as "a basic division of the Language of Mathematics into *textual* and *symbolic* halves: *Textual* refers to the parts of Mathematics that resemble natural language and the remaining material will be referred to as *symbolic*. Mathematical texts are largely composed out of textual sentences with symbolic material embedded, like islands, inside texts". Mathematical symbols form a code in a Mathematical expression because each symbol has a recognisable meaning. Each of these Mathematical symbols represents the many words which would be needed to explain an operation or expression (i.e. to detail the steps that are required to be taken by the mathematician). Ganesalingam (2013:3) explains that the function of symbolic Mathematics is to abbreviate material that would be "too cumbersome to state with text alone".

Ganeslingam (2013:3) cites this example:

$f\ (gag^{-1}) = f(g)f(a)f(g^{-1})$ would be written in text as:

The value of f at the product of g and a, and the inverse of g is equal to the product of the value of f at g the value of f at a and the value of f at the inverse of g". Thus we can deduce that Mathematical symbols are a kind of shorthand or code where every symbol has a predetermined meaning. The syntax of Mathematics demands a rigid sequencing within expressions. This syntax and these rules of syntax are learned, understood and used by mathematicians globally.

The next topic to consider is Mathematical English, or terminology. Mathematical English has three types of terms (vocabulary) according to Ganeslingam (2013:3), namely:

- Terms which have a specific, prescribed Mathematical meaning.
- Terms which have a dual meaning: a meaning in Mathematics, and everyday meaning.
- Language of Mathematics, which is the use of words to clarify meanings in Mathematical expressions.

The vocabulary within the Language of Mathematics is arranged into a prescribed and universally accepted sequence, which forms a communicable Mathematical sentence. A Mathematical sentence is referred to in Mathematical circles as a Mathematical algorithm or as a Mathematical expression. (Ganeslingam (2003:3).It is important to note that a Mathematical expression can be comprised of Mathematical symbols only or, alternatively, it can be a combination of both Mathematical symbols and Mathematical English. In summary, Mathematical symbols and Mathematical English are the fundamental components of the Language of Mathematics; together they can be considered as constituting the vocabulary of the Language of Mathematics.

Every Mathematical expression obeys rules or syntax that dictate a precise order of elements (i.e. symbols and/or words) so that they can be communicated to, and understood by, other mathematicians. Therefore, in order for a mathematician to deduce an answer, the Mathematical expression needs to be correctly interpreted by the mathematician or learner. For the learner, successful interpretation of Mathematical elements (vocabulary) represents the successful acquisition of the Language of Mathematics.

“There are 4000 languages in the world and all have one thing in common – they have a category for words representing nouns or objects and a category for representing verbs or actions” (Schwartz & Kenney, 2003:1). A ten-year project (1993-2003) at the Harvard Graduate School of Education, titled *the Balanced Assessment in Mathematics*, developed a model in which Mathematical nouns or objects are called *content* and Mathematical verbs or actions are referred to as *processes*. This model lists many Mathematical objects, but suggests that there are only four Mathematical processes, namely: modelling/formulating, transforming/manipulating, inferring and communicating (Schwartz & Kenney, 2003). Only the first process is applicable to the Language of Mathematics. The first process, namely modelling/formulating", refers to the translation of an everyday situation into the Language of Mathematics. However, Mathematical vocabulary (i.e. the Language of Mathematics) can be learned naturally and internalised effortlessly by learners who have learned from adults at home and at school through participation in meaningful activities and discussions involving Mathematics.

Unfortunately, many of the Mathematical English terms have dual meanings where the same word has different meanings in Mathematics and other subjects, which can lead to confusion. Examples of Mathematical English terms encountered in Grades 1, 2, and 3 could be: *equal, greater, less, bigger, smaller, higher, lower, shared, set.* Fiona Kampmann, speaking on the Language of Mathematics, also emphasises that the meaning of the same word is different in Mathematics and in other subjects, and she lists the following words as examples: *acute, area, improper, root, mean, braces, and contraction.* "Researchers have paid lip service to the unique vocabulary of Mathematics. They have done little to highlight the ambiguities, double meanings and other 'word' problems associated with the discipline. Ignorance of these causes can lead to impaired communication at best and serious Mathematical misunderstanding at worst" (Kenney, Hanciewicz, Heuer, Metsisto& Tuttle, 2005:1)

One of the best illustrations of the misunderstanding of a Mathematical English term is the following diagram to *find X.*

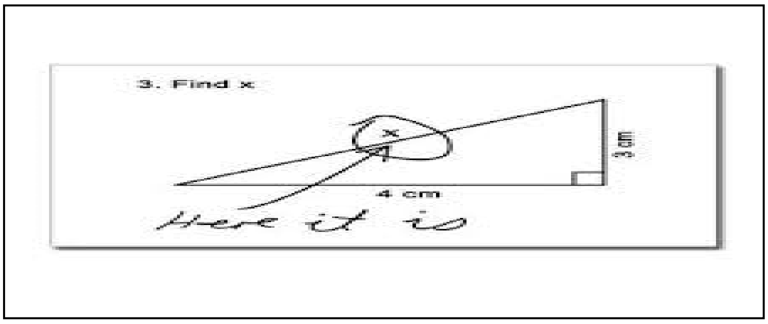


Figure 2.3: Misunderstanding arising from an ambiguous English word

In my opinion, the learner who is able to *Mathematicize* an everyday situation has grasped the essence of the Language of Mathematics. With the Grade 3 learners, this can be related to Piaget's stages of development; those learners who are struggling to grasp the Language of Mathematics should manipulate concrete objects as per Piaget's initial *sensori-motor stage*, and gradually progress from there into the abstraction required in Piaget's *pre-operational stage* (Louw, 1991). This progression is discussed in more detail in Section 5.1.

Teachers need to careful when compiling story sums for young learners. The following example by Gersaint (2014:3) illustrates the problems with interpretation of a story sum that a learner who is not fluent in English could experience:

"Story sum: Tom *earns* R300 000 a year. He is promised a R200 000 *raise* each year. How much will his *salary* be in 5 years?"Gersaint (2014: 3). The following words may be daunting for the learner: '*earns, raise, salary*'. Gersaint suggests the simplification of the story sum as a strategy to assist the learner.

"Story sum (amended): Tom's pay is R300000 a year and he will also get R200 000 more each year. How much will he get paid 5 years later?" Gersaint (2014:3). This illustrates how Mathematical concepts (especially Mathematical English terms) can be expressed in a way that is easy for learners to understand.

When tackling Mathematical sentences, and especially story sums, Kampmann (2014) suggests that learners should identify what they do or don't know, and should identify what they need to know. This strategy, proposed by Kampmann (2014), encourages a sort of meta-cognition in the acquisition of the Language of Mathematics as learners verbalise, then understand structure and critically examine their own thought and learning processes. This strategy is in stark contrast to the behaviourist approach, which requires demonstrable evidence of learning through activities, usually written (in a quiet classroom, where learners are busy). In my view, many learners can perform Mathematical operations mechanically, yet those same learners do not understand the underlying Mathematical concepts and have not yet fully mastered the Language of Mathematics.

2.3 THE LAND OF MATHEMATICS: AN ANALOGY

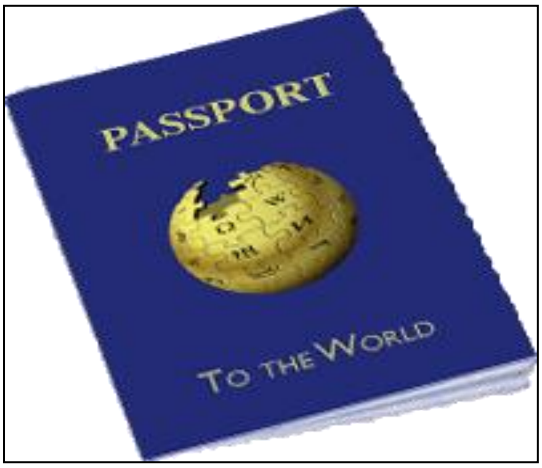


Figure 2.4: Analogy of Mathematics as a passport to the world

Teachers need to understand that the acquisition of the Language of Mathematics seems to have many similarities to the learning of a conventional language. In this analogy, every learner will spend his whole life as a citizen of the land of Mathematics, so it makes sense that the learner should be able to understand and communicate in the Language of Mathematics. Mastery of this language becomes a vital life skill. Mathematical 'sentences' (i.e. expressions) consisting of Mathematical symbols and Mathematical English are present at every level of the Language of Mathematics, from the elementary grades right though to tertiary education and almost every workplace.

In terms of vocabulary, Mathematics does not equal science in the number of terms, but the ISI Multilingual Glossary of Terms (for Mathematics) has approximately five thousand entries. This is an overwhelming number of entries to learn in order to claim mastery of the Language of Mathematics. In addition to knowing the vocabulary of the Language of Mathematics, the learner needs to be fluent in English in order to succeed within the context of the 'land of Mathematics'. Esty (2014) writes about Mathematical language and presents the analogy of visiting an overseas country that speaks an unfamiliar language without learning the language, and being completely reliant on translators for survival. I agree with Esty (2014) that in many Mathematics classrooms, teachers continue to translate every single concept in the Language of Mathematics for learners. It is the vision of this research that, as learners acquire the Language of Mathematics they will be empowered to become international citizens of the World of Mathematics.

2.4 THE GLOBAL NATURE OF THE LANGUAGE OF MATHEMATICS

2.4.1 The Language of Mathematics is a universal language

The Language of Mathematics is universal in that all the nations of the world use the same Language of Mathematics to communicate Mathematical solutions and concepts to each other (Ganeslingam, 2013:2). The Language of Mathematics is necessary in many careers. In the latest South African curriculum documents for Foundation Phase classes, Mathematics is described as “a human activity that involves observing, representing and investigating patterns and qualitative relationships in physical and social phenomena and between Mathematical objects themselves” (Department of Basic Education, 2011:6) and, according to the Department of Basic Education (2011:6) “Mathematics is a language that makes use of symbols and notations for describing numerical geometric and graphical relationships.” Whilst these definitions cover basic Mathematical activities, there is no mention of either the Language of Mathematics or the processes for acquiring this Language of Mathematics.

2.4.2 The TIMSS International results in Mathematics

TIMSS is an international assessment of the Mathematical proficiency of learners, which enables a country to benchmark itself against other countries. South Africa’s results in the TIMSS assessment have been discussed in depth in Chapter 1. It is important to note that South Africa has not participated in either the 2007 or the 2011 TIMSS studies. It is necessary to consider the implications of this non-participation in the light of the World Economic Forum 2013 report on the Global Competitiveness Index (2013:17), where South Africa’s (S.A) educational system was ranked 146th out of 148 economies. In the 2014 World Economic Forum report, the rating of the South Africa’s educational system descended even further; according to this report, the quality of South Africa's Mathematics and science education is placed in last place of the 148 participating countries, including countries with developing economies (Delwyn Verasamy, as reported in the Mail & Guardian, 2 June 2014). However, the South African Department of Education has rejected the World Economic Forum's 2013 report on Education, according to the South African Press Association (SAPA).

The South African Department of Education reported that the report's research was based purely on interviews with business executives (SAPA: 3 June 2014).This is a matter for further debate, which falls outside this research forum, but there can be little doubt, however, that raising the level of Mathematics education in South Africa has become absolutely vital for the future growth of the country. For the sake of learners in the Foundation Phase of South African schools, this research aims to be the catalyst for further research into the successful acquisition of the Language of Mathematics, and that further afield research into the successful acquisition of this language will have a global impact on young learners.

2.4.3 English as the universal medium of communication in Mathematics

The fact that English has been adopted in Mathematical circles as the universal language for communication between mathematicians is the result of world history and politics (Crystal 2002:5). The mastery of English is pivotal to the mastery of the Language of Mathematics, and if South Africans are to participate in the global village that has emerged, especially in fields where the Language of Mathematics is essential, such as in the sciences and engineering, they need to master this language. According to Crystal (2002:5), “English is an official or semi-official language (or has a special function such as language of choice for international communication) in over 70 of the world’s territories”.

According to Crystal (2002:5), in 2002 there were globally:

- 400 million first language English speakers;
- 400 million using English as a second language; and
- 700 million using English as a third language.

The total of this calculation is 1.5 billion English language speakers, which in 2002 represented a quarter of the world’s population of 1 billion (Crystal, 2002:10). The British Council website states that English is the official language (or has special status) in 75 countries, with a combined population of 2 billion people, and globally, one in four people speak English (2014). These facts relate directly to this research study because English is the global language used by mathematicians– Mathematical English is very much part of the Language of Mathematics. Based on these facts, there would appear to be a strong argument for English as one of the languages of instruction in schools. In South Africa, and in many other countries around the world, the vast majority of learners do not speak English as their home language and this presents enormous constraints and challenges within the educational system, which will be further explored in Section 3.3.

Many countries in Africa have chosen English as an official language; therefore, for many people in Africa, English is the language that is shared. Albaugh (2009:1) expresses the following point of view: "Historically, governments (of African states) have had no qualms about plunging learners into an unfamiliar linguistic environment and expecting them to absorb a new language through immersion. Today this model is being questioned by newer (African) states. These governments are not necessarily giving up the idea of a shared language, but many are allowing the use of more local languages early in education, thus raising the possibility of perpetual multilingualism within their borders". An examination of the history of language development in South Africa will shed light on why South Africa has also adopted the model of multilingualism in education.

Facilitated learning of the Language of Mathematics

The new paradigm of facilitating learning, proposed by Slabbert et al. (2011:118), has the following components of the cyclic (i.e. iterative) model for facilitated learning and is applicable to the acquisition of the Language of Mathematics:

Initiating learning is started by the facilitator but then taken forward by the learner into:

The Learning Phase, which is the learner's construction of meaning from either *objects* (from nature or events) or from *subjects* (from others or self), which leads to:

Maintaining learning, which is the partnership between the facilitator and the learner.

It is important to notice the momentum of this model, which allows for lifelong learning through a repeated return (iteration) to the initiation of new learning.

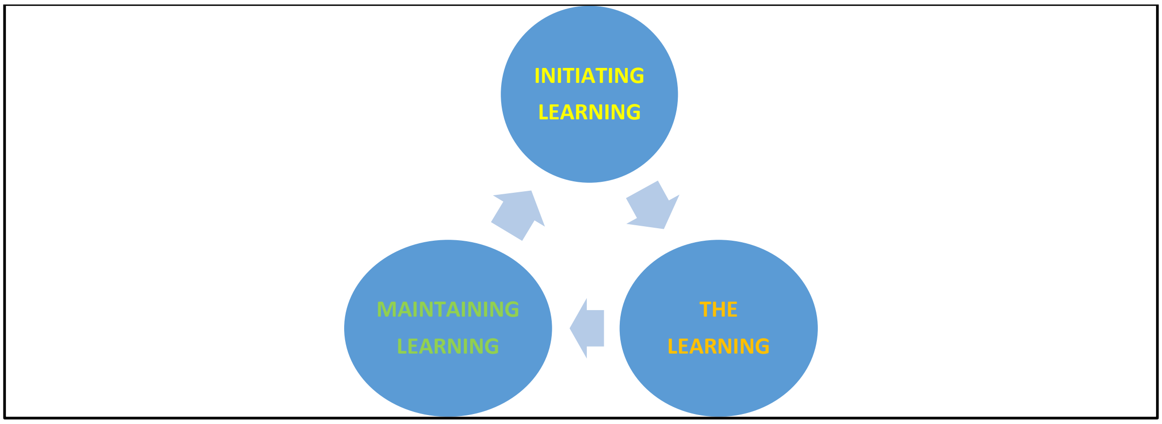


Figure 2.5: The new paradigm of facilitating learning (Slabbert et al., 2011:118)

The pedagogical knowledge relating to the Language of Mathematics is important. In a research paper exploring two teacher's Pedagogical Content Knowledge (PCK), Bakers and Chick (2006:60) found that the PCK of two teachers differed considerably. The researchers concede that "the range of teacher knowledge that teachers draw upon is vast – knowledge of content, of students, of curriculum, of pedagogy of psychology". The Language of Mathematics, by its very nature, demands a thorough understanding of each concept. Talented teachers are able to employ the most effective teaching approaches. Misguided teachers are of the opinion that the Language of Mathematics is taught through much repetition and rote learning. Mathematical problems cannot be solved without repeated attempts, which should never be labelled as failures, but rather as real learning.

2.5 CONCLUSION

In this chapter, the Language of Mathematics has been discussed in relation to the extensive use of English as a language of communication. The Mathematics teacher needs to be reasonably fluent in both English and Mathematical English so that facilitation strategies can be developed for learners, which would result in the acquisition of the Language of Mathematics. In the next chapter, I look at the local South African context and highlight some of the difficulties that Mathematics teachers encounter.

CHAPTER 3: LANGUAGE DEVELOPMENT IN THE SOUTH AFRICAN CONTEXT

3.1 THE HISTORY OF LANGUAGE DEVELOPMENT IN SOUTH AFRICA

This chapter is an exploration of the local South African educational system, which necessitates an understanding of both the current factors and the historical factors that influence it. This includes an examination of the history of the educational system from 1961 to 1994, when the South African government of the time imposed the apartheid system. In addition to the historical perspective, there must be cognisance of the current eleven different official languages recognised in the South African constitution. There must also be cognisance of the large number of immigrants from neighbouring African countries who attend South African schools, but have different languages, and therefore different Mathematical registers.

National education policies form the framework within which the language of Mathematics is currently facilitated in South African schools. The South African Department of Basic Education policies (2011) adopted the term 'Language of Learning and Teaching' (LoLT). Acquisition of the Language of Mathematics is facilitated through the LoLT, and when this is not the home language of the learner, there are language barriers that the learner must surmount.

In order to contextualise the controversies around the LoLT in South Africa, the history of language development in South Africa will be briefly outlined. The development of the various languages within the indigenous peoples of South Africa began many centuries ago. The introduction of European languages is comparatively recent. Silva writes: "English was the language of power during the 19th century, and was imposed in 1822 as the official language of the Cape Colony, replacing Dutch" (Silva, 2014:1). It was only in 1925, almost a century later, that Afrikaans was legislated as the official language of South Africa (Silva, 2014). This shows that the languages of English and Afrikaans in South Africa developed alongside each other. Owen-Smith (2012) is of the opinion that a language inequality has developed within the South African education system, and this will be discussed in more detail in Section 3.3. Other languages were also used among the different communities of South Africa: many South Africans learners still have the challenge of mastering more than one language. Evidence of the development of many South African languages was that in 1993, eleven official languages were named in the South African Constitution. In South Africa, there has been a move to "protect and promote the 11 official languages through policy formulation, legislation, and the implementation of language policy in order that all South Africans realise their language rights" (National Language Services of the Department of Arts and Culture, 2012:1).

The South African Languages Bill of 2000 was drafted by the Pan South African Languages Board to provide "an enabling framework for promoting South African linguistic diversity" (2000:1).In this Bill, it states that "everyone has the right, in terms of Section 30 of the Constitution to use the language of their choice" (Pan South African Languages Board, 2000:6).

3.2 MATHEMATICAL REGISTER IN THE LANGUAGES OF SOUTH AFRICA

With regard to the language of Mathematics, English has a vast vocabulary of Mathematical terms, which have been created over centuries of industrial development; this is referred to as the English Mathematical register. Compared to this, the Mathematical register of other languages, particularly the languages of the indigenous people of South Africa, has fewer words, and therefore needs to be supplemented. Albaugh (2009) notes the necessity for African languages to develop a Mathematical register for Mathematical concepts. Teachers of the Language of Mathematics should know the Mathematics register of their language of instruction well.

The South African National Language Service has generated equivalent terminology in Mathematics for every grade – from Grade 1 to the final year of schooling, which is Grade 12. The problem lies in the dissemination of these terms; they need to be introduced into the everyday language of South Africans, which, of course, includes the Language of Mathematics.

3.3 THE LANGUAGE OF MATHEMATICS WITHIN THE SOUTH AFRICAN CONTEXT

The debate around the language rights of learners revolves around the controversy regarding the Language of Learning and Instruction in the Foundation Phase grades.

The question is: should learners be using the English words of the Language of Mathematics (which are recognised internationally) or should they be taught the equivalent words in their home language?

I believe that there is an acceptable solution - to learn and use Mathematical words in English and also to use Mathematical words in their home language, i.e. multilingualism, although this solution has consequences. When one considers the large scope of the curriculum and the inflexible time allocations for Mathematics concepts in the Foundation Phase grades, the multilingual approach may not be feasible unless there is further research and consultation with stakeholders that result in radical changes. This concept of multilingualism is a very important debate as it affects the LoLT. It requires further research since it could have positive, long-term repercussions in all classrooms, including Mathematics classrooms, both now and in the future.

3.4 TEACHERS' VIEWS ON ENGLISH AS THE LANGUAGE OF LEARNING AND TEACHING

In an article entitled "Teaching Mathematics in a Primary Multilingual Classroom", Setati (2008:2) reports on research that involved six multilingual teachers of Grade 11 Mathematics classes. Each teacher was asked "Which language do you prefer to teach Mathematics in? Why? Without exception, the teachers chose English, citing the fact that English is an international language, coupled with other reasons which are: the lack of textbooks in African languages in the senior primary phase, English external examinations, and Higher Education institutions offering tuition in English. Setati then interviewed five Grade 11 learners as to the language in which they preferred to learn Mathematics; three of the five chose English, while the other two learners stated no particular preference (Setati, 2008:2). This research points to the perceptions of these teachers and learners regarding the LoLT in Mathematics classrooms and points to the fact that much more research is needed in this important aspect of the acquisition of the Language of Mathematics.

3.5 THE PEDAGOGY OF THE LANGUAGE OF MATHEMATICS

The situation in the Mathematics classroom seems to have been accurately summarised by Anthony and Waldshaw (2012:5),

> Many learners struggle with Mathematics and become disaffected as they continually encounter obstacles to engagement. Schools, communities and nations need to ensure that their teachers have the knowledge, skills, resources and incentives to provide students with the very best of learning opportunities. In this way, all students will have the opportunity to view themselves as powerful learners of Mathematics.

Sideropoulos (2014:1) warns that "Teachers cannot teach what they do not know." Teachers need to have acquired the necessary knowledge to handle Mathematical problems so that they can lead their learners forward. In addition, the language situation in South African classrooms is complex; almost every classroom has learners who are not fully conversant in English. As English is not their home language, these learners face a language barrier, particularly when learning the Language of Mathematics. In addition, the teacher could well face a class where he or she does not speak the language of the majority of the learners. Therefore, in the South African context, the pedagogy of the Language of Mathematics for second language learners of English is extremely complex and challenging. There is a strong debate concerning whether the Language of Mathematics and the LoLT should be intertwined.

3.6 The Language of Learning and Teaching (LoLT)

3.6.1 The change in the Language of Learning and Instruction from Grade 3 to Grade 4

The Language of Mathematics is inextricably linked to the LoLT (the Language of Learning and Teaching) in which the learners receive their Foundation Phase schooling. A report was issued by the Department of Basic Education in collaboration with the Unit for Policies in Education of the University of the Witwatersrand, which contained the following information (Department of Basic Education, 2010):

- Almost 80% of all Grade 4 learners are taught in either English or Afrikaans. From Grade 4, the majority were taught in English (65%); but 12.9% were taught in Afrikaans (6.8% were taught in isiZulu and 5.5% in isiXhosa).
- The curriculum and South African educational policies provide for all Foundation Phase learners to master English or Afrikaans. According to the 2010 report, of all the learners in Grade 4 nationally, only 1% of learners study

English in the Foundation Phase and 1% study Afrikaans in the Foundation Phase.

It would seem, from these facts, that the introduction of a totally new LoLT in Grade 4 would create challenges for young learners in the Foundation Phase in acquiring the Language of Mathematics. According to the Department of Basic Education report (2012), less than 5% of all Foundation Phase learners are taught an additional language and "the majority of learners who are learning in an African language did *not* study English or Afrikaans as an additional language in the Foundation Phase".

Table 3.1: Comparison of the Language of Learning and Teaching for Grade 3 and Grade 4 learners: (Department of Basic Education, 2012).

Language of Learning and Teaching in 2012	**Percentage of grade 3 learners (national)**	**Percentage of grade 4 learners (national)**
Afrikaans	9.9	12.3
English	27.7	79.1
Ndebele	0,8	0,3
isiXhosa	14.0	3.0
isiZulu	20.1	1.5
Sepedi	9.2	1.1
Sesotho	4.4	0.5
SiSwati	1.7	0.14
SeTswana	6.8	0.6
TshiVenda	2.4	0.3
Xitsonga	3.1	0.7
Total	**100%**	**100%**

This table would seem to indicate that, in South Africa, the change in the LoLT happens in Grade 4 and it is important to note that most of the Grade 4 learners (79.1%) have English as the LoLT, yet do not have English as their home language. The Language of Mathematics is rooted in English. Parents and educators who determine the LoLT are influenced by current global economic and political scenarios, as well as possible future career opportunities for learners.

Williams (2004:34) states that "The weight of evidence suggests that effective education in terms of adequate literacy and numeracy are more easily acquired in a language with which the learners are familiar. Conversely, using an unfamiliar language detracts from academic achievement." Cantoni (2007:26) endorses this view. The Early Childhood Development Learning Community posted the following statement on their website: "Choices around the Language of Learning and Teaching have a significant impact on the educational development and outcomes in a multi-lingual society like South Africa" (www.ecdlc.org).

3.6.2 Language barriers relating to the Language of Mathematics

Owen-Smith (2012:1) describes one of the by-products of the apartheid political system as language inequality. The following benefits of home language instruction and teaching are suggested by the Early Childhood Development Learning Corporation (EDCLC) website:

- "Access to education is increased;
- Reduced rates of repeating a grade through failure;
- Lower learner drop-out rates; and
- An acceptance of the learner's home language encourages development of personal and conceptual foundations for learning" (www.ecdlc.org).

At first glance, these benefits appear to be persuasive reasons for teaching Foundation Phase learners in their home language. However, as the discussion in Section 3.3.2 highlighted, in Grade 4, most (79.1%) of the Foundation Phase learners will be exposed to English for the first time as the LoLT. As an adult, one cannot grasp the enormity of the cultural and emotional shock for these young learners at the change in the LoLT in Grade 4 - particularly when they are confronted with Mathematical terms that are completely unknown and are foreign to their undeveloped, juvenile Mathematical conceptual framework.

According to the South African Helen Suzman Foundation, most learners in South African schools face a language barrier. Ntshangame (2011:11) argues that learners are being instructed in a language (English) that they are "not used to, a language that they are not in contact with where they live; they only hear the language inside their classrooms." Owen-Smith alludes to the gulf between the "Constitution and the South African educational policies on the one hand, and the grass-roots level implementation of the policies on the other" and maintains that "the majority can only use their own languages in the first three grades, if at all, unlike their English and Afrikaans-speaking counterparts; the result constitutes a serious social injustice" (Owen-Smith 2012:2). Whilst I acknowledge the possible social and political implications of policy changes in respect to the LoLT, I agree with Owen-Smith that *national* education decisions and policies need to address the problem of the LoLT because it has direct bearing on the acquisition of the Language of Mathematics, which in turn impacts the future career choices of South African learners.

As mentioned previously, the report titled "The status of the Language of Learning and Teaching (LoLT) in South African Public Schools" (2010), which was produced jointly by the University of the Witwatersrand Education Policy Unit and the Department of Basic Education, highlighted the fact that the National Language in Education Policy (LiEP) in South Africa enforces the practice of teaching using the home language of the learner in the Foundation Phase.

3.6.3 A multilingual approach to the acquisition of the Language of Mathematics

According to Owen-Smith (2004), multilingualism means that learners are taught in the medium of English and *simultaneously* in the medium of their home language. This option embodies an alternative facilitation process of the Language of Mathematics, which will enhance the learners' understanding of Mathematical concepts, and will simultaneously expand their knowledge of the Mathematical register within their home language.

When teaching and facilitating the Language of Mathematics, I propose that the language spoken in the classroom should be Mathematical English - with the learner's home language used to explain and support concepts taught in Mathematical English. Owen-Smith (2012:2) makes the point that not only is this solution "effective in big, diverse classes, it is cost-effective and is beneficial when taking into account psychological, social, cultural, political and moral reasons".

The Project for the study of Alternative Education in South Africa (PRAESA, 2014), which is a research and development unit under the auspices of the Department of Humanities of the University of Cape Town, has a possible solution for the pedagogic dilemma surrounding the LoLT. For a decade, PRAESA has spearheaded a project in South Africa to develop Mathematical and scientific terminology, and has been involved in bi-literacy and multilingualism initiatives that advocate "a bilingual language system within the classroom". According to the PRAESA website, "A well run mother-tongue based bilingual system where teachers and learners communicate in a language they command and understand offers the potential for an emotionally and intellectually satisfying connection to learning" (www.praesa.org.za). However, PRAESA acknowledges that "Most South Africans want (and perhaps need) to be proficient in English because of the immediate and obvious economic and social benefits of English" (www.praesa.org.za).

3.6.3.1 Benefits of a multilingualism approach to the acquisition of the Language of Mathematics

Learners in the Foundation Phase must acquire basic Mathematical concepts. Using the multilingual approach, the teacher would facilitate learning, as far as possible, in the child's home language so that it would be easier for him to master these concepts. However, once the learner understands a Mathematical concept, the term in Mathematical English should be introduced to the child and it should be explained that this term describes the concept that the learner has just acquired. The multi-bilingual approach to learning the Language of Mathematics appears to offer the following benefits:

- This learning material should not confuse the learner since the Language of Mathematics is introduced within a relevant context.
- The concepts will be introduced gradually, and the Language of Mathematics will not seem to be strange and foreign to learners.

Further research is necessary to substantiate the validity of the claims made by those advocating the multi-bilingualism approach to acquiring the Language of Mathematics.

3.7 FOUR PARADIGMS RELATING TO THE ACQUISITION OF THE LANGUAGE OF MATHEMATICS

"Education is a dynamic and multi-faceted social enterprise" (Moloi & Strauss, 2005). The theoretical framework of this research is based on the conceptual model of four educational paradigms, as outlined in the book 'A brave new world of education'. The four educational paradigms are *transmission, transaction, transformation, and transcendence* (Slabbert et al., 2011:137).

The following table condenses the attributes of the four education paradigms well (Slabbert et al., 2011:137):

Table 3.2: The attributes of the four education paradigms proposed by Slabbert et al. (2011).

EDUCATIONAL PARADIGM	**TRANSMISSION**	**TRANSACTION**	**TRANSFORMATION**	**TRANSCENDENCE**
AIM	To impart knowledge.	To understand knowledge.	To apply knowledge.	To maximise human potential.
FOUNDATION	Content.	Content.	Content.	Process (for content).
EDUCATION MODE	Direct teaching.	Interactive teaching.	Project education.	Learning to be authentic and holistic.
EDUCATOR ACTION	Tell, illustrate, demonstrate, and explain.	Questions, Discussions.	Give assignment, projects, guidance, help.	Confront learner with real-life challenge they have to solve themselves.
LEARNER AUTONOMY	None.	Some.	Much.	Total.
LEVEL OF LEARNING	Shallow.	Insightful.	Deep.	Transcendental.
LEARNING OUTCOME	Cognitive.	Social.	Multiple.	Authentic living of real life wisely.
LEARNING QUALITY	Low.	Medium.	High.	Maximum.

To relate this to the acquisition of the Language of Mathematics, one needs to consider the stage of development of each learner. In the initial stages of learning any new skill, including the Language of Mathematics, there needs to be a thorough grounding through plenty of facilitation and guidance. Learners of a new subject should be exploring and discovering new concepts at their own pace. As the learner's insights develop, knowledge of the Language of Mathematics can be expanded through careful facilitation and meaningful activities.

The acquisition of the Language of Mathematics using the four paradigms is in accord with the analysis of Mathematical tasks within the Balanced Assessment Program of Harvard University, where the four processes of the Language of Mathematics (i.e. modelling/formulating, transforming/manipulating, inferring and communicating) are considered to become progressively more difficult (Schwartz & Kenney, 2003). One could say that these four processes synchronise well with the four aspects of the education paradigm of Slabbert et al. (2011). A table representing these two models follows (Table 3.3):

Table 3.3: Comparison of Mathematical processes of the Language of Mathematics

The Balanced Assessment model by Schwartz & Kenney (2003)	**The education paradigms by Slabbert et al.(2011)**
Model/formulating	Transmission
Transforming/manipulating	Transaction
Inferring	Transformation
Communicating	Transcendence

Slabbert et al. (2011:137) recognise that operating within the transcendental paradigm is neither possible nor appropriate in every situation, and state that,

> The transcendental paradigm is the education paradigm for creating the future as it stands alone in its own right. To ensure that learners will be able to cope with the current education practice, they have to become competent in operating in all the paradigms. At certain times, operating in the other paradigms may be inevitable.

In line with the constructivist approach, I adhere to the tenet that learners should be given opportunities to fully grapple with, and acquire the concepts of the Language of Mathematics. However, I also view the four paradigms as being on a continuum. This research posits that there should be a pragmatic approach to the acquisition of the Language of Mathematics, which selects and adapts the approaches according to the dynamic, varying needs of the learner and class.

Learners' acquisition of the Language of Mathematics is a progressive development. The Language of Mathematics is developed through considered experimentation, "The individual develops this knowledge much as a scientist or construction worker does" (Kucer& Silva, 2013:5). Each discovery of a pattern and relationship develops into a concept, which, once tested, is translated into the learner's Language of Mathematics.

The acquisition of Mathematics can be represented in this flow diagram. This flow diagram accords well with the four paradigms of learning presented by Slabbert et al. (2011:137).

Communication>>>>Experimentation >>>>Experience>>>>Feedback

Figure 3.1: Flow diagram of acquisition of the Language of Mathematics

Table 3.4: Comparison of the learning paradigms of the Language of Mathematics

Communication >>>>.Transmission
Experimentation >>>>Transaction
Experience >>>>>>>>Transformation
Feedback >>>>>>>>>Transcendence

Research into the acquisition of language has, of course, relevance to the acquisition of the language of Mathematics. Askew (2012:37) clarifies that, "The structures we use throughout our lives (for thinking) are very much in place from an early age. Experience is what is needed, not waiting for learners to 'develop' into a particular form of thinking" (Numeracy in Early Learning conference). This view is endorsed by Henning in her presentation at the Early Childhood Education Research and Development Seminar on language in the Foundation Phase classroom, as she declares:

> Mathematics and language are both tools for inquiry, communication and reasoning and understanding of each informs the other. Learners naturally use both of them to 'decode' the environment and make sense of their experience. To see this, it might be more useful to think of Mathematics and language not as school subjects or

disciplines but more broadly as ways of knowing and ways of representing knowledge (Numeracy in Early Learning conference).

Boulet (2007:4) claims that, for learners of Mathematics, the operations are "taught as a recipe to be followed". Boulet (2007:3) cites an example of the learning of a long division operation by a Grade 5 learner named Maxwell. The operation is *148 divided by 3*. This example is extremely relevant in the South African context because this type of example is within the Grade 3 curriculum. Maxwell explains "3 *gazinta*12, 4 times; take away 12 from the 14, and bring down the 8, then 3 *gazinta* 28 nine times". He then asks the teacher "What does *gazinta* mean?" The teacher says, "Actually it's not *gazinta*, it is *goes into*". "Ah!" says the learner Maxwell, "you mean it slams into it like cars do in a car crash?" Boulet (2007:3) comments that in this example, "the language describing the steps impedes meaningful problem solving". This is an illustration of how the teacher's use of language could impede the acquisition of the Language of Mathematics. Conversely, a teacher's use of language and facilitations using meaningful contexts accelerates the acquisition of the Language of Mathematics by learners.

As already discussed, the latest definition of Mathematics by the Department of Basic Education (2011:6) is of "a human activity that involves observing, representing, and investigating patterns and qualitative relationships in physical and social phenomena and between Mathematical objects themselves." This definition is worth re-visiting to explore how it relates to the facilitation of the Language of Mathematics by the teacher. The terms o*bserving* and *investigating* imply the non-judgmental role of the teacher in order to facilitate the exploration and discovery of Mathematical concepts; the term *representing* could mean the translation of the characteristics and properties of a Mathematical concept into the Language of Mathematics. So, spoken words, including Mathematical English terms, could be used to describe and represent Mathematical patterns and relationships. In this way, the Language of Mathematics (Mathematical vocabulary) is introduced by the teacher into the learner's everyday activities. The Language of Mathematics is discovered and used coincidentally, as well as being used during guided discovery activities. It is possible that the success of learners of the Montessori Method in Mathematics is based largely on the learners' discovery through experiences, which the teacher has planned and implemented.

Physical and social phenomena (e.g. shopping, being a consumer in daily life) and observing cultural events (e.g. setting the table for a family get-together) indicate a one-to–one relationship (Charlesworth, 2000). The observation of patterns in nature can be an additional source of Mathematical learning – the shape of a spiders web, or honeycomb, can indicate shape, dimension, and spatial relationships. A barometer, rain gauge, or the height of the child or adult are all tools for incidental (and fun) learning of Mathematical measurement. The problem is that many of these Mathematical activities take time. It would therefore be helpful if the stakeholders and decision-makers analysed the current prescribed time allocation in the current South African Mathematics curriculum for the Foundation Phase (i.e. Grades 1, 2 and 3). In the Foundation Phase of primary school, the integration of subjects is a possible solution that would give the teacher (and learners) some of the extra time that is needed - because it is imperative that the rudiments of the Language of Mathematics be mastered by learners before Grade 4 when the level of abstraction in Mathematics escalates. The Department of Basic Education's revised curriculum (2011:8) gives guidelines on the time allocation and weighting of the Mathematics content areas for each grade (Table 3.5).

Table 3.5: The recommended time allocation for the different aspects of Mathematics in the Foundation Phase

CONTENT AREAS	GRADE ONE	GRADE TWO	GRADE THREE
NUMBERS, OPERATIONS AND RELATIONSHIPS	65%	60%	58%
PATTERNS, FUNCTIONS, AND ALGEBRA	10%	10%	10%
SPACE AND SHAPE (GEOMETRY)	11%	13%	13%
MEASUREMENT	9%	12%	14%
DATA HANDLING (STATISTICS)	5%	5%	5%

Discussing the acquisition of the Language of Mathematics by English language learners, Moschkovich (2002, 1) names three perspectives regarding Latino students, which are particularly noteworthy as they can be applied to English-language learners in South Africa, namely:

- "The acquisition of vocabulary;
- The construction of multiple meanings across registers;
- Their participation in Mathematical practices."

The findings of these research studies, considered collectively, have a direct bearing on the acquisition of the Language of Mathematics.

3.8 THE LANGUAGE OF MATHEMATICS AND MATHEMATICAL EXPRESSIONS

Mathematical expressions are a critical element of the Language of Mathematics, and are referred to as number sentences in the Foundation Phase of primary school. As discussed in Section 2.3, these number sentences lead the learner to an understanding of the concept of an object/number and the related action or operation. The learning of number sentences begins with the development of number sense, and these Mathematical concepts should be established as part of the learner's Mathematical vocabulary by Grade 3. Number sense does not mean simply "making connections within Mathematics but also between Mathematical topics and other subject areas in the curriculum" (Bell et al., 1998:106).To demonstrates number sense, Bell et al. (1998:106) recommend that learners:

- "Have developed reasonably good arithmetic skills along with reasonable algorithms and procedures for finding results they can't find mentally.
- Are flexible in thinking about using numbers and arithmetic and are willing to look for shortcuts to make their efforts more efficient.
- Can use their number and arithmetic skills to solve problems in everyday situations.
- Are familiar with a variety of ways to communicate their strategies and results.
- Can recognise clearly unreasonable results when they see numbers in print or other media or in their own work".

The role of the teacher is critically important in the facilitation of learning, i.e. the teacher's role in guiding the progress of the learners when acquiring the Language of Mathematics. In order to meaningfully assist learners, the depth of the teacher's own pedagogy must be established.

3.9 TRANSFORMATION THROUGH ACQUIRING THE LANGUAGE OF MATHEMATICS FROM THE LEARNER'S ENVIRONMENT

The teacher needs to initiate interesting learning experiences that will ring true to the learner's experiences and be relevant so that the learners acquire the Language of Mathematics without undue stress. This links to the fourth paradigm of learning – that of transformation, whereby the learner's conceptual framework of the Language of Mathematics is expanded. Rooke (2008:7) also makes the point that if a child enjoys playing games, then the learning of the Language of Mathematics can be facilitated through games, and gives these examples: bingo, dominoes, ten pin bowling, snakes and ladders, Monopoly, and Sudoku. The movement from the informal, spoken conventional language into the formal Language of Mathematics can be achieved through such activities:

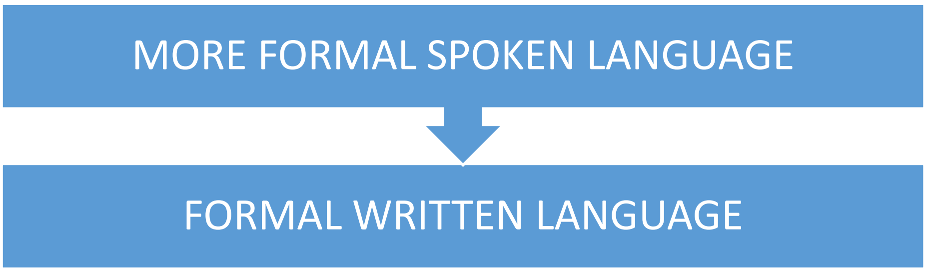


Figure 3.2: The movement from the informal, spoken conventional language into the formal Language of Mathematics

Boulet (2007:12) writes: "The teacher's own use of language in the Mathematics classroom serves as an important example of effective communication". Kinowa and Bhargawa (2003) describe areas of teacher pedagogy as:

- Being able to gauge the learner's grasp of Mathematical concepts; and

- Being able, as a facilitator, to use the Language of Mathematics to move the learners from behavioural to representational understanding of Mathematics.

3.10 THE INDIVIDUAL LEARNER'S ACQUISITION OF THE LANGUAGE OF MATHEMATICS

3.10.1 Developmental milestones in acquiring the language of Mathematics

An analysis of the developmental milestones in acquiring the Language of Mathematics is necessary. Two classic and complementary theories of the development of cognitive theories need to be examined, namely, those of Piaget and Vygotsky (Kinowa & Bhargawa, 2003:1)because, when considered together, they offer clarity on the developmental milestones in acquiring the Language of Mathematics itself, and the Mathematical knowledge that it constitutes.

According to Louw (1991:75), Piaget's stages of cognitive development can be divided into four distinct phases.

Table 3.6: Piaget's stages of cognitive development.

Stages of cognitive development	Stages of cognitive development	Age
Stage one	Sensori-motor period	Birth to two years
Stage two	The pre-operational phase	2-7 years
Stage three	Period of concrete operation	7-11 years
Stage four	Formal operational period	Adolescence

Vygotsky's theory complements and expands upon Piaget's thinking to form the foundation on which the Language of Mathematics is built (Kinowa& Bhargawa, 2003:1). According to Vygotsky, both the teacher and the social/cultural milieu of the child have an important bearing on how learners develop Mathematical concepts, when they are guided through the challenges of the environment by another more able learner or by a caring, interested adult. Erikson's psychosocial development also emphasises the influence of both culture and society on the development of the learner (Feldman& Papalia, 2011:29).

Table 3.7: A comparison between Piaget's Mathematical knowledge; Piaget's conceptual development, and Vygotsky's socio-cultural milieu (adapted from Kinowa & Bhargawa, 2003:1).

Piaget's Mathematical Knowledge	**Piaget's conceptual development**	**Vygotsky's socio-cultural milieu**
Physical knowledge – sourced from interactions between the child and the environment.	Sensori-motor period (birth to two years).	Socio-cultural milieu is influential.
Social (conventional) knowledge) – structured Mathematical learning experiences.	The pre-operational phase (2-7 years).	Both socio-cultural milieu and teacher are influential.
Logic-Mathematical knowledge – the inter-relationship between entities.	Period of concrete operation (7-11 years).	Both socio-cultural milieu and teacher are influential.

These theories stress the constructivist approach to learning and yet provide a gateway to the four paradigms of learning, as explained by Slabbert et al. (2011).The learner constructs his or her concepts of the Language of Mathematics through activity, reflecting on learning, and communicating what is learned.

3.11 LEARNER'S DEVELOPMENT OF PROBLEM-SOLVING ABILITIES RELATING TO THE CONCEPTS OF THE LANGUAGE OF MATHEMATICS

According to Davis and Keller (2013), the nine most basic Mathematical concepts that are developed in young learners are: pattern, sequencing, seriation, spatial influences, object perseverance, sorting, classifying, comparison, and one-to-one correspondence. Kinowa and Bhargawa view the three most important Mathematical concepts that young learners develop as: classifying; one–to–one correspondence; and seriation (Kinowa& Bhargawa, 2003:4). Once these concepts have been acquired, the learner has the tools with which to begin working independently.

There is a transition by the child from a stage of being "maximally assisted in problem solving by an adult or older child" to the stage of being able to "solve problems independently" (Kinowa & Bhargawa, 2003:3). This transition to independence can be represented as a continuum, and ties in with the gradual acquisition and eventual mastery of the Language of Mathematics.

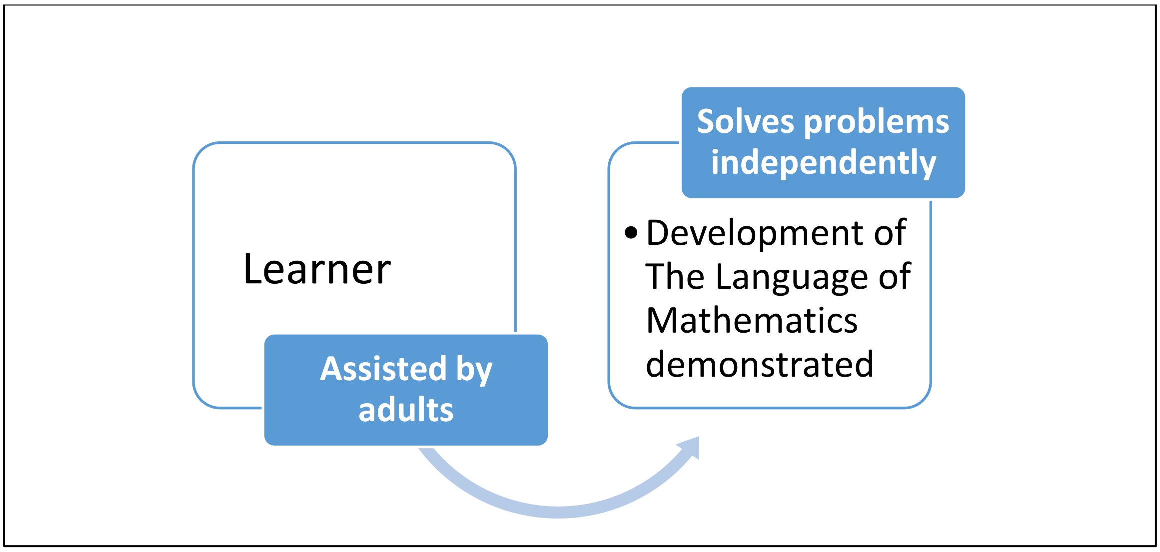


Figure 3.3: Model of the progression towards acquisition of the Language of Mathematics

The acquisition of Mathematical concepts is facilitated through language. The Language of Mathematics is the structure (or storehouse) within which the child's Mathematical concepts are stored and later used to communicate *Mathematically*. Therefore it would not be unreasonable to presume that the development of the Language of Mathematics occurs within the same time frame as the development of Mathematical conceptual frameworks.

3.12 THE IMPACT OF CULTURE ON THE TEACHING OF THE LANGUAGE OF MATHEMATICS

The relationship between the knowledgeable adult (teacher or parent) and the eager learner is the alchemy by which the golden Language of Mathematics is acquired. When there is a relationship of trust, mutual respect and learning, the acquisition of concepts is boundless. In many South African Mathematics classrooms, the opportunities for meaningful acquisition of the Language of Mathematics seem to be minimal. The Southern African Consortium for Monitoring Educational Quality (SACMEQ) 3 project highlighted the fact that there is a lack of basic materials (an exercise book, a pencil or pen and a ruler for each learner); they also reported that one in every five learners in their 2007research project was found to lack these materials. There is also considerable overcrowding in South African classrooms. The results published by SACMEQ in their 2006 research project reveals a high average teacher-learner ratio in South African primary school classrooms. Despite these challenges, there are a number of South African learners who succeed in mastering the Language of Mathematics. This fact highlights that a resilient learner must take on the responsibility of becoming accountable for his or her learning from a very early age and must persevere in acquiring the Language of Mathematics until they are successful. It is the position of this research that early Mathematical experiences are culturally bound, but that success in acquiring the Language of Mathematics is not restricted to a particular socio-economic or cultural milieu. For young learners, the mediation of learning experiences in Mathematics can happen anywhere because learners are open to learning.

The child's language concepts and Mathematical concepts develop simultaneously; these concepts develop naturally out of everyday experiences and out of the child's interests (Davis &Keller, 2013). Kinowa and Bhargawa (2003:1) note that "from Vygotsky's socio-constructivist perspective, learning is more likely to occur if adults or more competent peers mediate children's learning experiences". Hill (2003:1) talks of Vygotsky's "brilliant idea that children's cognitive abilities may develop through the interactions between the teacher and the learner."

TEACHER >>>>>>>>>>>>>	MEDIATED LEARNING EXPERIENCE>>>>>>>>>>>	LEARNER

Figure 3.4: Flow diagram of the teacher's role as facilitator in the acquisition of the Language of Mathematics

Hill (2003) states that this concept has been used by Feuerstein since the early 1960's and that schools "committed to the principles of cognitive education have incorporated the teaching of critical thinking into their curriculum and their aim is to teach learners to *learn how to learn"* (Kinowa & Bhargawa, 2003:1).Malmer (2004:3) explains that,

> The subject of Mathematics demands from the student both in the ability to concentrate and the ability to think and reason abstractly. This is why weaker students often have difficulties, particularly if they are not offered opportunities to learn at a slower pace and to receive extra support. It is a shame that all too many students are already prejudged as incompetent even during their first school years.

The constructivist paradigm based on Piaget's theory of cognitive development has long provided the "theoretical framework for educational practice in which learners acquire concepts through active involvement with the environment and construct their own knowledge as they explore their environment” (Kinowa & Bhargawa, 2003:3). Therefore, it is up to the teacher and parents to create environments that are rich in opportunities for the learning of many new Mathematical concepts, and the Language of Mathematics (which is universal). The most basic Mathematical concept that is imparted to young learners, regardless of culture, is counting. The learning of the names of numbers is the first step in acquiring the Language of Mathematics, but the learning of numbers is easier in some cultures than in others.

3.13 THE INDIVIDUAL LEARNER’S RESPONSE TO LEARNING THE LANGUAGE OF MATHEMATICS

Learning can be regarded as both an individual as well as a culturally determined variable. Adopting the stance that each individual has one or two dominant ‘intelligences’, Gardner (2006)has named the ‘multiple intelligences’ as being: linguistic intelligence, bodily knowledge intelligence, interpersonal intelligence, intrapersonal intelligence, musical intelligence, spatial intelligence, naturalistic intelligence, existential intelligence and, of course, logico-Mathematical intelligence. Malaguzzi, founder of the Reggio Emilia Approach, wrote the poem “The 100 languages” to describe the observation that learners express their thinking, for example, in drawing, writing, and painting using *languages*. From this viewpoint, one could reasonably deduce that excellence in acquiring the Language of Mathematics can be attributed to an individual having great logico-Mathematical intelligence. While some individuals clearly excel at the dimension described by Gardner as logico-Mathematical ability, the acquisition of the Language of Mathematics is an interplay of many different dimensions within each individual. Examples of these dimensions are:

- The individual’s learning style: a dominant auditory, visual or kinaesthetic learning style.
- The individual’s level of motivation to learn.
- The educational opportunities of their environment.

In light of this, it is my firm conviction that it is possible for every Mathematics learner in every conceivable environment to master the Language of Mathematics to a greater or lesser degree.

3.14 THE FUTURE IMPLICATION OF SUCCESSFUL ACQUISITION OF THE LANGUAGE OF MATHEMATICS

Gardner (2006:1) asserts that the "kinds of *minds* that people will need if they are to thrive in the world for the eras to come are: the Disciplined Mind; the Synthesising Mind; the Creating Mind; the Respectful Mind and the Ethical Mind." These are explained in the table that follows.

Table 3.8: Relating the five kinds of minds (Gardner, 2006:2) to the tenets of the Language of Mathematics.

The Five Kinds of Minds (Gardner, 2006:2)	**Tenets of the Language of Mathematics**
The Disciplined Mind – which has attained mastery in at least one way of thinking.	*Discipline:* A study of the Language of Mathematics will develop a highly objective and disciplined way of thinking.
The Synthesising Mind – which has combined or *synthesised* seemingly unrelated information.	*Synthesis:* The nature of the Language of Mathematics is essentially the contrast and synthesis of multiple elements and patterns.
The Creating Mind – which generates new ideas and thoughts.	*Creativity*: The acquisition of the Language of Mathematics involves considerable ingenuity and lateral thinking.
The Respectful Mind – which embraces both individual and group differences.	*Respectfulness*: Found within the circle of mathematicians world-wide since the Language of Mathematics is a universal phenomenon.
The Ethical Mind – which acts for the greatest good of others.	*Ethics:* This is intrinsic within the discipline of Mathematics research.

Thus, the acquisition of the Language of Mathematics stretches beyond the immediate need to achieve a short-term goal of academic achievement. It presumes that the learner, who has mastered the Language of Mathematics, has acquired the essential principles needed to face an unpredictable future.

3.15 CONCLUSION

It would appear that educationalists seem to have overlooked and ignored the issue of the Language of Mathematics and its pedagogy, resulting in a grave disservice being done to South African learners, both current and future. In this chapter, I have shown the importance of the Language of Mathematics for South African learners and have highlighted some of the major challenges within the education system, which are detrimental to many learners. The conclusion of this chapter ends as the chapter began – with the focus firmly on the individual, multi-dimensional learner.

CHAPTER 4: RESEARCH DESIGN

4.1 AN INTRODUCTION TO EDUCATIONAL RESEARCH

"The purpose of educational research is to develop new knowledge about the teaching-learning situation to improve educational practice" (Korb, 2012:1). Chapter 4 focuses on the research methodology that was adopted for this research and how the research question was explored. The philosophical paradigms which underpinned this research are then discussed. The research process and ethical considerations are also considered.

Silverman (2103:18) states that "research is a well-defined question that needs an answer." In other words, "research exists to bring about change" (Clough, 2012:188). Research is methodical and organised. Rajasekar, Philominathan and Chinnathambi (2013:1) describe research in the following way: "Research is a logical and systematic search for new and useful information on a particular topic. Research can make new contributions to the existing knowledge. Only through research is it possible to make progress in a field." Scott (2003) maintains that modern research uses diverse epistemologies.

4.1.1 The constructivist approach

The constructivist approach is the meta-theoretical paradigm within which this research is embedded. I have adapted a tabulated summary of the constructivist approach by Denzin and Lincoln (2011: 66) to demonstrate the applicability thereof to this research. The table relates the tenets of constructivism to the related paradigm positions and then applies these to the Language of Mathematics.

Table 4.1: Constructivism and associated paradigms related to the Language of Mathematics.

Constructivism **Denzin and Lincoln (2011:66)**	**Paradigm positions** **Denzin and Lincoln (2011:66)**	**Applications to this research project**
Aim of inquiry	Understanding.	Seeking to understand the facilitation processes in the acquisition of the Language of Mathematics.
Nature of knowledge	Individual or collective reconstructions. Coalescing around consensus.	Three individual interviews forming a collective sample. Validation of the interview data collected with participating teachers to achieve consensus.
Knowledge accumulation	Informal and sophisticated reconstructions. Vicarious experience	Semi-structured informal interviews (with open-ended questions) and non-participatory observations were used to collect valid data in three school environments.
Goodness or quality criterion	Trustworthiness and authenticity.	The minimisation of researcher bias by means of multiple data collection strategies.
Values	Formative Denzin and Lincoln (2011: 66)	Core value of this research is to improve educational practices, particularly the facilitation of the Language of Mathematics.
Ethics	Intrinsic – process tilt towards revelation.	Ethical principles of anonymity and confidentiality observed. No harm to participants.
Voice	“Passionate participant” as facilitator of multi-voice construction.	Three purposefully selected participants whose voices speak together regarding the facilitation of the Language of Mathematics.
Hegemony	Seeking recognition and input; offering challenges to predecessor paradigms.	Challenging the status-quo of Mathematical education in relation to the aspect of the Language of Mathematics.

These thoughts sum up the motivation for embarking on this educational research, which represents a first step towards another positive change in Mathematics educational practices. Through this research, it is hoped that there will be a new awareness of teachers' facilitation strategies relating to the acquisition of the Language of Mathematics.

4.2 QUALITATIVE EDUCATIONAL RESEARCH DESIGN

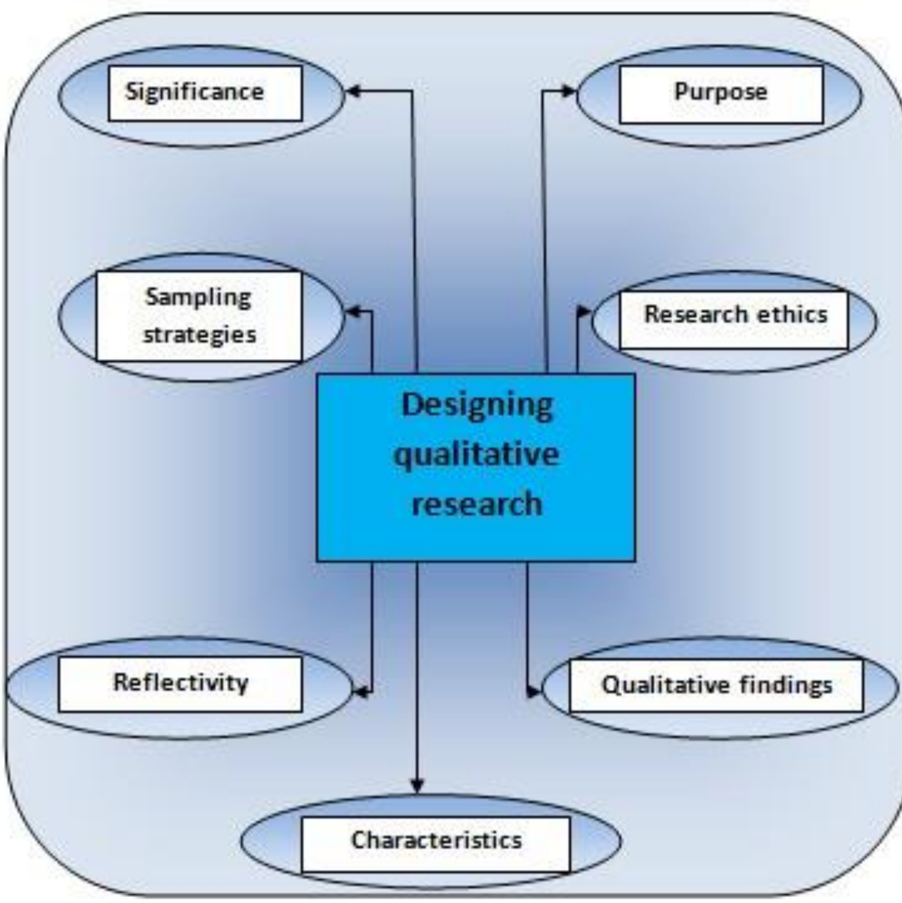


Figure 4.1: Illustration of the design of qualitative educational research (MacMillan et al. (2010:319)

4.2.1 Characteristics of qualitative educational research

Merriam (2012) emphasises that qualitative studies always focus on meaning and understanding. Qualitative research is "a person-centred, holistic perspective" (www.uir.unisa.ac.za). MacMillan et al. (2010:319) find that the characteristics of qualitative educational research are as follows: "[A] natural setting; rich description;

process orientation; inductive logic; participant perspectives; emergent design; context sensitivity; direct data collection; and complexity." In this research:

- The setting of this research took place in the natural setting of the teachers' classrooms.
- The observation of the Mathematics lessons caused as little disruption to the teacher and learners as possible.
- The description of the interaction and milieu was detailed. Seemingly insignificant details were noted.
- The logic used to discover the findings of this research was inductive, based on the evidence of the data collected.
- The participants' perspectives were sought using semi-structured interviews with open-ended questions.
- The design was emergent in that this was exploratory research, therefore no pre-conceived theories or notions were applied.
- The context of the research was that of private schools in affluent urban areas, and this factor was considered when the data was analysed.
- The data was collected directly through multiple data collection strategies by one researcher.
- The complexity of the facilitation acquiring the Language of Mathematics was recognised within this research.

4.2.2 Significance and purpose of educational research

The significance of this educational research may be far-reaching. The Mathematics teacher plays a crucial role in terms of the acquisition of the Language of Mathematics, and should have personally mastered the Language of Mathematics in order to guide the learners. As this research was based on the constructivist research paradigm, the role of the teacher was viewed primarily as that of facilitator and coach. There seems to be a lack of current research into the role of the Foundation Phase teacher in the acquisition of the Language of Mathematics. Therefore, the secondary purpose of this research was to investigate the teacher's facilitation of the acquisition of the Language of Mathematics within the multilingual context of South African classrooms, where the composition of classes is usually heterogeneous in terms of languages.

4.2.3 Sampling strategies

The Appreciative Inquiry approach, as described in the section on the axiological facet of this research, was the rationale for the sampling strategy that was applied. "You may be interested in the opinion and experience of experts or people with direct experience – a purposive rather than a random sample. In qualitative sampling, specific cases are chosen without needing or desiring to generalise to all such cases." (MacMillan et al., 2010:326) In this research project, the sampling strategy chosen was as per MacMillan et al. (2010), so that the teacher participants were purposefully chosen for their contribution on the basis of their years of experience and their standing within well-known private schools. The methodology of the research indicated that teachers in different schools should participate to provide rich data.

Table 4.2: Biographical data of the participating teachers

Criteria	**School**	**Years of teaching experience**	**Gender**	**Qualifications**
Participant teacher A	School 1	More than 20 years	Female	Post graduate
Participant teacher B	School 2	More than 20 years	Female	Post graduate
Participant teacher C	School 3	More than 20 years	Female	Post graduate

4.2.4 Ethics and validity considerations

"The importance of integrity, both intellectual and moral, holds the key to the best research" (Gregory 2005). The research did not commence until the Ethics Committee of the University of Pretoria had issued written approval of all aspects of the research.

The validity of the research was enhanced by using multiple data collection methods within the same time frame, which is discussed in more detail in this chapter. The research was subject to informed consent. The privacy and anonymity of the participating teachers and their classes have been preserved in this research. The confidentiality of these teachers' responses has been respected.

4.2.5 Reflectivity and the qualitative findings

Reflectivity on the part of the researcher was an important aspect of this research. The findings of the research became evident from the data collected. The researcher was cognisant of the exploratory nature of this research and was unbiased in terms of the findings, as these were grounded in the analysis of the data. The factors influencing the context (namely the class size, the heterogeneous composition of the classes, and the social dynamics) were considered when establishing the findings of the research. The researcher has endeavoured to minimise the contextual factors and focus on findings that are universally and typically applicable, i.e. within any classroom context.

4.3 GOALS OF THIS EDUCATIONAL RESEARCH

This exploratory research focused on the Grade 3 teacher's role in the acquisition of the Language of Mathematics in the multilingual South African context. This linked directly to the primary research goal, which was to answer the question: "How do teachers facilitate the acquisition of the Language of Mathematics in Grade 3 classrooms?"

As a result of this primary research goal, an important aspect was considered, namely the difficulties that multilingual learners in the South African context face when acquiring the Language of Mathematics; as well as the strategies used by South African Mathematics' teachers to assist these learners.

The primary focus of the research has been on the teachers as participants, i.e. their thoughts and beliefs about the Language of Mathematics, and their resultant actions in the context of Grade 3 Mathematics classrooms. Therefore, the data collected for this research required the input of Grade 3 teachers in the form of demonstration of lessons, documents (worksheets), and interviews to illustrate the teachers' facilitation processes relating to the Language of Mathematics.

4.4 STAGES OF THIS EDUCATIONAL RESEARCH

All research is contained within the boundaries of prescribed stages similar to those described by Mouton (2012:10), and Macmillan and Schumacher (2010, 1). These two sources describing the stages of an educational research study are compared in the table below in order to highlight the similarities between the two approaches to a research study.

Table 4.3: Comparison of the stages of an educational research study

	Mouton (2012:10)	**Macmillan & Schumacher (2010:1)**
1	Formulation of research problem	
2	Formulation of research question	Research Question
3	Research design: Conceptualisation	Research Methodology
4	Research design: Operational issues	
5	Research design: Data collection	Results of research
6	Research design: Data analysis and interpretation.	Interpretation of results

In this research, the steps as outlined by Macmillan and Schumacher (2010) have been adopted. This approach is appropriate for qualitative research, and particularly exploratory case study research, which is the nature of this research.

4.5 STEPS IN THE RESEARCH PROCESS

4.5.1 The research questions

The first stage in the research is deciding on the research questions (Macmillan & Schumacher, 2010).

The research sub questions were:

- What is the Language of Mathematics?
- What strategies are teachers using to facilitate the learning of the Language of Mathematics in Grade 3 classes?

The primary research question was: *How is the Language of Mathematics facilitated in Grade 3 classes?* The research questions were the result of much discussion. Arising from these discussions, the idea of researching the link between language and Mathematics concepts (i.e. the language of Mathematics) was conceived. The concept of the Language of Mathematics had been previously explored by a few researchers, but there seemed to be very little current research into the acquisition of Mathematical concepts (i.e. the Language of Mathematics) in the Foundation Phase.

4.5.2 The approaches to this research project

4.5.2.1 The ontological approach and the nature of reality

The ontological approach asks the question, "What is the nature of reality?"(Coldwell & Herbert, 2004:48). In Mathematics, each learner has to acquire the Language of Mathematics by constructing his or her own conceptual framework and perception of reality. According to Coldwell and Herbert (2004:8), the qualitative research methodology states that "reality is subjective and multiple as seen by the participants in the study". Baxter and Jack (2008:544) state that **"**Qualitative case study methodology provides tools for researchers to study complex phenomena within their contexts." The following illustration of case study research is informative.

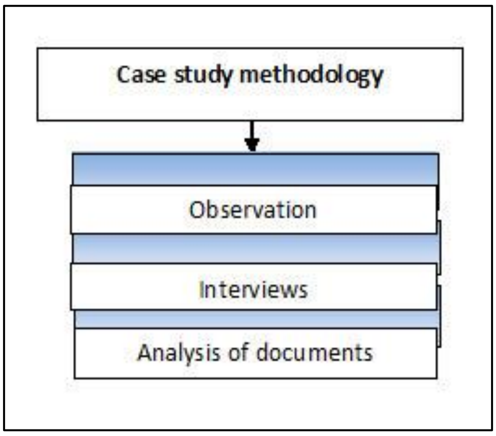


Figure 4.2: The case study methodology (www.nyu.ed., 2015)

Bell (2005) explains that case study methodology is suitable for an individual researcher because it studies only one aspect of the problem, which is the strength of the case study method. The ontological approach that was adopted in this research comprised the interpretivist and constructivist approach. Therefore, this research was based on the premise that individuals create their own understanding founded on the interaction between what they already know and believe, and the new phenomena or ideas with which they come into contact. In this way, each learner interprets a concept uniquely, while the teacher facilitates the progress towards this learning.

Therefore, when applied to this research, this ontological approach translates into each learner constructing his or her own interpretation of Mathematical terms and concepts. The emphasis on constructivism, however, is tempered by an appreciation of the value of formal knowledge, and of the well-established principles within the Language of Mathematics, which are universally accepted. It would be unrealistic to expect any young learner to develop a brand new set of Mathematical principles and knowledge. This is necessitates the role of the teacher as a facilitator and guide towards the mastery of the Language of Mathematics. The teacher will face the challenge of multiple learning styles, differing levels of abstract conceptualisation, and, in South Africa, teachers need to accommodate the many different cultural and linguistic alignments in the classes as well.

4.5.2.2 The epistemological aspects of this research

Gialdino (2009:1) asserts that epistemology is “how reality can be known - the characteristics, principles and assumptions that guide the process of knowing”. Ponterotto (2005:131) states that epistemology is the relationship between the “knower” (the research participant) and the “would-be knower” (the researcher). This research had to answer the epistemological question, “What is the relationship of the researcher to the research participants?”(Coldwell& Herbert, 2004:48). The research participants were teachers, but as the researcher, I chose to be uninvolved and distanced from both learners and teachers (both temporally and emotionally) during the observation phase of the research. The reason for this was that I did not want to impede or influence the facilitation process, as this may have resulted in biased data. During the teacher interviews, I aimed to remain professional while still being encouraging and warm to allow the teachers to feel free to express their views and share their experiences; the objective was to create rapport and trust.

"Ontology and epistemology drive the methodology and methods" (De Vos, Fouche & Delport, 2011:311).The epistemological aspect was central in this research, which had at its core an investigation of the process of knowing the Language of Mathematics.

4.5.2.3 The axiological facet of this research

According to Ponterotto (2005:131) "axiology concerns the role of researcher values. The researcher values are an integral part of who the researcher is". The axiological facet of this research was that, as far as possible, the research results were a true reflection of the processes of acquiring the Language of Mathematics. This could only be achieved through detailed descriptions of the multiple data sources. To reduce research bias, in line with the Appreciative Inquiry approach, only teachers of the highest calibre were selected. The flaws and anomalies that might have arisen with inexperienced teachers, and which may have adversely impacted the learners' acquisition of the Language of Mathematics, were thereby largely eliminated in order to enhance the axiological integrity of this research.

4.5.2.4 The rhetorical aspect of this research

In the interviews, I deliberately included the interview question, "What do you understand by the Language of Mathematics?" This was so that, as the researcher, I could gain insight into the participating teachers' conceptual framework regarding the Language of Mathematics.

4.6 DATA COLLECTION

4.6.1 Data collection instruments

Data collection in this research was achieved through three data collection instruments, namely: interviews, observation of each teacher-participant's lesson, and analysis of the documentation for Mathematics education issued by the national government.

4.6.1.1 Interview as a strategy for data collection

The interview questions were designed to be easily understood. In line with the qualitative approach, open-ended questions were included in the interviews when the knowledge and feelings of the participant teacher was important. The teachers' responses were then transcribed. "Open ended questions leave the participants completely free to express their answers as they wish, as detailed and complex, as long or as short as they feel are appropriate. No restrictions, guidelines or suggestions for solutions are given" (Bless and Higson-Smith, 1995:120). Closed questions in an interview are easier for the participant in that the choices are offered to them or a single answer is required. However, this limits the information that is obtained. In this research, the researcher was impartial and listened intently to the participant responses as these formed the basis of the data analysis.

The advantages and disadvantages of open-ended questions

Bless and Higson-Smith (1995:122) give the following advantages of open-ended questions:

- "Open-ended questions are not based on already conceived questions.
- Answers may be quite complex and not easily comparable to other respondents.
- Open-ended questions may relieve the anxiety of participants of giving "false" answers since they can speak freely.
- Monotony in the questions is avoided."

However, they counter that recording and scoring are problematic and are a disadvantage in this regard. In this research, no recording devices were used. The recording was done manually by the researcher during the interviews, and was then transcribed.

The advantages and disadvantages of interviews

Bless and Higson-Smith (1995:43) state that "The exploratory interview has the following advantages- it:

1. Does not impose structure onto the interview.
2. Can access what the subject feels is important.

3. Can clarify, interpret the subject's responses.
4. Has a better response rate.

The exploratory interview has the following inherent challenges:

1. It is very time-consuming and expensive.
2. Very difficult to standardize and analyse.
3. Research assistants need training.
4. There could be bias due to social desirability."

4.6.2 Overview of observation as a strategy for data collection

Observation is therefore an opportunity for the researcher to see and hear what is occurring through close scrutiny. In this research, the phenomenon under scrutiny is the facilitation process of each teacher-participant, where the objective is to gain an understanding of how they facilitate their Grade 3 learners' acquisition of the Language of Mathematics.

Observation is an attempt by the researcher to document, as much as possible, the setting and its participants. With this in mind, the criteria for the observation schedule were broad. Cohen (2001:185) categorises observation as either 'participant observation' or 'non–participant observation'. In participant observation, the observer actively engages with the group that is being observed. In non-participant observation, the observer avoids becoming a member of the group. Non-participant observation was deliberately chosen. One of the factors that influenced the choice of non-participatory observation was that, in general, Grade 3 learners may already experience stress in striving to acquire the Language of Mathematics, and therefore it would be unethical to create additional stress or upset the process of acquisition. Another factor to consider is that Grade 3 learners may view any 'participatory' researcher as yet another authority figure, who is unfamiliar to them. The focus of the observation was on the teacher-participants so as to understand the process of facilitation.

Qualitative methodology recommends that research should take place in as natural a setting as possible. Bearing this in mind, the observation was done without the introduction of machinery and technology in any form. Video-tapes and tape recorders would have disturbed the dynamics of the classroom, and possibly distracted the learners and/or the teacher-participants. The data collection of each lesson was done manually by the researcher.

The advantages and disadvantages of observations

Observation is a direct way of gathering data (CAAC 2011:7). For this reason, there is no pressure to give a socially acceptable or right answer, since the behaviour is not under the control of the researcher carrying out the observation. However, observation as a data collection method has its challenges. The observer may have an adverse effect on the setting (CAAC 2011:7). This would be particularly true where the researcher actively participates in the research setting.

4.6.3 Documents as a strategy for data collection

Documents are "tangible manifestations that describe people's experience, knowledge, actions and values" (MacMillan et al. (2010:360). This research did not require documents as a major source of data.

Two official documents that relate to the Language of Mathematics are the copies of the national Mathematics curriculum and each school's policy on Mathematics. The national Mathematics curriculum is available online at www.doe.thutong.org.za.

The advantages and disadvantages of documents as a data collection strategy

Documents are a tangible representation of the participating teacher's methodology in relation to a particular aspect of the Mathematics curriculum. As such, it sheds light on their approach to the Language of Mathematics. In the case of this research, the school policies were not provided.

4.7 OBJECTIVITY IN THE RESEARCH

Hammersley (2002:66) clarifies,

> The missing ingredient, the element which is required to produce objectivity in the qualitative sense is […] the acceptance of the critical tradition. A view that is objective is one that has been opened up to scrutiny, to vigorous examination, to challenge. It is a view that has been teased out, analysed, criticised, debated – in general, it is a view that has been forced to face the

demands of reason and of evidence. When this has happened we have some assurance (though never absolute assurance) that the view does not reflect the whim or bias of some individual: it is a view that has respectable warrant.

In this research, objectivity was attained through the use of more than one data source, and also through detailed descriptions, "Good description is fundamental to the research enterprise"(www.nyu.edu: 2015).

4.8 INTERPRETATION OF THE RESULTS THROUGH DATA ANALYSIS

The interpretation of the results collected were analysed in the context of the qualitative methodology, as discussed in Section 4.2 in this chapter. The results were analysed to discover commonalities and themes that could have indicated a theory related to the acquisition of the Language of Mathematics. This theory can only grow if it is supplemented with much more research over time.

4.9 SUMMARY N

The conclusion of this chapter on the research methodology of this research included a reflection on the guiding principles of qualitative methodology in general, as well as a reflection on the attributes and limitations of this particular research into the Language of Mathematics at Grade 3 level. Because there is no interpretation of the data in this chapter; the interpretation of the data will be covered in the next chapter.

CHAPTER 5: DATA ANALYSIS

5.1 INTRODUCTION

In the previous chapter, the transcripts of the teacher-participant interviews and the observations of the detailed transactions of three Mathematics lessons were presented. In addition, the CAPS documentation was scrutinised as a data gathering exercise. In this chapter, the themes that surface from the data that was gathered are presented and discussed.

The initial impression of these data is nothing remarkable or extraordinary. The question then arises: What alchemy or magic do these teachers use that turns them into great teachers, enabling their learners to acquire the Language of Mathematics? The development of a new-born infant provides an insight into this problem. One must ask, which comes first: thoughts or language/words? The answer is thought – but, as the infant develops, thoughts are refined, honed, polished and shaped by the *language* in which it is immersed and these simple thoughts evolve into even more complex thoughts. These demand expression in even more complex and carefully compiled language forms. This evolution of mankind leads to an upward, ever-expanding spiral of intertwined strands of thought and language.

5.2 MATHEMATICS AS A FORM OF LANGUAGE

What is Mathematics? The South African Mathematics curriculum, issued by the Department of Basic Education, answers,

> Mathematics is a language that makes use of symbols and notations for describing numerical, geometric and graphical relationships. It is a human activity that involves observing, representing and investigating patterns and qualitative relationships in physical and social phenomena and between Mathematical objects themselves" (Department of Basic Education, 2011: 8).

The experienced teachers who participated in this research study understood what Mathematics comprises. Their facilitation of the Language of Mathematics needed only three components, which were embodied within their words and actions.

5.3 THE THREE THEMES OF THIS RESEARCH

The three themes that were discovered through the data analysis relate to the following, as stated in the South African national curriculum for Mathematics:

1. The Language of Mathematics implies a "deep conceptual understanding in order to make sense of Mathematics" (Department of Basic Education, 2011:8);
2. Recognition that Mathematics is a creative activity involving fearless confidence and "a spirit of curiosity" (Department of Basic Education, 2011: 8);
3. Acquisition of the Language of Mathematics is the development of an individual's "mental processes that enhance logical and critical thinking, accuracy and problem-solving which will contribute to decision making" (Department of Basic Education, 2011: 8).

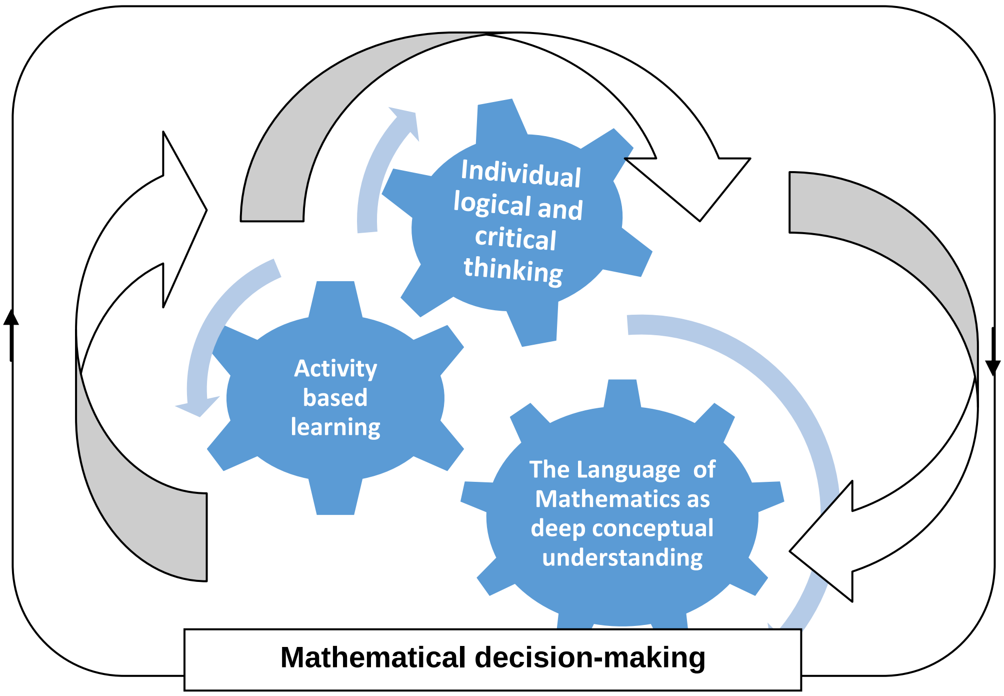


Figure 5.1: The three themes of this research related to an individual's decision-making process

These concepts or themes have been condensed into phrases:

1. The Language of Mathematics;
2. Activity based learning; and
3. Individual logical and critical thinking.

Each theme will be discussed as it presented in the data.

5.3.1 Theme 1: the Language of Mathematics as deep conceptual understanding

In answering the interview questions, the teachers (Participants A, B, and C from Schools 1, 2, and 3) were unanimous in their approval of their learner's acquisition of the Language of Mathematics. Participant A's response to the question on the importance of the Language of Mathematics was, "The Language of Mathematics helps with critical thinking, sequencing, understanding and processing."

The participating teachers were less outspoken when asked, 'What is the language of Mathematics?' The Language of Mathematics is a new concept in terms of these teachers' pedagogy, yet these teachers understood and facilitated the language of Mathematics intuitively in their teaching. Participant B clearly stated that this was an unfamiliar term, although she understood the term Mathematics, and understood the term language. She did *not,* however, know the term *Language of Mathematics*. Once I had explained the conceptual understanding of the term *the Language of Mathematics,* she explained that learning the terminology of Mathematics was important for learners. These teachers were all experienced and knowledgeable teachers who had been careful to keep up to date with the latest educational trends and thinking, yet the term *the Language of Mathematics* was new to each of them. This research was conducted on a very small sample size (three teachers), but it possible that this term is new to most teachers.

As mentioned in the introduction to this chapter, in the South African National Mathematics curriculum, there is mention of Mathematics being a language. In their definition of Mathematics, the South African National Mathematics curriculum states that "*Mathematics is a language that makes use of symbols and notations for describing numerical, geometric and graphical relationships (*Department of Basic Education, 2011: 8). The same notion is repeated, "Learners who are able to *communicate* effectively using *visual, symbolic and/or language skills in various modes" (*Department of Basic Education, 2011: 8). In the section on "Specific skills", the first specific skill listed is that "the learner should develop the correct use of the Language of Mathematics" *(*Department of Basic Education, 2011: 8). Beyond the introduction to the South African National curriculum, there is almost no mention of the Language of Mathematics, except in the geometry section, where the learner is required to describe geometric patterns *in words (*Department of Basic Education, 2011: 236).

The participating teachers all applied or used the Language of Mathematics in their lessons in an understated way. The terms were not highlighted or explained in great detail by each teacher, but were nevertheless part of their vocabulary. Each teacher confidently assumed that the Language of Mathematics is assimilated naturally by repetition, and within context – just as spoken languages are learned. The parents of a new child assume that their infant will learn the correct words and context of the home language just be using the words and by hearing the words used in meaningful ways. In the same way, these teachers gave the learners plenty of varied practice in using the Language of Mathematics without instilling any anxiety or negative connotations around these Mathematical English terms. Participant C used technology in the form of a music video in playing the video *Mr R's fraction song* so that the learners were exposed to the Language of Mathematics using a different medium.

In School 2, the Language of Mathematics was used incidentally in a lesson on money. The pirates *shared* the loot and diligently added up their takings. In Schools 1 and 3, fractions were graphically demonstrated when the learners combined the different fractions to make a *whole*, using the terms *quarters, halves* and so forth to describe what they were busy building. In School 3, the Grade 3 learners learned fractions by cutting their paper-cake to make *halves, quarters*, and so on. In every case observed, the learners seemed to acquire the Language of Mathematics in a natural and enjoyable way during their lessons and were free to verbalise their learning with their peers and teacher.

Participant B of School 2 drew attention to the fact that learners were able to *parrot* Mathematical terms that approximated to the Language of Mathematics without understanding their meaning at all and felt that “it was important for learners to use Mathematical terminology in the correct context”. By this statement, it is presumed that Participant B of School 2 meant that each learner had to construct his or her *own* context, i.e. the child’s uniquely individual understanding and conceptual framework.

5.3.2 Theme 2: Activity-based learning

In the interviews, all three teachers mentioned the importance of using concrete apparatus when teaching Mathematics, especially for the English Second language learners. The used of concrete apparatus is actually the tip of the iceberg for what can be termed *activity-based learning*. These teachers understood that young learners are naturally curious and capable problem-solvers, provided that they are given a milieu in which they have credible, relevant problems to solve. The average class of Grade 3 learners (aged between 7 and 9) is extremely energetic and will pursue the answer to a puzzle with incredible tenacity, if they are allowed the privilege of a trial-and-error approach and are not dissuaded from their constructive quest by an adult’s inflexible insistence on the *right* method.

Participant A of School 1 had a controversial, but interesting perspective of activity-based learning and concrete apparatus; she felt that learners spend a lot of time with computers and i-pads (and a popular Mathematics program, ‘Mathletics’, was named), but they do not get time to internalise the Language of Mathematics or to handle concrete apparatus so as to develop concepts for themselves. Each of the participating schools had the resources to buy a great deal of concrete apparatus. In every classroom, there were storerooms and/or high cupboards. In two of the classrooms, there were built-in facilities for technology. However, it was noted that in both the lessons on fractions, the learners’ were involved in creating their own fractions using paper, which could be applied in most educational settings.

In one classroom (School 1), the teacher (Participant A) let the learners draw around template shapes, illustrating *quarters, halves* etc. In this way, there was a concrete application of the *cutting away* of a shape. By shading only a section of the shape, the learners understood, (though activity–based learning), that this section or part was only one fraction of the whole. All three of the participating teachers used concrete apparatus as an integral part of the lesson and not merely as an introduction to the concept – but they combined the use of apparatus with challenging problems to solve. In all three classes of all three schools, there was a structuring of the work so that the content became increasingly complex. For instance, Participant A involved every child in the class in the creation of *fraction buildings*, starting with halves and quarters, progressing towards sixths and twelfths.

In every classroom of the three schools, the learners were undaunted by the challenge of increasing complexity because they understood, without being told, that they were developing their own strategies and thinking styles, relating the solutions to relevant problems in their worlds. This thought is reiterated in the National South African Mathematics curriculum, "Children should be encouraged to do, talk, demonstrate and record their Mathematical thinking" *(*Department of Basic Education, 2011: 12). The National South African Mathematics curriculum suggests that independent activities include, amongst others, "tasks which involve construction, sorting, patterning or measurement" *(*Department of Basic Education, 2011: 12).

Concrete apparatus is a valuable tool that learners can use to bridge *the real world* and the abstractions of the *Mathematical world*. The National South African Mathematics curriculum documentation stresses the importance of concrete apparatus for children with barriers to learning Mathematics, stating,

> It is important for learners who experience barriers to learning Mathematics to be exposed to activity–based learning. Practical examples using concrete objects together with practical activities should be used for a longer time than with other learners, as moving to abstract work too soon may lead to frustration and regression *(*Department of Basic Education, 2011: 12).

The training of teachers to facilitate the most effective methodologies for acquiring the Language of Mathematics was mentioned in two of the interviews (Schools 2 and 3). One can only surmise that the expertise of these Mathematics teachers was hard-won.

5.3.3 Theme 3: Individual logical and critical thinking

Learning is an individual process. Each of these teachers (Participants A, B, C) demonstrated that each child can construct his or her own Mathematical constructs. Beyond this, the deep and detailed understanding of every learner that these teachers had was clear. Each participant recognised the interplay between social/emotional/mental/physical elements of the child's inner world. They related to each child as an individual, and, as far as possible, tailored the pedagogy to the needs of that learner. A glimpse of this was given by Participant C (School 3) who highlighted the fact that emotional difficulties can impede the acquisition of the Language of Mathematics.

The teachers did not spend much time in *teacher–talk,* but in each lesson, they engaged the learners. In the lesson on pirate loot, the teacher (Participant B, School 2) encouraged the learners to use their imagination to be pirates experiencing an adventure. The activity of adding the pirate loot (School 2) involved logic and critical thinking, and also bridged concrete and abstract concepts. In the two lessons on fractions, the teachers (Participants A and C of Schools 1 and 3 respectively) engaged the learners' imagination by using the example of pizza, a popular treat in their neighbourhoods. The learners used logic and critical thinking skills to solve the problems presented to them. The learners observed in all three classrooms (Schools 1,2, and 3) worked consistently and interacted with each other to check their thinking or help when requested by a friend. The aspect of individual learning (i.e. independent work) is portrayed as only one aspect of the lesson structure in the South African National Mathematics curriculum (see table attached), but, in fact, it is the very essence of a successful lesson.

The South African National Mathematics curriculum documentation (2011:11) suggests guidelines for classroom management strategies during the Mathematics period.

Table 5.1: Table showing the guidelines for classroom management strategies during the Mathematics lessons.

Whole class activity	• Mental Mathematics; • Consolidation of concepts; • Classroom management: allocation of activities.
Small group activities	• Counting; • Number concept development (oral and practical activities); • Written recording; • Developing calculating strategies (oral and practical activities); • Patterns; • Space and shape; • Measurement; and • Data handling.
Independent work	• Practice and consolidation of concepts developed in that lesson.

The weekly time allocation within the Department of Basic Education Mathematics curriculum for Grade 3 is set at between four to four and a half hours. The participating teachers stated in their interviews that the curriculum puts undue time pressure upon both themselves and the learners because the curriculum is so broad. However, Participant B (School 2) stated that the content of the curriculum was good. Despite this demanding curriculum, these teachers recognised and applied the supremacy of individualised attention and learning in Mathematics. They always addressed the learners by name and were unfazed by mistakes; instead they praised and recognised the sustained effort of the learner, thereby building the learner's self-esteem. The teachers also subtly applied the concept of *buddy talk*, which is one of the methodologies proposed by Owen-Smith (2007). The teachers used the principle of allowing learners to think through the challenges posed by a

Mathematical activity, and then to discuss their thoughts for a short time with a buddy or friend. By being able to verbalise their thoughts to each other, learners could crystallise their thinking so that they could confidently complete the individual Mathematical activities. For English second language learners, this has another benefit as the learners may communicate with their buddy in their home language, and only then verbalise the answer in Mathematical English.

It is possible that in many group activities, one or two members can dominate the conversation, whilst others are precluded from the activity. This did not happen in any of the lessons that were observed. In all three lessons respectively, there was a clear demonstration of individual activities by learners and therefore individual acquisition of the Language of Mathematics taking place.

The core element of the development of an individual's logical, analytic and problem-solving ability, relating specifically to the acquisition of the Language of Mathematics, is the *ability to Mathematise*. This ability was identified by Schwartz and Kenny of Harvard University's project on *Balanced Assessment in Education* (2003).Participant C (School 3) explained this ability and gave an example. She stated that, "The Language of Mathematics is the ability to assimilate Mathematical problems and write them in a *Mathematical sentence* […] For example: Mary is twelve years old and her brother is twenty four years old, what is the age difference? This is where the child should be able to interpret and write into a number sentence: 24-12=12."

A completely independent view of the importance of the ability to Mathematise was given by Participant A (School 1) in explaining that "the acquisition of the language of Mathematics helps with critical thinking, sequencing, understanding and processing."As the researcher, I did not know that facilitating the acquisition of Mathematics would prove to be so multi-faceted. At the end of this research, my experience and newly acquired knowledge of the twin aspects of *language* and *the Language of Mathematics* lead me to the realisation, as yet unproven, that these *twin* aspects could actually be *Siamese twins,* which are separate yet inseparable.

5.4 CONCLUSION

In this chapter, I have presented the findings of this research, which resulted from an intensive data analysis of the transcribed observations (in Schools 1, 2, and 3), and interviews with each of the three participants (Participants A, B, and C.) In this chapter, evidence regarding the source of the data and its analysis has been provided. It is possible for the data analysis and synthesis to be combined not one chapter. I have chosen not to combine these two chapters to provide greater clarity for the reader and to create a logical flow to the recommendations that follow the synthesis, The teachers that were chosen are very busy professionals who work long hours under pressure and so I feel honoured to have been given of their valuable time in interviews. Although there was only one interview with each participant teacher, their responses did not require further elaboration and their insights were extremely valuable components of this research. By obtaining data from multiple sources, it was possible to identify themes within the data. Chapter 6, therefore, represents a summation of this research project.

CHAPTER 6: SYNTHESIS OF THE RESEARCH

6.1 INTRODUCTION

The initial aims and objectives were encapsulated in the main research question and two research sub-questions. The central research question was:

How is the Language of Mathematics facilitated in Grade3 classes?

The research sub questions were:

- What is the Language of Mathematics?
- What strategies are teachers using to facilitate the acquisition of the Language of Mathematics in Grade 3 classes?

These research questions dictated the choice of a qualitative case study research. The ethical considerations of the research were carefully considered. The approval of the Ethics Committee of the University of Pretoria was sought and obtained. In due course, the research was conducted in three schools. The finding of this qualitative research is that there are three themes, which emerged from the data collected. In order to facilitate the Language of Mathematics, the participating teachers seemed to utilise three elements, namely:

1. A knowledge and pedagogy concerning the elements of the Language of Mathematics;
2. The recognition that Mathematics is an active, creative and challenging voyage of discovery for learners; and
3. Acquisition of the Language of Mathematics is the result of the development of an individual's thinking and solutions to problems, which have been expressed and refined.

6.2 LITERATURE CONTROL FOR THE FINDINGS OF THIS RESEARCH

6.2.1 Supportive evidence in the literature for these findings

Table 6.1: Supportive evidence and interpretative discussion of the research findings

The theme	***Author and year***	***Supportive Evidence for this research***	***Interpretative discussion***
The Language of Mathematics as deep conceptual knowledge.	Schwartz and Kenny (2003).	The Balanced Assessment in Mathematics highlighted the ability to translate problems into Mathematics, i.e. the ability to 'Mathematicise'.	This research suggested that the acquisition of the Language of Mathematics is an essential component in the ability to 'Mathematicise'.
Facilitation of the acquisition of the Language of Mathematics.	Slabbert et al. (2011).	The four elements of the educational facilitation paradigm are: Transmission, Transaction, Transformation and transcendence.	Each of these four elements was evident in the data gathered on the facilitation process of acquiring the Language of Mathematics.
Integration of the Language of Mathematics into Mathematics classrooms is a necessity for English language learners.	Lager (2006), Bernardo (2010).	These research studies showed that language challenges in Mathematics (i.e. not understanding the questions) negatively impacted English language learners' results. Lager pleaded for the integration of Mathematics registers into Mathematics instruction. Bernardo suggested a lower level of English be adopted for questions.	The integration of the Language of Mathematics and the skilful facilitation of its acquisition results in successful learning and communication of Mathematical concepts.
Educator can overcome potential barriers to the learning of Mathematics.	Thomas et al. (2015).	Skilled educators can foresee and minimise potential barriers by adopting a learning framework.	Educators were able to overcome barriers by using 'buddy talk' and other techniques to optimise learning.
Logic Mathematical thinking is	Department of Basic	"Familiarity with the Language of Mathematics is a pre-cursor to all	Research shows that the Language of Mathematics is

The theme	***Author and year***	***Supportive Evidence for this research***	***Interpretative discussion***
enhanced by the acquisition of the Language of Mathematics.	Education.	understanding" (2014:8).	acquired and expressed both orally and in written formats.
Activity based Learning	Festus (2013).	Active learning is a process whereby learners are actively engaged in the learning process rather than passively absorbing lectures.	The lessons in all three schools (Schools 1, 2, and3) demonstrated activity-based learning.
Critical thinking in Mathematics.	Paul, Binker & Weil (1995).	Most students are not learning to think Mathematically.	The importance of learners' critical thinking in Mathematics was endorsed by all participating teachers of this research study.
Logical thinking in Mathematics.	Kuhn (1999).	There are three forms of second–order cognition: meta-cognitive, meta-strategic and epistemological cognition, which make critical thinking possible.	Participants A, B, and C implied an endorsement of the meta-cognitive aspect of acquisition of the Language of Mathematics.

6.2.2 Contradictory evidence in the literature for these findings

Table 6.2: Table showing contradictory evidence and interpretative discussion

Theme	***Author and year***	***Evidence contradicting these findings***	***Interpretative discussion***
Acquisition of the Language of Mathematics utilises the learner's existing strategies for learning and thinking.	Schleppergrell (2007).	Registers for the precise meanings of Mathematical words should be taught formally because the learning of school Mathematics requires new modes of learning and thinking.	This research utilised the existing modes of learning and thinking as a foundation for the acquisition of the Language of Mathematics.
There is a commonality between language and the Language of Mathematics.	Ganesalingam (2013); Kersaint (2014).	Words and Mathematical symbols are entirely dissimilar and independent.	Through verbalising and discussion of activity-based learning by the individual, there is a progressive and natural acquisition of the Language of Mathematics.
English language learners should not have differential instruction or lowered standards of assessment in Mathematics.	Willaford (2011); Weiland and Yoshikawa (2013).	There can be an under-estimation of the abilities of English language learners – as young as in the pre-school years.	The longer exposure to concrete apparatus and the encouragement of the verbalising of understanding will mitigate the difficulties of young English language learners in acquiring the Language of Mathematics.

6.2.3 Silences in the literature concerning these findings

Table 6.3: Silences in the literature and interpretative discussion

Theme	***Silence in** the **literature concerning these findings***	***Interpretative discussion***
Aspects of the facilitation of the Language of Mathematics	There seems to be a silence in the research regarding the transformative and transcendence aspect of facilitation (as elucidated by Slabbert et al., 2011) with reference to the acquisition of the language of Mathematics.	Research on aspects of facilitation needs to adopt the Appreciative Inquiry approach (as was done in this research), in order to maintain the highest ethical standards for vulnerable participants.

6.2.4 New insights regarding these findings

Table 6.4: New insights in the literature and interpretative discussion

Theme	***Interpretative discussion***
Types of Mathematisation.	There is evidence of both types of Mathematisation being facilitated in this research.
Strands of Mathematical proficiency relating to the ability to Mathematise.	There was evidence of the facilitation of a number of these strands of proficiency in this research.
Bilingualism does not affect a learner's ability to solve problems in Mathematics	This conceptualisation of the Language of Mathematics is implicit within this research.

6.2.5 Teacher pedagogy as it relates to the acquisition of the Language of Mathematics

In conclusion to this overview of the literature, the various strands of this exploration of the Language of Mathematics need to be drawn together. Fortunately, Anthony and Walshaw have formulated a statement of belief about teacher pedagogy, which mirrors my own views on the facilitation of the acquisition of the Language of Mathematics. Anthony and Walshaw (2012:6) declare that "Mathematics pedagogy must:

- Be grounded in the general premise that all learners have the right to access education and the right to access Mathematical culture;
- Acknowledge that all students can develop Mathematical identities and become powerful Mathematical learners;

- Be based on an interpersonal respect and sensitivity and be responsive to the multiplicity of cultural heritages, thinking processes and realities typically found in classrooms;
- Be focused on optimising a range of desirable academic outcomes that include conceptual understanding, procedural fluency, strategic competence and adaptive reasoning; and
- Be committed to enhancing a range of social outcomes within the Mathematics classroom that will contribute to the holistic development of students for productive citizenship"

This statement on Mathematics pedagogy forms the philosophical foundation on which this research into the acquisition of the Language of Mathematics is built.

6.3 DISCUSSION OF THE RESEARCH FINDINGS AS THEY RELATE TO THE RESEARCH QUESTIONS

"The research question is an answerable inquiry into a specific concern or issue" (www.study.com). In this research project, a start has been made towards answering the central research question, and the sub questions.

The central research question is:

How is the Language of Mathematics facilitated in Grade 3 classes?

The research sub questions are:

- What is the language of Mathematics?
- What strategies are teachers using to facilitate the acquisition of the Language of Mathematics in Grade 3 classes?

In this research study, the aim was to look beyond the obvious teaching techniques and teacher 'profiling'. This was done to find the philosophical standpoints of the participants that were the driving force behind their facilitation of the Language of Mathematics in the classroom. Using a variety of data collection methods allowed the three themes to emerge from the data.

Although these teachers did adopt a number of innovative and creative approaches in their lessons, it was their philosophies that were the most important finding of this research, and the primary goal was the contribution to the body of Mathematical research.

The Language of Mathematics has been clearly aligned with the ability of the Grade 3 learner to 'Mathematise', i.e. to perceive the meaning of Mathematical words and/or symbols. The learners' perceptions are then translated into the language of Mathematics, which requires that the teacher has an understanding of this process. The learner, who has mastered the Language of Mathematics, is then able to perform a Mathematical calculation and express the answer in an intelligible form using the Language of Mathematics. The basics of the conventions and rules of the Language of Mathematics should be mastered by Grade 3.

In this research, in every Grade 3 class that was observed, the learners were encouraged by their teachers to explore the characteristics and relationships within the Mathematical concepts taught. By exploring and experimenting, the learners were beginning to construct an individual but robust Mathematical concept. In this way, they were in the process of acquiring the Language of Mathematics. These vibrant and exciting lessons were a far cry from the quiet classes of learners completing piles of sterile worksheets, where the Mathematics teachers 'translate' Mathematics for the learners so that they achieve the 'right answer' and obey 'Mathematical convention'. The learning activities were individually based and the individual was, as shown by this research, made responsible for completing the exercises at his or her own pace. The participating teachers' maintained discipline, but simultaneously encouraged learner self-monitoring and accountability. In all three classes, the teacher was on hand to assist any learner who was feeling frustrated and needed assistance. The interactions between the teacher and the learners were characterised by empathy and warmth.

The activity-based strategy for acquiring the Language of Mathematics raises the question of sufficient resources within the school to be able to implement multiple activities in Mathematics. A study of the CAPS curriculum (2011) stresses this methodology. This research has shown that the onus is on the teacher to provide stimulating and relevant examples for their learners, and on the school to provide resources.

6.4 CONTRIBUTIONS TO KNOWLEDGE

This research has contributed to knowledge regarding the acquisition of the Language of Mathematics in the following aspects:

1. It has demonstrated that the philosophy of these teachers was to view each learner as being capable, imaginative and exploratory.
2. Based on this constructivist approach, these teachers created an environment that was optimal for energetic Grade 3 learners by using activity-based methods, visual aids and technology.
3. While in all the classes observed, each teacher was available to help the learners acquire the concepts of the Language of Mathematics, the learners were clearly accountable for their own learning. Independence, tenacity and resilience were the unwritten code for success in these classrooms.
4. The teachers' all recognised and valued the learners' ability to convert/translate sentences from English into the Mathematical equivalent, i.e. the Language of Mathematics. These teachers' goal was that each learner could 'Mathematise' the problems given to them in English.
5. The participating teachers had all kept their teaching knowledge current through formal and/or informal studies with the latest educational trends, yet the concept of the 'Language of Mathematics' was a new concept for each of them. Based on their experience and expertise, they were quickly able to assimilate this new learning.

This research has added its own small, but unique, contribution through the findings that resulted from the data collected. The Language of Mathematics can and should be acquired to a greater or lesser extent by every learner, including those who do not have English as their home language.

6.5 SUGGESTIONS FOR FURTHER RESEARCH

6.5.1 Recommendations for the Department of Basic Education

The CAPS curriculum (2011) emphasises the importance of the Language of Mathematics. The South African Department of Basic Education is publicly committed to improving the Mathematical skills of learners in South Africa. The acquisition of the Language of Mathematics may be the key to unlocking the door for learners to truly acquire Mathematical concepts, but this approach must begin in the Foundation Phase of school. Activities that are suitable for each grade would be helpful in assisting inexperienced teachers. I believe that a change of emphasis in the curriculum is required that directs the thinking of teachers towards facilitating the learners' acquisition of the Language of Mathematics as a fundamental and necessary human right. The Department of Basic Education also needs to provide resources to schools that emphasise the Language of Mathematics, for example, in the form of posters, cards, and short videos.

The translation of the Language of Mathematics into the eleven official languages has already been done, but the onus rests on the relevant government departments to disseminate this knowledge in digital and written format so that teachers and learners can translate it into their home language. The Language of Mathematics is global and it is, and will probably always be, based in English. Learning of the Language of Mathematics must commence in English, regardless of the home language or the LoLT. In this way, the learner will acquire the vocabulary that matches the conceptual framework from the beginning of their schooling, obviating confusion in later years.

6.5.2 Recommendations for teachers

The issue of discipline in the classroom is a source of concern globally. Nonetheless, teachers must commit to facilitating the acquisition of the Language of Mathematics in their classrooms. The learners must be held accountable for their learning of the Language of Mathematics. Regular assessment of the degree of acquisition will need to be slotted into Mathematics lessons. Failure to acquire the Language of Mathematics has dire consequences. Teachers can raise these issues at cluster meetings, and best practices can be shared among teachers for the benefit of learners.

Learners' logical thinking skills (i.e. left brain thinking) are combined with creative and imaginative thinking (i.e. right brain thinking) during the acquisition of the Language of Mathematics. The teacher needs to take this into account in facilitating the Language of Mathematics.

6.5.3 Recommendations for parents

The Language of Mathematics is an acquired skill. Although some have an innate aptitude for Mathematics, there is no such thing as a Mathematical brain. Parents must encourage their children to develop perseverance through practice in terms of mastering the Language of Mathematics. The mistakes that learners make usually represent considerable effort, and these errors in thinking can only be corrected by continued application until the corrected concept is mastered. In this research, the learners were given a great deal of both activity–based and book–based practise. Parents (and teachers) would do well to adopt this model.

6.5.4 Recommendations for teacher training institutions

Teacher training in facilitating the acquisition of the Language of Mathematics is necessary. When teachers are aware of this important aspect, lessons can incorporate the necessary components to assist learners in mastering the Language of Mathematics.

6.6 LIMITATIONS OF THE RESEARCH STUDY

The research aimed to explore teachers' facilitation, and the scope of the research did not extend to the analysis and interpretation of the learners' acquisition of the Language of Mathematics.

The research was limited by the practical constraint of time as there was only one researcher. The research sites were urban classrooms, which had small class sizes and were well equipped. Thus, the research was limited in that it cannot be generalised to all school situations. This limitation can be overcome by including rural classes.

The sample of participating teachers was purposefully chosen, and therefore one cannot assume that they are representative of the general teacher population; and their experience and pedagogy were unusual. There is nevertheless transferability of the results of this research since the findings were proven to be universally applicable.

6.7 CONCLUSION

This research has demonstrated that facilitation is a key factor in the acquisition of the Language of Mathematics. Learners internalise and establish the Language of Mathematics in the foundation phase. It is surprising, therefore, to note the dearth of research on this crucially important aspect. Countries with learners who have mastered the Language of Mathematics succeed in international benchmarking assessments, and also succeed in lucrative careers, to the benefit of themselves, their families and their communities. This research aimed to stimulate further research and the greater inclusion of the Language of Mathematics in the Foundation Phase curriculum. South African Mathematics learners should take their rightful place alongside the developed countries of the world, and hold their heads high, proud to be South African whilst celebrating linguistic and cultural diversity – and a mastery of the Language of Mathematics. If this were achieved, there could be far reaching benefits for both individuals and South African communities.

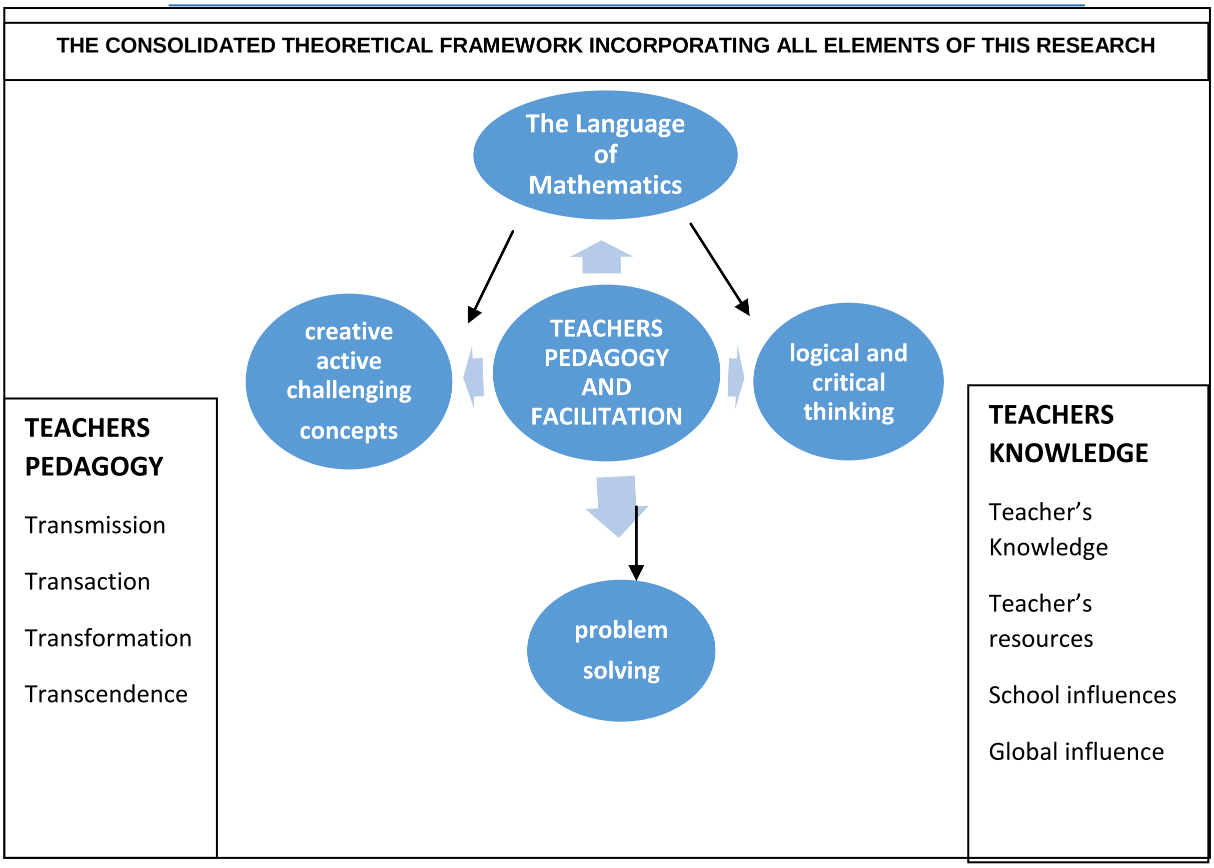


Figure 6.1: The consolidated theoretical framework for this research study

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ADDENDA

ADDENDUM A

THE LANGUAGE OF MATHEMATICS: OBSERVATION CHECKLIST

Date: ____________________ **School:** ______________________________

Number of children in the class	
Number of boys in the class	
Classroom dimensions	
Topic being facilitated	
Seating arrangements	
Posters	
Display of children's work	
Written work	
Visual media	
Teacher's resources	
Children's resources	

ADDENDUM B

INTERVIEW GUIDE

SEMI-STRUCTURED INTERVIEW QUESTIONS.

Participants: Grade 3 teachers.

1. How long have you been teaching?
2. What are your highest qualifications and what were your major subjects?
3. How would you rate yourself as a Mathematics teacher now?
4. Have you received any awards or recognition for your teaching?
5. How many grade 3 Mathematics classes do you teach and how many grade 3 learners do you have in a class?
6. Do you think that it is important for learners to learn the Language of Mathematics? If so, why? If not, why not?
7. What do you understand by the Language of Mathematics?
8. Can you tell me of a time when one of your learners made a breakthrough in learning the Language of Mathematics?
9. What strategies do you use to assist those who are English second language learners?