# UNIVERSITY OF FORT HARE

**THE PERCEPTIONS OF TEACHERS TEACHING MATHEMATICAL LITERACY AT THE FURTHER EDUCATION AND TRAINING LEVEL: A CASE STUDY CONDUCTED IN THE EAST LONDON EDUCATION DISTRICT**

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# DEDICATION

I dedicate this research to my late father, Sivarama Panicker, my late grandfather, Gopala Pillai, my late grandmother, Parukutty Amma, my late brother, Radhakrishna Pillai, my mother, Padmavathi Amma, my uncle, Soman Pillai, my sister, Remadevi Amma, and my brother, Manoharan Pillai.

# DECLARATION

I declare that the content of this dissertation is my own work and that all sources have been acknowledged in a complete list of references.

**SIVARAMA PANICKER MOHANAN PILLAI** **DATE**

# ABSTRACT

Mathematical Literacy is a compulsory subject at the Further Education and Training (FET) level in South Africa. All learners who do not select Mathematics are required to study Mathematical Literacy as their numeracy subject in Grade 10, the first year of studying at the FET level. This requirement coincided with the educational reforms which were introduced in South Africa after democracy was attained in1994.

Mathematical Literacy was introduced in Grade 10 in 2008, in Grade 11 in 2009 and in Grade 12 in 2010. Matriculants in 2012 comprised the cohort who wrote the Mathematical Literacy examination for the first time in South African history.

Although 4 years have passed since the introduction of Mathematical Literacy in Grade 12, many teachers are still not sufficiently competent enough to teach the subject. This fact has been demonstrated quite conclusively in the matriculation results of the past 4 years. The failure to teach the subject satisfactorily is the result of poor knowledge of the content of the courses, insufficient teaching materials and incorrect teaching methods.

This study has focused on uncovering the perceptions of teachers of the teaching of Mathematical Literacy and on how best to support and assist teachers in order to improve their knowledge of the content of their courses, to improve the methods of teaching the subject and to provide sufficient resources to support both teaching and learning. The study is also aimed to draw the attention of the Department of Education (DoE) to the need to provide better training in order to develop the competency of teachers in the subject and to overcome the lack of resources through developing innovative ways of teaching it.

A qualitative approach was adopted in order to conduct the research, as it aims to provide an explicit rendering of the structure, order and broad patterns pertaining to the teaching of the subject from a group of participants. Qualitative research is best suited to studies of this sort, as it provides the means to conduct an in-depth investigation of the thoughts, beliefs, attitudes and responses of teachers concerning the teaching of Mathematical Literacy at the FET level.

The research was conducted in 6 FET schools in the East London Education District. Six teachers of Mathematics and Mathematical Literacy in Grades 10, 11 and 12 were selected to comprise the research sample for the study. Semi-structured questions were used to collect the data.

The research study established that educators have divergent perceptions and beliefs concerning the teaching of Mathematical Literacy at the FET level. The study was also able to identify the problems, obstacles and difficulties encountered by the teachers in their attempts to teach the subject and the trends which emerged during the conducting of the research.

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# LIST OF ACRONYMS

| | |
|---|---|
| **AMSC:** | **American Mathematic Science Council** |
| **ACE:** | **Advance Science in education** |
| **CAPS:** | **Curriculum and Assessment Policy document** |
| **DoE:** | **Department of Education** |
| **FET:** | **Further Education and Training** |
| **GET:** | **General Education and Training** |
| **KLA:** | **Key Learning Areas** |
| **LA:** | **Learning Areas** |
| **MHRD:** | **Ministry of Human Resources Development** |
| **ML:** | **Mathematical Literacy** |
| **MKO:** | **More Knowledge Other** |
| **NCS:** | **National Curriculum Statement** |
| **NSC:** | **National Senior Certificate** |
| **NCERT:** | **National Council for Education for Research and Training** |
| **OECD:** | **Organization of Economic Co-Operation and Development** |
| **PCK:** | **Pedagogical Content Knowledge** |
| **PISA:** | **Programme for International Students Assessment** |
| **QCDA:** | **Qualification and Curriculum Development Agency** |
| **TIMSS:** | **Trends in International Mathematics and Science Study** |
| **RME:** | **Realistic mathematics Education** |

**SAUVCA:** **South African Vice Chancellors Association**

**SPK:** **Specialised Content Knowledge**

**UGC:** **University Grand Commissions**

**ZPD:** **Zone Proximal Development**

## Table of Contents


DEDICATION ..... i

DECLARATION ..... ii

ABSTRACT ..... iii

ACKNOWLEDGEMENT ..... v

LIST OF ACRONYMS ..... vi

LIST OF TABLES ..... xvi

LIST OF FIGURES ..... xvii

CHAPTER 1: INTRODUCTION

1.1 Introduction ..... 1

1.2 Background of the study ..... 2

1.2.1 FET school education in South Africa post-1994 ..... 2

1.2.2 Requirements for teaching Mathematical Literacy ..... 4

1.3 Statement of the problem ..... 5

1.4 Research questions ..... 5

1.5 Significance of the study ..... 6

1.6 Literature review ..... 7

Theoretical framework ..... 7

1.6.1 Vygotsky and social learning theories ..... 7

1.6.2 Bandura and social learning theory ..... 8

1.6.3 Basic social learning concepts ..... 9

1.6.3.1 People can learn through observation ..... 9

1.6.3.2 Mental states have a direct bearing on learning ability ..... 10

1.6.3.2.1 Intrinsic reinforcement ..... 10

1.6.3.3 Learning does not necessarily result in a change of behaviour ..... 10

1.6.3.4 The modelling process ..... 10

1.6.4 Rotter's Social Learning Theory ..... 12

1.6.5 Conceptualisation of Mathematical Literacy ..... 12

1.7 International perspectives ..... 13

1.7.1 Education in Mathematics in India ..... 13

1.7.2 Education in Mathematics in Australia ..... 14

1.7.3 Education in Mathematics in China ..... 14

1.7.4 Education in Mathematics in the United States of America ....................... 17
1.7.5 Education in Mathematics in the United Kingdom .................................... 20
1.7.5.1 The UK National Curriculum................................................................. 20
1.7.5.2 Functional mathematical skills .............................................................. 21
1.7.6 Education in Mathematics in Kenya……………………………………………21
1.7.7 Education in Mathematics in Japan.......................................................... 23
1.8 Mathematical Literacy from a national perspective...................................... 23
1.9 Research Methodology and design……………………………………………..25
1.9.1 Case studies .......................................................................................... 26
1.10 Sampling……………………………………………………………………….27
1.10.1 Purposive sampling ............................................................................... 27
1.10.2 Sample size…………………………………………………………………..27
1.11 Collection of data……………………………………………………………...27
1.12 Ethical consideration with respect to the conducting of interviews ............. 28
1.13 Analysis of data and research findings..................................................... 28
1.13.1 Analysis of data obtained from semi-structured interviews………………28
1.14 Reliability, trustworthiness and ethical considerations to be respected during the conducting of the research…………………………………………28
1.15 Recommendations, limitations and contributions to further research ......... 29
1.16 Conclusions……………………………………………………………………29
1.17 Structure of chapters ............................................................................... 29
CHAPTER 2: LITERATURE REVIEW: A THEORETICAL FRAMEWORK
2.1 Introduction .............................................................................................. 31
2.2 Mathematical Literacy ............................................................................... 31
2.2.1 An overview and history of Mathematical Literacy.................................... 32
2.2.1.1 Background of Mathematical Literacy ................................................... 32
2.2.1.2 The Mathematical Literacy Curriculum Reform ..................................... 33
2.2.1.3 The purpose of Mathematical Literacy .................................................. 33
2.2.1.4 The aims of Mathematical Literacy........................................................ 34
2.2.1.5 The definition of Mathematical Literacy ................................................. 35
2.2.1.6 The 5 key elements of Mathematical Literacy – National Curriculum Statement (NCS) and the Curriculum and Assessment Policy Statement (CAPS)......................................................................... 36
2.2.1.7 The composition of Mathematical Literacy in the CAPS curriculum ....... 38

2.2.1.7.1 The Mathematical Literacy Assessment Taxonomy ............................ 39
2.2.1.8 Pedagogical approaches to teaching Mathematical Literacy.................. 40
2.2.1.9 The Mathematical Literacy learner profile ............................................. 43
2.2.1.10 Some general concerns and perceptions regarding Mathematical Literacy.......................................................................................... 43
2.2.1.11 The choice of contexts ......................................................................... 44
2.2.1.12 Problems associated with the language of instruction.......................... 45
2.2.2 Different conceptions of Mathematical Literacy ......................................... 46
2.2.3 Contexts in which Mathematical Literacy can be applied .......................... 48
2.2.3.1 Context categories according to the requirements of stakeholders........ 49
2.2.4 Context categories according to processes.............................................. 50
2.3 Vygotsky and social learning theories ......................................................... 51
2.3.1 Social constructivist perspective.............................................................. 51
2.3.2 Zone of proximal development ................................................................. 52
2.4 Bandura and social learning theory.............................................................. 55
2.4.1 Examples of observational learning in action ........................................... 56
2.4.2 Factors which influence observational learning ........................................ 56
2.4.3 Real-world applications for observational learning ................................... 56
2.4.4 Observational learning as a positive force................................................ 57
2.4.5 Definition of self-efficacy .......................................................................... 58
2.4.6 The role of self-efficacy ............................................................................ 58
2.4.7 Sources of self-efficacy ............................................................................ 59
2.5 Rotter’s Social Learning Theory ................................................................... 60
2.6 Implications of social learning theory for teaching and learning Mathematical Literacy ........................................................................... 67
2.7 International perspectives of Mathematical Literacy…………………………..68
2.7.1 Education in Mathematics in India............................................................ 69
2.7.1.1 Obstacles encountered by the educational system ............................... 70
2.7.1.2 Education in Mathematics on the Indian subcontinent .......................... 71
2.7.1.3 The structure of the Indian educational system..................................... 72
2.7.1.4 Elementary education in India ............................................................... 72
2.7.1.5 Numbers of learners to be educated in India......................................... 73
2.7.1.6 The quality dimension of education in Mathematics in India .................. 74
2.7.1.7 Educational reforms ............................................................................... 76

2.7.1.8 Higher stages of education in India ...................................................... 79
2.7.1.9 The major challenge for education in Mathematics for India .................. 81
2.7.2 Education in Mathematics in Australia...................................................... 83
2.7.2.1 Australian students slipping behind in Mathematics ............................... 83
2.7.2.2 Mathematics and Numeracy.................................................................... 85
2.7.2.3 The milieu of teaching Numeracy ........................................................... 85
2.7.3 Education in Mathematics in China .......................................................... 86
2.7.3.1 China's present unprecedented curriculum reforms ............................... 87
2.7.3.2 The future of education in Mathematics in China ................................... 91
2.7.4 Education in Mathematics in the United States of America ....................... 94
2.7.4.1 Pre-test for identifying prevailing myths about the conditions of schools in the United States........................................................................................ 95
2.7.4.2 Developing mathematicians .................................................................... 97
2.7.5 Education in Mathematics in the United Kingdom .................................... 99
2.7.5.1 Performance in Mathematics according to the PISA report of 2012....... 99
2.7.5.2 Performance of students in different areas of Mathematics ................. 100
2.7.6 Education in Mathematics in Kenya ...................................................... 101
2.7.6.1 Existing conditions in education in Mathematics in Kenya ................... 101
2.7.6.2 Main findings from the survey ............................................................ 102
2.7.7 Education in Mathematics in Japan...................................................... 103
2.7.7.1 Performance of students in Mathematics, Reading and Science………..103
2.7.7.2 Mean scores achieved in Mathematics……………………………………...104
2.7.7.3 Distribution of low -performing and high-performing students in Mathematics…………………………………………………………………104
2.7.7.4 Gender difference in performance in Mathematics……………………...105
2.7.7.5 Performance in specific process and content areas of Mathematics….105
2.8 National perspective of Mathematical Literacy………………………………107
2.9 A synopsis of Mathematics and Mathematical Literacy in South Africa...... 109
2.9.1 The properties of Mathematical Literacy and Mathematics: Curriculum Assessment Policy Statements .......................................................... 109
2.9.1.1 The properties of Mathematical Literacy and Mathematics .................. 110
2.9.2 The learning outcomes of Mathematical Literacy and Mathematics - Curriculum Assessment Policy Statement (CAPS)................................ 112
2.9.3 Topics covered in Mathematical Literacy and Mathematics .................... 114

2.9.4 Composition of Mathematics and Mathematical Literacy ........................ 114
2.10 The teaching practices of teachers: a focal point of this study ................. 116
2.10.1Terminologies which are used to describe the teaching practices of Teachers ........................................................................................ 117
2.11 Teaching Pedagogy ........................................................................ 118
2.11.1 Setting tasks.................................................................................. 118
2.11.1.1 Modes of representation in teaching ................................................ 118
2.11.1.2 Motivational teaching strategies ....................................................... 119
2.11.1.3 Scaffolding teaching tasks: sequencing and difficulty levels .............. 120
2.11.2 Discourse ....................................................................................... 121
2.11.2.1 Interactions and relationships between teachers and learners........... 121
2.11.2.2 Peer learning: learner-learner interactions ....................................... 122
2.11.2.3 Posing effective questions................................................................ 122
2.11.3 Learning environment...................................................................... 122
2.11.3.1 Social and intellectual climate .......................................................... 122
2.11.3.2 Modes of strategies and pacing........................................................ 123
2.11.3.3 Administrative routines .................................................................... 123
2.12 Mathematical Literacy: Knowledge and perceptions of teachers............. 124
2.12.1 The relationship between knowledge and perceptions......................... 124
2.13 Overview of the various different domains of knowledge possessed by Teachers ........................................................................................ 127
2.14 An overview of the beliefs of teachers of Mathematics about Mathematics................................................................................... 129
2.14.1 The nature of beliefs......................................................................... 128
2.14.2 Schoenfeld's theory of beliefs: four general beliefs held by learners..... 129
2.15 The influence of the knowledge, beliefs and perceptions of teachers on their teaching practices ................................................................... 131
2.15.1 The influence of the knowledge, beliefs and perceptions of teachers on Learners........................................................................................ 131
2.15.2 The influence of the knowledge, beliefs and perceptions of teachers on their teaching........................................................................... 132
2.15.3 Findings with respect to the influence which their knowledge, beliefs and Perceptions have on teachers of Mathematical Literacy .................... 134
CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction ........................................................................................ 136
3.2 Reasons for adopting a qualitative approach in order to conduct this
Study ............................................................................................... 138
3.3 Research design ..................................................................................... 139
3.4 Designing and conducting a case study ................................................... 140
3.5 Analysis of results for a case study .......................................................... 141
3.6 Research population ................................................................................ 141
3.7 Sampling ................................................................................................. 142
3.7.1 Purposive sampling ................................................................................ 142
3.8 Sample size.............................................................................................. 142
3.9 Techniques used to collect data ............................................................... 143
3.9.1 Semi-structured interviews ..................................................................... 144
3.9.2 Semi-structured interview questions ....................................................... 144
3.9.3 Advantages of semi-structured questions ................................................ 145
3.10 Analysis of data and research findings .................................................... 145
3.10.1Document analysis .................................................................................. 146
3.10.2 General findings from the chief marker's report for Mathematical Literacy
of 2013 ............................................................................................... 147
3.11 Site and context of the study ................................................................... 148
3.12 Reliability, Trustworthiness and ethical consideration ............................. 148
3.12.1 The Hawthorne effect in modern research ............................................. 149
3.12.2 The halo effect........................................................................................ 149
3.13 Recommendations, limitations and contributions to further research ....... 152

CHAPTER 4: COLLECTING OF DATA, ANALYSIS OF DATA AND FINDINGS

4.1 Introduction ........................................................................................ 153
4.2 Presentation of data collected ................................................................... 154
4.3 Perceptions gained from the interviews..................................................... 180
4.4 Analysis of data and findings..................................................................... 181
4.4.1Teaching ................................................................................................ 182
4.4.1.1 The nature of teaching Mathematical Literacy...................................... 182
4.4.1.2 An inclusive Mathematical Literacy classroom ..................................... 183
4.4.1.3 Teaching strategies.............................................................................. 186
4.4.1.4 Professional development ................................................................... 187

4.4.2 Assessments ..... 187
4.4.3 Availability of resources ..... 187
4.5 Findings of the research study ..... 188
CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS
5.1Introduction ..... 191
5.2 Contextualisation of Mathematical Literacy ..... 191
5.3 Literature review: Mathematical Literacy ..... 191
5.4 Research design and methodology ..... 192
5.5 Conclusions and recommendations ..... 193
5.6 Limitations of the study ..... 195
5.7 Further recommendations ..... 195
5.8 Recommendations for future studies ..... 196
5.9 Conclusion ..... 196
REFERENCES ..... 198

APPENDICES

APPENDIX A: Ethical Clearance ........................................................................ 214
APPENDIX B: Application for the consent from participants ............................ 216
APPENDIX C: Application for the consent from the Principals ......................... 217
APPENDIX D: Application for the consent from the District Director ................ 218
APPENDIX E: Consent form for Mr SPM Pillai’s Respondents ........................ 219
APPENDIX F: Interview schedule ..................................................................... 220
APPENDIX G: Letter from the Language Editor ............................................... 229

LIST OF TABLES:

Table 1: Mathematical Literacy results achieved in matriculation examinations For the Past five years ..... 3

Table 2: Nature and degree of integration of context with Mathematics within a pedagogical situation ..... 41

Table 3: Numbers for primary education in India ..... 73

Table 4: The properties of Mathematics and Mathematical Literacy ..... 110

Table 5: Learning Outcomes for Mathematical Literacy and Mathematics ..... 113

Table 6: Composition of Mathematics and Mathematical Literacy ..... 114

Table 7: Relationship between knowledge and perceptions ..... 125

Table 8: Overview of the various different domain of Mathematical knowledge ..... 127

Table 9: Schoenfeld’s theory of beliefs ..... 130

Table 10: Guba’s four criteria for ensuring the trustworthiness of qualitative research ..... 150

LIST OF FIGURES:

Figure 1: Percentage passes for Mathematical Literacy........................................ 4
Figure 2: Mathematical content and real-life contexts ......................................... 37
Figure 3: Weighting of the topics according to the Mathematical Literacy curriculum.......................................................................................................... 39
Figure 4: Zone of proximal development (McLeod, 2012) ................................... 52
Figure 5: The 5 strands of proficiency in Mathematics ........................................ 97
Figure 6: Differences between positivism and interpretivism by Pizam and Mansfeld (2009) ............................................................................................ 137

# Chapter 1

## 1.1 Introduction

Mathematical Literacy has been introduced as a specific subject for the last 3 years of schooling, which is known as the Further Education and Training (FET) phase of secondary education in South Africa and comprises Grades10, 11 and 12. All learners who do not elect to include Mathematics in the subjects selected for Grades 10, 11 and 12, owing to poor performance or poor examination results, have been required, since 2005, by the Department of Education (DoE) to study Mathematical Literacy as a compulsory subject in the FET phase. This decision was reached after a great deal of discussion and debate concerning issues pertaining to making forms of mathematical studies compulsory for all learners in the FET phase (DoE, 2005). Some of these issues concerned differentiation in mathematical studies, the level of mathematics needed for entry into tertiary studies and the possibility that learners in schools in particularly low socio-economic environments would be doomed to inferior standards of mathematical studies (DoE, 2005).

Apart from these debates and differences of opinion, there is general agreement that a mathematically literate populace is needed and that schools need to produce mathematically literate graduates, (DoE, 2005). The debates and differences of opinion referred to earlier took place and were expressed in various forums, mainly by academics from tertiary institutions, (DoE, 2006a). In this study some of the concerns emanating from these debates and deliberations are related to similar concerns in the literature which is specifically linked to what the goals of Mathematical Literacy should be, discussed in relation to the National Curriculum Statement Grades 10-12, 2005, which informs this study, (DoE, 2006a). The key concerns are the teachability of Mathematical Literacy, the lack of a recreational component in Mathematical Literacy, Mathematical Literacy as an action component, the dilemma of contexts for Mathematical Literacy and the resilience of the improvised qualitative strategies adopted by people to resolve quantitative dilemmas (DoE, 2006a).

# 1.2 Background of the study

## 1.2.1 FET School Education in South Africa post-1994

Educational reform in South Africa in the aftermath of 1994 resulted in the introduction of a new educational curriculum for all South Africans. The reforms, which were mainly related to curricula, were intended to purge the apartheid content from school curricula. The most comprehensive reform had been the introduction of Curriculum 2005, an outcomes-based education approach, designed with the intention of being learner-centred (Zafar, 2004; Brown, 2003; Sibuquashe, 2005).

The adoption of the Constitution of the Republic of South Africa (Act 108 of 1996) provided a basis for the transformation of school curriculum and development. In its preamble the aims of the constitution are listed as being to:

- Heal the divisions of the past and establish a society based on democratic values, social justice and fundamental human rights.
- Improve the quality of life of all citizens and free the potential of each person.
- Lay the foundations for a democratic and open society in which the government is based on the will of the people and every citizen is equally protected by law.
- Build a united and democratic South Africa which is able to take its rightful place as a sovereign state in the family of nations (DoE, 1996; Constitution of South Africa, 1996).

Education and school curricula have an important role to play in realising these aims. Consequently, a school curriculum aims to develop the full potential of each learner as a citizen of a democratic South Africa. The constitution gives"everyone the right…..to further education, which the state through reasonable measures must make progressively available and accessible. " The National Curriculum Statement Grades 10-12 (General) of 2005 lays a foundation for the achievement of these goals by stipulating Learning Outcomes and Assessment Standards and by spelling out the key principles and values which underpin the curriculum, (DoE, 2005).

Curriculum 2005 comprises 8 learning areas, each with its own specific and unique features. One of the key design features of the curriculum was that each learning area had to be linked to other fields of knowledge. Mathematical Literacy was a major addition as a learning field in the curriculum. The learning fields of the curriculum comprised Languages, Literacy and Communication, Mathematical Literacy, Mathematics and Mathematical Sciences, Natural Sciences, Technology, Human and Social Sciences, Arts and Culture, Life Orientation and Economic and Management Sciences (Heinemann, 2005).

The design features for Curriculum 2005 were complex and within 5 years of its introduction, it was revised. The Minister of Basic Education at the time, Kadar Asmal (2002), maintained that the curriculum as a whole had to be made more understandable to enable it to be effectively implemented in the classroom.

Mathematical Literacy was introduced against the background of poor performance in the subject Mathematics among South African learners (Blaine, 2005; Brombacher, 2006; Christiansen, 2007; Graven and Venkat, 2008; OECD, 2003 and Mavuagara-Shava, 2005). Since 2006 it has become compulsory for learners to study one mathematically-related subject to Grade 12. Mathematics is compulsory until Grade 9, whereupon learners have a choice between Mathematics and Mathematical Literacy. The introduction of Mathematical Literacy was the result of a concerted effort by the DoE to improve the mathematical abilities of not only a select few, but also the general population of South Africa (Venkat, 2007). Mathematical Literacy was introduced specifically to encourage awareness of mathematics and the roles which it plays in everyday life in domains such as personal finance, understanding statistical information and the many other positive contributions which an understanding of mathematical concepts makes to modern life (Blaine, 2005). Against this background, statistical data concerning the success with which Mathematical Literacy has been taught since its introduction are presented below.

### Table 1: Mathematical Literacy results achieved in matriculation examinations over the past 5 years

| YEAR | NO. WROTE | NO. ACHIEVED AT 30% AND | % | NO.ACHIEVED AT 40% AND | % |
|---|---|---|---|---|---|

| | | ABOVE | | ABOVE | |
|---|---|---|---|---|---|
| 2010 | 280836 | 241576 | 86,0 | 181794 | 64,7 |
| 2011 | 275380 | 236548 | 85,9 | 178899 | 65,0 |
| 2012 | 290713 | 254083 | 87,4 | 178498 | 61,0 |
| 2013 | 324097 | 282270 | 87,1 | 202291 | 62,4 |
| 2014 | 312054 | 262495 | 84,1 | 185528 | 59,5 |

(DoE, 2015)

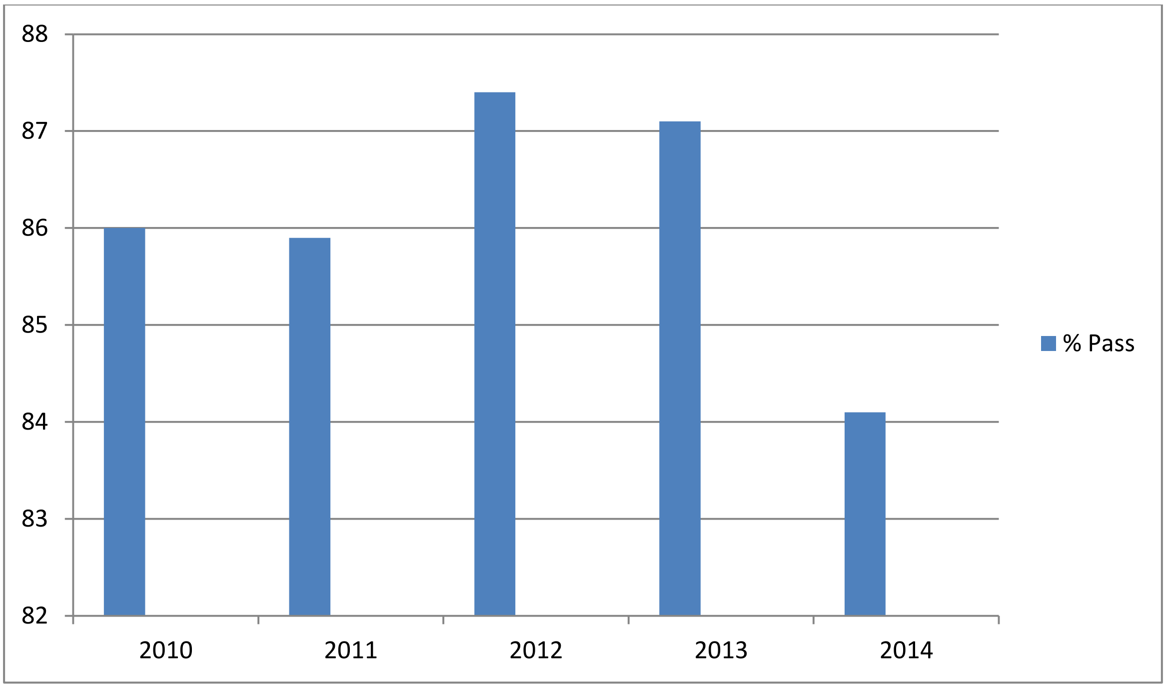



**Figure 1: Percentage passes for Mathematical Literacy**

(DoE, 2015)

## 1.2.2 Requirements for teaching Mathematical Literacy

According to the Mathematical Literacy Subject Guidelines (South Africa, 2007b:12), educators should meet certain minimum requirements in order to teach Mathematical Literacy. They should have a minimum of Grade 12 Mathematics, but preferably they should have higher levels of knowledge of the subject. A diploma or a degree in education and training in outcomes-based education are compulsory. In addition, educators should also be qualified assessors and moderators and they should display enthusiasm for the subject. Mbekwa (2006) suggests that for various reasons not all of these criteria are currently being met.

## 1.3 Statement of the problem

Many learners, teachers and parents tend to have negative attitudes towards Mathematical Literacy and to regard it as an inferior subject. According to Mbekwa (2007), some teachers regard the subject as a dumping ground for learners who underperform in Mathematics.

From personal experience in teaching Mathematical Literacy, the researcher has found that insufficient knowledge of the content of the subject and training in the teaching of it, a lack of textbooks and study guides devoted to Mathematical Literacy, insufficient foundational mathematical knowledge among learners, apart from the effect of "sinking into the administrative swirl" created by the new programmes, all contribute to the difficulties encountered by teachers attempting to teach Mathematical Literacy as a relatively new subject for all learners at the FET level.

This state of affairs has a direct bearing on how teachers deal with the implementation of Mathematical Literacy, explicitly from the point of view of their established pedagogical practices in the classroom. It is apparent that in a great many cases teachers are either not adequately trained, lack knowledge concerning the content of the subject or lack the pedagogical abilities needed to teach Mathematical Literacy from an informed position. This statement of the problem generated the research questions, which will be covered in the sections which follow.

## 1.4 Research questions

From the development of the title, the background and the statement of the problem, the following research questions have been formulated.

## Main question

- What are the perceptions of teachers with respect to the teaching of Mathematical Literacy at the Further Education and Training level?

## Sub-questions

- What are the challenges which teachers encounter in the teaching of Mathematical Literacy, particularly in the context of the implementation of the Curriculum and Assessment Policy Statement (CAPS)?
- Are the teaching and learning resources in the schools adequate for teaching Mathematical Literacy effectively?

## 1.5 Significance of the study

The researcher regards it as imperative to conduct a study which focuses on the instructional skills of teachers of Mathematical Literacy, as the findings of the study will make it possible to propose ways in which the skills and practices of teachers may be improved, to advise the Department Of Education (DoE) with respect to strategies to improve interventions designed to enable teachers to teach Mathematical Literacy effectively and to correct the flaws which have been identified in the present curriculum.

Koellner (2006) believes that in order to achieve a coherent vision for school Mathematics, no factor is more important than the teacher. While a teacher requires a sound knowledge of the content of his or her subject and the principles and strategies for specialisation when teaching a specific subject, in the case of Mathematics and Mathematical Literacy, the enthusiasm of teachers is needed to encourage learners and to make them aware of the functional role which mathematics plays in their daily lives.

Through the medium of the study the researcher developed a deeper understanding of the perceptions of teachers concerning the teaching of Mathematical Literacy (ML) as a specific subject in the curriculum at the FET level. In addition, this study evaluated the knowledge and teaching skills of teachers with respect to ML, the methods and pedagogy of teaching and learning ML at the FET level and the present approach to the subject.

# 1.6 Literature review

## Theoretical framework

### 1.6.1 Vygotsky and social learning theories

Social learning theories help us to understand how people learn in social contexts by learning from one another and serve to inform us of how we, as teachers, construct active learning communities. Vygotsky (1962), a Russian teacher and psychologist, explains that we learn through our interactions and communications with others. Vygotsky (1962) examined how our social environments influence the learning process. He suggested that learning takes place through the interactions students have with their peers, teachers and other experts. Consequently, teachers can create a learning environment which maximises the ability of learners to interact with one another through discussion, collaboration, and feedback. In addition, Vygotsky (1962) maintains that culture is the primary determining factor for the construction and accumulation of knowledge. The cultural lenses through which knowledge is acquired will be discussed further in this study.

Vygotsky suggested "that language [including the language of mathematics] is the main tool that promotes thinking, develops reasoning, and supports cultural activities through reading and writing" (Vygotsky 1978). By regarding mathematics as a language in this sense, a mathematically-oriented environment may be created in which directed and guided interactions can occur through the mathematical expertise of a teacher.

In essence, Vygotsky recognised that learning always occurs within a particular social context, from which it cannot be separated. Consequently, instructional teaching and learning strategies which promote the distribution of expert knowledge, in which students work together collaboratively to conduct research, share their results and perform or produce a final project, help to create a collaborative community of learners. The construction of knowledge occurs within Vygotsky's (1962) social context, “which involves student-student and expert-student collaborations to solve real world problems or to perform tasks which build on each person's language, skills and experience, shaped by each individual's culture"

(Vygotsky, 1978, p. 102). The teaching and learning of Mathematical Literacy as it is explained in the National Curriculum and Assessment Policy Statement (DoE, 2010) informs us that the pedagogy of the way in which it is to be taught and the intended learner-centred approach implies that teaching and learning should take place within a collaborative and a cooperative context as an effective method of fostering a learner-centred approach. This clearly concurs with Vygotskian thinking and consequently, the adoption of Vygotskian theory as the theory to be applied in order to conduct this study is apt.

### 1.6.2 Bandura and social learning theory

Social learning theory posits that people learn from one another via observation, imitation and modelling. The theory has often been classified as a bridge between behaviourist and cognitive learning theories, because it encompasses attention, memory and motivation (Bandura, 1997). People learn through observing the behaviour of others, attitudes and outcomes of those behaviours. "Most human behaviour is learned observationally through modelling from observing others; one forms an idea in Mathematical Literacy of how new behaviours are performed, and on later occasions this coded information serves as a guide for action" (Bandura, 1997). This theory is related to Vygotsky's social learning theories and Lave's Situated Learning Theory, which also emphasises the importance of social learning. Social learning theory explains human behaviour in terms of continuous reciprocal interactions between cognitive behaviours and environmental influences in order to learn any subject. For the purposes of this study the theories will be applied specifically to the teaching and learning of Mathematics and Mathematical Literacy.

The social learning theory proposed by Albert Bandura has become perhaps the most influential theory of learning and development. While the theory is rooted in many of the basic concepts of traditional learning theory, Bandura believed that direct reinforcement could not account for all types of learning. Although the behavioural theories of learning suggested that all learning was the result of associations formed by conditioning, reinforcement, and punishment, Bandura's social learning theory proposed that learning can also occur simply by observing the actions of others. His theory added a social element, as he maintained that people can learn new information and behaviours by watching others. Often referred to as observational learning or modelling, this type of learning can be used to explain a wide variety of behaviours.

Learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behaviour is learned observationally through modelling: from observing others one forms an idea of how new behaviours are performed, and on later occasions this coded information serves as a guide for action, (Bandura, 1997).

## 1.6.3 Basic social learning concepts

There are 3 core concepts at the heart of social learning theory. First is the idea that people can learn through observation. Next is the notion that internal mental states constitute an essential component of this process. Finally, this theory recognises that the mere fact that something has been learned does not necessarily imply that it will result in a change in behaviour.

## 1.6.3.1 People can learn through observation

## Observational learning

In his famous Bobo doll experiment, Bandura demonstrated that children learn and imitate behaviours which they have observed in other people. The children in Bandura's studies observed an adult acting violently towards a Bobo doll. When the children were later allowed to play in a room with the Bobo doll, they began to imitate the aggressive actions which they had previously observed, (Cherry, 2015).

Bandura identified 3 basic models of observational learning:

- A live model, which involves an actual individual demonstrating or acting out behaviour.
- A verbal instructional model, which involves descriptions and explanations of behaviour.

- A symbolic model, which involves real or fictional characters displaying behaviours in books, films, television programmes or online media.

All 3 of these models have implications for the teaching of Mathematical Literacy, following the guidelines of the CAPS.

### 1.6.3.2 Mental states have a direct bearing on learning ability

#### 1.6.3.2.1 Intrinsic reinforcement

Bandura found that external, environmental reinforcement was not the only factor to influence learning and behaviour. He described *intrinsic reinforcement* as a form of internal reward, such as pride, satisfaction, and a sense of accomplishment. This emphasis on internal thoughts and cognitions help to connect learning theories to cognitive developmental theories. While many textbooks place social learning theory with behavioural theories, Bandura himself describes his theory as a “social cognitive theory”.

### 1.6.3.3 Learning does not necessarily result in a change of behaviour

While behaviourists believed that learning results in a permanent change in behaviour, observational learning demonstrates that people can learn new information without exhibiting new behaviours (Bandura, 2006; Pajeres, 2004; Collins et al., 2004; Hockenbury and Hockenbury, 2006; Ferguson, 2010).

### 1.6.3.4 The modelling process

Not all observed behaviours are effectively learned. Factors involving both the model and the learner can play a role in whether social learning is successfully accomplished. Certain requirements also need to be fulfilled and certain steps followed. The following steps are involved in the observational learning and modelling process:

- **Attention**

  In order to learn, a subject needs to be paying attention. Anything which distracts the attention of a subject is going to have a negative effect on observational learning. If the model is an interesting one or there is a novel aspect to the situation in which the behaviour is observed, a subject is far more likely to dedicate his or her full attention to learning than in situations which he or she finds dull or uninteresting.

- **Retention**

  The ability to store information is also an important factor in the learning process. Retention can be affected by a number of factors, but the ability to retrieve information later and act upon it is vital in observational learning.

- **Reproduction**

  Once a subject has paid attention to a model and retained the information related to a particular behaviour, he or she may attempt to perform the behaviour which had been observed. Further practice of the learned behaviour leads to improvement and the development of the skill or skills required enacting the behaviour.

**Motivation**

In order for observational learning to be accomplished successfully, a subject needs to be sufficiently motivated to imitate the behaviour which has been modelled. Reinforcement and punishment can play important roles in motivation. Although experiencing these motivators directly can affect learning significantly, a case could also be made for learning through observing the experiencing of reinforcement or punishment by another person. For example, if a student were to see another student being rewarded with extra credits for arriving in class on time, it seems likely that he or she might begin to arrive a few minutes early each day in order to receive the same reward (Bandura, 2006; Pajeres, 2004; Hockenbury and Hockenbury, 2006; Ferguson, 2010).

## 1.6.4 Rotter's Social Learning Theory

## Overview of the theory

The chief principle in Rotter's social learning theory is that personality represents an interaction of an individual with his or her environment. It maintains that a personality cannot be conceived as being internal to an individual and independent of the environment in which the individual concerned experiences the world. It also posits that behaviour cannot be regarded as being an automatic response to an objective set of environmental stimuli. Instead, behaviour is to be understood by taking both the individual, in terms of his or her life history, learning and experiences and the environment, in terms of those stimuli of which he or she is aware and to which he or she responds, into account. Please refer to 2.5 for more discussions.

## 1.6.5 Conceptualisation of Mathematical Literacy

Mathematical Literacy as a school subject denotes a type of practical mathematics which is beneficial to the everyday mathematical requirements and usage of learners. The term refers to the ability of an individual to identify and understand the role of mathematics in the world and also to the ability of an individual to use mathematical concepts to make well-founded judgements (Doyle, 2007). Many learners share the perception that Mathematics is a difficult discipline to master and also a difficult subject to teach. In most cases, students develop this perception as a result of adopting an incorrect approach to learning and attempting to make progress in the subject of Mathematics (Siebert and Draper, 2012). The new CAPS curriculum (2010) represents a considerable achievement, in that it concentrates on mathematical concepts which relate to gaining a more practical understanding of them from a "hands on" approach. The many educators who were involved in the development of Mathematical Literacy can be proud of Kramer (2005), who pioneered Mathematical Literacy as a relevant but alternative school subject to Mathematics as a pure subject and discipline. Kramer introduced Mathematical Literacy as a more functional approach to the teaching and learning of Mathematics.

The following sections will be devoted to a discussion of national and international perspectives of Mathematics and Mathematical Literacy.

# 1.7 International perspectives

## 1.7.1 Education in Mathematics in India

Research in education in Mathematics constitutes a significant component of the work which is carried out in the field of education in Mathematics in India. Although departments of universities conduct a great deal of research in education, they tend not to attract large numbers of people who have been trained in Mathematics or who are inclined towards the subject. In addition, the idea of research providing solutions to curricular conundrums or pedagogical problems remains outside of the framework of decision-making in education. This is not said to belittle the very great contributions made by both governmental and non-governmental initiatives towards reforms which have been characterised by innovation and commitment. However, these reforms do not, at present, rest on a scaffolding of research and rigorous critique. The system needs to develop a means of actively pursuing research on several fronts towards well formulated questions and to use the answers to influence policy. It needs be added that while India provides a sufficiently large arena, with enormous diversity, to present a self-contained universe for analysis and research, international influences can only add to this richness (University Grant Commission, UGC, 2011).

Although Indian society, with its cultural and work-based practices, also offers many avenues with respect to Mathematics which a pedagogue could incorporate into a toolkit, a coherent body of research needs to be created in order to make realistic use of such possibilities, (http://nime.hbcse.tifr.res.in/articles/01 Ramanujam.pdf). In India, Mathematics is a school subject which is accorded great importance and all learners are required to study the subject. The fact that it is compulsory for all learners to take Mathematics from the pre-grade level to the end of their schooling emphasises the status of Mathematics in Indian education. Please refer to 2.7.1 for more details.

## 1.7.2 Education in Mathematics in Australia

From the points of view of both politics and the school curriculum, serious problems emerged during the early 1990s in Australia, when the Statements and Profiles covering eight Key Learning Areas (KLAs) were produced. The Australian Mathematics Sciences Council (AMSC) vigorously criticised the development, structure and approaches which were used to create the Mathematics Profiles.

Although the Trends in International Mathematics and Science Study (TIMSS) report on Australian educational performance of the mid-1990s showed Australia to be performing statistically above both the UK and the USA, there seemed to be little enthusiasm for attempting to bridge the gap between Australia and those countries whose levels of performance were higher. There was also no concerted effort to try to overcome problems related to the supply of or the lack of studies in specific disciplines in many primary teacher courses in their universities (Organisation of Economic Co-operation and Development (OECD), 2003; 2013a).

The Australian Mathematical Sciences Institute (AMSI) was formed in order to provide a national infrastructure for the mathematical community. In 2006 a new review of advanced mathematical sciences was completed. From being statistically above both England and the USA in the TIMSS report of 1995, the 2007 results showed Australia now statistically below both of these countries. The Programme for International Students Assessment (PISA) report of 2012 shows Australian students slipping behind in Mathematics (OECD, 2013a; Education at a Glance, 2013). Please refer to 2.8.2 for more facts.

## 1.7.3 Education in Mathematics in China

As education in Mathematics in China has its own unique history, cultural contexts and national characteristics, by studying its past, present and future, especially in the case of the elementary classes, we have an opportunity to learn from the successes and mistakes of the past, to find solutions to existing problems and to prepare for the future.

The history of education in Mathematics in China which is covered in this chapter will also be discussed in Chapter 2. Education in Mathematics in ancient China was relatively advanced during the period of the Sui Dynasty, between A.D 581 and 618.In the school of mathematics of the Imperial College, the highest educational institute at that time, there were 2 court academicians, 2 assistants and eighty students. During the time of the Tang and Song Dynasties, the size of the mathematics school was further enlarged, with the student body reaching a peak of two hundred students. Later, however, from the Ming Dynasty to the Qing Dynasty, education in Mathematics declined, owing to greater emphasis being placed by the Imperial Examination on the writing of essays (Dianzhou, 2003; Dauben, 2010; Yang, 2012).

During the Qing Dynasty, China's traditional arithmetic education relied solely on individual endeavours, in which the government played little role. After 1840, foreign missionaries taught western mathematics in Christian schools, although the level of instruction was not necessarily high. In 1862, the Astronomy and Mathematics Institute was established in the nation's capital and education in Mathematics began in earnest. In 1898 the Capital College was founded, in which courses in Mathematics were formalised. Until 1906, the algebra textbook still used the traditional page layout in which the text read vertically and horizontally from right to left. The constants and variables were denoted by Chinese characters, rather than Roman letters. After the 1911 Revolution, in which the Qing Dynasty was overthrown, Elementary Mathematics was offered in almost all of the schools, building upon the western system of teaching Mathematics. During the thirty years between1919 and 1949, education in Mathematics in China was modelled mainly on the ways in which the subject was taught in Europe and the United States of America, using textbooks from Great Britain and the USA. However, the teaching methods were traditional, in that the teacher taught while students listened, without much interaction between them (Dianzhou, 2003; Dauben, 2010; Yang, 2012).

After the People's Republic of China was established in 1949, the entire educational system imitated that of the Soviet Union. During the 1950s elementary education in Mathematics in China had 3 principle characteristics. First, content was condensed and concentrated and the system rigorously emphasised logic and deduction.

Secondly, the philosophy of teaching centred around 3 elements, namely teachers, the curriculum and teaching methodology. Thirdly, there were 5 essential links in teaching, namely, organising the classroom, introducing the new content, teaching the new content, consolidating it through practice and assigning homework (Dianzhou 2003; Ministry of Education (MoE), 2001; Dauben, 2010; Yang, 2012).

In 1963 China reflected on its educational system and issued new guidelines, based on the educational system of the Soviet Union, while taking into account practical conditions in China. The new ideas stressed the importance of basic knowledge and basic skills and aimed to develop the abilities of students in skills such as basic computation, spatial imagination, logic and analysis. Emphasis was placed on careful teaching of the essentials and allowing students to learn through intensive practice. Classroom teaching still comprised 5 links, but added enlightening the thinking of students. Elementary education in Mathematics rose to a new height at that time. The 10-year Cultural Revolution from 1966 to 1976 destroyed normal education and ended conventional teaching activities, with education in Mathematics being no exception. The curriculum of Elementary Mathematics, at that point, lacked systematic coherency, with excessive emphasis being placed on applications pertaining to manufacturing and labouring. Students acquired mathematical knowledge only in a piecemeal fashion and, as a result, the quality of education declined severely.

After 1976, education in Elementary Mathematics quickly returned to the pre-1963 track. The quality of teaching improved dramatically. In 1977 the national college entrance examination system was restored, and students showed unprecedented enthusiasm for learning. Education in Elementary Mathematics entered a new era through exchanges with western countries. New educational methodologies from abroad were introduced. The practice of standardised tests was adopted for China's college entrance examination, based on Bloom's taxonomy of educational objectives was popularised and adapted to the idea that passing examinations was the main goal of students in China. The "problem solving" slogan proposed for Mathematics education in the USA in 1980 also spread through all of China. George Polya's theory for the teaching of problem-solving became the most studied material for

Chinese teachers of Mathematics (Dianzhou, 2003; MoE, 2001; Dauben, 2010; Yang, 2012).

Education in Elementary Mathematics in China took the entire decade of the 1980s to recover from the damage of the past. The examination system, consisting of the college entrance examination and various other examinations, permeated policy making, teaching content and teaching methods with unprecedented depth (Dianzhou, 2003; MoE, 2001; Dauben, 2010; Yang, 2012). In 1986 the Compulsory Educational Act was promulgated and 9 years of elementary and secondary education became mandatory for all citizens. After 1990 the whole nation made education a top priority, promoting the reform and development of the educational system. Since the 1990s, under the auspices of the strategic plan for reviving the nation through technology and education, “ability training” has been advocated, propelling the reforming and development of elementary education to a new level. Every subject, including Mathematics, was reformed to meet the demands of ability training. New curriculum guidelines were adopted for Elementary Mathematics education. The idea of general Mathematics education was gradually accepted, the college entrance examination policy was revised, computer technology was integrated into teaching and students were permitted to use calculators in their examinations (Dianzhou, 2003; MoE, 2001; Dauben, 2010; Yang, 2012). Please refer to 2.8.3 for further discussions.

### 1.7.4 Education in Mathematics in the United States of America

Critics have deplored the quality of education in Mathematics for over fifty years. In a recent National Science Foundation special report titled *Math: What’s the problem?* (Zacharias, 2009), William Schmidt traces the poor achievements of students in the US in Mathematics to the simple fact that the United States has not adequately taught Mathematics to its children for generations. This travesty has resulted in a situation in which it is socially acceptable for adults in US society to say, “I’m not good at Math,” as if it were a joke or a badge of honour. Schmidt suggests that Americans have routinely communicated to their children that only a few people have a “math gene,” but that most do not, a notion which he claims is both completely

wrong and profoundly damaging. He maintains that although not everyone may excel in Mathematics, everyone has the ability to develop a strong mathematical foundation. In addition, the problem in the United States has a new urgency, with features notably different from those of the past (Cohen, 2011; Ball, 2009).
The new urgency stems from 4 pressing realities. The first concerns the persistent gaps in the achievement gains among the various different social and ethnic groups. African-American and Hispanic students in the US consistently score lower and exhibit lower achievement gains than their white and Asian American counterparts, even when social class is taken into account (Riegle-Crumb and Grodsky, 2010). Similar gaps are evident when comparisons are based on family incomes, once again even when taking social class into account (Lubienski and Crane, 2010).

The second point contributing to the urgency complements the first. In this same system, in which the education of a diverse population of students already presents serious obstacles and difficulties, and in which achievement in Mathematics can be predicted on the basis of the race and family income of students, the school population is changing dramatically. Drawing from the US census, the Federal Interagency Forum on Child and Family Statistics (2010) reported that in 1972 about 80 percent of the students in the United States were white and about 20 percent were underrepresented minorities. At present about 55 percent of students are white and, according to its projections, white students in US schools will be a minority by 2023. Although there is little change in the proportion of African-American students, there are large changes in the Hispanic and the non-Asian-American Asian population, a group whose achievement patterns are similar to those of Hispanic and African-Americans (Lubenski and Crane, 2010).

A third cause for urgency is language diversity. The Federal Interagency Forum on Child and Family Statistics (2010) reported that in 1979 about 9 percent of US students spoke a language other than English in their homes and that this group now constitutes about 21 percent of US students. Although these differences in home languages have resulted in a variety of problems for both teachers and students, they require careful consideration. It is significant to note that many of the children whose home language is not English learn to speak English well at school, as it has been found that only 5percent of those who speak a language other than English at home and have difficulty speaking English (Lubenski and Crane, 2010). Having large numbers of students coming from homes in which English is not spoken creates difficulties for teachers attempting to communicate with their parents, which is often made all the more difficult by the fact that although the children often speak English, the parents very often do not. As the relationship between the school and the home is a crucial one for the academic success of children, the problems encountered while attempting to communicate with parents are rapidly becoming increasingly culturally and linguistically complex. This phenomenon, too, contributes towards the urgent need to reconsider the problems encountered in education in Mathematics and to design a system to improve it (Cohen, 2011; Ball, 2009).

In addition to the imperatives resulting from which social and ethnic groups are represented in the schools and how well they are being served, the country also requires more complex academic achievements from all students than ever before. These increased expectations increase the demands which are placed on the education system and increase the need to find solutions to the problem of education in Mathematics. In addition, state curriculum frameworks now specify goals which are considerably more challenging than those in the past. As an example, the State of Michigan recently decided that, in order to graduate from high school, all students needed to pass a state-certified Algebra 2 course, a requirement which was stipulated in a context in which 25 percent of the students entering the ninth grade in Detroit, Lansing, Pontiac, Flint and several other cities in the state of Michigan drop out before completing high school. The predictions for what might happen over the next few years, as the system requires students, who are inadequately prepared and who, typically, have not taken this course to begin, suddenly, not only to take it, but also to pass it, would not appear to be optimistic. While the idea of requiring students to take the Algebra 2 course may have merit, a number of related issues deserve both thoughtful consideration and public debate. States across the country are setting higher expectations, although they have been unable to meet current ones. Schools whose students are not coping well with Mathematics at present are being asked to teach more Mathematics to more students. This dramatic double rise in demands, in terms of what is to be taught and to whom it is to be taught, greatly intensifies the urgency of the problem (Cohen, 2011; Ball, 2009). At present education in Mathematics remains an important focus in schools in the US. The facts covered in this section will also be discussed in Chapter 2 (2.8.4).

### 1.7.5 Education in Mathematics in the United Kingdom

Although the UK did not participate in the 2003 or 2006 PISA studies, England performed very well in the TIMSS in 2007, taking a high position for both the fourth and eighth grades out of the fifty-eight participating countries (National Centre for Education Statistics, 2008a). By law, all children between ages 5 and sixteen years must receive full-time education. The United Kingdom introduced a National Curriculum in 1992, to which state schools need to adhere until learners reach the age of sixteen years. Core subjects of the National Curriculum are English, Mathematics and Science, which are offered at various different levels.

#### 1.7.5.1 The UK National Curriculum

Within the framework of the National Curriculum, schools are free to plan and organise teaching and learning in the way that best meets the demands of their pupils. The Qualifications and Curriculum Development Agency (QCDA) provides guidelines and assistance in this regard. The National Curriculum is organised in 4 key stages. Key Stage1, for children between the ages of 5 and 7 years, and Key Stage 2, for children between the ages of 7 and eleven years, comprise the Primary Curriculum, while Key Stage 3, for children between the ages of eleven and fourteen years, forms part of the Secondary Curriculum (Government of United Kingdom, 2010a). Through this strategy, the government aims to develop the literacy and numeracy levels of children in the first two Key Stages, in order to develop their mathematical thinking and number skills, with an emphasis on understanding and application. A document addressed to learners, schools and families, which is known as The Primary Framework for Literacy and Mathematics, makes recommendations concerning how literacy should be incorporated in daily Mathematics lessons (Government of United Kingdom, 2010b). The secondary curriculum focuses on developing the skills and qualities which learners need not only to succeed in school, but also in the broader community and in later life.

### 1.7.5.2 Functional mathematical skills

Numeracy appears in the Early Year Foundation Stage, which spans the period from birth to 5 years, as a part of the learning area which is designated Problem-solving, Reasoning and Numeracy. In the Primary Curriculum for children between the ages of 5 and eleven years and the Secondary Curriculum for children between the ages of eleven and sixteen years, Mathematics, no longer referred to as Numeracy, appears as one of the 10 compulsory school subjects. Functional Mathematics frequently appears in the Secondary Curriculum, referring to the functional mathematical skills which learners need to acquire. Learners need these skills and abilities to play an active and responsible role in their communities, in their everyday lives, in their educational settings and in the workplace (QCDA, 2010a). Functional mathematical skills are a subset of the key processes set out in the programme of study. These key processes are representing, analysing, interpreting, evaluating, communicating and reflecting. All teaching needs to contribute to the development of these key processes. It requires pupils to be introduced to a range of real-life uses of mathematics, including its role in the modern workplace (QCDA, 2010b). The functional skills need to be developed in the 5 strands of Mathematics, namely, Mathematical Processes and Applications, Number, Algebra, Geometry and Measures and Statistics. Individuals who possess functional mathematical skills understand a range of mathematical concepts and knowhow and when to use these concepts. They have the confidence and capability to use mathematics to solve increasingly complex problems, are able to use a range of tools, including integrated computer technologies, as appropriate, possess the analytical and reasoning skills needed to draw conclusions, are able to justify how these conclusions are reached and to identify errors or inconsistencies, and are able to validate and interpret results, to judge the limits of the validity and to use the results effectively and efficiently (QCDA, 2010c). Please refer to 2.7.5 for more discussions.

## 1.7.6 Education in Mathematics in Kenya

When Kenya gained independence in 1963, the government adopted the existing western system of education, which was an 8-4-2 system, which was changed to a

7-4-2-3 system in 1966 (Eshiwani, 1993, pp. 36-38). Despite the richness of the country's traditions, many changes were required to enable the society to be modernised. Owing to inadequate natural resources in the country, there was a particularly great need to develop human resources. Consequently, education was perceived to be an essential resource and a passport to economic development in Kenya, (Wanjohi, 2011).

The present 8-4-4 education system was introduced in Kenya in early 1985, with the curriculum being designated as the course of study, as opposed to the previous system, in which the national textbook had been interpreted as providing the curriculum. The new system enforced an increase in the content of secondary school Mathematics, placing a heavy burden on both students and teachers. As a result, there has been a public outcry about the poor performance in Mathematics at the secondary school level (Wanjohi, 2011). The chief defect of Kenya's educational system is that it is career-oriented, with a pronounced focus on certification through the parameter of examinations. The process of teaching in Kenyan classrooms has taken on a ritual character, as the teachers teach the students, with no active interaction taking place between the teachers and the students. The students are ready to repeat what they have received from their teachers in examinations, in order to obtain a certificate and employment. When they graduate from school, they usually breathe a deep sigh of relief, never to venture near Mathematics again (Wanjohi, 2011).

However, there is a great need to use the Mathematics classroom to foster the development of questioning minds, as students should never accept the authority of anyone without engaging in independent, critical thought. There needs to be a constant dialogue between students and their teachers. In an ideal educational system, teachers would also simultaneously be students and students would also simultaneously be teachers. Should a direction of this sort be pursued, education would ensure our economic, intellectual, cultural and political development (Wanjohi, 2011). Please refer to 2.8.6 for further discussions.

### 1.7.7 Education in Mathematics in Japan

Although the Japanese school system ensures equity in education opportunities, the relationship between the socio-economic status of students and performance is weaker than the OECD average and differences in performance between advantaged and disadvantaged schools have widened since 2003. Students in Japan generally feel less confident about their ability to solve a set of Pure Mathematics and Applied Mathematics problems than the average student in other OECD countries, but they have shown improvement over time. Although Japanese students were found to take less pleasure and to have less interest in learning Mathematics, to be less open to problem-solving and to experience more anxiety learning Mathematics than the OECD average. Refer to 2.7.7 for more discussions.

## 1.8 Mathematical Literacy from a national perspective

One definition of Mathematical Literacy is provided by the Programme for International Student Assessment (PISA), (OECD, 2000). This definition is phrased in terms of desirable outcomes as a means of enabling a learner "to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen" (OECD, 2000:21). Mathematical Literacy is not a scaled-down version of Mathematics, but a subject in its own right (Prentice, 2006), which applies mathematical principles in everyday, real-life situations (DoE, 2005). Learners are encouraged to develop their confidence in thinking along numerical terms to interpret, analyse and solve real-life problems in different contexts (South Africa, 2007a; Graven and Venkat, 2008; Graven and Venkat, 2009; Graven, 2011).

Teachers tend to have diverging views with respect to what they believe Mathematical Literacy entails. Some tend to think that Mathematical Literacy is a watered-down form of Mathematics, while others believe that it is a different, but still difficult, subject (Mbekwa, 2006). It is important that teachers who are required to teach Mathematical Literacy should be adequately trained in order to be prepared to cope with the requirements of the subject. It seems that the DoE may not have placed sufficient emphasis on the training of Mathematical Literacy teachers before introducing the subject in the schools (Mbekwa, 2006). Effective Mathematical Literacy teaching and learning depends on teachers who understand and can teach learners to understand (South African Universities' Vice Chancellors' Association (SAUVCA, 2003). Teachers need to be trained to facilitate the acquisition of Mathematical Literacy, rather than simply teaching the subject (Romberg, 2003). This approach is explained eloquently in the paper titled "Creating new mathematical stories: Exploring potential opportunities within Maths clubs", which was presented by Graven (2011) at the 17th Annual National Congress of the Association for Mathematics Education of South Africa, at the University of the Witwatersrand, Johannesburg.

Research in schools also indicates that various different approaches are being adopted by teachers to the teaching of Mathematical Literacy (Graven and Venkat, 2007). Some lean towards a mathematically-based approach, while others follow and lean towards encouraging literacy, as opposed to teaching learners to perform specific mathematical operations (Graven and Venkat, 2007; Mavuagara-Shava, 2005; Graven, 2011). Differences were also found among those teachers who adopt a content-driven approach to the subject (Venkat, 2007). It seems that although there are several different types of resources available to teachers to assist them to create an appropriate scenario for teaching Mathematical Literacy, they are still required to work with updated relevant material which is drawn from their teaching environments. Venkat and Graven concur with the Vygotskian theory that Mathematical Literacy is embedded in specific social and cultural thinking and environments, in that the way in which Mathematical Literacy is taught is determined by the teaching and learning context in which instruction is provided. The Vygotskian approach ensures that the teaching methods are current and authentic (South Africa, 2007a; Graven and Venkat, 2007; Mavuagara-Shava, 2005; Graven, 2011), and that learners are able to identify with the concepts which are presented to them in their Mathematical Literacy courses.

With respect to interaction in the classroom, Graven and Venkat (2008) found that learners felt that they were given more time to understand in their Mathematical Literacy classes, owing to the slower pace of instruction, the learner-centeredness of the subject, working in pairs and groups and the validity and availability of alternative problem-solving methods. The following sections will be devoted to international perspectives concerning mathematics education in a series of discussions which focus on individual countries.

# 1.9 Research methodology and design

The main research question and the sub-questions indicated that an interpretivist paradigm was adopted in order to conduct the study and to develop an appropriate research methodology and design, as employing an interpretivist paradigm would enable the researcher to develop a deep and nuanced understanding of the perceptions of teachers as they communicate their thoughts, ideas and beliefs with respect to the research topic. Prominence was given to the significance of the study in the statement of the research problem. Refer to Chapter 3 for further discussion. A research design is a plan or a blueprint which indicates how a researcher intends to conduct a research study. A research design focuses on the desired end result of a study and its principal concern is the type of study which is to be planned. The qualitative approach adopted by this study will entail a focus on the lived experiences of teachers in their daily teaching of Mathematical Literacy. The most suitable research instrument would be the semi-structured interview, as it permits the use of both closed-ended and open-ended questions.

Semi-structured interviews are used to gather detailed qualitative textual data. This method offers a balance between the flexibility of an open-ended interview and the focus of a structured ethnographic survey, and it is used during both the early and late stages of exploring the research domain or the specific research question (Zorn, 2010). It can be used to generate rich descriptive data concerning the personal experiences of the participants. Information gathered during semi-structured interviews can range from general topics or domains to more specific insights in terms of the factors and variables which the research study seeks to investigate (Zorn, 2010).

### 1.9.1 Case studies

Case studies are in-depth studies of particular phenomena, events and occurrences. They are used to narrow down a very broad field of research into one easily researchable topic. While case studies did not answer a particular question completely, they will give some indications and allow further elaboration and the creation of hypotheses concerning a particular subject. Some maintain that because a case study is conducted in a narrow field that its results cannot be extrapolated to answer an entire question, as case studies consider only one narrowly defined example. On the other hand, it may also be maintained that a case study provides more realistic and comprehensive results than a purely statistical survey is able to provide (Shuttleworth, 2008; Robertson, et al., 2010).

The best evaluation probably lies between the two extremes of the opinion continuum, and in most cases it is probably best to try to synergise the approaches characterised by the two schools of thought. It is valid to conduct case studies, but they need to be accompanied by more general statistical processes. For example, a statistical survey might show how much time people spend talking on mobile telephones, but case studies conducted among a narrow group of people will determine why this should be so in particular specific contexts (Shuttleworth, 2008).An important attribute of case studies is their flexibility, and a case study may introduce new and unexpected results while it is being conducted, taking the research in new and unanticipated directions.

A final and peripheral point is that case studies make more interesting topics than purely statistical surveys, which has been recognised and appreciated by teachers and professionals for many years. While the general public may have little interest in pages of statistical calculations, well-placed case studies can have a strong influence on the perceptions of societies (Shuttleworth, 2008; Shuttlewoth, 2009: Robertson, et al., 2010).

## 1.10 Sampling

### 1.10.1 Purposive sampling

Although the rationale for electing to employ purposive sampling has been covered more extensively in Chapter 3, respondents who possess very specific attributes were required for this study, as they need to be teachers of Mathematical Literacy in the FET Grades 10, 11 and 12 in a semi-rural area. Such specific requirements would make the use of random sampling counterproductive for the purposes of this study.

### 1.10.2 Sample size

Six Mathematics and Mathematical Literacy teachers selected from the respective FET grades, namely, 10, 11, and 12, formed the research sample for the study. These teachers, 4 of whom are female and 2 of whom are male, work in 6 different high schools in the East London education district. Refer to Chapter 3 for further details.

## 1.11 Collection of data

One of the best ways to collect data for a qualitative research study was through interviews, as their use aligns well with an interpretivist approach. In the case of this study, the researcher developed an understanding of the teaching environment which constitutes the world in which the respondents live and have their experiences of teaching Mathematical Literacy. As an interview lends itself to a researcher being able to probe into areas of interest by asking additional questions after a particular question has been asked, it served to enable the researcher to gain greater insights into the pedagogical experiences and perceptions of the respondents as experienced by them (Denzin and Lincoln, 2005). Within the context of classroom-based practices, the researcher uncovered and understood the views, feelings and beliefs of the respondents about Mathematical Literacy.

# 1.12 Ethical considerations with respect to the conducting of interviews

Semi-structured interviews allowed individuals to disclose thoughts and feelings which are often private. The extent to which they are effective depends upon the interpersonal skills of the interviewer, in terms of being able to establishing a rapport with the respondents. Although these qualities in researchers are valuable, they are applied in a very sensitive domain from an ethical standpoint. The types of questions to be asked and the ethical considerations pertaining to confidentiality and, in some cases, anonymity, needed to be comprehensively assessed and discussed. Trust and confidentiality are fundamental values (Nigel, 2010) which required to be rigorously upheld when conducting these semi-structured interviews in the fields of the social sciences and education (Edwards and Holland, 2013).

# 1.13 Analysis of data and research findings

## 1.13.1 Analysis of data obtained from semi-structured interviews

Analysing qualitative data entailed breaking it up into themes, patterns and relationships. In this study the content of data pertaining to Mathematical Literacy was transformed into conceptual findings which informed the study. In qualitative research it is very difficult to capture meanings in a short and structured manner (Mouton, 2004).

# 1.14 Reliability, trustworthiness and ethical considerations to be respected during the conducting of the study

As the researcher is both an insider and an outsider during the conducting of this research study, all standards pertaining to reliability, trustworthiness and professional research ethics was applied from a professional perspective. Trustworthiness is underpinned by credibility, in that the data which is gathered during the conducting of a research study was representative of the responses given by the participants (Guba and Lincoln, 2003; Thomson, 2011). The researcher ensured that the respondents knew exactly what the purpose of the research was, that they understood that participation was strictly voluntary and that all reasonable precautions were taken in order to ensure that confidentiality was maintained during the conducting of the research.

# 1.15 Recommendations, limitations and contributions to further research

The conclusions and recommendations were shaped by the data which was collected and analysed. The voices of the teachers of Mathematical Literacy in the research sample was crucial importance with respect to understanding the challenges and obstacles which impede the teaching and learning of Mathematical Literacy at present and adversely affect the results achieved by learners in the subject in Grades 10, 11 and 12.This study had a limitation, in that it was a case study which was conducted in 6 schools. Further studies could be conducted in a greater range of schools, in order to develop the social and cultural contexts in which they are conducted, in both urban and rural areas. Studies in which the voices of learners are heard are also recommended.

# 1.16 Conclusion

This outlines the study which the researcher conducted in order to develop a deep understanding of the “how?” and “why?” questions which pertain to the teaching and learning of Mathematical Literacy and the obstacles and problems which hinder it from being taught and learned effectively at present. As has already been noted, the voices of the teachers have made an invaluable contribution to the understanding gained from this research endeavour.

# 1.17 Structure of chapters

## Chapter 1: Introduction to and background of the study

This chapter provided an overview of the research to be conducted in order to determine and understand the perceptions of teachers teaching Mathematical Literacy at the FET level.

## Chapter 2: Literature review

Chapter 2 discussed an in-depth review of the relevant literature and an explanation of the conceptual framework on which the study is based. Comparisons were made between the different conceptions of Mathematical Literacy, in both South Africa and in other countries.

## Chapter 3: Research design, approach and methodology

Chapter 3 is devoted to a discussion of the research design and the methodology which were adopted for the research. The ethical considerations which were covered in Chapter One was described in greater detail and the measures which were taken to ensure the validity and trustworthiness of the results were explained, followed by a discussion of the methods which were used to collect and analyse the data and the methods which were used to obtain a research sample.

## Chapter 4: Collection and analysis of research data

Chapter 4 focused on a presentation of the findings of the study from the data which was collected. The answers given by the respondents to each of the semi-structured questions are presented. The trends which emerged from the responses were identified, prior to being analysed in Chapter 5.

## Chapter 5: Recommendations, limitations and conclusions

Chapter 5 is devoted to the analysis of the data, the conclusions were drawn from the findings, and the recommendations offered were based on the conclusions and suggestions for future studies.

# Chapter 2

# Literature review

# A theoretical framework

## Introduction

The literature review took the form of a critical and integrated perspective bringing together views of various different researchers, in order to place this research study in a relevant and meaningful context. It is important to note that South Africa is the only country which offers Mathematical Literacy (ML) as a compulsory alternative subject to Mathematics in Grades 10 to 12 and that the study focuses on teachers of ML teachers and their perceptions of teaching the subject at the Further Education and Training (FET) level. This distinction will become clear when international literature is reviewed. The theoretical framework upon which this study is based is provided by the Social Learning Theory, particularly with respect to the work of Vygotsky, Bandura and Rotter. The literature review will also discuss national and international perspectives concerning Mathematical Literacy. Comparisons will be made between the various different conceptions of mathematical literacy, the contexts in which mathematical literacy can be applied, international studies which measuring the mathematical knowledge of learners, meanings and definitions of mathematical literacy and the role which the subject Mathematical Literacy plays in the school curricula. The chapter will also investigate the relationship between knowledge and perceptions of the subject and the influence which the knowledge, beliefs and perceptions of teachers exerts on their teaching and on the learners. The findings concerning the influence which the knowledge and perceptions of the teachers of Mathematical Literacy has on the teaching of the subject constitute the principal focus of this study.

## 2.2 Mathematical Literacy

Mathematical literacy is not a term whose precise definition is universally agreed upon and across the world there is a range of different conceptions of what the term connotes, which will be discussed in this section. As Mathematical Literacy (ML) is a school subject in South Africa, it is important to understand the motivation and purpose of ML in the South African curriculum and to compare it with the role which the concept of mathematical literacy plays internationally.

## 2.2.1 An overview and history of Mathematical Literacy

### 2.2.1.1 Background of Mathematical Literacy

One of the principal reasons for the implementation of ML as an alternative subject to Mathematics at the FET level concerned the low levels of mathematical knowledge, skills and literacy among learners in South Africa which were reflected in the results of international studies (DoE, 2003a). The last occasion on which South Africa took part in the international Trends in International Mathematics and Science Study (TIMSS), was in 2003, when learners in Grade 8 participated and came last out of forty-six countries (National Centre for Education Statistics, 2008b). Recently, the World Economic Forum (WEF) ranked South Africa one hundred and twentieth for Mathematics and Science education, well behind our troubled neighbour Zimbabwe, which was ranked seventy-first (Maths Excellence, 2009). At present South Africa’s General Education and Training (GET) learners do not participate in studies of this sort. A 4-year Foundations for Learning Campaign was introduced in 2008, in the Foundation and Intermediate phases, in order to improve the reading, writing and numeracy skills and abilities of all South African children (DoE, 2008a). Another reason for implementing ML was provided by the need to address the concern that the content of Mathematics is too abstract for many learners and that it is taught primarily to prepare learners to proceed to study subjects which are based on mathematics or the natural sciences at the tertiary level (Graven and Venkat, 2007, p. 340; Graven, 2011). ML offers an alternative to learners who do not need to study pure Mathematics for this purpose.

### 2.2.1.2 The Mathematical Literacy Curriculum Reform

Curriculum 2005 was introduced in 1998, shortly after the birth of the new democracy in post-apartheid South Africa, and it was based on the principles of outcomes-based education (OBE) (DoE, 2009). This curriculum was revised in 2000 and in 2002 the National Curriculum Statement (NCS) for the Further Education and Training (FET) phase was developed. In 2009 a task team reviewed the curriculum and, apart from problems related to learning materials and teacher training, the curriculum documents were deemed to be in need of streamlining (DoE, 2009). The task team found that some of the documents contradicted each other while, in other instances, they were excessively repetitious. The review supported the move by the DoE away from OBE and Learning Outcomes (LO), which were replaced with clear content, concept and skill standards and clear and concise assessment requirements (Department of Education (DoE), 2009). The various subject-specific documents were replaced by a single document which was known as the Curriculum and Assessment Policy Statement (CAPS) (DoE, 2009), which was implemented in 2012 and its curriculum remains the current curriculum for all subjects at the GET and FET (Gr 10, 11 and 12) levels of school education. Mathematical Literacy was introduced at Gr 10, 11 and 12 levels only as a subject to be examined.

### 2.2.1.3 The purpose of Mathematical Literacy

The purpose of Mathematical Literacy is to ensure that all learners develop an understanding of Mathematics and how its concepts are crucial for understanding the conventions of the modern world, in order to use mathematical information to make important decisions which affect their lives, their work and society. Great importance is given to enabling learners to interpret and critically analyse everyday situations in order to solve problems. With this goal in mind, ML aims to ensure a broadening of the education of learners, preparing them to meet the demands of a modern world (DoE, 2003a). According to the DoE (2008b; 2011a), the purpose of the subject includes the ability of each learner to become:

- A self-managing person, who is able to solve problems which relate to financial issues such as mortgage bonds, hire purchase and investments, and who has developed the skills needed to perform tasks such as estimating and calculating length, areas and volumes, reading maps, following timetables and understanding house plans, sewing patterns and quantities in recipes.
- A contributing worker, who is able to cope with the requirements of the workplace in terms of using fundamental numerical and spatial skills, with understanding an order to deal with work-related formulae, statistical charts and schedules and understanding instructions which include numerical components.
- A participating citizen, who has acquired a critical stance regarding mathematical arguments presented to him or her in the media or from other platforms.

These 3 groups of abilities, with which ML aims to equip learners, correspond with the international conception of learner competence, in which it is maintained that for learners to be competent, they need to possess more than knowledge alone, and that they need to know how to use and apply their mathematical knowledge (Gillert et al., 2004; Hope, 2007; Jablonka, 2003; Skovsmose, 2007).

### 2.2.1.4 The aims of Mathematical Literacy

The aim of ML is to equip learners to become skilled citizens who are capable of meeting the demands which they will encounter in their future lives. The process through which this aim is achieved involves the mastering of mathematical content through solving contextualised problems.ML aims to develop the following abilities in learners (DoE, 2008):

- The ability to use basic mathematics to solve problems encountered in everyday life and in work situations.
- The ability to understand information which is represented in mathematical ways.
- The ability to engage critically with mathematically-based arguments encountered in daily life.

- The ability to communicate mathematically (DoE, 2008).

### 2.2.1.5 The definition of Mathematical Literacy

Mathematical Literacy provides learners with awareness and understanding of the role which mathematics plays in the modern world. Mathematical Literacy is a subject which is driven by life-related applications of mathematics. It enables learners to develop the ability and confidence needed to think numerically and spatially, in order to interpret and critically analyse everyday situations and to solve problems (DoE, 2003a, p. 9).

According to this definition, there are 3 key elements of Mathematical Literacy, namely, the mathematical content, the contexts, which should involve everyday life-related problems, and the abilities and behaviours which a mathematically literate person needs to possess, which include problem-solving through interpreting and analysing the problem, with confidence (Bowie and Frith, 2006). In the new CAPS document (DoE, 2011a) these 3 key elements of ML have been extended to 5 key elements, which will be covered in the following section.

When the national definition of ML and the purpose for which it is taught are compared with equivalent ideas abroad, a definite correspondence can be found in the Programme for International Student Assessment (PISA) (National Centre for Educations Statistics, 2008b; OECD, 2003).The purpose of PISA is to measure the extent to which students are able to make use of their mathematical knowledge in realistic day-to-day situations (McCrone et al., 2008, p.35). The definition of Mathematical Literacy adopted by PISA (OECD, 2003) is “the capacity to identify, to understand and to engage in mathematics and make well-founded judgements about the role that mathematics plays, as needed for an individual’s current and future life, occupational life, social life with peers and relatives and life as a constructive, concerned and reflective citizen” (OECD, 2003, p.20).

The correspondence between international and national perceptions underscores the emphasis which is being placed on the role which mathematics plays in the world and the value of promoting literacy in mathematical concepts in order to improve personal lives of people, their skills and abilities at the workplace and their ability to participate actively in their societies and in the economies of their countries. Shared objectives serve to guide learners to engage in mathematical reasoning and to understand and appreciate the degree to which mathematics is embedded in everyday life situations. However, perceptions of Mathematical Literacy in South Africa and abroad are slightly different, as in South Africa the term mathematical literacy refers to both a subject and a competence, while elsewhere it refers to a competence only (Christiansen, 2007).

#### 2.2.1.6 The 5 key elements of Mathematical Literacy – National Curriculum Statement (NCS) and the Curriculum and Assessment Policy Statement (CAPS)

On the basis of the purpose, the aims and the definition of Mathematical Literacy, the DoE (2011a) lists 5 key elements:

- The use of elementary mathematical content, in which the focus is not on formal, abstract mathematical concepts and mathematical content is not taught in the absence of relevant contexts.
- Real-life contexts, which need to be authentic and relevant, and to relate to the daily lives of learners, their future workplaces and their wider social, political and global environments.
- Solving familiar and unfamiliar problems, in order for learners to develop the ability and the skills needed to interpret both the familiar and the unfamiliar real-life contextual problems which they encounter in the world. They should have the ability to apply both mathematical and non-mathematical techniques and considerations in order to explore and make sense of the context.

The interplay between content, context and competencies is illustrated in the figure 2.

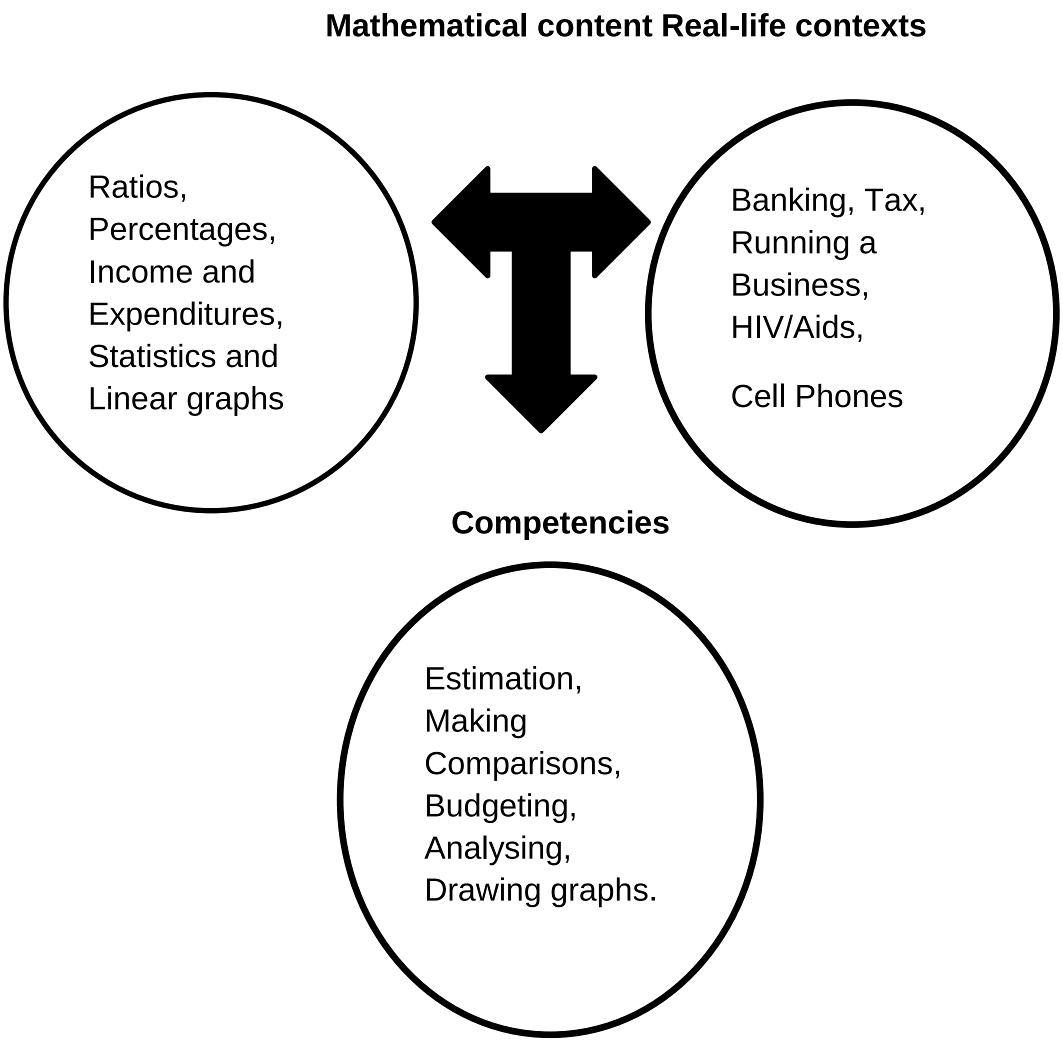



**Figure 2: Mathematical content and real-life contexts**

(DoE, 2011a, p. 11), (Botha, 2011)

- Decision-making and communication, in that a mathematically literate person should be able to compare possible solutions, to make decisions regarding the most appropriate choice for a given set of conditions and to communicate his or her decisions through the use of appropriate terminology.
- The use of integrated content or skills, or both, in solving problems. As most real-life problems entail a range of mathematical concepts, learners need to use mathematical content or skills, or both, which have been drawn from a

range of different topics, and to identify and use a range of techniques and skills which have been integrated from a range of content topics.

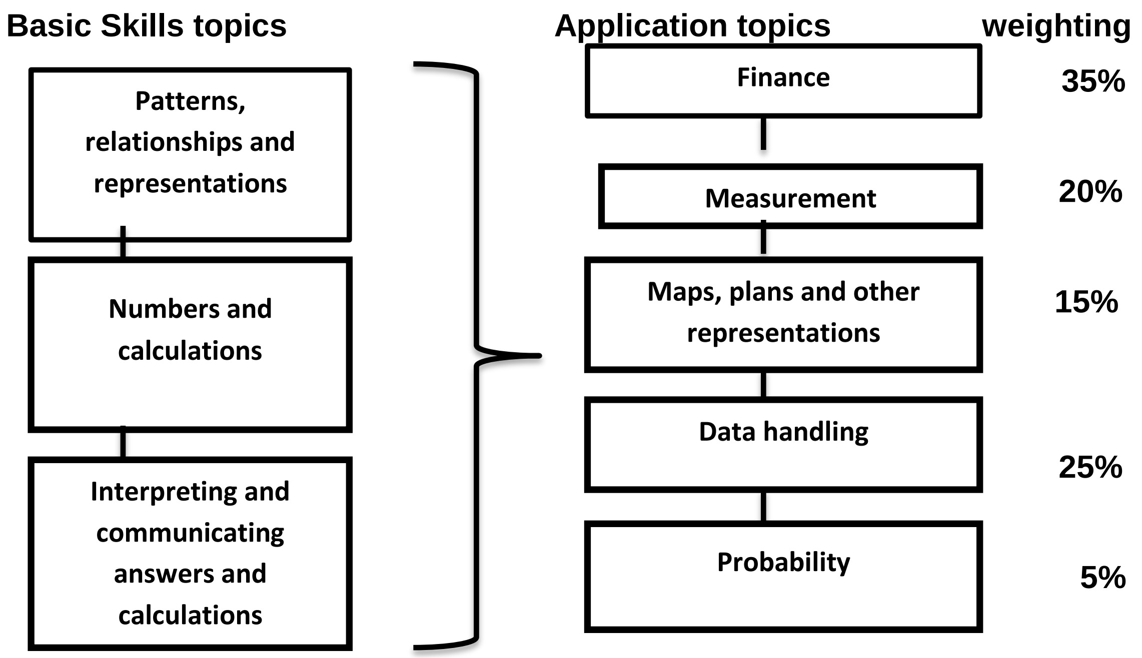
### 2.2.1.7 The composition of Mathematical Literacy in the CAPS curriculum

The topics for Mathematical Literacy in the new CAPS (DoE, 2011a) replace those of Learning Outcomes (LO) in the current NCS. The content, contexts and competency skills appropriate to ML are offered in topics and divided into 2 sets of topics, namely, (DoE, 2011a):

**Basic Skills topics:** As most of the content in these topics includes the mathematical contents and skills to which learners have already been exposed in Grade 9, teachers are provided with an opportunity to revise important mathematical concepts and to provide learners with the opportunity to explore and use these concepts in various contexts.

**Application topics:** These topics contain contexts which can be related to situations from everyday life, the workplace and business environments and also to the wider social, national and global issues of which learners are expected to make sense. A profound understanding of the content and skills from the Basic Skills topics is required to make sense of the contexts and content from the Application topics.

An overview and weighting of the topics according to which the ML curriculum has been organised for Grades 10, 11 and 12 (Botha, 2011) is presented in figure 3




(DoE, 2011), (Botha, 2011)

**Figure 3: Weighting of the topics according to the ML curriculum (Botha, 2011; DoE, 2011)**

## 2.2.1.7.1 The Mathematical Literacy Assessment Taxonomy – CAPS curriculum

Assessments should be conducted at different levels of cognitive demand, from the simple reproduction of facts to detailed analysis and the use of varied and complex methods and approaches (DoE, 2011a, p. 91). The following assessment taxonomy framework is used in South Africa:

- Level 1: Knowing.
- Level 2: Applying routine procedures in a variety of contexts.
- Level 3: Applying multi-step procedures in a variety of contexts.
- Level4: Reasoning and reflecting (DoE, 2011a p. 84).

According to Venkat, Graven, Lampen and Nalube (2009), the emphasis in Levels 1 and 2 is on routine calculations, whereas the key aims of ML are emphasised primarily in Levels 3 and 4. While Level 3 develops the ability of learners to think numerically and spatially, Level 4 is concentrated on critically analysing everyday life situations.

Although the DoE (2011a) explicitly stipulates that Mathematical Literacy involves the use of both mathematical and non-mathematical techniques and considerations to explore and make sense of authentic real-life scenarios (p. 92), the taxonomy should not be regarded as being associated exclusively with different levels of mathematical calculations or complexity. In the process of determining the level of complexity and the cognitive demand of a task, considerations should also be given to the extent to which the task requires the use of integrated content and skills drawn from different topics, the complexity of the context in which the problem is posed, the influence of non-mathematical considerations on the problem and the extent to which the learner is required to make sense of the problem without guidance or assistance (D0E, 2011a, p. 92)

## 2.2.1.8 Pedagogical approaches to teaching Mathematical Literacy

The DoE suggests that the focus of teaching Mathematical Literacy should be the integration of content and skills in real-life contexts. Teachers should provide learners with opportunities to *analyse problems and devise ways to work mathematically when solving them* (p. 9) *and develop and practise decision-making and communication skills* (DoE, 2011a p.10). According to Brown and Schafer (2006) and Botha (2011), the emphasis in the Mathematical Literacy curriculum is on contextualised mathematics. These contexts should be realistic and demand real-life authenticity to provide learners with opportunities to apply and use mathematics in order to make sense of the world, instead of allowing learners to concentrate on the mathematical content alone (Bansilal, Mkhwanazl and Mahlaboratoryela,2010; Botha, 2011). These problems should relate to the daily lives of learners, their future workplaces and the wider social, political and global environment (DoE, 2011a, p.12). Mathematical Literacy focuses on de-compartmentalisation, in that mathematical topics are no longer taught in isolation from one another (North, 2005, p. 35). All textbooks for the subject Mathematics are written accordingly, with the initial 4 learning outcomes being integrated to enable teachers of Mathematical Literacy to teach ML in a de-compartmentalised manner.

In a longitudinal study conducted by the Marang Centre at the University of the Witwatersrand, Graven and Venkat (2009) found that the learners who participated in the study were, for the most part, positive about Mathematical Literacy, which they attributed to the substantial changes which the teachers had made to their pedagogic practices. The teaching of Mathematical Literacy differs from traditional methods of teaching Mathematics, in that the nature of the tasks in Mathematical Literacy in terms of the way in which they engage with scenarios, as opposed to merely incorporating mathematical operations in word problems, and the nature of interaction in Mathematical Literacy, with its much slower pace and emphasis on discussion and group work (p. 2). Venkat (2007) maintains that if learners are engaged in problems which are presented in real-life situations, they will develop valuable skills such as mathematical reasoning, interpreting and applying mathematical concepts. The table below by Botha (2011, p. 32) and Graven and Venkat (2007, p. 74) presents a spectrum of pedagogical agendas which comprehensively covers the question of the nature and degree of integration of context with mathematics within specific pedagogical situations.

**Table 2: Nature and degree of integration of context with Mathematics within a pedagogical situation**

| **1.Context-driven (by learners' needs)** | **2. Content and context-driven** | **3. Mainly content-driven** | **4.Content-driven** |
|---|---|---|---|
| <u>Driving agenda:</u><br><br>To explore contexts with which learners need to interact and engage in their lives (current, future citizenship) and to use | <u>Driving agenda:</u><br><br>To explore a context in order to deepen the understanding of maths, to learn maths (new or GET) and to deepen the | <u>Driving agenda:</u><br><br>To learn maths and then to apply it to various contexts. | <u>Driving agenda:</u><br><br>To give learners a second chance to learn the basics of maths from the GET band. |

| | | | |
|---|---|---|---|
| maths to achieve this. | understanding of the context. | | |
| Pedagogic demands:<br>• Involves identifying contexts and scenarios needed for the above agenda.<br>• Teaching needs increased discussion of contexts and critical engagement with them and the mathematics embedded in them.<br>• Teaching might require revising or learning of new maths, but largely in order to promote critical engagement with and understanding of contexts. | Pedagogic demands:<br>• Involves selecting real contexts (possibly edited or adapted) which enable the above agenda.<br>• Teaching needs discussion of contexts, but this needs to be balanced with revising maths and learning new maths in new ways. Contextual and mathematical learning need to be balanced and connected in a dialectical relationship which enables the agenda. | Pedagogic demands:<br>• Involves selecting contexts to which GET maths can be applied (contrived or more realistic) and editing these to enable applications appropriate to the level of learning.<br>• Teaching focuses on mathematical learning and its use in applications, and does not necessarily require much discussion of context. | Pedagogic demands:<br>• Involves revision of GET maths without the need for pedagogic change except in relation to slower pacing.<br>• Contexts do not feature to any great extent, except in relation to their use in teaching GET basics (e.g. in the case using cakes to provide an illustration of fractions). |

(Botha, 2011)

Graven and Venkat (2007) analysed the definition and purpose attributed to contexts in Mathematical Literacy and concluded that Agenda 2 represented the core business of Mathematical Literacy in terms of the requirements of the DoE (2003a).

They characterise the 4 agendas a spectrum and not a continuum, which could be interpreted to imply that teachers move along it in one direction (Graven and Venkat, 2007, p. 77). They contend that teachers may use different agendas at different times, as required. Although Agenda 2 is the primary driving agenda, a teacher may adopt other agendas at various points in order to support this agenda or to aid meeting the demands of the curriculum.

### 2.2.1.9 The Mathematical Literacy learner profile

Although some learners have been found to display positive attitudes and enthusiasm towards Mathematical Literacy as a subject, the majority appear to be relatively uninterested in Mathematics and Mathematical Literacy and their negative feelings tend to result in a fear of anything mathematical (Vermeulen, 2007). According to Vermeulen (2007), although learners could avoid these negative experiences and feelings of anxiety in the past by not choosing Mathematics, now they are obliged to confront them. He maintains that that the incorrect beliefs of the parents of the learners and those of society at large, teaching methods which are based on beliefs of this sort, the attitudes which teachers have displayed towards learners and the classroom culture of teachers have all contributed towards the negative feelings and perceptions of learners. According to Mbekwa (2007, p. 227) it is difficult to teach Mathematical Literacy because learners lack understanding, interest and motivation, as a result of perceiving Mathematical Literacy as a dumping ground for underperformers in Mathematics (p. 227).

### 2.2.1.10 Some general concerns and perceptions regarding Mathematical Literacy

As Mathematical Literacy is a relatively new subject and different from Mathematics, clear guidelines pertaining to issues such as the pedagogical approaches to be adopted for the teaching of Mathematical Literacy should have been provided by the DoE, but instead, in the absence of precedents concerning pedagogy and assessment (Graven and Venkat 2007, p. 67), multifarious interpretations of the aims of the curriculum have emerged. Bowie and Frith (2006) expressed concern about a perception that Mathematical Literacy could be interpreted as being a slightly toned-downed standard grade Mathematics with word sums (Bowie and Frith, 2006, p.32). Experience and research have indicated that in Mathematics learners, and in many cases also teachers, find words or application problems requiring conceptual understanding more difficult than routine problems which require factual recall or the use of routine procedures (Abedi and Lord, 2001; Grobler, Grobler and Esterhuyse, 2001; Johari, 2003; Schoenfield, 1988). The experience of the researcher aligns with that of De Villiers (2007), who explains that while learners cope well with theory and linear functions in Mathematics, they are often unable to solve problems which make use of mathematical concepts when they are presented in real-life contexts. Even in Mathematical Literacy both teachers and learners find the process of mathematising contexts complex, as a good understanding of both the context and the mathematical content is required (Bowie and Frith, 2006). A further concern is the number of Mathematical Literacy teachers who have other specialisations who also teach the subject. It is known that in the past, before Mathematical Literacy was introduced, there was a shortage of appropriately qualified teachers of Mathematics (Sidiropoulos, 2008), which suggests that a change is required, not only in pedagogical content knowledge, but also in understanding the nature and value of Mathematical Literacy (Mbekwa, 2007, p.205).

## 2.2.1.11 The choice of contexts

Apart from the complexity of solving problems, the contexts to which mathematics should be applied in Mathematical Literacy are not clear to teachers. A further concern is how a mathematical progression is to be made through the years with respect to the complexity of contexts. A good understanding of the contexts is required by both teachers and learners in order to mathematise a context (Bowie and Faith, 2006). For example, when working on personal finances, topics such as budgeting, compound interest, mortgage payments and retirement options are not necessarily among the life experiences of all teachers and learners. Often, they have inadequate experiences of banks, rates of interest, risk and return on investments. To teach one mathematical content topic requires several periods to explain the context which is involved. The situation is further complicated by the fact that real-life banks normally use their own formulae programmes and do not calculate interest in the manner in which learners are taught (Christiansen, 2007). In order to choose contexts, teachers are able to use the principle employed by PISA (OECD, 2003), which categorises contexts according to their distance from the learner. Consequently, teachers of Mathematical Literacy are able to include contexts from the personal lives of learners, school life, work, sport, the local community and society as a whole. It is crucial that the contexts which are chosen should be authentic and applicable to the environment of the learners.

#### 2.2.1.12 Problems associated with the language of instruction

In South Africa, the majority of learners are taught in English, which is often not their mother tongue. According to Graven and Venkat (2009), integrating the teaching of Mathematical Literacy into contexts of this sort could be problematic, owing to the increased need to use relatively sophisticated English. Many researchers have pointed out the difficulties which learners experience with contextualised problems and the role which language plays in conceptual understanding (Mbekwa, 2007; Botha 2011). Maree (2000) maintains that insufficient language skills and use of language contribute significantly to under-achievement among learners in Mathematics. In his evaluation of the mistakes made by learners in Mathematics, language constituted the most significant problem which was identified. He expressed his concern about learners having to disentangle problems in Mathematics which require sophisticated language skills, while they actually lack the minimum language skills even to be able to understand what is being asked.

There has been a considerable amount of debate regarding Mathematical Literacy as the only alternative to Mathematics and many teachers expressed their concern about the existence of two extremely different levels of Mathematics, particularly if South Africa’s diverse population is taken into account (Maths Excellence, 2009; Botha, 2011). This group of teachers recommends a 3-level system consisting of 2 formal Mathematics subjects and Mathematical Literacy as a third option to accommodate the diverse skills and needs of our learners. Their intention is that Mathematical Literacy should then be taken by learners who do not wish to take either of the formal Mathematics courses, in order to equip them with basic numeracy skills. They contend that the lack of flexibility in the curriculum at present could result in the downgrading of mathematical skills. On the other hand, a number of people in the school education system are against the type of 2-level system which was used in South African schools until 2007. According to Kitto (personal communication, February 23, 2011), this opposition stems from the fact that as very few township and rural schools offered Mathematics at the higher grade level under the NATED 550 system, an overwhelming percentage of the higher grade candidates were white. This state of affairs denied a large number of academically competent black students the chance to demonstrate their abilities and to study for qualifications in engineering and other scientific disciplines. She reasons that the policy makers are trying to ensure that everyone who has the ability to study towards careers in science and engineering has access to the qualifications in Mathematics which are needed (Botha, 2011).

### 2.2.2 Different conceptions of Mathematical Literacy

Hope (2007) pointed out the similarities between the basic tenets of Mathematical Literacy and the theory of Realistic Mathematic Education (RME). RME uses a theoretical framework which relies on real-world applications and modelling a didactical belief propagated by Hans Freudenthal (Gates and Vistro-Yu, 2003, p. 67). Freudenthal and his colleagues laid the foundations of RME in the early seventies in order to address the world-wide need to reform the teaching and learning of mathematics and to move away from Mathematics education. Freudenthal's theory of RME rests upon the following 5 components:

- Using a real–world context as a starting point for learning.
- Bridging the gap between abstract and applied mathematics by using visual models.
- Having students develop their own problem-solving strategies, rather than memorise rules and procedures.

- Making mathematical communication, perhaps in the form of journaling or oral presentations, an integral part of the lesson.
- Making connections to other disciplines using meaningful real-world problems. (Hope, 2007, p. 30)

Hope (2007, p. 30) also believes that Mathematical Literacy requires an appropriate pedagogy. From the perspective of the pedagogical approach which is adopted for teaching Mathematics, it could be suggested that traditional instruction in Mathematics in schools is more formal, less intuitive, more abstract, less contextual, more symbolic and less concrete than the type of instruction which would expand the thinking of students and develop mathematical literacy. According to Hope (2007), mathematising is a term used by The Organisation of Economic Co-operation and Development (OECD) which involves 5 elements:

- Starting with a problem whose roots are situated in reality.
- Organising the information and data according to mathematical concepts.
- Transforming a real-world, concrete application to an abstract problem whose roots are situated in mathematics.
- Solving the mathematical problem.
- Reflecting back from the mathematical solution to the real-world situation to determine whether the answer makes sense, (p. 29).

Gillert et al. (2004); Gillert et al., (2013) use Mathematical Literacy as a metaphor referring to well-educated and well-informed individuals. According to them, the different conceptions of mathematical literacy are based on the relationship between mathematics, reality and the society. Their concept of mathematical literacy involves gaining a level of mathematical understanding which surpasses the minimal abilities of calculating, estimating, gaining a measure of number sense and a basic geometrical understanding by appreciating the power of mathematics, with its potential to abstract from concrete realities by generating concepts and structures for universal application (p. 59). They also believe that these abilities can be developed by experiencing mathematical modes of thinking, such as searching for patterns, classifying, formalising and symbolising, seeking the implications of premises, testing conjectures, arguing and thinking propositionally (p. 59), all of which form the basis of mathematical modelling. Mathematical Literacy requires the mathematical competence to understand the mathematical methods involved and the analytical competence to demystify the justifications for specific mathematical applications and to assess their consequences (p. 66). Although some of these concepts are formal and involve higher-order mathematical skills, other researchers regard Mathematical Literacy as a fundamental requirement for all people, recognising its essential value to learners in contexts which arise in the course of their everyday living (McCrone and Dossy, 2007; Powell and Anderson, 2007; Skovsmose, 2007). McCrone and Dossey (2007) believe that Mathematical Literacy is not concerned with studying higher levels of formal mathematics, but rather with making mathematics relevant and empowering for everyone (p. 32). They even call for mathematics to play greater part in non-mathematics classes and for teachers to promote the Mathematics which is embedded in their subjects.

Skovsmose (2007) refers to Mathematical Literacy as Mathematics in Action and considers the role of Mathematical Literacy in the lives of mathematicians and non-mathematicians alike. He based his study on 2 types of literacy, either functional or critical, which are terms introduced by Apple in 1992. Functional literacy is defined by competencies which a person possesses to fulfil a particular function at work (p. 4), whereas critical literacy addresses themes such as working conditions and political issues. Skovsmose (2007) prefers to talk about reflective knowledge with respect to mathematics, rather than critical literacy. Reflective knowledge refers to a competence in evaluating how mathematics is used or could be used (p. 4.), while critical literacy entails the skill required to use and apply those models. Making unambiguous distinctions between these two types of literacy is not a simple undertaking and very different interpretations could be made, depending on the specific context of the learner (p. 4).

### 2.2.3 Contexts in which Mathematical Literacy can be applied

Prescribing the different contexts in which Mathematical Literacy can be applied is as complex as conceptualising Mathematical Literacy. In this section the different categories of contexts have been discussed, as well as the role which technology plays in determining these contexts.

### 2.2.3.1 Context categories according to the requirements of stakeholders

Contexts in which Mathematical Literacy can be applied depend on the philosophy, values or principles embraced by stakeholders, and they could also be guided by concerns such as socio-economic demands (Jablonka, 2003). Jablonka categorised the different, and, in some cases, conflicting contexts in which mathematics can be applied as Mathematical Literacy for:

- Developing Human Capital - looking at the world through mathematical eyes where higher order mathematical skills are applicable, where mathematics is not regarded as culture-bound and value-driven.
- Cultural Identity - incorporating ethno-mathematical practices to avoid privileging Western academic mathematical knowledge.
- Social Change - to uncover and communicate phenomena which are of a social or political nature, such as unemployment, life expectancy and national income, in an attempt to overcome the dominance of academic mathematics in the curriculum.
- Environmental Awareness - the mathematical content comprises arguments which are underpinned by mathematical visualisations, quantitative mathematics which is characterised as not aiming at an analytical solution but serving as thought experiments and computational mathematics, which include the use of simulation packages, graphing calculators and spread sheets.
- Evaluating Mathematics - includes reasoning with condensed measures and indexes, formalising transactions, reasoning with platonic models, constructing surface models and numerology.

As an example of the conflict which exists between some of these conceptions, Jablonka referred to instances in which the application of mathematics within a cultural identity is restricted to contexts situated in a specific culture, whereas in environmental awareness, the focus is on applying mathematics to contexts which are of a global nature. There is also the complex problem of cultural identity, in which Ethno-mathematics has been suggested as a necessity for overcoming and preventing cultural conflicts in the classroom. Gillert et al., (2011) categories are similar to those of Jablonka, in terms of literacy for professional competence in a technological world, for civic responsibility and the preservation of heritage, for personal growth and self-fulfilment and for social and political change (p. 76). The different contexts in which Mathematical Literacy can be applied can also be categorised according to various processes involved in applying mathematics in real-world contexts.

### 2.2.4 Context categories according to processes

By categorising the content into 4 processes, Skovsmose (2007) illustrated how Mathematics in Action can operate in powerful ways and exercise great power (p. 8). The following categories explain the different conceptions of mathematical literacy.

- Construction - includes systems of knowledge and techniques, by means of which technology, in the broadest interpretation of the term, is maintained and further developed (p. 8), for example in the construction of the computer.
- Operating - bringing technology into operation in work practices and job functions. The operator may not be aware of the mathematical content of the procedure he or she performs (p. 11), for example, ticket reservations in the travel industry and procedures for buying and selling houses.
- Consuming - as citizens we are consumers who are required to evaluate statements from experts which are made every day in the media, for example, numbers and figures concerning elections, the economy, exchange rates and investments are mixed with advertising, special offers and so on (p. 13).
- Marginalising - a study concerning the growth of favela-like neighbourhoods gloomily testifies that free-growing globalised capitalism is not an inclusive economy. Instead, it marginalises, in great measures, people as being disposable, condemning them to peripheral income-generating activities such as drug dealing, selling sunglasses, lighters and other items which it is possible to hawk at traffic lights and stop streets (p. 14).

Skovsmose (2007) concluded that Mathematical Literacy could be either functional or critical, but that the distinction is difficult to maintain, vague and possibly even elusive (p.17). In many of these processes, technology plays a significant role in the processes of selecting contexts. The following sections will be devoted to a discussion of the prominent theorists and the social learning theories which provided the basis on which the theoretical framework which underpins this study could be constructed.

# 2.3 Vygotsky and social learning theories

## 2.3.1 Social constructivist perspective

This study has drawn extensively from the social constructivist perspective of Lev Vygotsky and attempts to demonstrate how this perspective aims to develop educators within their own environment in order to contribute positively towards the on-going process implementing Mathematical Literacy.

Vygotsky's (1896 – 1934) Social Development Theory was later developed into his Social Constructivist Theory. He based his theory on the connections between individuals and their experiences and interactions within their different socio-cultural contexts (Crawford, 1996). The main ideas in Vygotsky's theory, as they are explained by Crawford (1996), are based upon:

- The fundamental role of social interaction. Unlike other theorists before him, who believed that development precedes learning, he believed that social learning is a prerequisite for development.
- A More Knowledgeable Other (MKO), who is able to guide an individual to enable him or her to construct meaningful learning. The MKO could be a teacher, a sibling or even a peer, as long as he or she is more knowledgeable than the individual who is being guided.
- The zone of proximal development (ZPD). The ZPD is the distance between what a learner knows and the knowledge which the MKO has at his or her disposal. Within this space learning can be constructed.

## 2.3.2 Zone of proximal development

The **zone of proximal development** (ZPD) has been defined as "the distance between the actual developmental level, as determined by independent problem-solving and the level of potential development, as determined through problem-solving under adult guidance, or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). Vygotsky views interaction with peers as an effective way of developing skills and strategies. He suggests that teachers should use cooperative learning exercises in which less competent children develop with help from more skilful peers - within the zone of proximal development. Vygotsky believed that when a student is in the ZPD for accomplishing a particular task, providing appropriate assistance will give the student a sufficient "boost" to accomplish it (McLeod, 2012).

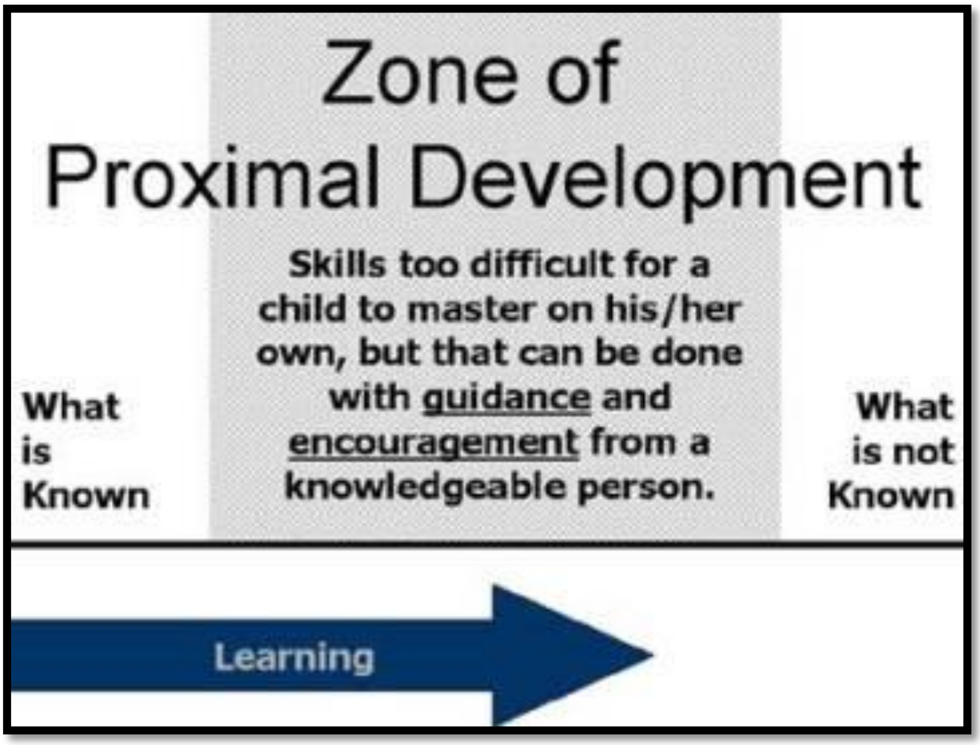



**Figure 4: Zone of Proximal Development (McLeod, 2012)**

The ZPD has become synonymous in the literature with the term scaffolding. However, it is important to note that Vygotsky did not use this term in his writings, and that it was introduced by Wood et al. (1976). The concept of scaffolding may be expressed in terms of a student mastering a particular task, with the benefit of scaffolding, after which the scaffolding can be removed and the student will be able to complete the task again on his or her own (McLeod, 2012).

**Wood and Middleton (1975) - Scaffolding**

The following study provides empirical support for both the concept of scaffolding and the ZPD.

**Procedure**: 4 year-old children were required to use a set of blocks and pegs to build a 3D model shown in a picture. Building the model was too difficult a task for a 4 year-old child to complete alone.

Wood and Middleton (1975) observed how mothers interacted with their children to build the 3D model. The type of support included:

- General encouragement, such as"Now you have a go".
- Specific instructions, such as"Get four big blocks".
- Direct demonstration, such as showing a child how to place one block on top of another.

The results of the study showed that no single strategy was best for helping a child to progress. The mothers whose assistance was most effective were those who varied their strategies according to the progress which the child was making. When a child was progressing well, they became less specific with the help which they offered. When a child started to struggle, they gave increasingly specific instructions until the child started to make progress again.

The study illustrates scaffolding and Vygotsky's concept of the ZPD. Scaffolding, in the form of assistance, is most effective when the support is matched to the needs of the learner. This puts them in a position to achieve success in an activity which they would previously not have been able to perform alone (McLeod, 2012).

Wood et al., (1976) enumerated specific processes which aid effective scaffolding:

- Gaining and maintaining the interest of a learner in a task.
- Making the task simple.
- Emphasising certain aspects which will help with the solution.

- Controlling the child’s level of frustration.
- Demonstrating the task (McLeod, 2012).

”From a Vygotskian perspective, the teacher's role is mediating the child's learning activity as they share knowledge through social interaction” (Dixon-Krauss, 1996, p. 18). Scaffolding is a key feature of effective teaching and can include modelling a skill, providing hints or cues and adapting material or activity (Copple and Bredekamp, 2009).

In the classroom scaffolding can be provided in almost any task. The following guidelines are for instruction by making use of scaffolding (Silver, 2011; McLeod, 2012):

- Assess the learner's present knowledge and experience with respect to the academic content.
- Relate the content to what learners already understand or can do.
- Break a task into small, more manageable tasks with opportunities for intermittent feedback.
- Use verbal cues and prompts to assist learners (Silver, 2011; McLeod, 2012).

A contemporary application of Vygotsky's theories is found in "reciprocal teaching", which is used to improve the ability of learners to learn from texts. When this method is used, teachers and learners collaborate in learning and practising 4 key skills: summarising, questioning, clarifying, and predicting. The role of the teacher in the process is reduced over time (Gerber, 2011; Shava, 2005).

Vygotsky's theories also feed into current interest in collaborative learning, in which group members should have different levels of ability, to enable more advanced peers to help less advanced members of the group to operate within their zone of proximal development. This approach has very positive implications for the teaching and learning of Mathematical Literacy.

The role of social interaction and verbal communication is central in Vygotsky’s blend of constructivism for learning Mathematics (Danels and Aughilen, 1995; Romberg and Grinsfenin, 1988; Shava, 2005). This is inferred from the fact that the learning of Mathematics by students is mediated by their interactions with their parents, their families, their peers and their teachers. In tandem with this mediation, their interactions with the rest of their social environments play a role in enabling themto construct their own mathematical meanings. From this perspective learning becomes a social product, in which the type and the amount of informed knowledge which a learner brings to a school affects his or her construction of Mathematical meaning (Gerber, 2011; Shava, 2005).

Vygotsky also believed that individuals will be most likely to learn skills and gain knowledge which they find useful to themselves. Consequently, knowledge and newly-learned skills will inevitably be influenced by the social and specifically familiar environment of learners. In this research the researcher endeavours to focus on how an educator becomes a “learner” again when he or she is confronted with the need to introduce new subject matter, and also on how they cope with exploring new territories.

Those educators who were involved from the beginning of the implementation of Mathematical Literacy in 2007 had considerably less support in the form of More Knowledgeable Others (MKOs) than those who became involved at a later stage. Educators who started teaching Mathematical Literacy in 2007 were given an opportunity to attend a once-off workshop presented by the Department of Education over a period of 5 days. These educators, subsequently, were required to workshop and support educators who had been either unable to attend the workshop or started teaching the subject at a later stage. In this way, “new” educators had the opportunity to learn from the “old” or experienced educators. The experienced educators acted as “more knowledgeable others” to the inexperienced educators Gerber (2011).

In essence, Vygotsky recognises that learning always occurs and cannot be separated from a social context, which is of particular relevance for the teaching of Mathematical Literacy.

## 2.4 Bandura and social learning theory

The reader is respectfully requested to refer to section 1.6.2 of Chapter 1 for an in-depth discussion of the development of Bandura’s social learning theories, particularly with respect to observational learning.

### 2.4.1 Examples of observational learning in action

- A child watches his mother folding the laundry. He later picks up some clothing and imitates folding the clothes.
- A young couple goes on a date to a Chinese restaurant. They watch other diners in the restaurant eating with chopsticks and copy their actions in order to learn how to use these utensils.
- A young boy watches another boy on the playground get into trouble for hitting another child. He learns, from observing this interaction, that he should not hit others.
- A group of children play hide and seek at recess. One child joins the group, but has never played before and is not sure what to do. After observing the other children play, she quickly learns the basic rules of the game and joins in.

### 2.4.2 Factors which influence observational learning

According to Bandura's research, there are a number of factors which increase the likelihood that behaviour will be imitated. We are more likely to imitate:

- People we perceive as warm and nurturing.
- People who receive rewards for their behaviour.
- When we
- have been rewarded for imitating the behaviour in the past.
- When we lack confidence in our own knowledge or abilities
- People who are in a position of authority over our lives
- People who are similar to us in age, sex, and interests
- People who we admire or who are of a higher social status
- When the situation is confusing, ambiguous, or unfamiliar

### 2.4.3 Real-world applications for observational learning

Bandura's research in observational learning raises an important question: If children were likely to imitate aggressive actions viewed on a film clip in a laboratory setting, does it not also stand to reason that they will imitate the violence which they observe in popular films, television programs, and video games? The debate concerning this topic has raged for years, with parents, educators, politicians, and film makers and manufacturers of video games weighing in with their opinions of the effects of violence in the media on the behaviour of children. But what does the psychological research suggest?

### 2.4.4 Observational learning as a positive force

Although observational learning is often linked to negative or undesirable behaviours, it can also be used to inspire positive behaviours. Television programming has been used to promote a range of healthy behaviours in areas throughout the world, including Latin America, Brazil, India, and Africa. For example, non-profit organizations have produced programming aimed at preventing the transmission of HIV and AIDS, reducing pollution and promoting family planning. Observational learning can be a powerful learning tool. Although the concept of learning is often associated with direct instruction or methods which rely on reinforcement and punishment, a great deal of learning takes place in much more subtle ways and relies on watching the people around us and modelling their actions. This learning method can be applied in a wide range of settings, including job training, education, counselling, and psychotherapy (Ferguson, 2010).

Bandura's social learning theory has had important implications for the field of education. Today both teachers and parents recognise the importance of modelling appropriate behaviours. Other cleassroom strategies, such asencouraging children and building self-efficacy, are also rooted in social learning theoryeducation.The concept of self-efficacy is central to Bandura's social cognitive theory, which emphasises the role of observational learning, social experience and reciprocal determinism in the development of personality (Ferguson, 2010).

Self-efficacy is often explained to laymen in the manner of the discourse which follows. When you face a challenge, do you feel as if you are able to rise up and accomplish your goal, or do you give up in defeat? Are you like the famous little train engine from the classic children's book, who said "I think I can, I think I can!", or do you doubt your own abilities to overcome the difficulties which life throws your way? Self-efficacy, or your belief in your own abilities to deal with various situations, can play a role in not only how you feel about yourself, but whether or not you successfully achieve your goals in life (Ferguson, 2010).

The attitudes, abilities and cognitive skills of a person comprise what is known as the self-system. This system plays a crucial role in how we perceive situations and how we behave in response to different situations. Self-efficacy constitutes an essential component of this self-system (Bandura, 1994; 1995).

### 2.4.5 Definition of self-efficacy

Self-efficacy may be defined as "the belief in one's capabilities to organise and execute the courses of action required to manage prospective situations." In this sense, self-efficacy is reflected in the belief of a person in his or her ability to succeed in a particular situation. These beliefs act as determinants of how people think, behave and feel (Bandura, 1997).

Since Bandura published his seminal 1977 paper, "Self-Efficacy: Toward a Unifying Theory of Behavioural Change," the subject has become one of the most studied topics in psychology. Why has self-efficacy become such an important topic among psychologists and educators? As Bandura and other researchers have demonstrated, self-efficacy can have a dramatic and significant influence on a wide range of factors, from psychological states to behaviour to motivation (Bandura, 1997).

### 2.4.6 The role of self-efficacy

Nearly all people are able to identify the goals which they wish to accomplish, the things which they would like to change and the accomplishments which they would like to attain. However, most people also realise that converting these ambitions into actions is usually not as easily accomplished as entertaining them may be.

Bandura and others have found that self-efficacy plays a crucial role in how goals, tasks and challenges are approached.

People with a strong sense of self-efficacy:

- View challenging problems as tasks to be mastered.
- Develop a deeper interest in the activities in which they participate.
- Form a stronger sense of commitment to their interests and activities.
- Recover quickly from setbacks and disappointments.

People with a weak sense of self-efficacy:

- Avoid challenging tasks.
- Believe that difficult tasks and situations are beyond their capabilities.
- Focus on personal failings and negative outcomes.
- Quickly lose confidence in their own abilities (Bandura, 1997; Ferguson, 2010)

## 2.4.7 Sources of self-efficacy

The beliefs through which self-efficacy is expressed begin to form in early childhood, as children deal with a wide variety of experiences, tasks, and situations. However, the growth of self-efficacy does not end during youth, but continues to evolve throughout life, as people acquire new skills, experiences and understanding.

- **Mastery experiences**

The most effective way of developing a strong sense of efficacy is through mastery experiences. Performing a task successfully strengthens our sense of self-efficacy. However, failing to deal adequately with a task or a challenge can undermine and weaken self-efficacy (Bandura, 1997).

- **Social modelling**

Witnessing other people successfully completing a task is another important source of self-efficacy. Seeing people similar to one succeed by sustained effort raises observers' beliefs that they too possess the capabilities to master comparable activities to succeed (Bandura, 1997).

- **Social persuasion**

It is also asserted that people could be persuaded to believe that they have the skills and capabilities to succeed. Consider a time when someone said something positive and encouraging that helped you achieve a goal. Getting verbal encouragement from others helps people overcome self-doubt and instead to focus on giving their best effort to the task at hand (Bandura, 1997).

- **Psychological responses**

Our own responses and emotional reactions to situations also play an important role in the development of self-efficacy. Moods, emotional states, physical reactions and stress levels can all affect how people feel about their personal abilities in a particular situation. A person who becomes extremely nervous before speaking in public may develop a weak sense of self-efficacy in these situations.

However, "it is not the sheer intensity of emotional and physical reactions that is important but rather how they are perceived and interpreted." By learning how to minimise stress and elevate moods when facing difficult or challenging tasks, people can improve their sense of self-efficacy, (Bandura, 1997).

## 2.5 Rotter's social learning theory

When Rotter developed his social learning theory, the dominant perspective in clinical psychology at the time was Freud's psychoanalysis, which focused on deep-seated instinctual motives as determinants of behaviour. Individuals were believed to be naive regarding their unconscious impulses and treatment required long-term analysis of childhood experiences. Learning approaches at the time were dominated by drive theory, which held that people are motivated by physiologically-based impulses, which they are driven to satisfy. By developing social learning theory, Rotter departed from instinct-based psychoanalysis and drive-based behaviourism. He believed that a psychological theory should embody a psychological motivational principle, and chose the *empirical law of effect* as his motivator. The law of effect contends that people are motivated to seek positive stimulation or reinforcement, and to avoid unpleasant stimulation. Rotter combined behaviourism and the study of personality, without relying on physiological instincts or drives as motivating forces (Strickland, 2014; Mearns, 2009; Rotter, Lah and Rafferty, 1992; Haggbloom, et al., 2002).

Rotter describes personality as a relatively stable set of potentials for responding to situations in a particular way. For this reason, the theory is particularly relevant to the teaching of Mathematics and Mathematical Literacy at the FET level. Rotter maintains that personality and consequently, behaviour, are always changeable. Change can refer to changes in the ways in which an individual thinks, or to changes in the environment to which an individual responds, as determinants of behavioural change. Although he does not believe there is a critical period after which personality becomes set, he maintains that the more life experience goes into developing particular sets of beliefs, the more effort and intervention will be required for change to occur. Rotter's view of people is an optimistic one, as he conceives them as being propelled by their goals, seeking to maximise their reinforcement, rather than simply by the desire to avoid punishment (Strickland, 2014; Mearns, 2009; Rotter, Lah and Rafferty, 1992; Haggbloom, et al., 2002).

Rotter has 4 main components in his social learning theory model for predicting behaviour. These are behaviour potential, expectancy, reinforcement value and the psychological situation.

- **Behaviour potential:** Behaviour potential is the likelihood of engaging in a particular behaviour in a specific situation. It expresses the probability that a person will exhibit a particular behaviour in a particular situation. In any given situation, there is a range of possible behaviours in which an individual can engage. There is behaviour potential for each possible type of behavioural response and an individual will exhibit whichever behaviour has the highest potential.
- **Expectancy:** Expectancy is the subjective probability that a given behaviour will result in a particular outcome or reinforcer. If an individual has high or strong expectancies, he or she is confident that the behaviour will result in the anticipated outcome. Conversely, low expectancies imply that the individual believes that it is unlikely that his or her behaviour will result in reinforcement. If the possible outcomes are equally desirable, individuals will tend to engage in the behaviour which has the greatest likelihood or the highest expectancy of resulting in reinforcement. In order to have high expectancy, individuals need to believe both that they have the capacity to enact the behaviour effectively and that that behaviour will result in reinforcement. Expectancies are formed on the basis of past experience. The more often a particular

behaviour has resulted in reinforcement in the past, the greater is the expectancy that it will achieve the desired outcome in the present. In addition, people do not need to have direct experience of reinforcement of a particular behaviour. Rotter explains that our observations of the outcomes of the behaviours of others affect our own expectancies. If we observe someone else being punished for a particular behaviour, we do not have to experience the punishment personally to form an expectancy that this behaviour is likely to be punished. It is important to emphasise that expectancy is a subjective probability, as irrational expectancies constitute a common source of pathology. There may be no relationship whatsoever between the subjective assessment of an individual of the likelihood of experiencing a particular reinforcement and the actual objective probability of its occurrence. People can either overestimate or underestimate the likelihood, and both distortions can potentially be problematic (Strickland, 2014; Mearns, 2009; Rotter, Lah and Rafferty, 1992).

- **Reinforcement value:** Reinforcement is another name for the outcomes of our behaviour. Reinforcement value refers to the desirability of these outcomes. Those occurrences which we actively desire to take place have a high reinforcement value. Conversely, those occurrences which we wish to avoid have a low reinforcement value. If the likelihoods of experiencing a range of possible reinforcement are the same and expectancies with respect to each are equal, we will tend to exhibit the behaviour with the greatest reinforcement value, which is directed towards the outcome which we desire most. As the term social learning theory suggests, the social environment is of primary importance in the shaping of our behaviour. Social outcomes, such as approval, love or rejection, are powerful influences on our behaviour. For people, the most significant reinforcers are often social reinforcers (Strickland, 2014; Mearns, 2009; Rotter, Lah and Rafferty, 1992; Haggbloom, et al., 2002).

As is the case with expectancy, reinforcement value is subjective, which implies that the desirability of the same event or experience can vary to a very great extent, depending on the life experience of the individual or individuals who are likely to experience it. Punishment from a parent or a teacher would, in many cases, serve as negative reinforcement for most children and tend to discourage the behaviour which prompted it. However, children who receive little positive attention from parents or teachers have been known to seek out punishment, because it has a higher reinforcement value than neglect. The value of any given reinforcer is determined, in part, by other reinforcers to which experiencing the original reinforcer might lead. For example, doing well in an examination in a particular subject could have a heightened reinforcement value if the student in question believed that doing well in that subject could result in added status or privileges, such as being able to work in the laboratory of a popular or respected professor. Consequently, even an apparently trivial event can have a very strong reinforcement value, either positive or negative, if the individual concerned regards it as a means of experiencing other highly valued reinforcers. The least amount of reinforcement which still has a positive value is known as the minimal goal. If people achieve an outcome that equals or exceeds their minimal goal, they will feel that they have succeeded. When the level of reinforcement falls below an individual's minimal goal, the reinforcement is experienced as failure. As people differ with respect to their minimal goals, the same outcome may represent success to a person who has a low minimal goal, while it may be experienced as failure to another person who has a higher minimal goal (Strickland, 2014; Mearns, 2009).

**Predictive Formula:** Behaviour Potential (BP), Expectancy (E) and Reinforcement Value (RV) can be combined into a predictive formula for behaviour:

**BP = *f*(E and RV)**

This formula can be read as follows: behaviour potential is a function of expectancy and reinforcement value. This equation can be interpreted as the likelihood of a person exhibiting a particular behaviour is a function of, or is dependent upon, the probability that that behaviour will lead to a given outcome and the desirability of that outcome. If expectancy and reinforcement value are both high, then behaviour potential will be high. If either expectancy or reinforcement value is low, then behaviour potential will be lower (Stickland, 2014; Mearns, 2009; Rotter, Lah and Rafferty, 1992; Haggbloom et al., 2002).

- **Psychological situation:** The psychological situation is an expression of Rotter's idea that each individual's experience of the environment is unique. Although the psychological is not a factor in Rotter's formula for predicting behaviour, Rotter believes that it is always important to keep in mind that different people will inevitably interpret any given situation differently, as they will have different expectancies and reinforcement values in the same situation. Consequently, it is people's subjective interpretation of the environment, rather than an objective array of stimuli, that is meaningful to them and which determines how they behave.
- **Generality versus specificity:** An important dimension of personality theories concerns the generality, as opposed to the specificity, of their constructs. General constructs are broad and abstract, while specific constructs are narrow and concrete. Both types of constructs have their advantages. A theory with general constructs allows one to make many predictions, across situations, from knowing only a small amount of information. The disadvantages of general constructs, though, are that they are harder to measure and the predictions made from them have a lower level of accuracy. Specific constructs, on the other hand, are easier to measure, and they can be used to make more accurate predictions. However, these predictions are limited to being situation-specific. For example, knowing that someone is a generally hostile person allows us to make predictions that this individual will be hostile towards a range of people. Across situations, this person is likely to be more hostile to others than someone who exhibits low levels of hostility. However, our ability to predict how hostile this person would be towards Jane, for example, is limited, because there may be other factors which determine whether this individual would treat Jane in a hostile way during a particular encounter, such as the liking which the individual feels for Jane, or situational factors, which may inhibit expressions of hostility. On the other hand, if we know that this person hates Jane, we can predict with a high level of accuracy that he or she will be hostile towards Jane. However, in this instance we should not be able to predict whether this person will treat

other people in a hostile way. The strength of Rotter's social learning theory is that it explicitly blends specific and general constructs, offering the benefits of each. In social learning theory all general constructs have a specific counterpart. For every situation-specific expectancy there is a cross-situational generalised expectancy. Social learning theory blends generality and specificity to enable psychologists to measure variables and to make a large number of accurate predictions from these variables (Strickland, 2014; Mearns, 2009; Rotter, Lah and Rafferty, 1992; Haggbloom et al., 2002).

- **Locus of control:** The only exposure which many people have to the ideas of Julian B. Rotter is in relation to his concept of generalised expectancies for control of reinforcement, which is more commonly known as the locus of control. The locus of control refers to the very general, cross-situational beliefs which people have about what determines whether or not they experience reinforcement in their lives. People can be classified along a continuum from very internal to very external. People with a strong internal locus of control believe that the responsibility for whether or not they experience reinforcement ultimately lies with them. Internals believe that success or failure result from their own efforts. By contrast, externals tend to believe that the reinforcers which are experienced in life are controlled by luck, chance, or powerful other people. Consequently, they tend to perceive very little in terms of the effects which their own efforts have had on the amount of reinforcement which they receive. Rotter has written extensively about the problems which have arisen concerning the interpretations of people of the locus of control concept. First, he has warned people that locus of control is not a typology. It represents a continuum, not an either/or proposition. Secondly, as a locus of control is a generalised expectancy, it can predict the behaviour of people across situations. However, there may be some specific situations in which people who, for example, are generally external may behave as if they were internals. This change occurs because their learning history has shown them that they have control over the reinforcement which they receive in certain situations, although in general they perceive little control over what happens to them. This phenomenon emphasises once again the importance of conceiving of personality as the interaction between an individual person and the environment (Strickland, 2014; Mearns, 2009).

- **Psychopathology and treatment.** Rotter is strongly opposed to the conception of the medical model of mental disorders as being diseases or illnesses. Instead, he conceives of psychological problems as maladaptive behaviour brought about by faulty or inadequate learning experiences. For Rotter, the symptoms of pathology, like all behaviour, are learned. Accordingly, treatment should take the form of a learning situation in which adaptive behaviours and cognitions are taught. In this sense, the therapist-client relationship is similar to a teacher-student relationship. The existence of a positive relationship between a client and a therapist gives the therapist increased reinforcement value for the client. This, in turn, allows the therapist to influence the behaviour of the client, mainly through praise and encouragement. Much of current cognitive-behavioural treatment has its roots in Rotter's social learning theory, although these debts often go unacknowledged. According to Rotter, pathology can develop as a result of difficulties arising at any point in his predictive formula. Behaviour can be maladaptive, owing to an individual never having learned more healthy behaviours. In a case of this sort, the therapist would make direct suggestions concerning new behaviours for the client to try and use techniques such as role-playing to develop more effective coping skills, (Strickland, 2014; Mearns, 2009).
- **Expectancies** can result in pathology when they are irrationally low. If people have low expectancies, they do not believe that their behaviours will be reinforced. Consequently, they put little effort into their endeavours. As they do not actively try to succeed, they are likely to fail, and, when they fail, their low expectancies are confirmed. This process of decreasing expectancies is a common occurrence in pathology which is known as a *vicious cycle.* When clients have low expectancies, therapists attempt to increase their confidence by using their therapeutic influence to help clients to gain insights into the irrationality of their expectancies and encourage them to attempt to enact behaviours which they have been avoiding from a fear of failure. Social learning therapists usually attempt to raise the expectancies of their clients with respect to reinforcement. Problems related to reinforcement value can

result in pathology. Reinforcers are the goals which people endeavour to attain in their lives. If unrealistically high and unattainable goals are set in the sense of minimal goals which are too high, those who set them for themselves are likely to experience frequent failure, which can result in the development of the vicious cycle described earlier. In situations of this sort, therapists usually try to help their clients to lower their minimal goals, in order to develop reasonable, achievable standards for themselves. Flexibility in setting minimal goals is generally regarded as an indicator of good mental health. In this context it is believed that it is better to strive, one step at a time, to attain a series of goals than it is to set a single distant, lofty and unattainable goal. A therapist, whose approach is informed by the work of Rotter, also encourages clients to consider the long-term consequences of behaviour, rather than merely the short-term consequences, (Strickland, 2014; Mearns, 2009; Rotter, Lah and Rafferty, 1992; Haggbloom, et al., 2002).

The Social Learning Theory is a school of psychology which views personality as being shared by the interpersonal environments in which people are raised (Harry and Susan, 2009). This study serves to confirm that education and learning theories have a definite influence on the ways in which teachers teach and learners learn. Social learning refers broadly to any kind of influence, such as the influence which our relationships with others have on our behaviour, our beliefs and our values as teachers. Social learning theory sees social goals, such as receiving approval from others, dominating others or depending on others, as powerful motives which direct our behaviour as teachers and learners, (Harry and Susan, 2009).

These conclusions introduce the conceptualisation of Mathematical Literacy (ML) as a school subject in the study.

## 2.6 Implications of social learning theory for teaching and learning Mathematical Literacy

The social learning theory represents a school of psychology which views personality being shaped by the interpersonal environments in which people are raised (Harry and Susan, 2009). To this the researcher would like to add that, as a result of a lack of opportunities and discrimination during the apartheid era, the majority of South Africans were effectively prevented from acquiring proper numerical knowledge. At present social learning refers broadly to any kind of influence which our relationships with others have on our behaviour, beliefs and values. In social learning theory social goals, such as receiving approval from others, dominating others or depending on others are powerful motives (Harry and Susan, 2009).

## 2.7 International perspectives of Mathematical Literacy

With the increased emphasis on the application value of mathematics, science and technology, the objectives of subjects such as Mathematical Literacy have tended to move towards personal fulfilment, employment and full participation in society (OECD, 2004, p. 37). Throughout the world Mathematical Literacy, as an application of specific skills, is generally perceived to be embedded in the subject Mathematics, while using real-life contexts to re-contextualise mathematical concepts. From the literature it is evident that Mathematical Literacy varies in breadth and depth and that it needs to be interpreted according to the purpose for which and the context in which it is being used (Gillert et al., 2001; Hope, 2007; Jablonka, 2003; McCrone and Dossy, 2007; Powell and Anderson, 2007; Skovsmose, 2007; Botha, 2011; Reddy et al., 2015). Jablonka (2003) explains that the context in which Mathematical Literacy is applied sometimes requires higher order mathematical skills, while McCrone and Dossy (2007) believe that Mathematical Literacy should be promoted even in classes in which Mathematics is not the subject ostensibly being taught, in order to make Mathematics relevant and to enable it to empower all learners. In the way in which the subject is taught in South Africa, Mathematical Literacy focuses on making sense of real-life contexts and scenarios (DoE 2011a, p. 9) and requires an understanding of only basic mathematical concepts and calculations, and does not require an understanding of complex or abstract mathematical principles (DoE, 2011a, p. 11).

### 2.7.1 Education in Mathematics in India

The spirit of modernity and development in nations is generally reflected in their investment in the education of their children. While education in the natural sciences is often termed as an investment made by society in the envisioned future, education in the “high road of mathematics” could be said to constitute its hope for the yet to be envisioned future. Presidents and prime ministers are often heard reminding their people that education in the sciences and Mathematics are needed to equip the youth of the nation to meet the challenges of the ”new economy”. Modern nations place great value in fostering a mathematically literate society and aim to promote the growth of mathematically advanced intellectual elite which is able to shape the knowledge economy of the 21st century. At the same time, proficiency in Mathematics is universally considered to be difficult to achieve (Ministry of Human Resources Development (MHRD), 1986, 1993; National Council for Education for Research and Training (NCERT), 2005; 2006b; National Board of Higher Mathematics, 2012; University Grant Commission (UGC), 2011; 2012).

Although India, with its strong mathematical tradition, could be expected by the world to produce excellence in Mathematics, this may be an unreasonable expectation, as the country is grappling with problems of endemic poverty, and even universalising education presents significant problems. However, despite adversities of this sort, India has managed to produce mathematicians such as Ramanujam and Harish-Chandra. Taken together, these facts make up an intriguing picture.

Apart from the expectations of the global elite, the hopes and aspirations of the Indian people themselves need to be considered. In a population which is largely poor by the standards of almost any country in the world, education is perceived to hold the key to breaking out of poverty. As many adult education programmes in India have demonstrated, the illiterate poor regard the ability to calculate, to estimate and to predict as essential skills that education is able to impart, skills whose natural home in the school curriculum is mathematics. However, there appears to be a general sense of disappointment that school education does not, in fact, impart skills of this sort. In a public hearing in 2006, in which a curriculum group met members of the general public, a grocer bitterly complained that he could never find educated young recruits who could calculate when stocks would need to be replenished and what the quantities should be.

Education in Mathematics in India appears to be characterised by a combination of serious problems in the educational system, and a growing population of young people who approach them with a sense of hope, in a land of many innovations and initiatives, and a system which appears to operate rather chaotically. The following sections of the study will endeavour to provide a bird’s eye view of the vast landscape of education in Mathematics in India (MHRD,1993; NCERT, 2006b; National Board of Higher Mathematics, 2012; UGC, 2011; 2012).

## 2.7.1.1 Obstacles encountered by the educational system

The landscape of education in Mathematics in India requires a very broad vision to encompass and comprehend it effectively. It is not only a matter of scale and magnitude in terms of the numbers of children and teachers which constitute the system, but the system itself is also messy, as it has democratic modes of functioning in which there are pulls from many social and political quarters of society. As it is desired that every child should learn Mathematics and enjoy the subject, the reality of achieving this by democratic means with many millions of children and teachers presents huge, if not insurmountable obstacles and encumbrances to the successful functioning of the system. Before an investigation is made into how this state of affairs affects education in Mathematics specifically, it is essential to acquire an understanding of the vast system in which instruction in the subject is provided.

The law known as the Right of Children to Free and Compulsory Education Act, which is often abbreviated to the Right to Education or RTE Act, came into force in India on April 1, 2010. It guarantees 8 years of elementary education to every child in the age group between 6 and fourteen years in an age-appropriate classroom in the vicinity of his or her neighbourhood. According to the National Board of Higher Mathematics (2012) and the UGC (2011; 2012), this right also implies the right of every Indian child to a high standard of education in Mathematics.

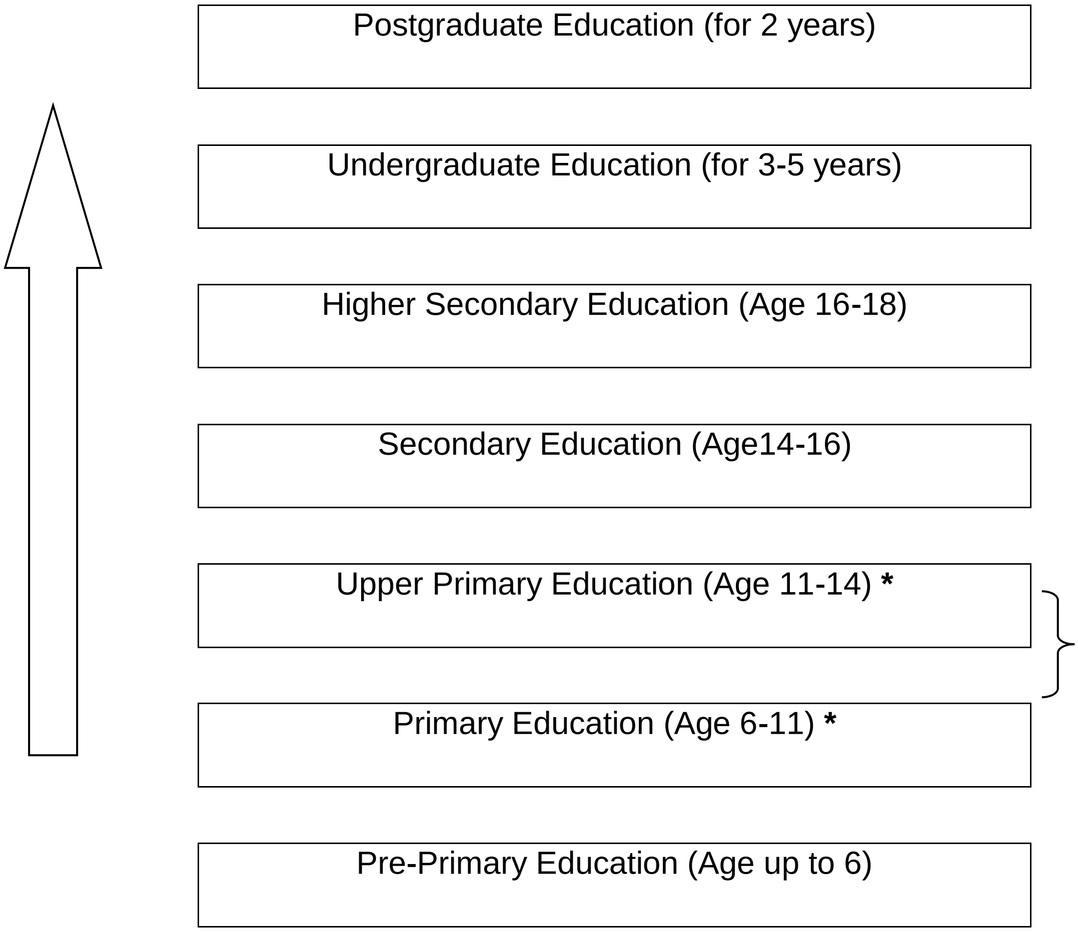
#### 2.7.1.2 Education in Mathematics on the Indian subcontinent

Education in India is provided and controlled by 3 administrative levels, namely, the central government in Delhi, the state governments and local authorities, which are largely private. Education is regulated by both the central government and the individual states, which has crucial implications for designing and implementing curricula and pedagogical practices, policies for hiring and training teachers, monitoring schools, setting standards and ensuring that they are maintained and the procedures for certification and ensuring the overall health of the system. The various states are responsible for these functions, with the central government playing a largely regulatory role while assisting with funding. This structure simultaneously enables many decentralised initiatives, but it also serves to challenge attempts to reform education at the national or centralised level.

The linguistic and cultural diversity of the Indian subcontinent accommodates a range of voices and approaches and offers multiple ways of teaching and learning Mathematics. Many states in India are geographically as large as some European nations and often larger in population. Education within these states is administered through further divisions of educational districts, but there is little decentralisation within the state. Curricula and pedagogical approaches and procedures are not designed and developed at the local level, and the state educational authority is as remote as the central government from the viewpoint of a school. While this system enables curricular homogeneity, it tends to stifle local pedagogic ingenuity (Ministry of Human Resource Development (MHRD), 1993; National Council for Education and Training (NCERT), 2006b; National Board of Higher Mathematics, 2012; UGC, 2011; 2012).

## 2.7.1.3 The structure of the Indian educational system

India’s education system is structured in developmental stages from the pre-primary to the post-graduate levels, as is shown below:




(National Board of Higher Mathematics, 2012; UGC, 2011, 2012)

## 2.7.1.4 Elementary education in India

Elementary education, which comprises the primary and upper primary stages, is managed separately from secondary education, which includes the higher secondary level. Undergraduate education typically entails 3-year courses, with between 4 and 5 years being required for professional degrees. Universities are regulated centrally but managed within their individual states, with a system of affiliated colleges providing undergraduate education.

The Ministry of Human Resource Development (HRD) governs the overall Indian education system, with each state government having its own Education Ministry and a Central Advisory Board of Education providing the platform for exchanges between the central government and the various states and also for those between individual states. There are forty-three Boards of School Education in the country, which formulate syllabuses, train teachers and offer certification. For school education the National Council of Educational Research and Training (NCERT) is the highest ranked body for curriculum-related matters, but except for the Central Board of Secondary Education (CBSE), for which it designs curricula, its role is largely advisory with respect to the other boards of education. At the university level, while each university formulates its own curricula, the University Grants Commission regulates their functioning. There is a vibrant Open University system and also the National Institute of Open Schooling, which seek to provide access to education in a manner which cuts across the potential barriers formed by these structures (National Board of Higher Mathematics, 2012; UGC, 2011; 2012).

### 2.7.1.5 Numbers of learners to be educated in India

Even a cursory look at the numbers involved indicates the daunting nature of implementing a system of education in a country having a population as immense as that of India, but, for the purposes of this discussion, only data from primary education will be considered.

**Table 3: Numbers for primary education in India (in millions, as of 2009)**

| | Total | Number in rural areas |
|---|---|---|
| Number of children (ages 6-11) | 134 (boys-69, girls-65) | 108 |
| Number of schools | 1.28 | 0.8 |
| Number of teachers | 5.8 | 4.5 |

(UGC, 2012)

The numbers reveal a picture of a large education system, with a significant rural sector and millions of girls who do not appear to be receiving primary education. That the government is the main provider of education to the population becomes evident when it is considered that, of the 1.28 million schools, 1.03 million are government-run. Of these, 0.8 million have classes only for the primary stage and 0.23 million have classes up to upper primary levels. The average number of teachers in a primary-only school is 2.98 and 6.96 for schools which have Classes 1 to 8.The average pupil to teacher ratio is thirty-six for primary-only schools and thirty-three for schools with both primary and upper primary levels (UGC, 2012).

### 2.7.1.6 The quality dimension of education in Mathematics in India

Why should it matter for the teaching of arithmetic and basic algebra whether the number of schools is one thousand or one million? If a threshold value of n possibly amounting to 3 or 4 is employed, perhaps teaching Mathematics to $10^m$ children entails the same amount of effort per teacher as $10^n$ children for any value of $m>n$. To a certain extent, this viewpoint is embedded in much of the educational administration in India, and educators in Mathematics are deeply aware of the harm which attitudes of this sort can cause to children's education.

According to some Indian scholars, the central challenge of Indian education lies in dealing effectively and appropriately with the metaphorical triangle of *quantity, quality* and *equality.* The state sector in education is beset by major shortages and an uneven distribution of resources, which is made particularly evident by the high percentages of single classroom schools, which can be as high as 38 percent in large populous states such as Andhra Pradesh. Such extreme shortages of resources impose great constraints on the quality of education. Much worse, and especially relevant to education in Mathematics, is the lack of qualified and committed teachers. No system can perform at higher levels than those of the quality of its teachers, and content knowledge of Mathematics is crucial for teaching the subject. Set against this consideration is the data that nearly 43 percent of teachers in elementary education in India do not possess a college or university degree of any kind, let alone an appropriate qualification in Mathematics (UGC, 2012).

Indian society is riven by divisions, which presents great difficulties for maintaining quality and ensuring equality in education. As studying Mathematics is compulsory, access to high quality education in Mathematics becomes the right of every child. On the other hand, there is a considerable amount of research which, although it is not specific to classrooms in which Mathematics is taught, suggests that the preconceptions, bias and behaviour of teachers results in discrimination against children from the groups with low socio-economic status, the so-called Scheduled Castes (SCs) and Scheduled Tribes (STs).

Mention has been made of the missing millions discerned among girls at the primary level. Those girls who do attend school are also subjected to social discrimination. In rural areas preconceptions such as that of Mathematics being “unnecessary” for girls can be detected, even among teachers. Despite the better performance by girls than boys in Board examinations in recent years, the stereotype that boys are better at Mathematics than girls appears to persist (UGC, 2012).

The social context of Indian education is reflected in the sharp disparities between different social and economic groups, which are reflected in the rates of school enrolment and completion. Consequently, girls belonging to SC and ST communities among the rural and urban poor and the disadvantaged sections of religious and other ethnic minorities are most vulnerable with respect to disparities in education, which is confirmed by data supplied by the National Board of Higher Mathematics (2012) and the UGC (2011, 2012).

Set against such a bleak picture is also hope, arising from several wellsprings of activity:

- Against all odds and amidst extreme diversity, we find children who take to Mathematics and teachers who are committed to education in Mathematics.

Although statistically small, they still make up a large number, given the size of the Indian population.

- While social barriers present great obstacles, the confidence and energy released by overcoming them is very positive. As Mathematics is a discipline of thought which does not have a great need for texts, laboratories and other paraphernalia, and as it is also a discipline which greatly inspires confidence and self-esteem in those who are able to master it, it becomes an instrument which can be used to break out of adversity for children from these disadvantaged sections of the population, and particularly for girls.
- Southern India has seen how the growth of computing and Information Technology industry offers a sense of hope to people. Possibly as a result of popular perceptions of computing, there has been a surge in interest in education in Mathematics. Associated with this phenomenon is a noticeable increase in participation in learning mathematics among girls and children from underprivileged sections of society.
- The educational reform process initiated during the past decade has seen great changes and upheavals across the country with respect to school Mathematics, in terms of attitudes and approaches to the subject. Although it may be too early to tell whether these efforts will lead to radical shifts, the trend is nevertheless a positive one.
- Finally, the dramatically increased use of technology, which has only recently become a significant factor, may help India to solve some of the problems in the educational system which has been discussed in these sections (UGC, 2012).

## 2.7.1.7 Educational reforms

Although Mathematics has been regarded as an essential part of any school curriculum from early on, perspectives have differed considerably. While the Zakir Hussain Committee of 1937 viewed education in Mathematics in relation to work, the National Policy on Education in 1986 characterised the subject as a “vehicle to train a child to think, reason, analyse and to articulate logically”. Although the form of education in Mathematics has, to a large extent, remained unchanged over the past fifty years, in recent times, in response to global curricular changes, India too has seen a considerable curricular acceleration in school Mathematics. For example, calculus, which had been taught only at the college or university level 3 decades ago is now taught at the higher secondary level. On the other hand, projective geometry has almost entirely disappeared from the school curriculum. At the undergraduate level, the core curriculum remains much the same, although the influence of computer science and other modern disciplines can be seen in the mix of courses which is on offer (UGC, 2012).

Through all of these changes and developments, a single strain has been persistent, namely, the experience of anxiety and failure which is commonly associated with Mathematics. Excessive use of procedure and the pressure of Board examinations and entrance examinations for access to prestigious institutions have created a culture of highly competitive preparation among the urban elite, which has taken a toll on the meaningful teaching and learning of Mathematics. On the other hand, in almost all Boards if there are specific disciplines in which significant numbers of failures are recorded, Mathematics is principal among them. It is referred to as the ”killer” subject and studies have shown that a large number of children have been failing or dropping out before completing elementary school because they could not cope with the demands of the curriculum.

Towards the end of the last century, a perception that education in Mathematics was becoming increasingly burdensome and ineffective had gathered momentum. The Report titled “Learning Without Burden’ (Ministry of Human Resource Development, 1993) had pointed out that children were not in fact”dropping out”, but were being ”pushed out”, owing to the ”burden of non-comprehension”, as a result of an irrelevant curriculum, whose concerns were remote from the lives of the majority, and often rendered ”boring and uninteresting” by out-dated teaching strategies. This shift from the conventional ”deficit theories”, which attribute the inability of children to learn to some ”deficit”’ in their mental abilities or their home background, resulted in a critical review of the curriculum and the traditional teaching and learning processes, which had been based on rote memorisation of facts (UGC, 2012).

The National Curriculum Framework (henceforth “NCF 2005”’) responded to this directive and guided the development of new curricula and textbooks based on how children actively construct knowledge, rooted in social and cultural practices (National Council for Educational Research and Training (NCERT), 2005).The NCF 2005 position paper on the teaching of Mathematics (NCERT, 2006a) begins by explaining that the primary goal of education in Mathematics is the “mathematisation of the child’s thought processes” and the development of the “inner resources of the growing child.” It goes on to argue for a “shift from content to process”, recommending a multiplicity of approaches, to liberate school Mathematics from the “tyranny of the one right answer obtained by applying the one algorithm that has been taught”. It emphasises the need for processes such as “formal problem-solving, the use of heuristics, estimation and approximation, optimisation, the use of patterns, visualisation, representation, reasoning and proof, making connections and mathematical communication”.

As a consequence, many Boards of Education in the various states undertook curricular review exercises, as a result of which the last few years have witnessed a great number of dramatic changes. Although the lofty goals articulated by the NCF 2005 may be difficult to achieve, some significant shifts have been discernible in textbooks and pedagogic processes, particularly in the field of elementary education. However, secondary education, weighed down as it is by the shadow of Board examinations, remains very difficult to reform.

The Board examinations at the end of their school careers remain landmark events in the lives of children, and, as passports to economic mobility, they have a crucial influence on attitudes towards education. These examinations cast long shadows and inordinately influence classroom assessment. In fact, the traditional pattern of examinations in Mathematics has been a matter of serious concern, as it has not only served to intimidate children, but it has often also discouraged more creative teachers, as their efforts in the classroom to encourage independent thinking, interpretation and analysis tend to be obliterated by the focus on procedural questions which are devoid of meaning and contextual relevance. In this context, the pressures of a democratic society on the results of Board examinations also need to be acknowledged. When single subject failures tended to be high in Mathematics, the pressure to set examinations which fewer pupils failed became pronounced. This development has resulted in a situation in which pass rates have increased among those who sit the Board examinations, while many give up and drop out much earlier. This assessment implies that improved pass rates in many of these examinations may not necessarily attest to high competence or mastery of the subjects in question (National Board of Higher Education, 2012; UGC, 2012).

In order to find a solution to problems of this sort, in many parts of the world students have been streamed into Basic Mathematics and Advanced Mathematics courses, with the former providing a variant of what is known as Mathematical Literacy in South Africa and entails the development of skills which the state considers essential for its citizens, and the latter being dictated by disciplinary objectives. However, a solution of this would be problematic in India, as it would inevitably be perceived as being yet another form of social discrimination, with the Advanced Mathematics course simply not being offered in many of the schools which children from the poorer sections of the population attend. In fact, this very state of affairs prevailed in many states in India in which there was streaming until the 1960s.In a society which is already deeply riven by many social schisms, the possibility that the rights of disadvantaged children to a high standard of education in Mathematics might be subverted presents a problem of great magnitude (National Board of Higher Education, 2012; UGC, 2012).

The reforms which have been discussed have come about because outside of the formal educational system the country has had a range of educational initiatives, which have been mainly experimental and small-scale, but which have nevertheless been carried out by passionately committed educationists. The valuable lessons obtained from their work have contributed significantly to the process of national reforms. Pioneering work of this sort is still visible in India, across geographic regions, from the level of primary schools to that of university education (National Board of Higher Education, 2012; UGC, 2012).

## 2.7.1.8 Higher stages of education in India

Although elementary education has been covered at considerable length and the situation in both secondary and tertiary education is similar, the fact that India has the third largest higher education system in the world, after China and the USA, suggests that a great deal of emphasis is placed on the importance of Mathematics.

According to “India 2009: A Reference Annual” (Ministry of Information and Broadcasting, 2009), India has twenty universities which are run by the central government and two hundred and fifteen which are run by states. In addition, there are one hundred autonomous institutions which are deemed to be universities which do not receive their funding directly from the government. Almost sixteen thousand colleges are affiliated to these universities, among which are one thousand eight hundred which are exclusively for women.

India is also home to various institutions in which world class research in the field of Mathematics is carried out. A group of highly advanced Indian mathematicians has been contributing to the development of many areas of Mathematics. The legendary genius, Srinivasa Ramanujam, has inspired generations of young Indians to take up mathematics as a calling.

India boasts institutions of technology and medicine which have been globally acclaimed for their standards of undergraduate education. These, the boom in the Information Technology industry and the resulting generation of employment during the last two decades, have resulted in a great deal of emphasis being placed on training in Mathematics, and the nation is striving to expand its pool of scientifically-equipped manpower (National Board of Higher Education, 2012; UGC, 2012).

This endeavour has created a situation in India in which higher education in Mathematics forms a very sharp pyramid. A few elite institutions offer excellent opportunities for research in Mathematics and a small number for education in Mathematics as a component of courses in technology or engineering education, or, in some instances, management studies. However, among the large number of universities and the vast number of affiliated colleges, which provide the bulk of tertiary education in Mathematics, there is an overall rigidity in curricula, pedagogy and the modes of assessment, which often serve to make education in Mathematics ineffective, which adversely affects the prospects of developing a potent pool of teachers of Mathematics for the future. Small innovative initiatives towards developing a meaningful interactive pedagogy at the undergraduate level provide hope for solving this problem on a larger scale in the future (UGC, 2012).

### 2.7.1.9 The major challenge for education in Mathematics for India

If one were to asked to isolate and to point to one single challenge as the most important among the plethora of problems which have been mentioned, it would have to be that of creating a sufficiently large pool of good teachers of Mathematics. Although the numbers exist at the elementary stage, many do not have the required understanding of Mathematics, the correct attitude towards the subject or comprehension of how children learn or fail to learn Mathematics. The social inequalities in India and the rural schools, which are poor in resources, call for even greater competence on the part of teachers than are required by richer, more democratic societies. This state of affairs calls for new modes of developing teaching professionals, which have yet to be formulated (UGC, 2012).

At the higher education stages, the numbers are daunting. The existing pool of teachers is woefully inadequate for meeting the requirements of education in Mathematics, particularly in view of the likelihood of the universalization of school education becoming a conceivable reality within a generation. Owing to the numbers, the problem of rigour and depth in mathematical knowledge and practice becomes more acute. Devising systemic measures in order to achieve adequate standards of quality in the preparation of teachers is perhaps the most urgent need in education in Mathematics in India today (UGC, 2012).

Extensive research needs to be conducted in the field of education in Mathematics in India. Although university departments conduct research in education, as a result of their typical structure, they tend to attract mainly people who are neither trained in nor inclined towards Mathematics. In addition, the idea of research providing solutions to curricular conundrums or pedagogical problems remains outside of the framework of decision-making in education. This is not said to belittle the tremendous contributions made by both governmental and non-governmental initiatives towards reforms which have been characterised by innovation and commitment. However, these reforms do not yet rest on a scaffolding of research and rigorous critique. The system needs to develop a way of actively pursuing research on several fronts towards well-formulated questions and to use the answers to influence policy. At this point it needs to be added that India provides a sufficiently large arena, in which there is a degree of diversity which is without parallel in almost any other country in the world, to provide a self-contained universe for analysis and research, and that international influences can only add to this richness (National Board of Higher Mathematics, 2012; UGC, 2012).

The challenge of providing education in Mathematics, which is of a sufficiently high standard for all, at the school level, is immense and the country needs to put a great deal of effort into the necessary development in order to achieve this.

- The need for a large body of teachers with expertise in Mathematics and training in Pedagogy is acute.
- Although the government is the central player in Indian education, it is not monolithic.

India’s diversity has also given rise to a range of innovative initiatives, some of which are small, some of which are large and some of which have come from the government (National Board of Higher Education, 2012; UGC, 2012).

Although the problems which are endemic to the system for providing education in Mathematics in India are many, many of them are not dissimilar to those which are encountered in other societies and nations. The immense size and diversity of the Indian subcontinent, its low levels of resources and an almost ungovernable polity all serve to complicate the problems, but the sense of hope which prevails suggests that India may yet solve these problems, which obliges us to take a hard look at Mathematics, not only in terms of curricula to cope with the diversity of the population and pedagogical approaches to be adopted for providing instruction in widely varying settings, but also within a social context.

When India is able to provide a high standard of education in Mathematics for all, education in Mathematics as a discipline would have acquired new insights and new formulations with which to work (MHRD, 1986, 1993; NCERT, 2005; 2006b; National Board of Higher Mathematics, 2012; UGC, 2011; 2012).

As was emphasised in Chapter 1, Indian society, with its cultural and work-based practices, also offers avenues for mathematical explorations which a pedagogue could incorporate into a toolkit. However, a body of research needs to be developed in order to make realistic use of such possibilities. . (http://nime.hbcse.tifr.res.in/articles/01_Ramanujam.pdf).To conclude this section, Mathematics is perceived to have sufficient importance and significance as a school subject in India that all learners are required to study it.

## 2.7.2 Education in Mathematics in Australia

### 2.7.2.1 Australian students slipping behind in Mathematics (OECD report updated on December 04, 2013; Education at a Glance, 2013)

A new report which compared Australian high school students with their counterparts in sixty-five other countries shows that the nation is slipping still further behind in Mathematics. The 2012 PISA measures the skills in Mathematics of half a million fifteen years-olds in countries throughout the world. It found that Australians placed seventeenth in Mathematics and those Asian countries, such as China, Singapore, Korea and Japan, are pulling ahead of Australian students. The results show that the performance of Australian students is slipping by a margin of approximately half a year of schooling, compared with 10 years ago. The decline was more pronounced among girls than among boys, with girls dropping to the OECD average. The report also found significant differences among students in different parts of the country. Tasmania and the Northern Territory logged well behind other states. Approximately fourteen thousand five hundred Australian students from nine hundred and seventy-five schools were measured in the assessment, which was conducted by the Australian Council for Educational Research (ACER) for the OECD. Gender, indigenous status and socio-economic status still tend to determine the levels of performance among Australian students, as those from wealthy backgrounds show a difference of approximately 2-1/2years of schooling compared with students from the lowest socio-economic group (OECD, 2013; Education at a Glance, 2013).

In 2008 all Australian regional governments agreed that instead of the 8 different arrangements, a single unified national curriculum was to be implemented in 2013, which would play a key role in delivering education of the desired quality (Australian Curriculum, Assessment and Reporting Authority, n.d.). Queensland is the second largest region and a study of the Education Department of Queensland provided insights into the role which numeracy plays in the educational system of Australia.

According to the PISA 2003 results, in which the focus was on Mathematics, Australia came twelfth out of forty-one countries (OECD, 2004). In the TIMMS of 2007 they came fourteenth out of the fifty-eight participating countries for learners in Grades 4 and8 (National Centre for Education Statistics, 2008). For the past few years the raising of the numeracy levels of Australian learners has received serious attention. Numerous documents and guidelines are available to parents, which supply them with information concerning numeracy and providing guiding principles for supporting their children to develop their numeracy ((OECD, 2013; Education at a Glance, 2013).

In a document titled “Numeracy: Lifelong Confidence with Mathematics-Framework for Action 2007-2010”, which serves as an action plan to improve numeracy education, the Minister for Education and Training declared that the Queensland Government (QG) recognises numeracy as a key pillar of learning and an essential component (QG, 2007b, p.1) of their curriculum. He also said that teachers have an important role to play in helping learners to become confident appliers of mathematics in their everyday lives. A Queensland Certificate in Education (QCE) is awarded at the end of Year 12 to a person who, in addition to achieving twenty credits in the required pattern of learning, has met the requirements for literacy and numeracy. Learners can meet QCE numeracy requirements by satisfying a number of possible options, including a good pass in one of their 3 mathematics subjects at school and passing a short course in numeracy which was developed by the Queensland Studies Authority (QSA, 2009b, p. 1). Although numeracy is clearly an important component of the Queensland school curriculum, there appears to be no clearly articulated indication or description of a connection between Mathematics and numeracy in this curriculum ((OECD, 2013; Education at a Glance, 2013).

### 2.7.2.2 Mathematics and Numeracy

The QSA (2009a) provided a clear explanation of Mathematics with respect to numeracy by explaining that the focus of Mathematics is on the development of the knowledge of learners and on ways of working in a range of situations, from real life to the purely mathematical, whereas numeracy refers to the confident use of mathematical knowledge and problem-solving skills, not only in the Mathematics classroom, but across the school curriculum and in everyday life, work or further learning (p. 9). In the definition of numeracy provided by the Queensland Government (QG, 2007b), it is explained that to be numerate is to be able to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life (p. 2). Mathematics and numeracy are interrelated and it is the responsibility of the Mathematics curriculum to introduce and develop the mathematics which underpins numeracy (QSA, 2009a, p. 9). As numeracy refers to the ability to use mathematics to solve life-related problems, it is essential to determine the contexts in which mathematics could be applied and what the role of the teacher is in developing the skills of learners in this regard.

### 2.7.2.3 The milieu of teaching Numeracy

In Years10 to 12, which correspond to Grades 10 to 12 in South Africa, Numeracy relates to specific context across a broad range of work and study options (QG, 2007a) and involves:

- Applying mathematical skills in new contexts such as analysing data to inform decision-making, deciding how to estimate or calculate an answer, depending on the purpose and calculating dimensions and quantities of materials in vocational tasks, such as construction or hospitality.

- Selecting, sequencing and evaluating information in order to understand texts and to communicate with other people.
- Using particular communication skills needed to participate effectively in the workplace, such as industry terms and customer services (QG, P.1).

Teachers are the key role players in the selecting of contexts which are relevant to the learners. They need to recognise numeracy demands and opportunities within the curriculum (QG, 2007b, p. 10) which enable learners to develop their numerical knowledge, skills and confidence. In this endeavour, teachers are required to create opportunities intentionally in which learners can, among other activities, explore mathematical ideas with concrete or visual representations and hands-on activities; experience practical and contextualised learning; communicate about mathematical issues; develop calculator and computer skills and use multiple solution strategies (QSA, 2006). According to the Queensland Government (QG, 2007b), the understanding of the content of Mathematics as a subject, on the part of teachers, needs to be developed with respect to the nature of Mathematics as a discipline, the mathematically-related topics which they teach, the relationship of those topics to further learning and everyday life and the impact of information and communication technologies on the teaching and learning of Mathematics (p. 4).

If the national curriculum documents of Australia, the UK and Ohio and North Carolina in the US are compared, it becomes evident that Australia accentuates the importance of mathematical literacy in an education system. Through their national documents for learners, schools and parents, they drive an intensive awareness campaign in order to raise the levels of numeracy among their learners. Regardless of the terminology which may be used, numeracy, functional mathematical skills and quantitative literacy are embedded in Mathematics and involve the competency or skill to use and apply Mathematics to solve contextualised problems (Botha, 2011).

### 2.7.3 Education in Mathematics in China

Education in Mathematics in China has its own unique history, cultural contexts and national characteristics. By studying the past, present and future of education in Mathematics in China, particularly in the elementary classes, we are able to learn from the successes and mistakes of the past, to find solutions to existing problems and to prepare for the future (Dianzhou, 2003; MoE, 2001; Dauben, 2010; Yang, 2012).

### 2.7.3.1 China's present unprecedented curriculum reforms

The present reforms, which promote training in specific abilities, constitute the eighth reforming of the elementary curriculum since the establishment of the People's Republic of China. The scope, intensity and speed of these reforms have no precedent. The Mathematics Curriculum Standards for Full-Time Compulsory Education (hereafter abbreviated to Mathematics Curriculum Standards) were first written in 1999 and underwent many revisions before they were announced in March of 2001 (Ministry of Education of China, 2001). In the autumn of 2001, the teaching material which had been compiled according to the Mathematics Curriculum Standards was introduced in thirty-eight experimental districts, among four hundred and twenty-seven thousand students. By the end of 2003, the nation had one thousand eight hundred and forty-two experimental districts and thirty-five million students were using the new teaching material. All first grades in China were due to begin to use it by the autumn of 2005 (Dianzhou, 2003; MoE, 2001; Dauben, 2010; Yang, 2012).This development is relevant to one of the research questions in this study, which concerns adequate resources.

The Mathematics Curriculum Standards comprises of 4 parts, namely, the preface, the goals of the curriculum, the standards for content and suggestions concerning the ways in which the standards should be applied (Dianzhou, 2003; MoE, 2001; Dauben, 2010; Yang, 2012).

**Preface**

Purpose: The Mathematics curriculum should emphasise basic concepts, the generalisation of knowledge and future development. Education in Elementary Mathematics is intended for every child and not to be the sole preserve of a privileged elite. Although every student is intended to learn useful mathematical skills and to acquire necessary basic concepts, students will develop at differing rates in Mathematics.

Design: Compulsory education is divided into 3 phases. The first is for Grades 1 to 3, the second for Grades 4 to 6 and the third for Grades 7 to 9. For each phase, objectives for knowledge and skills, mathematical thinking, problem-solving and learning attitudes are elaborated in the standards.

**Goals of the curriculum**

The Mathematics Curriculum Standards sets overall goals and goals for each phase of compulsory education. The overall goals are:

- Through studying, students should be able to acquire essential mathematical knowledge and necessary skills, which will both promote their development and prepare them for their future lives.

- Students should learn to apply mathematical thinking to everyday life and to their studying of other subjects.

- Students should learn the value of mathematics and feel the close relationship between mathematics, nature and human society.

- Students should develop their creativity, practical abilities and personalities, through learning Mathematics (Dianzhou, 2003; MoE, 2001; Dauben, 2010; Yang, 2012).

**Guidelines with respect to content**

For each phase, content guidelines have been established for Number and Algebra, Space and Graph, Statistics and Probability, and Practice and Applications. The content of Number and Algebra includes numbers and arithmetic, equations and inequalities and functions. The content of Space and Graph includes the shape, size spatial positions and transformations of all planar or solid geometric objects. The content of Statistics and Probability includes studying real-life data and their randomness. Practice and Applications is mainly intended to help students to synthesise and make effective use of their knowledge and experience. Through self-exploration and cooperation, students are expected to solve challenging and comprehensive problems with applications which are close to real-life scenarios, to develop their problem-solving abilities, to deepen their understanding of the content covered in Number and Algebra, Space and Graph and Statistics and Probability, in order to appreciate the interrelationship which exists among all of the various aspects of Mathematics (Diaozhou, 2003; Dauben, 2010; Yang, 2012).

**Suggestions for successful implementation**

In order to guarantee its successful implementation, Mathematics Curriculum Standards offer suggestions for teaching, appraisal, the compiling of teaching material and the development and use of the resources of the curriculum (Dianzhou 2003); (MoE 2001).These suggestions are relevant to the research questions in this study.

The Mathematics Curriculum Standards have the following characteristics

- Through the transformation of the function of education, the Mathematics Curriculum Standards strive to embody "knowledge and skills," "process and methods," and "emotional development and values" as comprising the function of education. The emphasis in education is shifted from imparting knowledge through indoctrination to developing learning ability.
- By breaking from the old course system, some old, complex, difficult, and eccentric course contents have been replaced by carefully selected basic knowledge and ability training which enables students to prepare for their life-long learning. The content of textbooks moves closer to the everyday life experiences of students, the development of modern society and the new achievements of science and technology.
- The emphasis on improving the methods of both teaching and learning Mathematics promotes an interactive process between teachers and students, through which both parties communicate and improve together. The teaching of Mathematics should start from the life experience and pre-existing knowledge of students, create lively and interesting scenarios and guide students to observe, experiment, conjecture, deduce and communicate. Through mathematical activities, students become able to master basic knowledge, develop skills, learn to observe and to analyse phenomena and motivate themselves to learn. Students are the masters of mathematical learning, while teachers are the organisers, guides and collaborators.

- By placing emphasis on comprehensive appraisals of the learning of students, the Mathematics Curriculum Standards emphasise that in order to assess learning, teachers need to pay attention to the development of students and to gather information concerning all aspects of learning, not only the proficiency displayed by students, but also the emotions, attitudes and personalities which are displayed during their learning. Appraisal enables the performance of students in mathematical tasks and activities, particularly their abilities in problem-solving, innovation and the application of knowledge, to be assessed and evaluated.
- By emphasising the need to make use of new technologies, the Mathematics Curriculum Standards encourage students to use calculators for complex computations from the beginning of the second education phase, in order to enable them to put more energy into exploratory and creative mathematical activities. Students are encouraged to use calculators and computers as tools to acquire new knowledge and to solve general practical problems. The learning experience of students can be enriched by making use of various teaching aids, enhancing interaction between students and teachers and providing animated displays of the teaching content, (Dianzhou, 2003; MoE, 2001; Dauben, 2010; Yang, 2012).

The changes which have been made to the content of the curriculum lie mainly in the emphasising of particular aspects and the reduction of others. Emphasis is placed on enabling students to abstract mathematical models from practical problems, to explore the fundamental laws behind them and to acknowledge the diversity which exists in the ways in which problems can be solved. Requirements with respect to complexity and the speed of computation have been reduced. For example, students are no longer required to master the mixed arithmetic of fractions and decimal numbers before the seventh grade.

Both teachers and students embraced the reforming of the curriculum. In a poll conducted by the Ministry of Education of China, more than 90 percent of teachers expressed their understanding of and support for the reforms, and more than 95 percent of students indicated that they enjoyed classes in Mathematics more than before. The new reforms to the curriculum are being extended to the whole country by the Ministry of Education (MoE, 2001; Dianzhou, 2003; Dauben, 2010; Yang, 2012).

### 2.7.3.2 The future of education in Mathematics in China

Education in Elementary Mathematics in China has a strong cultural tradition, and it has accumulated rich experience during the course of the past several decades. Although it is anticipated that it will have even greater success after the implementation of the reforms, many problems have yet to be solved. Along with the development of modern science and technology, the value of use of mathematics will receive more attention from the public, as a digitised society makes high quality education in Mathematics essential. In addition to 9 years of compulsory education, most Chinese young people will study for a further4 years at high school, after which approximately 20 percent or more of the eligible age group will enrol in universities. Although almost all of the departments in the universities offer courses in Mathematics, with the steadily increasing population of students, the numbers of students who experience difficulties in learning Mathematics will inevitably increase. If the unacceptable differences in abilities are not dealt with effectively, it appears very possible that the "equally poor" effect which was experienced in other countries could also be felt in China (Dianzhou, 2003).

Although the reforming of education in Elementary Mathematics promises remarkable achievements for the future, they will be attained only through years or decades of effort. While the training of the past was characterised by solid and rigorous procedures, future emphasis will be placed on the development of creativity and ability to solve practical problems among students. Curriculum design will be centred on helping students to realise their true potential. Consequently, through learning Mathematics, students stand to improve and develop both academically and personally (MoE, 2001; Dianzhou, 2003; Dauben, 2010; Yang, 2012).

New models for education will continue to emerge. Students will play the central role in their learning of Mathematics and the role of teachers will be redefined. In future classes, the 5 Link teaching model will lose the popularity which it once had. In the past, 2 principal teaching models held sway in China. While one emphasised training through large volumes and high intensity of practice in problem-solving, the other emphasised classroom teaching using small incremental steps, quizzes, and detailed explanations of teaching materials. Both of these approaches will fade away. Students will have more interest in learning through self-motivated exploration, communication, collaboration, and creative thinking. As a result, Chinese students will extend their advantages in solving textbook problems to better mathematical modelling of practical problems. The role of teachers will be akin to that played by leaders, guides, collaborators and participants, as opposed to playing the active central role. However, the role of teachers as directors in the teaching of Mathematics will not change (Diaozhou, 2003; Dauben, 2010; Yang, 2012).

Modern technologies will be extensively adopted in the teaching and learning of Mathematics. In the near future, teachers will use computers, as they used blackboards and chalk in the past, and software designed to facilitate education in Mathematics will be popular. The majority of teachers will be able to develop their own teaching aids. Education in Mathematics will enter a new digitised era.

Education in Elementary Mathematics in China will develop its own styles and models with a clear scientific orientation and an emphasis on practice and experiments. Research in education in Mathematics will shift its emphasis from solving mathematical problems to a comprehensive study of the fundamental principles of mathematical education. The success of Chinese education in Mathematics will draw international attention, resulting in increased collaboration and communication between Chinese educators and those in other countries. It is to be hoped that the young generation of Chinese teachers of Mathematics will make a significant contribution to education in Mathematics, not only in China but also internationally (Diaozhou, 2003; Dauben, 2010; Yang, 2012).

In the PISA results of 2009, students in Shanghai, China, achieved the top scores in every category, Mathematics, Reading and Science(PISA 2009; 2012). While discussing these results, PISA spokesman Andreas Schleicher, Deputy Director for Education and head of the analysis division at the OECD’s directorate for education, described Shanghai as a pioneer of educational reform, in whose educational system "there has been a sea change in pedagogy". Schleicher explained that Shanghai had abandoned its focus on educating a small elite, and instead was working to construct a more inclusive system. The pay and training of teachers had been significantly increased, the emphasis on rote learning had been reduced and the focus of classroom activities was now on problem-solving (PISA 2009; 2012). Schleicher also explained that PISA tests which had been administered in rural China had produced some results which approached the OECD average. Citing as-yet-unpublished OECD research, Schleicher said, "We have actually done PISA in twelve of the provinces in China. Even in some of the very poor areas you get performance close to the OECD average." Schleicher maintained that, for a developing country, China's 99.4 percent enrolment in primary education is "the envy of many countries". He added that junior secondary school participation rates in China are now 99 percent and that in Shanghai, not only has senior secondary school enrolment raised to 98 percent, but admissions into higher education have reached 80 percent of the relevant age group. Schleicher believes that this growth reflects quality and not merely quantity, which he contends that the top PISA ranking of Shanghai's secondary education confirms. He noted that China had also expanded the degree of access to schools and moved away from learning by rote. According to him, Russia performs well in rote-based assessments, but not in the PISA, whereas China performs well in both rote-based and broader assessments, (PISA, 2009; 2012).

Critics of the PISA counter that in Shanghai and other Chinese cities, most children of migrant workers are allowed to attend city schools only up to the ninth grade, after which they are required to return to the hometowns of their parents to attend high school, as a result of restrictions, thereby skewing the composition of the city's high school students in favour of wealthier local families. A population chart of Shanghai, reproduced in The New York Times, shows a steep dropping off in the numbers of fifteen year-olds residing there. According to Schleicher, 27 percent of Shanghai's fifteen year-olds are excluded from its school system, and subsequently, from testing by the PISA. As a result, the percentage of Shanghai's fifteen year-olds tested by the PISA was 73 percent, which was significantly lower than the 89 percent tested in the US (PISA, 2009; OECD, 2012).

Education professor Yong Zhao noted that the PISA of 2009 did not receive much attention in the Chinese media, and that the high scores in China are the result of excessive workloads and testing, adding that it is "no news that the Chinese education system is excellent in preparing outstanding test-takers, just like other education systems within the Confucian cultural circle: Singapore, Korea, Japan, and Hong Kong" (PISA, 2009; OECD, 2012).

## 2.7.4 Education in Mathematics in the United States of America

The complexity of the problems which beset education in Mathematics in the US were discussed extensively in Chapter 1. In order to illustrate the nature of the overall problem, a short pre-test which highlights a number of prevailing myths concerning the condition of schools in the United States, which colour common perceptions of the problem. This simple pre-test is intended to provide a sense of how these myths operate. It consists of 5 common statements, some of which are supportable with evidence, while others are not. In order to obtain an accurate assessment of the condition of education in Mathematics in the US, the statements need to be examined and classified as being either myths or true statements.

Pre-test for identifying prevailing myths about the conditions of schools in the United States

- The United States system for providing education in Mathematics used to educate our nation’s young people much better than it does today.
- Problems in society, such as inequality, poverty and the eroding family unit, are so great that the schools are unable to cope.
- The education of teachers and Mathematics curricula are similar to those of fifty years ago.
- College and university programmes prepare teachers better than alternative routes into teaching do (Cohen, 2011; Ball, 2009).

### 2.7.4.1 Pre-test for identifying prevailing myths about the conditions of schools in the United States

The 4 pressing problems in education in Mathematics, discussed in Chapter 1, also provide an important measure for judging progress. From the vantage point of 10 years into the future, a better education system would not produce significant gaps in terms of academic achievement between, on one hand, underrepresented minority students and students living in poverty and, on the other, their white and middle-class counterparts. It is to be expected that the achievements of students should differ, because people differ from one another in many significant respects, but those differences should not be predictable on the basis of ethnicity or family wealth. Cohen (2011) and Ball (2009) maintain that although they are not an arguing that everyone should be treated the same or come out looking the same, in an acceptable, equitable education system, social identifiers would not be predictors of different levels of achievement. They identify gaps between the levels of achievement of the marginalised and the privileged as constituting the gap which needs to be eliminated (Cohen, 2011; Ball, 2009).

In addition, all students would have reliable access to high quality instruction in Mathematics, no matter who they are or where they live. The United States is far from this goal at present (Cohen, 2011; Ball, 2009). In the United States today, the likelihood that teachers understand Mathematics and are able to teach it skilfully to every student is generally low, and it is even lower in schools which serve underrepresented poor communities. The requirements appear to be less stringent for no other occupation in the country. When someone goes to a dentist for a root canal treatment, the dentist is expected to know what he or she is doing. If a hairdresser does not cut hair well, clients do not return. The situation for teaching is different, the target for teaching needs to be set for high levels of academic achievement by all students, and it needs to be maintained (Cohen, 2011; Ball, 2009).

In the United States learners take part in both the PISA study and the TIMSS. In the TIMSS 2007 results they took the eleventh position for the fourth grades and the ninth position for the eighth grades, out of the fifty-eight countries participating (National Centre for Education Statistics, 2008a).

Although the term “quantitative” is common in the discourse of US educators in Mathematics, it does not appear often in their curricula (J. Kilpatrick, personal communication, May 24, 2010). Kilpatrick is an expert, advisor, consultant and professor in Mathematics Education at the University of Georgia, who serves on various mathematical boards and councils. The US does not have a single national curriculum in Mathematics. While searching for the term “quantitative literacy” in the national curricula in the Departments of Education of Ohio and North Carolina, Kilpatrick eventually located a reference on the web page of the National Council of Teachers of Mathematics (2010), in which it was maintained that consumer mathematics should develop a broader quantitative literacy and should consist primarily of work in informal statistics, such as organising and interpreting quantitative information.

Instead of using the term ”mathematical literacy” when referring to the competency of applying mathematical knowledge to life-related problems, Australia and the UK generally use the term ”numeracy”, while the US refers to ”quantitative literacy” (Botha,2011).

## 2.7.4.2 Developing mathematicians

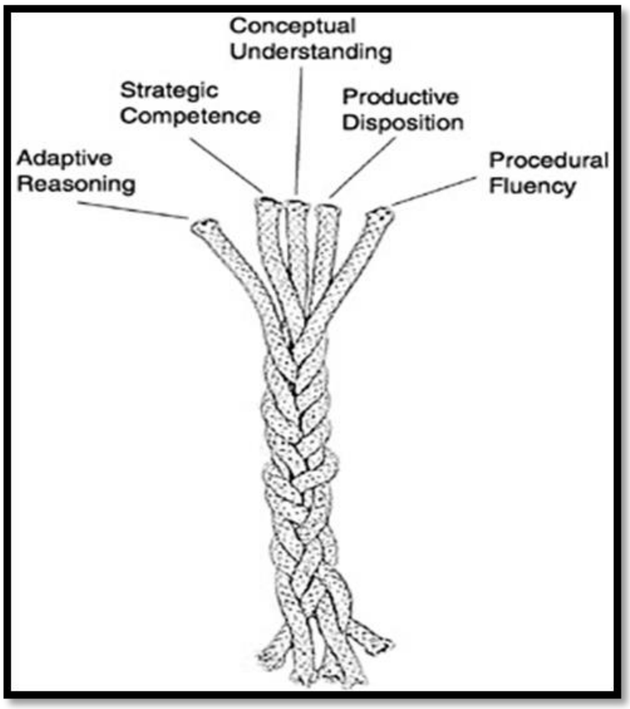



**Figure 5: The 5 strands of proficiency in mathematics (NRC, 2010; Kilpatrick, 2001; Graven, 2015)**

**Conceptual understanding** refers to the "integrated and functional grasp of mathematical ideas which enables the students to learn more ideas by connecting those ideas to what they already know". The building of conceptual understanding is beneficial, in that it supports retention and prevents common errors.

**Procedural fluency** may be defined as the skill required carrying out procedures flexibly, accurately, efficiently and appropriately.

**Strategic competence** is the ability to formulate, represent and solve mathematical problems.

**Adaptive reasoning** is the capacity for logical thought, reflection, explanation and justification.

**Productive disposition** is the inclination to see Mathematics as sensible, useful and worthwhile, coupled with a belief in diligence, (National Research Council (NRC), 2001; 2010).

Two studies have compared high achievers in Mathematics in the PISA and those in the U.S. National Assessment of Educational Progress (NAEP). Comparisons were made between those scoring at the "advanced" and "proficient" levels in Mathematics in the NAEP with corresponding levels of performance in the PISA. Overall, thirty nations had higher percentages than those of students in the US at the "advanced" level of mathematics. The only OECD countries with worse results were Portugal, Greece, Turkey, and Mexico. Six percent of US students were "advanced" in Mathematics compared with 28 percent in Taiwan. Massachusetts, the highest ranked state in the US, was ranked fifteenth in the world when it was compared with the nations participating in the PISA. Thirty-one nations had higher percentages of "proficient" students than the US. Massachusetts was again the best state in the US, but it ranked only ninth in the world when compared with the nations participating in the PISA (PISA, 2009; OECD, 2012).

Among the thirty-four OECD countries, the performance of the United States was below average in Mathematics in 2012 and the US was given a ranking of twenty-seventh, although this ranking was the best estimate, as it could actually be between twenty-third and twenty-ninth as a result of possible errors in sampling and measurement. Performance in Reading and Science were both close to the OECD average. The United States was ranked seventeenth in Reading, in a range of ranks between fourteenth and twentieth, and twentieth in Science, in a range of ranks between seventeenth and twenty-fifth. There has been no significant change in these levels of performance over time. The scores in Mathematics of the top-performer, Shanghai-China, indicate a level of performance which is the equivalent of over 2 years of formal schooling ahead of that found in Massachusetts, which is a high performer among states in the US. While the U.S. spends more per student than most countries, this expenditure does not necessarily translate to superior performance. For example, the Slovak Republic, which spends approximately USD 53 000 per student, performs at the same level as the United States, which spends over USD 115 000 per student. Slightly more than 1 in 4 students in the US do not reach the PISA baseline Level 2 for proficiency in Mathematics, a higher-than-OECD average proportion, which has not changed since 2003. At the opposite end of the proficiency scale, the US has a below-average share of top performers. Students in the United States have particular weaknesses in performing mathematical tasks which have high cognitive demands, such as taking real-world situations, translating them into mathematical terms and interpreting the mathematical aspects of real-world problems. An alignment study between the Common Core State Standards for Mathematics and the PISA suggests that a successful implementation of the Common Core Standards would also yield significant performance gains in the PISA (2012). Socio-economic backgrounds exert a significant influence on the levels of performance among students in the United States, with some 15 percent of the variations in the relative levels of performance among students being explained by this factor, which makes the US similar to the OECD average in this respect. Although the effects of socio-economic backgrounds have diminished over time, disadvantaged students continue to show less engagement, drive, motivation and self-belief than those from more affluent backgrounds. Students in the US are largely satisfied with their school system and tend to have positive perceptions of teacher-student relations. However, they do not feel strongly motivated to learn Mathematics: only 50 percent of students agreed that they were interested in learning Mathematics, which is slightly below the OECD average of 53 percent (PISA, 2012). US students are improving slowly in Mathematics and Science but still lagging internationally (Desilver, 2015).

### 2.7.5 Education in Mathematics in the United Kingdom

#### 2.7.5.1 Performance in Mathematics according to the PISA report of 2012

Students in the United Kingdom score an average of four hundred and ninety-four points in Mathematics, which corresponds with the OECD average and is comparable with the scores of the Czech Republic, Denmark, France, Iceland, the Republic of Ireland, Latvia, Luxembourg, New Zealand, Norway and Portugal. The mean performance in Mathematics has remained unchanged since 2006 and 2009.The proportions of top performers, which comprise those students who attain the proficiency Level 5 or 6, who are able to develop and work with models for complex situations, work strategically using broad, well-developed thinking and reasoning skills, and low performers, who comprise those students who do not attain the baseline proficiency Level 2, are similar to those of the OECD average. Students who do not attain the baseline proficiency Level 2 are able, at best, to extract relevant information from a single source and to use basic algorithms, formulae, procedures or conventions to solve problems involving whole numbers. In the UK the proportion of top performers was 12 percent, compared with an OECD average of 13 percent, while the proportion of low performers was 22 percent, compared with an average of 23 percent. Boys in the United Kingdom outperform girls in Mathematics by an average of twelve points, which is similar to the OECD average gender gap of eleven points. Scores for Mathematics in England and Scotland were similar, with averages of four hundred and ninety-five and four hundred and ninety-eight points, respectively. In both cases the scores showed little change from those of the PISA of 2009, in which they were four hundred and ninety-three and four hundred and ninety-nine points, respectively. The score for Northern Ireland was four hundred and eighty-seven, compared with a score of four hundred and ninety-two in the PISA 2009. As had been found in the PISA of 2009, performance in Mathematics in Wales was lower than that of the rest of the United Kingdom, with a score of four hundred and sixty-eight points, compared with one of four hundred and seventy-two points in the PISA of 2009 (OECD, 2012)

### 2.7.5.2 Performance of students in different areas of Mathematics

The United Kingdom's fifteen year-old learners do not show large differences in their scores on the three mathematical processes measured in the PISA. While they have the highest mean scores for interpreting, applying and evaluating mathematical outcomes, they have the lowest mean scores for formulating situations mathematically, and they perform close to their overall performance level for employing mathematical concepts, facts, procedures and reasoning (OECD, 2012).

Of the 4 mathematical content areas assessed by the PISA, UK students scored above their overall Mathematics score in *uncertainty and data* and recorded a similar score to their overall mathematics score in the areas of *change and relationships* and *quantity*. Their performance in *space and shape* was somewhat below their overall performance. These strengths and weaknesses may reflect differences in the priorities of the curriculum and in the course content which is available to fifteen year-olds. The *space and shape* subscale, in which UK students struggle the most, is closely linked to geometry, but also draws on other areas, such as spatial visualisation, measurement and algebra (OECD, 2012).

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### 2.7.6 Education in Mathematics in Kenya

Owing to the new policy on industrialisation, Kenya has the choice to begin to make changes in the Mathematics classroom, motivated by a real will to overcome existing problems. A report made by the Teachers Service Commission (TSC) identified a shortage of teachers of Mathematics and Science and an abnormally high rate of attrition among teachers of these subjects. Many teachers have left, either to teach in the better-paying private schools or to work in the private sector. In 1997 the government, through the TSC, attempted to stem this flow by paying teachers of ”special” subjects, including Mathematics and Science, a series of 3 increments, making them more highly paid than their colleagues who teach other subjects (Wanjohi, 2011; Eshiwani, 1993).

The Strengthening of Mathematics and Science in Secondary Education (SMASSE) national team embarked on a baseline study in pilot districts, in which video recordings were made, interviews were conducted and questionnaires were administered to all of the stakeholders in education. Students completed questionnaires which sought to obtain information concerning their experiences in Mathematics classes and were interviewed in order to evaluate their experiences at school. Head teachers were interviewed in order to obtain information concerning school policies and practices. Questionnaires were also administered to teachers and interviews were conducted in order to learn about their experiences in their Mathematics classes and school practices (Wanjohi, 2011; Eshiwani, 1993).

#### 2.7.6.1 Existing conditions in education in Mathematics in Kenya

In Kenya Mathematics is a compulsory subject up to the secondary school level. In recent years levels of performance in Mathematics in national examinations have dropped significantly, which has become a major concern for society in Kenya. The Kenya National Examination Council (KNEC) has continued to raise concern regarding poor levels of performance in examinations in Mathematics which are sat for the Kenya Certificate of Secondary Education (KCSE). The KNEC (1996) identified inadequate coverage and practice and an inability to master simple and basic concepts as the chief causes of poor performance.

Despite the Kenya's government efforts towards the realization of Education For All (EFA), it continues to experience a number of challenges. These include gender disparities, high poverty levels, shortage of teacher supply, HIV/Aids pandemic and inadequate financial resources (Wanjohi, 2015).

## 2.7.6.2 Main findings from the survey

When students were asked:

- Whether or not they liked Mathematics, 81 percent responded yes.
- What they consider as most important factor in a Mathematics class, formulae were indicated by 31 percent, explanation by 19 percent, calculation by 13 percent and exercise by 12 percent.
- Why they study Mathematics at school, 21 percent believed that Mathematics was necessary in order to obtain employment, 18 percent thought that Mathematics is necessary for understanding other subjects, 17 percent thought that the importance of Mathematics lay in its ability to enlighten them and 15 percent thought that they studied Mathematics in order to contribute towards nation-building (Wanjohi, 2011).

Other findings from the study:

- Students perform poorly with respect to understanding and applying the basic concepts of Mathematics.
- The quality of teaching is poor.
- Most of the students felt that the classroom environment was harsh and unfriendly.
- Students do not understand that basic Mathematics is needed in order to function effectively in society.

- Students appear to lose interest in learning Mathematics as they progress through the school system.
- The performance of students in Mathematics at the end of their secondary school education is the lowest when it is compared with that for other subjects in the curriculum (Wanjohi, 2011; Eshiwani, 1993).

The following points obtained from the perspective of the teachers were particularly significant:

- A severe shortage of qualified teachers of Mathematics to teach in the secondary schools
- A lack of high quality Learning and Teaching Support Materials (LTSM)
- A lack of motivation provided by the national government to teachers in the secondary schools.
- Unscientific systems for assessment in secondary schools (Wanjohi, 2011).

## 2.7.7 Education in Mathematics in Japan

Since 2003 the pleasure and the interest which the Japanese students take in learning mathematics have increased. Classrooms in Japan were more conducive to learning than those in many other countries and economies in 2003, and they became even more so by 2012.While Japan allocates human and educational resources equitably between socio-economically advantaged and disadvantaged schools, some differences in physical infrastructure and learning time have been found between advantaged and disadvantaged schools (OECD, 2013a).

### 2.7.7.1 Performance of students in Mathematics, Reading and Science

Students in Japan are consistently high performers in Mathematics, Reading and Science. They even improved significantly in Reading between 2009 and 2012. Among the thirty-four OECD countries, Japan is ranked second in Mathematics and first in both reading and Science. However, as these results are based on a sample of students, its relative position could be between second and third in Mathematics, between first and second in Reading and between first and third in Science. Among the sixty-five countries and economies which participated in the 2012 PISA assessment of fifteen year-olds, Japan was ranked seventh in Mathematics and fourth in both Reading and Science, with its range of ranks being between sixth and ninth in Mathematics, between second and fifth in Reading and between third and sixth in Science (OECD, 2013a).

### 2.7.7.2 Mean scores achieved in Mathematics

Students in Japan score an average of five hundred and thirty-six points in Mathematics, which is significantly higher than the OECD average of four hundred and ninety-four points and comparable with Liechtenstein, Macao-China and Switzerland. Shanghai-China, Singapore, Hong Kong-China, Chinese Taipei and Korea all score higher in Mathematics than Japan. Japan's mean performance has not changed significantly since 2003, when it was five hundred and thirty-four points, which represents an annualised change of 0.4 points. Since 2006, Japan has improved its performance in Mathematics from five hundred and twenty-three to five hundred and thirty-six points (OECD, 2013b).

### 2.7.7.3 Distribution of low-performing and high-performing students in Mathematics

Changes in the average performance of a country or an economy can result from changes at different levels of the performance distribution, among low performers below the baseline Level 2 or among top performers at Levels 5 or 6 or by changes among both groups of performers. Some 11 percent of students in Japan do not reach the PISA baseline Level 2 for proficiency in Mathematics. At best, these students are able to extract relevant information from a single source and to use basic algorithms, formulae, procedures or conventions to solve problems involving whole numbers. This proportion is below the OECD average of 23 percent and has not changed over time. Some 24 percent of students in Japan reach the highest levels of proficiency in Mathematics at Levels 5 or 6. At these levels students are able to develop and work with models of complex situations and to work strategically, using broad, well-developed thinking and reasoning skills. This proportion is higher than the OECD average of13 percent and has not changed over time. Over 55 percent of students in Shanghai-China reach these highest levels of mathematics proficiency, and between 30 and 40 percent of students in Hong Kong-China, Korea, Singapore and Chinese Taipei reach these levels (OECD, 2013a).

### 2.7.7.4 Gender differences in performance in Mathematics

Boys in Japan outperform girls in Mathematics by an average of eighteen points, which is above the OECD average of eleven points; although a significant gender difference was not found in 2003.

### 2.7.7.5 Performance in specific process and content areas of Mathematics

Students in Japan show relative strength in formulating situations mathematically. In this area of Mathematics, Japanese students score eighteen points higher than Japan's overall mean score for Mathematics. In two other areas, employing mathematical concepts, facts and procedures, and reasoning and interpreting, applying and evaluating mathematical outcomes, Japanese students score lower than the country's overall Mathematics score, by 6 and 5 points respectively. Japanese students show relative strength in handling tasks related to space and shape and, to a lesser extent, change and relationships. In space and shape, Japanese students score twenty-one points higher than Japan's mean score for performance in Mathematics and in change and relationships they score 6 points higher. By contrast, in the content categories quantity and uncertainty and data, Japanese students score eighteen and 8 points below the mean score respectively (OECD, 2013a).

Both national and international studies have been conducted in order to improve the content knowledge and teaching methods for Mathematics. Several revisions have been made to curricula, both in South Africa and abroad, to improve the quality of Mathematics as a school subject. Views and opinions have been expressed with respect to the understanding, the operations and the philosophies of Mathematics, and particularly with respect to Mathematical Literacy, in a great many countries. While this perspective provides the basis for the statement of the problem to be investigated by this research, use will be made of the points covered in this section in Chapter 2.

In conclusion, to define, evaluate, position or conceptualise Mathematical Literacy is a daunting task. Although different perceptions of the concept exist, the most common conceptualisations of Mathematical Literacy are Mathematics in Action (Skovsmose, 2007), Mathematics in Context (McCrone and Dossey, 2007; Powell and Anderson, 2007) Realistic Mathematics Education (Hope, 2007) and mathematising (Gillert et al., 2001; Hope, 2007; Botha, 2011). The different perspectives concerning Mathematical Literacy undoubtedly illustrated how the different conceptions vary in their degrees of complexity with respect to the mathematical knowledge and skills which are required, as some conceptions of mathematical literacy require advanced and expert mathematical knowledge and higher order cognitive skills.

Although some researchers emphasise the formal application of mathematics by mathematicians to real-world contexts which demand a high level of mathematical knowledge and the necessary competence to use and apply it (Gellert et al., 2001; Hope, 2007; Jablonka, 2003; Skovsmose, 2007; Botha, 2011), other researchers remain convinced that all people need some basic level of literacy to empower them to make well-informed decisions in their daily lives, while running households, managing the finances of their families or making contributions in their workplaces or to society as a whole (McCrone and Dossey, 2007; McCrone et al., 2008; Powell and Anderson, 2007; Skovsmose, 2007; Botha, 2011). Although the value of being mathematically literate is abundantly evident, the extent to which Mathematical Literacy could improve educational practices and contribute to the quality of life of people, or even the development of the country, remains unknown (Gillert et.al., 2001; Jablonka, 2003; Skovsmose, 2007; Botha, 2011).

It is true that both national and international studies have been conducted in order to improve the content knowledge and teaching methods for Mathematics. Several revisions of curricula have been made in order to improve the quality of the teaching and learning of Mathematics, both in South Africa and in countries abroad. These have been reflected in the discussions of the ways in which Mathematics is taught and mathematical literacy is understood throughout the world, which have constituted a significant component of this chapter.

## 2.8 National perspective of Mathematical Literacy

In South Africa the term mathematical literacy refers to both a school subject and to the competency of individuals, while in most other countries it refers mainly the latter (Christiansen, 2007, p.91). The original NCS Grades 10-12 General (DoE, 2003a) were based on OBE, social transformation and integration and applied competence. These principles encourage a leaner-centred and activity-based approach to the teaching of the subject.

The Programme for International Student Assessment (PISA) (OECD, 2000) defines Mathematical Literacy in terms of desirable outcomes, in that the subject is to be taught in order to enable learners to make well-founded judgements and to use and engage with mathematics in ways which meet the needs of their lives as constructive, concerned and reflective citizens" (OECD, 2000: p. 21). Mathematical Literacy is not a scaled-down version of Mathematics, but a separate subject in its own right (Prentice, 2006). It aims to apply mathematical principles in everyday, real-life situations (DoE, 2005). Learners are encouraged to develop their confidence in thinking in numerical terms to interpret, analyse and solve real-life problems in different contexts (DoE, 2007a; Graven and Venkat, 2008).

Teachers tend to have diverging views concerning what they consider Mathematical Literacy to entail. While some tend to think of Mathematical Literacy as a watered-down form of Mathematics, others believe that it is a different, but still difficult, subject (Mbekwa, 2006). It is important that teachers who are required to teach Mathematical Literacy should be trained in order to be sufficiently prepared to cope with the requirements of the subject. It would appear that the DoE did not give adequate attention to the training of Mathematical Literacy teachers before actual implementation of the subject in the schools took place (Mbekwa, 2006).Effective teaching and learning of Mathematical Literacy depends upon teachers who have a sound understanding of the subject and are able to impart an adequate understanding of it to learners (SAUVCA, 2003). Educators need to be trained to instil and develop Mathematical literacy in learners, as opposed to merely teaching the subject (Romberg, 2003).

Research in schools indicates that different approaches are used by teachers to teach Mathematical Literacy (Graven and Venkat, 2007). While the approach of some teachers tends to concentrate on the purely mathematical aspects of the subject, others tend to adopt an approach which is inclined towards literacy (Graven and Venkat, 2007; Mavuagara-Shava, 2005). Differences have also been found among those teachers who employ a content-driven approach (Venkat and Graven, 2007). It appears that although there are various different types of resources available to educators to assist them to creating appropriate scenarios for teaching Mathematical Literacy, educators still need to work with updated material drawn from their environments. In this respect, Venkat and Graven concur with the theories of Vygotsky by suggesting that the teaching and learning of Mathematical Literacy are embedded in social and cultural thinking and environments, in that perceptions of Mathematical Literacy stem from the teaching and learning context in which it is presented. Adopting the Vygotskian approach ensures that the activities which are employed in order to teach and learn Mathematical Literacy are both current and authentic (South Africa, 2007a; Graven and Venkat, 2007; Mavuagara-Shava, 2005) and that the learners are able to identify with the contexts in which it is taught and learned.

From the point of view of interaction in the classroom, Venkat and Graven (2008) found that learners felt that they were given more time to understand in Mathematical Literacy, owing to the slower pace than that of Mathematics at which it is taught, the learner-centred manner in which it is taught, working in pairs and groups and the validity and availability of alternative problem-solving methods.  A range of complex factors (e.g. social disadvantages, language issues, teacher content knowledge and absence of teacher support) challenge Mathematical learning, attention is increasingly being drawn to the limited opportunity to learn Mathematics (Graven, 2015). Both limited learning time and access to quality learning, impact on Mathematics learning. Learners tend to equate Mathematical success with teacher dependency, compliance and careful listening rather than independent thinking, problem-solving or sense – making (Graven, 2015). TIMSS results from 1999 to 2014 show that South Africa has among the highest gaps in Mathematics Education (Graven, 2016).

The next section discussed international perspectives of education in Mathematics, in order to equip this study with a broader perspective from which to evaluate the teaching and learning of Mathematical Literacy in South Africa.

## 2.9 A synopsis of Mathematics and Mathematical Literacy in South Africa

As Mathematical Literacy is a compulsory subject for Grade 10, 11 and 12 learners who do not choose Mathematics as subject, parents and learners should have an understanding of what each subject entails and what the implications of each are for further studies. For example, the DoE (2003a) explains that those learners who wish to proceed to tertiary studies which are of a mathematical nature, such as Engineering, Accountancy, Architecture and Natural Sciences, should not take Mathematical Literacy. An overview of the premises of the subject, its learning outcomes and the topics to be covered by it will be provided in the following sections, as will a discussion of the pedagogical approach for teaching Mathematical Literacy and the Mathematical Literacy learner profile.

### 2.9.1 The properties of Mathematical Literacy and Mathematics: Curriculum Assessment Policy Statements

In the table below the premises of Mathematics and Mathematical Literacy are discussed according to the purposes, aims, definitions and educational and career links of the 2 respective subjects, as they have been set out by the DoE (2003a, 2003b, 2008b, 2011a, 2011b).

### 2.9.1.1 Table 4: The properties of Mathematical Literacy and Mathematics

| | **Mathematical Literacy** | **Mathematics** |
|---|---|---|
| **Purpose** | To provide learners with an awareness and an understanding of the role which Mathematics plays in the modern world, enabling learners to become self-managing people, contributing workers and participating citizens (DoE, 2003a, 2011a). | To develop an appreciation of the discipline itself and a deep understanding and successful application of knowledge and skills. This competence contributes not only to personal and social development, but also to the scientific and economic development of learners (DoE, 2003b, Botha, 2011, p.36). |
| **Aim** | To equip learners to understand information which is represented in mathematical ways and to solve problems encountered in everyday life and in work situations (DoE, 2008b). Learners who study Mathematical Literacy should have the ability or skills to think mathematically, in order to interpret, analyse and solve problems (DoE, 2003a). | To allow learners to develop into citizens who are able to deal with the mathematics that forms a part of the society in which they live and of their daily lives. It is particularly Important for learners to acquire skills such as investigating, generalising and proving, as opposed to acquiring only content knowledge for its own sake (DoE, 2003b). |

| | | |
|---|---|---|
| **Definition** | Mathematical Literacy provides learners with awareness and an understanding of the role which mathematics plays in the modern world. It is a subject which is driven by life-related applications of Mathematics. It enables learners to develop the ability and the confidence to think numerically and spatially, in order to interpret and critically analyse everyday situations and to solve problems (DoE, 2003a). | Mathematics enables creative and logical reasoning about problems in the physical and social world and in the context of Mathematics itself….it entails observing patterns and rigorous logical thinking, resulting in theories of abstract relations…it enables us to understand the world and make use of that understanding in our daily lives (DoE, 2003b).<br><br>According to the CAPS, mathematics is a language which makes use of symbols and notations for describing numerical, geometric and graphical relationships. It is a human activity which involves observing, representing and investigating patterns and qualitative relationships in physical and social phenomena and between mathematical objects themselves (DoE, 2011b, p.10). |
| **Career links** | Mathematical Literacy should not be taken by learners who intend to study mathematically-based disciplines such as engineering, accountancy or the natural sciences. Learners who study Mathematical Literacy who proceed to higher education | The subject provides a platform for linkages to Mathematics in higher education institutions. Mathematics is essential for learners who intend to pursue careers in the physical, mathematical, computer, life, earth, space, and environmental sciences |

| | | |
|---|---|---|
| | institutions will have developed the skills needed to deal effectively with mathematically-related requirements in disciplines such as the social and life sciences (DoE, 2003a). | or in technology. Mathematics also plays an important role in the social, management and economic sciences (DoE, 2003b). |

If these properties are examined, it becomes clear that the 2 subjects are essentially different and should not be compared. Sidiropoulos (2008) maintains that the distinction between Mathematical Literacy and Mathematics is not a distinction in terms of the level of the content of the 2 subjects, but rather a distinction in terms of the kind of content in each (p. 208). Mathematics, on one hand, is regarded as a purely academic subject in the form of an abstract science which requires mathematical rigour and a high level of cognitive thinking and reasoning, based on a sound conceptual understanding of the content. Mathematical Literacy, on the other hand, does not focus on abstract mathematical concepts but, instead, primarily on developing practical skills in order to be able to use elementary mathematical content to find concrete solutions to numeric, spatial and statistical problems associated with everyday life experiences (DoE, 2011a; Maffessanti, 2009). A shared aim, however, is the development of competent learners, who are able to use their mathematical knowledge to solve personal, social and real-life problems.

## 2.9.2. The learning outcomes of Mathematical Literacy and Mathematics – Curriculum Assessment Policy Statement (CAPS)

With the introduction of Mathematical Literacy in 2008, the similarities between the learning outcomes for Mathematical Literacy and Mathematics, which may be seen in the table below, created a considerable amount of concern, as some people perceived Mathematical Literacy to be a lower grade mathematical subject (Botha, 2011). The learning outcomes for Mathematics in the senior phase in the General Education and training band for Grades 8 and 9 and for Mathematical Literature and

Mathematics at the FET level, as they were applied from 2008 to 2011, are listed below (DoE, 2003a, 2003b, 2010).

**Table 5: Learning Outcomes for Mathematical Literacy and Mathematics**

| | Mathematics (GET: senior phase) | Mathematical Literacy (FET phase) | Mathematics (FET phase) |
|---|---|---|---|
| Learning Outcome1 | Number, operations and relations | Number, operations and relations in contexts | Number, operations and number relations |
| Learning Outcomes 2 | Patterns, functions and algebra | Functional relationships | Functions and algebra |
| Learning Outcomes 3 | Measurement | Space, shape and measurement | Space, shape and measurement |
| Learning Outcomes 4 | Handling data | Handling data | Handling data and probability |

The first two columns show how the learning outcomes for Mathematical Literacy build on the learning outcomes for Mathematics in the GET band (DoE, 2005).Some researchers maintain that Mathematical Literacy, being a new subject with a different focus, should not have used the same content-based learning outcomes as Mathematics, as this scenario has resulted in creating stumbling blocks for the teachers (Bowie and Frith, 2006; Christiansen, 2007; North, 2005; Botha, 2011).This concern about similar learning outcomes has been addressed in the new CAPS (DoE, 2011a) and will be discussed in the section below.

### 2.9.3 Topics covered in Mathematical Literacy and Mathematics

Different concerns regarding the relationship of content to context in Mathematical Literacy had been expressed by academics prior to the new CAPS. There had been questions about the content knowledge which needs to be taught by the teachers of Mathematical Literacy, the contexts which they should use (Geldenhuys, Kruger and Moss, 2009; Julie, 2006; Vithal and Bishops, 2006), and whether the content should determine the context or vice versa (Bowie and Frith, 2006; Graven and Venkat, 2007). Although these issues were not elucidated clearly in the original NCS for Mathematical Literacy (DoE, 20o3a), the new CAPS (DoE, 2011a) does address them (Botha, 2011).

In Mathematical Literacy the topics are divided into 2 groups, namely, the Basic Skills Topics, which comprise elementary mathematical content and skills to which learners have already been exposed in Grade 9, and the Application Topics, which contain the contexts which are related to scenarios involving daily life, workplace and business environments and wider social, national and global issues (DoE, 2011a, p. 13). For this purpose it is necessary to list the content areas and topics covered in the Mathematics Senior Phase, from Grade 7 to Grade 9 and those covered in Mathematical Literacy and Mathematics in the FET phase. Different terminologies are used for content areas and topics across the different bands (DoE, 2011a; DoE, 2011b; DoE, 2010), as is indicated below.

### 2.9.4 Composition of Mathematical Literacy and Mathematics across the different bands

**Table 6: Composition of Mathematics and Mathematical Literacy** – Presentation below by DoE (2011b)

| Content areas:<br><br>1. Number, operations and relations<br>2. Patterns, functions and algebra<br>3. Space and shape-geometry<br>4. Measurement<br>5. Handling data-statistics | Basic Skills Topics:<br><br>1. Interpreting and communicating answers and calculations<br>2. Numbers and calculations with numbers<br>3. Patterns, relationships and representations<br><br>**Application topics:**<br><br>1. Finance<br>2. Measurement<br>3. Maps, plans and other representations of the physical world<br>4. Handling data<br>5. Probability | Main Content topics:<br><br>1. Functions<br>2. Number patterns, sequences and series<br>3. Finance, growth and decay<br>4. Algebra<br>5. Differential calculus<br>6. Probability<br>7. Euclidean geometry and measurement<br>8. Analytical geometry<br>9. Trigonometry<br>10. Statistics |
|---|---|---|
| **Content topics:**<br><br>Example: Exponents, integers, functions and so on under number 1 above are referred to as the content topics | **Content topics:**<br><br>A range of content topics based on Senior Phase content topics only | **Curriculum Statement**<br><br>Instead of using content topics, descriptions are used to explain the content under each main topic. Example: Practical problems involving optimisation and rates of change (DoE, 2011b, p.11) under no. 5 above. |

(DoE, 2011b)

South Africa was the first country in the world to introduce Mathematical Literacy as a school subject in 2006 in the FET band in Grades 10 to 12 (Christiansen, 2007). The decision to implement a compulsory mathematical subject in the FET band was motivated, to a very large extent, by the perceived need to improve the low levels of mathematical knowledge and the skills which Mathematical Literacy aims to develop. One of the purposes of Mathematical Literacy is to provide an opportunity for each learner to become mathematically literate in order to deal effectively with mathematically-related requirements in disciplines such as the Social and Life Sciences (DoE, 2003, p.11).

The approach to the teaching and learning of Mathematical Literacy should provide opportunities to engage with Mathematics in diverse contexts, at a level to which learners have ready access (DoE, 2003c). However, the teaching of Mathematical Literacy in a contextualised and de-compartmentalised manner, in which the content topics are integrated, complicates the teaching of the subject, as at present, teachers lack the knowledge and skills to do so (Botha, 2011).

## 2.10 The teaching practices of teachers: a focal point of this study

The process of teaching and learning is extensive and involves specific pedagogical concerns and influences. The general practice of teaching involves more than the teaching activities in the classroom and includes others, such as working with parents and colleagues and engaging in professional development (Franke et al., 2007). However the instructional role of the teacher is played in the classroom, in which his or her goals, knowledge and beliefs all serve as driving forces behind his or her instructional efforts to guide and mentor learners in their pursuit of knowledge (Artzt et al., 2008). Various different terminologies are used in the literature to describe the performance of teachers or the act of teaching in the classroom. Terminologies such as the behaviour of teachers, instructional behaviour, instructional practices, classroom practices, classroom processes and classroom instruction are frequently used to describe the practices of teachers.

### 2.10.1 Terminologies which are used to describe the teaching practices of teachers

| | |
|---|---|
| **Classroom practice** | The focus is on 3 features, namely, discourse, norms and building Relationships (Franke et al., 2007; Botha, 2011). |
| **Classroom instruction** | Involves interactions among teachers and students concerning mathematical subject matter (Kilpatrick, 2001, p.107; Botha, 2011). |
| **Classroom processes** | Interaction which takes place between teachers and learners and all of the factors which influence this interaction (Koehler and Grouws, 1992, Botha, 2011). |
| **Instructional practice** | Refers to the qualitative dimensions of the behaviour of teachers with respect to their teaching (Englert et al., 1992, Botha, 2011). |

Instructional practice constitutes the principal focus of this study of the perceptions and practices of teachers of Mathematical Literacy. Englert et al., (1992) and Botha, (2011) characterise instructional practices as entailing the qualitative dimensions of the teaching and learning processes. Qualitative dimensions concern the ability of teachers to apply appropriate cognitive strategies in meaningful and purposive activities, to promote classroom dialogues, to adjust instructional procedures when it is necessary to do so and to establish classroom environments in which students participate cooperatively and collaboratively in enquiry-related activities. In order to examine the instructional practices of teachers, (Artzt et al., 2008) use a phase dimension framework which is built on 3 observable aspects of lessons in Mathematical Literacy, namely, tasks, discourse and the learning environment.

Social constructivism suggests that all knowledge is constructed and based upon not only prior knowledge, but also the cultural and social context (Ollerton, 2009).

Perceptions of teaching Mathematical Literacy tend to differ to a considerable degree among teachers. While Artzt et al., (2008) advance tasks, discourse and the learning environment as comprising the dimensions of instructional practices, Franke et al., (2007) identify discourse, norms and building relationships as the 3 features of classroom practices. From these perspectives the practices of teachers could be described in terms of a social environment in which all of the people in the classroom, in their relationships with one another, have an opportunity to construct and advance their knowledge through communicating while pursuing their conjectures and interpretations in order to accomplish challenging tasks. For the purposes of this study the dimensions suggested by Artzt et al., (2008) are most appropriate, as they articulate the practical pedagogical concerns of classroom practice which are fundamental to teaching Mathematical Literacy successfully.

The following sections will be devoted to a brief discussion of these dimensions of pedagogical practice and refer to appropriate commentary concerning them in the literature, with a particular emphasis on their relevance to the teaching of Mathematical Literacy.

## 2.11 Teaching pedagogy

### 2.11.1 Setting tasks

As prior knowledge contributes significantly to the construction of knowledge, the purpose of setting tasks is to provide opportunities for learners to connect their knowledge to new information and to build on their knowledge and interest through active engagement in meaningful problem-solving (Artzt et al., 2008, p.10; Botha, 2011, p. 42).

#### 2.11.1.1 Modes of representation in teaching

As teaching involves the orchestrating of content, it becomes crucial for teachers to plan their actions in order to enable learners to progress in their cumulative understanding of a particular content area (Franke et al., 2007, p. 228; Botha, 2011, p. 42). In the case of Mathematical Literacy, the modes of representation which are employed are the forms for representing mathematical concepts through the use of oral or written language, diagrams, manipulations, computers or calculators (Artzt et al., 2008; Botha, 2011). Geldenhuys et al., (2009) recommended that teachers should increase the use of resources such as computers. Although some people believe that the introduction of modern technology to teaching represents an unnecessary wastage of money and time, others feel that the mere presence of computer technology in schools can only serve to enhance the quality teaching and learning. When computer technology is used correctly, it has great potential to raise the levels of achievement of school children. In the opinion of the researcher, as Mathematical Literacy is related to real-life concerns such as the interest rates for home loans, personal income tax and hire purchase instalments, having access to computer technology could enrich the understanding and interest in the subject of learners. The application value of computer technology is almost limitless and working directly with computers could serve to enable learners to expand upon the information which they receive in Mathematics Literacy classes concerning interest rates or even general information regarding income taxes (Botha, 2011). The value of incorporating modern technology into Mathematics Literacy classes depends entirely upon how teachers present the content which relates to real-life experiences.

#### 2.11.1.2 Motivational teaching strategies

The tasks which teachers use in their lessons should possess attributes which attract and sustain the attention and emotional investment of learners over time (Artzt et al., p. 13). Dewey, cited by Bransford et al., 2000, explained the shortcomings of the teaching methods and course content which are employed at present by means of the following observation:

"From the standpoint of the child, the great waste in school comes from his inability to utilise the experience he gets outside…while on the other hand, he is unable to apply in daily life what he is learning in school. That is the isolation from life." (p. 147).

The researcher contends that Dewey's concern has been addressed by the DoE (2003a) by implementing Mathematical Literacy, with the purpose of providing opportunities for learners to experience how Mathematics relates to the world, enabling them to use mathematical information to make valuable decisions affecting their life, their work and society (DoE, 2003a). The idea of connecting the school and home environments is consistent with the contention of Moll and Gonzalez (2004), who maintain that teachers need to know and understand the home environments of the learners whom they teach, as doing so would enable them to understand the ways in which learners comport themselves in the classroom and participate in the learning activities. It is particularly important in the teaching and learning of Mathematical Literacy, in which emphasis is placed on the content being taught in context and making the subject applicable to real-life situations (DoE, 2003a), that teachers should take into consideration the knowledge which learners bring to their classrooms.

#### 2.11.1.3 Scaffolding teaching tasks: sequencing and difficulty levels

The difficulty levels and the sequencing of tasks need to allow students to use their past knowledge and experience to help them to understand the requirements of a task (Artzt et al., 2008, p.13; Botha, 2011, p.43). Bransford et al., (2000) maintain that tasks need to be at the appropriate level of difficulty in order for learners to remain motivated, as tasks which are too easy cause learners to become bored, while those which are too difficult cause frustration. Hechter (2011b) found that the cognitive levels of the assessment tasks set by both teachers in her study were on a relatively low level. Bansilal (2008), whose study consisted of an analysis of the answers given by thirty–eight teachers of Mathematical Literacy to various questions which had been taken from a test and the final examination in a module of the Advanced Certificate in Education (ACE) ML programme, found that the teachers found questions which contained several different steps difficult.

### 2.11.2 Discourse

As the teaching environment created by teachers need to be conducive to learning, the discourse in class should provide opportunities for learners to express themselves, to listen, to question, to respond and to reflect upon their thinking (Artzt et al., 2008). Franke et al., (2007) believe that classrooms involve people who work in social, cultural and political contexts which shape how they perform their work and how that work is interpreted (p. 227), both of which are dependent upon the knowledge, skills and pedagogical approaches of individual teachers.

#### 2.11.2.1 Interactions and relationships between teachers and learners

As teachers play a crucial role in orchestrating the discourse in their classes, they need to know how to use both verbal and non-verbal strategies in order to communicate effectively (Artzt et al., 2008). According to Franke et al., (2007), teaching is multifaceted and should be regarded as deliberate and intentional work, in which they orchestrate the content, the representation of the content and also the relationships of all of the people in the classroom to one another. They maintain that teachers need to have the ability to elicit responses and to interpret what learners do and know, to act appropriately on the basis of the information which they receive and to be able to make decisions which emerge from complex interactions. Franke et al., (2007) do not regard learning as receiving information, but rather as engaging in sense-making as the teacher and learners participate in the process together. This study is also concerned with the influence of the interactions between teachers and learners on the levels of performance achieved by learners. In this respect, it is significant to note that a study conducted by Bansilal et al., (2010) found that continuous support and feedback provided by tutors to practising student ML teachers in the ACE ML programme improved the performances of the student teachers over the semester. Bansilal et al., (2010) regarded this increased interaction within the communities of practice as having provided positive learning opportunities to the student teachers.

### 2.11.2.2 Peer learning: learner-learner interactions

Contributing to the development of conceptual understanding of learners are the opportunities which they have to interact with each other in ways which enable them to support, strengthen and challenge the ideas of one another (Artzt et al., 2008; Botha, 2011, p. 44). The practice of teaching does not entail only the actions of the teacher, but rather the evolution of relationships between the teacher and the learners and among the learners themselves, concerning Mathematics and engaging together in constructing mathematical meaning (Botha, 2011). Franke et al., (2007) expressed their concern that many Mathematics classrooms do not provide sufficient opportunities for learners to develop their mathematical understanding. They believe that learners need to be given the opportunity to become sufficiently encouraged and curious to talk about mathematical problems in order to develop their mathematical expertise (p. 229). Researchers in South Africa have emphasised the importance of learner-centred approaches, in which learners become involved in their lessons, by taking part in discussions and through group work (Brown and Schafer, 2006; Venkat, 2007; Venkat and Graven, 2008; Botha, 2011, Graven, 2011; DoE, 2005; 2011).

### 2.11.2.3 Posing effective questions

The value of proficient oral questioning lies in the encouragement which teachers are able to give to learners to make their knowledge, skills, and attitudes, in relation to the problem under consideration, public (Artzt et al., p.16). By understanding the mathematical thinking of learners, teachers are able to provide opportunities for asking questions which are linked to these specific modes of thinking, which will elicit discussion and which will draw on connections which learners need to make in order to comprehend the work (Franke et al., 2007).

## 2.11.3 Learning environment

Artzt et al., (2008) explain that a learning environment comprises a particular social and intellectual climate, the use of effective modes of instruction, the pacing of the content and attending to certain administrative routines. By contrast, for Botha

(2011), a learning environment entails the rethinking of what should be taught, how it should be taught and how it should be assessed. Although the question of how the content should be taught is a concern which is common to both conceptualisations, the questions of what should be taught and of how learners should be assessed are not integral to the learning environment envisaged by Artzt et al., (2008).

### 2.11.3.1 Social and intellectual climate

The social and intellectual climate defines the tone, style and manner of the interpersonal interactions in the classroom and contributes to the social and cognitive growth and development of learners (Artzt et al., 2008, p.14). Productive educational practices in the contexts of both Mathematics and Mathematical Literacy are characterised by learners perceiving themselves to be comfortable, confident, and knowledgeable with respect to their abilities to engage in mathematics (Franke et al., 2007, p. 227). Creating an atmosphere of trust and mutual respect is crucial for the development of valuable discourse between teachers and learners and among learners themselves (Botha, 2011).

### 2.11.3.2 Modes of strategies and pacing

Modes of strategies and pacing comprise the strategies which teachers use in the classroom to help learners to attain the objectives of specific lessons and to pace the activities to ensure that learners have sufficient time to participate and construct new knowledge (Artzt et al., 2008). The use of cognitively guided instruction is suggested, by several researchers, as a means of supporting the development of mathematical understanding among learners (Carpenter et al., 2000; Bransford et al., 2000 Franke et al., 2007; Botha, 2011, p. 45). This approach to teaching helps learners to overcome their misunderstandings and correct their misconceptions of key concepts. Another effective strategy which has been suggested makes use of interactive lecture demonstrations (Franke et al., 2007).Several effective strategies for teaching Mathematical Literacy have been proposed by researchers in South Africa, namely, mathematical modelling (Brown and Schafer, 2006), discussions and group work (Venkat and Graven, 2008), co-operative learning and project work (Vithal, 2006).

#### 2.11.3.3 Administrative routines

Artzt et al., (2008) describe administrative routines as the procedures or activities which are undertaken in order to ensure the effective organisation and management of classrooms, while Botha (2011) regards them as providing on-going evidence of proper organisation of classes and encouraging the constructive interpersonal relationships upon which learner-centred approaches to teaching and learning are based.

## 2.12 Mathematical Literacy: knowledge and perceptions of teachers

This section of the study focuses on the relationship between knowledge and perceptions, provides an overview of the various different domains of knowledge possessed by teachers and discusses what is meant by the perceptions of teachers, followed by a discussion of the influence which the knowledge of teachers exerts upon their perceptions and the influence which their knowledge and perceptions, in turn, exerts upon their instructional practices in the teaching of Mathematical Literacy.

### 2.12.1 The relationship between knowledge and perceptions

There is no agreement with respect to the definitions of knowledge and perceptions, their relationship, or even their influence on teaching (Botha, 2011). He points out some differences and relationships between knowledge and perceptions and emphasises that, in practice, the lines between knowledge and perceptions can easily become blurred.

**Table 7: Relationships between knowledge and perceptions**

| | KNOWLEDGE | PERCEPTIONS |
|---|---|---|
| Described as: | Evident, dynamic, emotionally neutral, internally structured. | Both evidential and non-evidential, static, emotionally bound, organised into systems. |
| Develops with: | Age and experience | Episodically |
| Functions: | • Conceptual knowledge, or knowledge which is rich in relationships, is used in problem-solving situations.<br>• The amount, accessibility and organisation of knowledge distinguish experts from novices. | • Have both affective and evaluative functions.<br>• Act as information filters.<br>• Have an influence on how knowledge is used, organised and retrieved.<br>• Are powerful predictors of behaviour, which can either be consistent or inconsistent with perceptions. |

Artzt et al., (2008) define the knowledge, which is imparted to teachers during their training and acquired from their experience of teaching, as an integrated system of internalised information which is acquired over time concerning learners, the content of subjects and pedagogy, while they define perceptions as comprising an integrated system of internalised assumptions about the subjects which they teach, learners, learning and teaching (p.20). They believe that perceptions function as an interpretive filter for the knowledge and goals of teachers and have a significant influence on their classroom practices (p.20). Their assessment of the nature of knowledge and perceptions and the roles which they play corresponds with that of

Botha (2011), except that Artzt et al. (2008) also describe knowledge as being organised into systems.

Liljedahl (2008) emphasises that any discussion concerning the knowledge of a teacher cannot be restricted to a discussion of his or her knowledge of Mathematics and knowledge of teaching Mathematics or Mathematical Literacy, but also needs to include a discussion of his or her perceptions. He believes that the actions of teachers in the classroom are, to a very large extent, guided by what they believe about Mathematics or Mathematical Literacy and how the subject in question should be taught. He goes on to explain that distinguishing between knowledge, on one hand, and beliefs and perceptions on the other, represents a false dichotomy, as beliefs and perceptions become knowledge, once the truth criterion has been satisfied (p. 2). Leatham (2006, p. 92) explains this reasoning as follows:
"Of all the things we believe, there are some things that we 'just believe' and other things that we 'more than believe – we know'. Those things we 'more than believe' we refer to as knowledge and those things we 'just believe' we refer to as perceptions or beliefs. Thus beliefs and knowledge can profitably be viewed as complementary subsets of the things we believe."

Botha (2011) focuses on 2 interrelated aspects of knowledge, perceptions and beliefs, which serve as both the filters through which their learning takes place and as crucial domains in which change also needs to take place.

In student teacher training it is important that both students' mathematical knowledge and perceptions need to be developed and restructured. In my experience, once a student's mathematical knowledge base is enhanced, the new or enriched knowledge influences the student's beliefs about mathematics, reorganising and broadening the student's beliefs about mathematics, reorganising and broadening the students' existing belief system. On the other hand, when students' beliefs about mathematics are restructured, they sometimes become more receptive to new mathematical knowledge (Botha, 2011).

## 2.13 Overview of the various different domains of knowledge possessed by teachers

The most fundamental aspect of effective and proficient teaching of mathematics is a high level of knowledge (Kilpatrick, 2001; Taylor, 2008). A teacher needs proper knowledge of subject matter and a high level of PCK to ensure effective teaching (Ma, 1999; Botha, 2011). In Taylor's (2008) study, short tests of proficiencies such as literacy and Mathematics were conducted in primary and secondary schools throughout South Africa. His findings indicated quite clearly that teachers do not have the knowledge which the curricula require to teach learners with the required degree of proficiency. In order to overcome problems concerning the inadequacy of teachers, the school system needs to re-establish the emphasis on expert knowledge (Taylor, 2008). The teaching of Mathematics and Mathematical Literacy needs to be carried out by specialised professionals, as both subjects require content knowledge, knowledge of the curriculum, knowledge with respect to the teaching of Mathematics and Mathematical Literacy and knowledge of how learners learn the subjects and acquire proficiency in them. This assessment poses the question of how these various different categories of mathematical knowledge are to be organised (Botha, 2011). The categories or domains of mathematical knowledge which have been identified by leading researchers are presented below, with a brief summary of each.

**Table 8: Overview of the various different domains of mathematical knowledge**

| **Shulman Categories of knowledge 1986** | **Grossman Components of Pedagogical Content Knowledge(PCK) 1990** | **Borko and Putman Domains of knowledge 1996** | **Ball, Thames and Phelps Domains of knowledge of teaching 2005** | **Hill, Ball and Schilling Domain map for mathematical knowledge for teaching 2008** | **Jakobsen, Thames and Ribeiro Domains of mathematical Knowledge 2013** |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 1.Subject matter<br>Content knowledge | 1.Purpose for teaching mathematics | 1.General pedagogical knowledge and beliefs | 1.Knowledge of subject matter<br>-Common knowledge of content of<br>Mathematics<br>-Specialised knowledge of content of Mathematics | 1.Knowledge of subject matter<br>-Common Content Knowledge<br>-Specialised Content Knowledge<br>-Knowledge of the mathematical horizon | 1.Knowledge of subject matter -Common Content Knowledge (CCK)<br>-Horizon Content Knowledge (HCK)<br>-Specialized Content Knowledge (SCK) |
| 2.Pedagogical Content Knowledge (PCK) | 2.Understanding and conceptions and misunderstandings and misconception among learners | 2.Knowledge and beliefs with respect to subject matter | | | |
| 3.Knowledge of curriculum | 3.Curriculum and curricular materials | 3.PCK and beliefs and perceptions | 2.PCK<br>-Knowledge of Content and Students<br>-Knowledge of Content and Teaching | 2.PCKKnowledge of Content and Students<br>-Knowledge of Content and Teaching<br>-Knowledge of curriculum | 2. PCK<br>Knowledge of Content and Students<br>(KCS)<br>-Knowledge of Content and Teaching (KCT)<br>-Knowledge of Content and Curriculum (KCC) |
| | 4.Instructionalstrategies and representations for teaching topics | | | | |

(Beswick, 2012; Jakobsen, Thames and Ribeiro, 2013; Botha, 2011)

## 2.14. An overview of the beliefs of teachers of Mathematics about Mathematics

Thompson (1992) emphasises the complexity which is entailed when attempting to distinguish between beliefs and knowledge and found that in many cases, teachers treat their beliefs as knowledge. There is no agreement concerning how beliefs are to be evaluated, as belief cannot be directly observed or measured, but must be inferred from what people say, intend and do (Pajares, 1992; Thompson, 1992).

### 2.14.1 The nature of beliefs

Beliefs are formed through a process of enculturation and social construction and influence the perceptions and behaviour of individuals and the ways in which they process new information. It appears that although long-held beliefs tend to be fixed and difficult to change, newly-formed beliefs are most vulnerable to change (Pajares, 1992, p. 316; Botha, 2011). Some of the inferences and generalisations which Pajares (1992) made regarding the beliefs of teachers with respect to education are listed below:

- Beliefs are formed early and tend to self-perpetuate, persevering even against contradictions caused by reason, time, schooling or experience.
- The belief system has an adaptive function, in that it helps individuals to define and understand the world and themselves
- Epistemological beliefs play a key role in the interpretation of knowledge and cognitive monitoring.
- Beliefs are prioritised according to their connections or relationship to other beliefs or other cognitive and affective structures. Apparent inconsistencies may be explained by exploring the functional connections and the centrality of the beliefs.
- By their very nature and origin, some beliefs are more incontrovertible than others.
- A change in beliefs during adulthood is a relatively rare phenomenon, of which the most common cause is often a conversion from one authority to

another or a gestalt shift. Individuals tend to hold on to beliefs based on incorrect or incomplete knowledge, even after scientifically correct explanations are presented to them.

- Beliefs need to be inferred, and this inference needs to take into account the congruence among the belief statements of individuals, the intentionality to behave in a predisposed manner and the behaviour which is related to the belief in question.
- Beliefs concerning teaching tend to be well-established by the time a student enters an institution of higher education in order to train as a teacher (Pajares, 1992, pp. 324-326).

### 2.14.2 Table 9: Schoenfeld's theory of beliefs: four general beliefs held by learners

**Some beliefs held by learners and their effects in practice**

| Belief | Effects in practice |
|---|---|
| The processes of formal mathematics, such as the ability to prove theorems, have little or nothing to do with discovery or invention. | Students fail to use information from formal Mathematics when they are in "problem-solving mode". |
| Students who understand the subject matter can solve assigned mathematics problems in five minutes or less. | Students stop working on a problem after just a few minutes as, if they have not solved it, they have not understood the relevant material, and consequently, they are unable to solve it. |
| Only geniuses are capable of discovering, creating or really understanding Mathematics. | Mathematics is studied passively, with students accepting what is passed down "from above"' without any expectation that they will be able to make sense of it for themselves. |
| One succeeds in school by performing | Learning becomes an incidental by- |

| | |
|---|---|
| the tasks, to the letter, which are set by the teacher. | product of ”getting the work done”. |

(Botha, 2011; Schoenfeld, 1998)

Beliefs play an important role in how Mathematical Literacy is perceived as a subject. Perceptions constitute a significant factor in the potential success of Mathematical Literacy, as those of some teachers and learners, concerning Mathematical Literacy, have been influenced by comments made by people outside of the field of Mathematics and tend to regard Mathematical Literacy as a worthless and insignificant subject as a result (Botha, 2011).

Leatham (2006) maintains that the ways in which the various beliefs of an individual are related to one another are just as significant as what the individual believes. According to Thompson (1992), a belief system, with respect to the subject of Mathematics, would consist of conscious and subconscious beliefs, preferences concerning Mathematics as discipline, concepts, meanings, rules and mental images. In Thompson’s (1992) study of teachers with respect to their **beliefs, views, perceptions and preferences,** she points out that the actions and behaviours of people tend to be influenced by the nature of their beliefs. She goes on to describe a belief system as a metaphor for examining and describing how the beliefs of an individual are organised (p. 30). She also maintains that belief systems are dynamic in nature, because they undergo change and restructuring as individuals evaluate their beliefs against their experiences. According to Thompson (1992) and Botha (2011), the beliefs of teachers are formed through the development of a network of interrelated ideas concerning Mathematics, the teaching and learning of the subject and also through their experiences at the various schools at which they teach.

## 2.15 The influence of the knowledge, beliefs and perceptions of teachers on their teaching practices

While Pajares (1992) acknowledges the complexity of a psychological construct such as beliefs, through his extensive study of the findings of numerous researchers, he found a strong relationship between the beliefs of teachers concerning education and their planning, instructional decisions and classroom practices (p. 326), although the link to the outcomes of learners has not been explored extensively. The goals, knowledge, beliefs and cognitions of teachers have been identified by several researchers as constituting the driving force (p.17) behind their instructional practices (Artzt et al., 2008, p.17; Botha, 2011, p.54). The following section will be devoted to a discussion of the influence of the knowledge, beliefs and perceptions of teachers of Mathematical Literacy on the learners whom they teach and on their teaching of the subject.

### 2.15.1 The influence of the knowledge, beliefs and perceptions of teachers on learners

The beliefs of learners have been, for the most part, found to be consistent with the beliefs, perceptions and views held by their teachers (Thompson 1992; Ford, 1994; Botha, 2011). Ford refers to a study which he conducted, in which teachers were found to regard good problem-solvers as the more intelligent learners. He found that this belief was consequently adopted by the learners themselves, who tended to claim that you need to be particularly intelligent in order to be able to solve problems. This finding is supported by those of a study conducted by Manson (2003), in which it was found that learners who had been assessed as being low achievers expressed the belief that in mathematics, intelligence counts for 90 percent and effort 10 percent, and that the intelligence with which a person is born may be exploited but not improved. The inevitable conclusion drawn by these learners was that a person either can or cannot do Mathematics, as a result of inborn ability, or the lack of it, alone.

Teachers need to accept and acknowledge their responsibility towards learners and they need to provide learners with opportunities for positive learning experiences. The attitude of teachers towards a particular subject is also significant. In this respect teachers have the responsibility to ensure that Mathematics comes alive for learners, that learners find it constructive and useful and develop a strong interest in the subject. Ollerton (2009) maintains that although teachers cannot force learners to have a positive relationship with their subject, they need to realise that their attitudes and general demeanour have a great influence (p. 2) on the degree to which learners become receptive to learning. Teachers have the knowledge and skills needed to create a positive learning atmosphere, in which sufficient opportunities are provided to learners to develop their knowledge and skills. In order to accomplish this, teachers need to begin with a positive attitude towards the subject and the learners.

### 2.15.2 The influence of the knowledge, beliefs and perceptions of teachers on their teaching

In practice, teachers spontaneously convey their ideas concerning Mathematics to their learners. The beliefs of teachers concerning Mathematics as a subject and how it needs to be taught often serve as a foundation on which their instructional practices are built (Botha, 2011; Liljedahl, 2008; Pajares, 1992). Liljedahl (2008) identifies 4 components of the beliefs of teachers, which in principle are very similar to one another, with each consisting of 3 different perceptual perspectives. Ernest (1998) describes 3 separate philosophies of Mathematics, namely, instrumentalist, Platonist and problem-solving, while Torner and Grigutsch (1994) characterise their 3 perspectives in terms of the toolbox aspect, the system aspect and the process aspect, which will be described below.

The toolbox aspect of mathematics comprises a set of rules, formulae, skills and procedures, while mathematical activity entails calculation and using rules, procedures and formulae. The system aspect is adopted by teachers who believe that Mathematics is characterised by logic, rigorous proofs, exact definitions and a precise mathematical language, and that using mathematics entails accurate proofs and the use of a precise and rigorous language. The process aspect is adopted by teachers who believe that mathematics is a constructive process, in which relationships between different notions or perceptions and sentences play an important role. In this case the mathematical activity involves creative steps, such as generating rules and formulae, thereby inventing or reinventing the mathematics (Liljedahl, 2008, p. 2-3)

Beliefs regarding the nature of mathematics will inevitably influence a teacher's choice of a teaching approach. Teachers, who hold traditional beliefs will, in all probability, believe that mathematics is an abstract phenomenon, which is far distant from reality. These teachers will almost certainly struggle to relate mathematics to real-life situations and tend to believe that mathematics consists of a set of rules and procedures which need to be learned mechanically with little or no connection to one another and hardly any relevance to their everyday lives. They also tend to separate mathematics from the realm of discovery and creativity (Manson, 2003; Schoenfeld, 1988; Botha, 2011). Thom, cited by Golafshani (2002), maintains that all mathematical pedagogy, even if scarcely coherent, rests on a philosophy of mathematics (p. 204). He comments on the disparities which occur in those instances in which the knowledge, beliefs and perceptions of teachers are not reflected in their instructional teaching practices, owing to constraints such as fixed curricula, limited time and other external factors.

### 2.15.3 Findings with respect to the influence which their knowledge, beliefs and perceptions have on teachers of Mathematical Literacy

Sidiropoulos (2008) found that the instructional practices of teachers of Mathematical Literacy were neither aligned to the Mathematical Literacy curriculum, nor to their alleged beliefs or their understanding of it. She maintains that external strategies and inventions which promote the required depth of their understanding of the subject are required in order to change their instructional practices. She also found that the negative and low expectations, which some teachers had with respect to learners, negatively affected their implementation of the curriculum in class. One of the teachers believed that everyone could perform adequately in Mathematical Literacy if the subject were to be taught correctly, but when the same teacher was asked about the poor performance of the learners in his class, the blame was placed on their past history in Mathematics. Mhlolo (2008) believes that teachers of Mathematical Literacy have not been equipped with the conceptual skills required to implement the subject correctly and that they need to re-conceptualise their knowledge and beliefs concerning the subject. He goes on to explain that there is a problematic relationship between the teachers themselves and the idealised teachers in policy documents. He characterises it as a mismatch, a dislocation or a disjuncture between espoused policy images and the personal identities of teachers. Although there are many teachers of Mathematical Literacy who do not meet the requirements as they have been set out by the DoE, research studies, such as those of Venkat and Graven (2007), have revealed the existence of successful teachers of Mathematical Literacy.

Venkat and Graven (2007) and Graven (2011) conducted a longitudinal study at an inner city school in Johannesburg in order to investigate the experience of positive and knowledgeable teachers of Mathematical Literacy of teaching the subject. They suggest that negativity among learners is associated with a lack of substantive change in the pedagogic practice of teachers, in that teachers still incorporate the kinds of tasks and pedagogic practices which have predominated in the earlier experiences of Mathematics of the learners.

To conclude, this chapter focused on a review of the literature which was relevant to this research and examined the contributions which were made by several different studies. The chapter also provided an in-depth discussion of the social learning theories which are relevant to education in Mathematics and an overview and history of education in Mathematical Literacy. The composition of Mathematical Literacy in the CAPS curriculum and the pedagogical approaches to teaching Mathematical Literacy, including the problems presented by the language of instruction in the South African context. The chapter also provided an appraisal of Mathematics and Mathematical Literacy from both the national and international perspectives, before proceeding to an in-depth examination of the knowledge, beliefs and perceptions of teachers on the pedagogy which is used in the teaching of Mathematical Literacy, which is a significant focal area of the study. The next chapter will be devoted to a discussion of the methodology which was adopted and employed to conduct the study.

# Chapter 3

# Research Methodology and Design

## 3.1 Introduction

This chapter will be devoted to a discussion of the methodology which was employed in order to conduct this study. The interpretative research paradigm was introduced in section 1.8 of Chapter 1. The qualitative approach which was introduced in Chapter 1 will be discussed in detail, as will the case study research design and the selection of the research sample, the techniques which were used to collect the data, the strategies which were adopted in order to analyse the data, the criteria pertaining to the trustworthiness of the findings and the ethical considerations which were respected during the conducting of the research study will also be covered.

The nature of the main research question and the sub-questions served to convince the researcher that the study should be conducted within an interpretivist framework, which would be reflected in the methodology and the research design, as an interpretivist approach would permit the researcher to develop the deepest possible understanding of the perspectives of the teachers as they communicated their thoughts, ideas and beliefs concerning the pedagogy of Mathematical Literacy.

As the word implies, an interpretive approach entails researchers interpreting data collected in order to conduct a research study, thereby adding a subjective human dimension to a study. Accordingly, interpretive researchers assume that access to reality, whether it be a given or a socially constructed reality, may be gained only through social constructions, such as language, consciousness, shared meanings and instruments (Myers, 2008, p. 38).

Interpretivism is “associated with philosophical position of idealism, and is used to group together diverse approaches, including social constructionism, phenomenology and hermeneutics approaches that reject the objectivist view that meaning resides within the world, independently of consciousness” (Collins, 2010, p.

38). In addition, interpretivist studies usually focus on meanings and may employ multiple methods in order to reflect different aspects of a particular phenomenon, event or occurrence.

The basic differences between positivism and interpretivism are illustrated by Pizam and Mansfeld (2009) in the following table.

| **Assumptions** | **Positivism** | **Interpretivism** |
|---|---|---|
| *Nature of reality* | Objective, tangible, singular | Socially constructed, multiple |
| *Goal of research* | Explanation, strong prediction | Understanding, weak prediction |
| *Focus of interest* | What is general, average and representative | What is specific, unique, and deviant |
| *Knowledge generated* | Laws<br><br>Absolute, in terms of time and context, and value-free | Meanings<br><br>Relative, in terms of time, context and culture, and value-bound |
| *Subject/Researcher relationship* | Rigid separation | Interactive, cooperative, participative |
| *Desired information* | How many people think and perform specific actions or have specific problems | What some people think and do, the kinds of problems with which they are confronted and how they deal with them |

**Figure 6: Differences between positivism and interpretivism by Pizam and Mansfeld (2009)**

## 3.2 Reasons for adopting a qualitative approach in order to conduct this study

A qualitative approach was adopted to conduct this study, as it aimed to provide an explicit rendering of the structure, order and broad patterns found among a group of participants (Gerber, 2011). Qualitative research does not introduce treatment, manipulate variables or impose the researcher's operational definitions of variables on the participants. Rather, it allowed meanings to emerge from the participants. The voices of the teachers who participate in the study are of great importance, as their participation will inform, to a very great extent, the understanding which the researcher acquires with respect to the problems, obstacles and difficulties which have been encountered since the introduction of ML, both as a teaching and as a learning subject, in rural areas of South Africa. A qualitative approach is flexible, in that it can be adjusted to meet the requirements of specific settings and research concepts, and the methods and tools which are used to collect data can be adjusted as the research progresses (Gerber, 2011).

Qualitative research aims to generate a comprehensive, in-depth understanding of specific phenomena, events or occurrences through first-hand experience, truthful reporting, questions and actual conversations. From this perspective it may be said that qualitative research endeavours to gain the most comprehensive understanding which is possible of the subjective perceptions of participants from their verbalised responses and the attitudes which they express, either verbally or non-verbally, and the meanings which they attach to them and how these perceived meanings influence their behaviour (Gerber, 2011). The understanding which is to be gained is one which is based upon neutral description, rather than a desire to explain or to predict specific phenomena (Mouton, 2004, p. 49; Mouton, 2010). Hogan et al., (2009) point out that qualitative research aims to uncover specific meanings, emotions and practices, which emerge through the interactions and the interdependencies which exist among people Gerber, 2011, p. 4). White (2005) concurs with this assessment by emphasising that qualitative research is concerned with conditions or relationships which exist, beliefs and attitudes which are held, effects which are felt and trends which develop.

It also provides opportunities for marginalised groups to voice their opinions concerning matters which are of concern to them and which may have been overlooked by conventional research. This study aims to provide a comprehensive description of the perceptions of teachers of Mathematical Literacy of teaching the subject, from research conducted in the setting in which the participants have the experiences which shape their perceptions. The overall aim of the research is to develop an understanding of the meanings which the teachers give to their experiences, in order to generate a description of the phenomena which are of interest for the purposes of this study, in terms of the meanings which the teachers attach to Mathematical Literacy as a subject and the way in which it is taught (Nieuwenhuis, 2007). Qualitative research is best suited to this particular study, as it will enable the thoughts, beliefs and attitudes of the teachers to be gauged from their richly detailed responses to the questions which are put to them by the researcher concerning the teaching of Mathematical Literacy at the FET level.

Specific and focused questions, which require focused answers, will be put to the participants and their responses will be recorded for subsequent analysis. As a specific type of response is sought, the questions need to be the same for all respondents. In addition, great care will be taken on the part of the researcher to ensure that the possibility of influencing the responses given by the participants, through the phrasing of the questions, is precluded. Both the reliability and the validity of the findings depend upon this criterion being fulfilled, necessitating the maintaining of objectivity and neutrality in the case of each participant while the semi-structured interviews are conducted, in order to obtain an accurate, truthful understanding of the knowledge, beliefs and perceptions of the participants.

## 3.3 Research design

Struwig and Stead (2003) describe a research design as the method which is used to gather and analyse information in order to find a solution to a specific research problem. The research design describes the research process and focuses on the tools and procedures which are employed to conduct an effective research study (Mouton, 2004; Robertson et al., 2010).

The research design for this study took the form of a case study. Although a great deal of general background concerning the nature and specific attributes of case studies was furnished in section 1.8, a few more points which have been cited by various researchers are of particular relevance to this study. According to Cohen et al., (2001), case studies can establish causes and effects and also observe effects in real contexts, recognising that contexts constitute a powerful determinant of both causes and effects (p. 181). Edwards and Talbot (1999) define a case study as a unit of analysis in which each case has within it a set of interrelationships which both bind it together and shape it, but which also interacts with the world. One of the principal strengths of case studies in qualitative research lies in the fact that they permit finely tuned explorations of complex sets of interrelationships (p. 51). Edwards and Talbot (1999) distinguish 3 distinct types of case studies, namely, explanatory, descriptive and exploratory studies. This research takes the form of an exploratory case study, in which the focus of the study has already been decided upon and explained in the conceptual framework. The focus is the case itself and its own particular features, which makes it an eminently suitable means of examining complex phenomena (Edwards and Talbot, 1999, p. 53). In this study the teachers of Mathematical Literacy are regarded as the unit which is to be studied, in order to conduct an in-depth investigation of their perceptions of teaching the subject. The researcher's personal involvement in the case study provides a sense of proximity to the research process which is similar to that of an ethnographic study (Cohen et al., 2001, p. 79). The analysis of the data enables underlying meanings to emerge, thereby providing an understanding of the phenomena with which the study is concerned, which would not be possible if they were to be studied by using more ostensibly objective research methods. It is to be hoped that the findings will be reflected in an improved preparation programme for teachers of Mathematical Literacy and advance the building of relevant theories (Botha, 2011).

## 3.4 Designing and conducting a case study

In the designing of a case study, it is important to plan and design how the study is to be conducted and to ensure that all of the data which is collected is relevant. Unlike scientific reports, there is no strict set of rules to guide qualitative studies.

Consequently, the most important consideration is to ensure that the study is focused and concise: if it is not, the researcher will be obliged to wade through a great deal of irrelevant information (Shuttleworth, 2008; Robertson et al., 2010). It is best to compile a short list of 4 or 5 bullet points detailing the specific principal objectives to be accomplished during the conducting of the study. If care is taken to ensure that all of the research fulfils the requirements laid out by these points, the study cannot fail to meet its objectives in terms of answering the research questions. When conducting a case study, even more so than when administering a questionnaire or a survey, it is important for a researcher to maintain a passive demeanour at all times. In a case study a researcher is more of an observer than an experimenter and researchers need to remember that, even in a multi-subject case, each case needs to be treated individually, to allow cross-case conclusions to be drawn (Shuttleworth, 2008; Shuttleworth, 2009; Robertson et al., 2010).

## 3.5 Analysis of results for a case study

Analysing the results of a case study involved the opinions and judgement of researchers more than those obtained from employing statistical methods. The usual procedure is to try to collate the data into a manageable form and to construct a narrative around it. Examples should be included in the narrative, while at the same time keeping it concise and interesting. Although it is useful to show some numerical data, it needs to be borne in mind that the aim of this case study was to discern trends and not to analyse every last piece of data. In addition, this case study is based on opinion, it is by definition designed to provoke reasoned debate. There can be no right or wrong answer in a case study (Shuttleworth, 2008; Robertson et al., 2010). Its reliability depends on the evidence presented for the case, articulated in the form of this research study.

## 3.6 Research population

This case study required the intensive collecting of high quality data; it is usually preferable to work in-depth with a relatively small number of respondents. The inductive approach employed also required research samples to be small, information-oriented, but still representative of the overall population (Edwards and Talbot, 1999). In this study the research population comprised teachers of Mathematics and Mathematical Literacy in a semi-rural area (township) in the Eastern Cape, who comprised the research sample as there are limited studies undertaken in semi-rural areas, also referred to as township schools. Six schools and six teachers (one teacher from each school) were used in this study.

## 3.7 Sampling

### 3.7.1 Purposive sampling

Purposive sampling was used when information-rich participants were sought. The participants are required to embody specific characteristics which are central to the concerns of the research (Struwig and Stead, 2003; Nkwi, Nyamongo and Ryan, 2004). Purposive sampling enabled researcher to identify and choose participants who best satisfy the needs and objectives of the research (Neville, 2005). For all of these reasons, teachers of Mathematical Literacy were selected to participate in the study. These respondents were able to reflect upon and explain the teaching strategies and skills which they employ in order to teach Mathematical literacy and their teaching experiences while teaching the subject. The respondents are teachers in FET schools who teach Mathematical literacy in Grades 10, 11 and 12. It is to be hoped that they would be able to contribute significantly to this particular study of Mathematical Literacy at the FET level (Cresswell, 2012).

## 3.8 Sample size

It should be added to the information supplied concerning the research sample in section 1.9.2, stating that six Mathematics and Mathematical Literacy teachers were selected from six schools and that the language of instruction, at all 6 of the schools at which the teachers who comprised the research sample teach, is English, which is not the mother tongue of either the teachers or the learners. This fact will inevitably exert a considerable influence on the perceptions of the teachers of Mathematical Literacy of the subject, as it has been presented to them to teach and of their ability to teach it to the learners in a non-mother tongue.

The Grade 10, 11 and 12 (FET level) is the only grades doing Mathematical Literacy as a subject. The schools are in one education district. For the purpose of this study six teachers were selected as the researcher focussed on the intensity of the responses when data was collected.

## 3.9 Techniques used to collect data

As case studies are usually time-consuming to conduct, they do not constitute an easy option, because their focus is on meaning and the complexity of interrelations, which demand a great deal of high quality data (Edwards and Talbot, 1999). Cohen et al. (2001) explains that case studies are conducted in order to portray, analyse and interpret the uniqueness of behaviour (p. 79). The use of semi-structured interviews in this study, as the technique for collecting data, ensured both the quality of the data and the trustworthiness of the findings. The interviews allowed a greater deal of insight into the subjective realities of the participants than would have been possible from more easily administered quantitative techniques, such as surveys. The interviews made use of predetermined categories, which were derived from the conceptual framework of the study.

According to Opdenakker (2006), interviews provide one of the best means of collecting data in qualitative research. The interview process lends itself to a researcher being able to pose questions which provide unique insights into the lived experiences and perceptions of respondents (Denzin and Lincoln, 2005). In the case of this study, the purpose of the interviews were to gain insights into the ways in which the participants conceptualise the teaching practices of Mathematical Literacy, with particular respect to the planning of their lessons, evidence of their Pedagogical Content Knowledge (PCK) and their perceptions of the teaching of Mathematical Literacy, the Mathematical Literacy curriculum (CAPS) and the learners to whom they teach Mathematical Literacy. How the pedagogy pertaining to the subject is perceived by the teachers of Mathematical Literacy is of great relevance to the study.

After extensively researching several different techniques for gathering data, the researcher used semi-structured questioning as the sole method to be employed to collect the data, as it would provide the optimal means of collecting rich and focused data concerning the pedagogy of teaching Mathematical Literacy from the respondents. In addition, the fact that all the questions were focused and structured will serve to preclude the possibility of any bias on the part of the researcher contaminating the data which is collected.

### 3.9.1 Semi-structured interviews

After extensively researching different techniques for collecting data, the researcher used only questions posed in semi-structured interviews in order to gather data for this case study, as he believed that this method allowed him the best possible opportunity to collect rich and focused data from the respondents. In addition, using the method should preclude the possibility of any bias during the process of collecting data, as all of the questions were focused and sufficiently structured to avoid wandering beyond the immediate concerns of the study. When they are correctly constructed and responsibly administered, semi-structured questions become a vital instrument by means of which statements can be made about specific groups of people or entire populations (Berkel, 2006; Bernard and Ryan, 2010). *www.d.umn.edu/~cspiller/csd8235/listeningpractice/semistructuredquestions.htm*

### 3.9.2 Semi-structured interview questions

Semi-structured questions are exactly as their name implies, namely, direct questions which ask for specific pieces of information from participants, in the case of this study, questions which are specific to the subject ML. Questions of this type have their greatest value when they are asked in order to obtain facts and specific pieces of information. By their nature they limit the participant's field of choice and length of response. When they are paired with open-ended questions, semi-structured questions can help to define a topic, after which open-ended questions may be used to elicit more information concerning the topic. In this study focused semi-structured questions are framed with specific reference to the subject upon which the study focuses and for the sole purpose of extracting only data which is of relevance to this subject and all of its implications in the areas of interest which have been identified.

## 3.9.3 Advantages of semi-structured questions

- Strong in reality.
- The questions are set.
- The researcher is able to focus on questions which are aligned to specific research questions.
- The researcher is able to obtain in-depth contributions from the respondents which are relevant to the study (Cohen, Manion and Morrison, 2010).
- Semi-structured questions provide an opportunity to generate rich data.
- The language used by the participants is considered as essential for gaining insights into their perceptions and values.
- Contextual and other relevant aspects are regarded as being significant to the task of understanding the perceptions of others.
- The data which is generated can be analysed in different ways (Nigel, 2008).
- The use of semi-structured interviews in qualitative research can provide reliable and comparable qualitative data (Cohen and Crabtree, 2008).

## 3.10 Analysis of data and research findings

The analysis of data involves the data being broken down into themes, patterns and relationships, in which the content of Mathematical Literacy and all of the concerns relating to the subject which the study had identified was processed into conceptual findings. With qualitative research it is very difficult to capture meaning in a short and structured manner (Mouton, 2004). According to Cohen et al., (2001), analysing data involves “organising, accounting for, and explaining the data; in short, making sense of the data…., noting patterns, themes, categories and regularities” (p. 147). They go on to explain that conducting an early analysis will reduce the problem of data overload, as huge volumes of data rapidly accumulate in qualitative research. Edwards and Talbot (1999) concur with this practice, as they believe that continuous analysis of data keeps control of the project, reflects on the approach and design of the project and serves to inform the subsequent process which is employed to gather data. In order to analyse the responses obtained from interviews as qualitative data, it needs to be acknowledged that the process represents a reflexive, relative interaction between the researcher and the de-contextualised data, which already entails interpretations of a social encounter (Cohen et al., 2001, p. 282).

Cohen et al. (2001, p.148) have developed guidelines for analysing qualitative data in the form of an overall analytic strategy, whose purpose is to move from describing cases thematically, to explaining the phenomena, to eventually generating a theory. The process is commenced by establishing units of analysis for the data, indicating the respects in which the units are similar and different and giving codes to the data. This procedure is followed by the creating of a domain analysis, in which the data is divided into groups, patterns and themes, according to the conceptual framework of the study. A case study narrative is then written, giving a description of each case, thereby providing the reader with all the information which is needed to understand the case in all of its uniqueness. At this point relationships and linkages between the various domains are established. In this study an appropriate context for the data was created by establishing relationships and linkages between the domains and also between the sets of data, which were obtained from the interviews and the observations. This was done by identifying and confirming cases, by selecting underlying associations between the subsets of data (Cohen et al., 2001).

A broad view of a research study is obtained by means of a summary, in which the main features of the research so far are recorded, indicating the major themes, issues and problems which have emerged from the data, and also identifying negative or discrepant cases. From this vantage point, speculative inferences from the analysis of the data may be made in order to draw tentative conclusions and to consider the implications of these potential findings (Patton, 2002).

### 3.10.1 Document analysis

Document analysis is frequently used to augment the data which is gathered during the course of conducting qualitative research studies. The documents which may be consulted may take the form of journals, relevant articles in magazines and newspapers or even records which are kept concerning the phenomenon, event or occurrence which forms the focus of a specific research study. The information provided by the documents has the potential to add an extra dimension to the data which is gathered and can also serve either to confirm or to call into question the findings which emerge from the research data. For the purposes of this research study, the document analysis drew on 2 main sources.

The first of these is the National Curriculum Assessment Policy Statement document (CAPS, 2010), which were used to shape questions in the semi-structured interviews which are directly related to the curriculum. Documents based on the results achieved in the subject were used to formulate the semi-structured questions. In addition, an analysis of the results for Grades 10, 11 and 12 in 2013 will be reviewed for the purposes of this study.

The second is the chief marker's report concerning the performance of learners in the matriculation examination with respect to the various different concepts covered in the Mathematical Literacy curriculum, which is distributed to the schools in order to guide the responses of learners. It is a significant document for this study, as it specified both the standards which needed to be attained and the requirements, in terms of assessment, for the subject Mathematical Literacy.

### 3.10.2 General findings from the chief marker's report for Mathematical Literacy of 2013

- Candidates seem to perform well in questions requiring short answers, but to perform poorly in questions requiring extended responses in the form of sentences.
- Candidates also struggle to understand the questions properly, owing to poor background in the language.
- It is evident that there is a lack of substantive preparation and that there are few opportunities for practical application through homework exercises and work in class at the schools.

- Inaccurate interpretations of questions by candidates owing to poor language competencies, especially in the language of assessment.
- Mathematical skills represent a significant area of deficiency, with predictable implications for the academic achievement of learners.
- Despite the improved pass rates in Mathematics and Mathematical Literacy, the lack of foundational competencies in numeracy remains a challenge across the board.
- The report indicates a lack of basic knowledge of concepts which are prerequisites for higher level thinking. Candidates were not familiar with basic terminology and lost marks unnecessarily as a result of this deficit. This is clearly indicative of a gap in content knowledge, curriculum coverage and teaching, which need urgent remediation ( ECDoE, December 2013).

## 3.11 Site and context of the study

The research was conducted in 6 FET schools situated in a semi-rural area within the East London Education District. It will provide an opportunity to gain rich insights into the teaching experiences of the teachers who teach in these particular schools. The area is a semi-rural one, in the sense that it is not located in a remote rural region or district. It has electricity, running water, flush toilets and other amenities. The inhabitants of the area are low income earners.

## 3.12 Reliability, trustworthiness and ethical considerations

In order to meet the criteria for conducting sound qualitative research, the researcher considered professionally respected criteria such as trustworthiness and reliability in the conducting of this study and also bore in mind the Hawthorne and halo effects. As the researcher was aware that different researchers refer to different criteria in order to assess the credibility of a research study, he elected to use the terms trustworthiness, and reliability interchangeably, as all of the terms refer to useful parameters for confirming the soundness of any qualitative research study (Shuttleworth, 2009).

### 3.12.1 The Hawthorne effect in modern research

Many types of research make use of human research subjects and the Hawthorne effect is a source of unavoidable bias which researchers need to try to take into account when they analyse their results (Shuttleworth, 2009). If researchers conducting qualitative research are not aware of the possibility of subjects modifying their behaviour as a result of being aware that they are being observed, the Hawthorne effect can become the main factor which influences their results.

### 3.12.2 The halo effect

Researchers tend to believe that people have little awareness of the nature of the halo effect and the extent to which it influences their personal judgements (Shuttleworth, 2009). The halo effect is a type of cognitive bias in which the overall impression which is gained of a person influences how his or her character is perceived. The overall impression of a person, in the sense of an internalised evaluation, which may be expressed by a statement such as “He is nice”, influences subsequent unfounded evaluations of that person’s specific traits, which could be expressed by internalised evaluations such as “He is also smart” (Schneider, Gruman and Coutts, 2012).

Nieuwenhuis (2007) refers to the criterion of trustworthiness and explains that when qualitative researchers speak of the validity and reliability of research, they are usually referring to research which is credible and trustworthy (p. 80). Cohen et al. (2001) refer to the validity and reliability of qualitative research and do not evaluate in terms of credibility or trustworthiness. They regard validity as an important criterion for both quantitative and qualitative research, in order to ensure that a particular instrument measures what it is intended to measure. A study may be declared reliable if the findings from a particular group are replicated when a similar group in a similar context is investigated. Consequently, reliability refers to consistency and applicability over time, with respect to research instruments and groups of respondents. It is concerned with precision and accuracy (Cohen et al., 2001, p.117). After a careful consideration of these concerns, the researcher arrived at the conclusion that the validity of this qualitative research study could be ensured by the honesty, depth, richness and scope of the data which was obtained as a result of employing the research design and the research methods which have been described in this chapter (Cohen et al., 2001, p.105).

**Table 10: Guba's 4 criteria for ensuring the trustworthiness of qualitative research**

| Criterion | Possible provision made by researcher |
|---|---|
| Credibility | • Adoption of appropriate, well-recognised research methods<br>• Development of early familiarity with the culture of participating organisations<br>• Random sampling of individuals serving as informants and different sites<br>• Tactics to help ensure the honesty of informants, interactive questioning concerning dialogues pertaining to the collecting of data<br>• Negative case analysis<br>• Debriefing sessions between the researcher and his or her superiors<br>• Peer scrutiny of the project<br>• Use of reflective commentary<br>• Description of the background, qualifications and experiences of the researcher<br>• Member checks of data collected and information theories formed<br>• Detailed description of |

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| | phenomenon under scrutiny<br>• Examination of previous research to frame findings. |
| Transferability | • Provision of background data to establish the context of the study and a detailed description of phenomenon in question, to allow comparisons to be made |
| Dependability | • Employment of overlapping methods<br>• In-depth methodological descriptions to allow the study to be repeated |
| Confirmability | • Triangulation of the results to reduce the effect of bias on the part of the investigator<br>• Admission of the researcher's own beliefs and assumptions<br>• Recognition of the shortcomings in the methods used to conduct the study and their potential effects<br>• In-depth methodological descriptions to allow integrity of research results to be scrutinised<br>• Use of diagrams to demonstrate the audit trail |

(Guba, 1981, Shenton, 2002)

To continue the discussion of the ethical considerations which were respected during this study which was commenced in section 1.10, the domain of ethics in research in the social sciences is concerned with the upholding of the moral issues, which are implicit in the research, with respect to the people who are either directly involved in or affected by the research project. To ensure that the study adhered to the requirements of professional research ethics, an ethical clearance was requested from the University of Fort Hare by means of a formal application. This application was submitted after the proposal to conduct the research study had been successfully defended at the faculty level. The application specified the sensitivity level of the research activities, the approach to the research, its design and methodology and provided comprehensive details regarding the participants and the ethical standards maintained during the conducting of the research.

## 3.13 Recommendations, limitations and contributions to further research

In conclusion, this study served to provide a detailed account of the research which the researcher undertook in order to develop an understanding of the perceptions of teachers regarding their teaching of Mathematical Literacy as a compulsory subject at the FET level. Although the fact that the study was conducted in only 6 schools is an obvious limitation, it is the considered opinion of the researcher that this potential disadvantage was more than offset by the depth of detail obtained from the semi-structured interviews and the strong possibility that these findings may be generalised to other schools in similar circumstances. The possibility is certainly worthy of being explored by future studies. The voices of the teachers were of invaluable assistance and contributed significantly to this study in its endeavour to align their perceptions to the CAPS document and the chief marker's report. The similarities and differences in the perceptions of the teachers of ML which were presented in this study should provide a solid basis for further research, particularly in view of the scarcity of competent and qualified teachers of Mathematics and Mathematical Literacy.

# Chapter 4

# Collecting of data, analysis of data and findings

## 4.1Introduction

At the outset of a qualitative study a researcher should have a very clear idea of the research question which is to be answered (Merriam, 1998:124). Although the researcher cannot be certain what the precise outcome of the research will be, it is often possible to make certain predictions. The conclusions and recommendations were shaped by the data which had been collected and the trends which emerged from the responses given by the participants. The questions which were put to the participants in the interviews was appended to the end of this thesis.

Mouton (2004) prescribes 2 distinct steps for analysing and interpreting data. The first is to break the data up into manageable portions and the second is to identify any emerging themes in order to establish any commonalities which may be inherent in the data. This chapter presents the transcribed responses to the interview questions. The emerging trends identified enabled the drawing of conclusions and the making of the recommendations which are presented in Chapter 5.

This chapter includes an analysis of relevant policy documents, namely, the CAPS and the chief marker's report, which was used to augment the themes which emerged from the analysis of the data which was collected from the interviews with the participants. Semi-structured questions were put to the participants, who comprised a research sample of 6 teachers, each of whom represented 1 of 6 schools in semi-rural areas.

The broad aim of this study was to conduct an investigation of the perceptions of teachers of teaching Mathematical Literacy at the Further Education and Training (FET) level, with specific reference to determining what their understanding of Mathematical Literacy as a subject at the FET level is and the challenges which they encounter when teaching the subject, particularly in the context of implementing the subject in accordance with the requirements of the CAPS. The investigation was conducted for the overall purpose of using the information obtained from the teachers concerning their assessments of the teaching methods and the resources which are being used to teach Mathematical Literacy at present, in order to improve the results at the FET level. The following sections will be devoted to the collecting of the data, the analysing of it and the findings which emerged.

## 4.2 Presentation of data collected

The replies of the participants to the questions in the interviews are tabulated below in order to present them clearly and unambiguously and the participants are identified by numbers between 1 and 6 only. Each response is presented separately, which allowed for cross-referencing in order to identify the trends which emerged. The interviews were conducted by making use of a single set of questions, with each participant being interviewed in a single sitting. The following table from page 154 to 178 presents the evidence and data collected from the six respondents.

| | | Respondent 1 | Respondent 2 | Respondent 3 |
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| 1 | Age (years) | 50 | 45 | 46 |
| 2 | Gender | Female | Male | Female |
| 3 | Qualifications | ACE (ML); B. Ed Honours | ACE (ML); B. Ed Honours | Degree |
| 4 | Experience | 24years | 20 years | 26 years |
| 5 | Have you been trained to teach ML at the FET level?<br><br>Give details. | Yes, I have been trained to teach Mathematical Literacy. I did my ACE and B. Ed Honours at the University of Fort Hare. | Yes, I have passed ACE (ML)<br><br>and B. Ed (Honours). | Yes, ACE in Mathematical Literacy from the University of Fort Hare in 2007. |
| 6 | Have you ever participated in an ML teacher development programme?<br><br>Give details. | Yes, I attended a 2-week workshop on ML at the University of Fort Hare. I also attended several workshops organised by the Department of Education. | Yes, I attended NCS (ML) workshops for 1 week. This was in conjunction with the introduction of the NCS in 2006.I also attended several short workshops and seminars, including a CAPS | Yes, I am a very active member of the cluster, where challenging topics are discussed. |

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| | | | introduction workshop. | |
| 7 | Do you find the CAPS curriculum for ML challenging?<br><br>Please explain. | Yes, It is difficult for the learners to incorporate their everyday life experiences in their learning activities in the classroom. | Yes, the CAPS curriculum is challenging, because the syllabus is a bit more advanced than the NCS syllabus. This is a challenge for the learners. | Yes, it deals with real-life problems, which are sometimes challenging, such as tariffs, taxes, travel allowances and so on. |
| 8 | Do you have textbooks and study guides available to teach ML at your school?<br><br>What other resources do you require? Give an Idea. | No, I do not have enough textbooks, especially for Grade 12.Learners share textbooks. I also need a teacher's guide for the textbook. I use the study guides as well, but we don't have enough copies for the learners. | Yes, but not sufficient. We have three hundred and ninety learners studying ML in Grades 10, 11 and 12.Sometimes I have to make copies from master copies of textbooks and study guides.<br><br>I also make use of past | Yes. For some topics one needs to download information about certain companies or departments. One cannot rely on textbooks only. |

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| | | | question papers. | |
| 9 | Do you think that the resources which you have are assisting you to improve your learners' ML results?<br><br>How? | Yes, textbooks cover all the topics that are required to be taught. There are also exercises that assist learners with the understanding of Mathematical Literacy. | Yes, these resources assist me in my day-to-day teaching. Through class work, homework and other forms of practice, the learners' level of understanding and the overall results have improved. | Yes, they can easily relate and see that what they are doing in class is exactly what they are going to do in a work environment. |
| 10 | Do you think that the current learner-centred approach is appropriate for teaching ML at the FET level?<br><br>Explain. | Yes, It encourages the creativity of the learners. It also encourages their thinking skills. Learners also learn to take the initiative and be more active. | Yes, the learner-centred approach is appropriate for ML.ML being a contextualised subject, learners are expected to be the key players. The educator's role is minimal. | Yes, everything done in class should focus on the learners and they should take a leading role. |
| 11 | Would you appreciate it if you attended more workshops and in-service | Yes, to familiarise me with the types of exercises that are expected to be used in | Yes, when teachers attend more workshops, definitely these assist to enrich and | Yes, so that the standard of the papers can be upgraded. The teachers should keep on |

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| | training to develop your teaching skills in ML?<br><br>Why? | the process of helping the learners to sharpen their thinking skills. | improve their knowledge and skills. Regular workshops, conferences and seminars are necessary to update every profession. | training to meet the standard. |
| 12 | Do you think the current assessment system, especially the Continuous Assessment (CASS), is relevant to ML at the FET school level?<br><br>Why? | Yes, it gives an idea of how the learners are coping or understanding the content before the final examinations. The continuous assessments also help to boost the learners' year marks. | Yes, CASS is relevant because CASS informs us about the learners' performance in a classroom situation. This assessment is continuous throughout the year and therefore it is more practical, rather than assessment within a limited time, such as 3 hours. | Yes, so that the learners can get used to working individually. |
| 13 | Do you think that the revision or upgrading of the content of the ML syllabus in South Africa is necessary? | It is difficult for me to comment on that, because I feel that ML has been made more difficult than before for the type of learners that we | Yes, because revision and upgrading of the syllabus at regular intervals is essential for every learning area or subject. The world is | Yes, so that it can meet the standards set by tertiary institutions and different careers. |

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| | Why? | have now. It can be revised, but with the content needs to be considered. | changing fast in terms of technology, science and the information system. Therefore, the new generation must be equipped with advanced studies. | |
| 14 | Can the Annual National Assessment (ANA) assist teachers and learners to improve the standard of numeracy in teaching and learning in South African public schools?<br><br>How? | No, I have seen and noticed that with GET, ANA has failed dismally. | Yes, ANA is a national DoE plan. It is being introduced to improve the standard of numeracy and literacy in South Africa. (International studies show that the standard of Mathematics is very low in South Africa). ANA allows a uniform assessment throughout South Africa. Through this assessment, teachers can improve their teaching strategies if their results are | Yes and no, ANA can only work if the standard of teaching is the same as that of the question papers. The reason is that the standard of papers is far above that of the classroom. |

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| | | | poor. But, unfortunately, I can't see any improvement so far from these examinations. | |
| 15 | How do teachers conceptualise or understand ML at the FET level? Explain. | It is easily understandable because it focuses on everyday life situations.<br><br>It is a compulsory subject for FET learners in Grades 10 to 12 who do not take Mathematics.<br><br>It is basically for the learners to achieve numeracy and, therefore, it will assist them in their daily life situations when they become adults. | Mathematical Literacy is a compulsory subject for those learners who do not take Mathematics at the FET level. It is a contextualised and daily life-related subject. This subject is introduced with a view to improve the standard of numeracy among the citizens of South Africa. | Curriculum 2005 was introduced by the South African democratic government with a view to healing the harm done by the apartheid government.<br><br>The government's intention was to create citizens who are numerically literate. Curriculum 2005 made numeracy a compulsory subject. Mathematics and Mathematical Literacy were the 2 numerical subjects in the curriculum. Learners who do not take Mathematics must |

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| | | | | choose ML. Mathematical Literacy focuses the on mathematics which is needed for citizens' daily life situations. ML mainly deals with contexts. |
| 16 | What are the challenges which teachers encounter when teaching ML, particularly in the context of implementation the CAPS? | Learners have language problems and struggle to interpret questions properly.<br><br>A weak foundation in mathematics is another challenge for the learners trying to understand this subject. | As the CAPS curriculum is a bit more advanced than the previous curriculum and great importance is given to applications in the CAPS, it is a challenge for learners whose mathematical background is weak. | The CAPS curriculum is a revised and modified version of the NCS. The content is more advanced.<br><br>Unfortunately, the foundation of today's learners is very weak.<br><br>Therefore, it is a challenge for the educators to teach this curriculum to the learners, especially in rural and semi-urban areas. |

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| 17 | Do you think that the methods which are used to teach ML can improve the results which are possible at the FET level?<br><br>How? | Yes. Teaching methods can improve the results.<br><br>Teachers must use the proper methods which create interest in learners to learn Mathematics.<br><br>Teachers can narrate interesting stories that can motivate attention among the learners. | Yes. In our society we have good teachers and poor teachers. We call them good or poor because of their teaching style. Some teachers are gifted with good talent to teach learners and others are not. Therefore, we can say that teaching methods have a role in improving the results. | Yes, teaching methods can influence the learners to build proper concentration.<br><br>It is the teacher's born ability to motivate learners to learn numeracy, which, for most learners, is boring. |
| 18 | How do you teach ML to learners? Describe a model ML lesson. | I do not use textbooks only when teaching. They must deal with real life situations, not maps only. I encourage learners to study ML contents and not browse through worked examples, only when preparing for examinations. For example, learners must be taught to | When I start a certain topic, I check learners' prior knowledge in the related fields by asking some simple and complex questions. The approach of the curriculum is learner-centred and I guide the learners to group them. Group leaders will be | I start off with an introduction and examine the prior knowledge that the learners have gained from the previous grade.<br><br>I explain the topic to them, but the learners are given the driving seat, as the curriculum follows the learner-centred |

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| | | write ratios as ratios and not as factors. | chosen from each group and these leaders will guide each group to proceed with the study and class work. | approach where the educator's role is minimal.<br><br>When I feel that the learners have understood the concepts, I give them class work and homework. |
| 19 | How do you know when you have delivered a successful lesson? Describe the feelings or reactions that you have when you get the sense that you delivered the lesson well. Give some examples of how you feel. | The feedback given by the learners through class work or tests helps me to understand how the work has been understood by the learners.<br><br>When the learners' response was poor after I delivered a topic concerning scales and maps, I felt bad, but I decided to do it again and to change the approach. The results were | I experience it from the facial expressions of the learners. Then I ask some questions. If I get correct answers from these learners I see that my lesson was successful. | When I mark the class work and the homework I will know whether the students understood or not.<br><br>If the majority of them can do the work correctly, I come to the conclusion that my lesson was successful. |

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| | | better than before. | | |
| 20 | Which assessment strategies have you used most to assess your learners? Describe your experience of using these strategies. | The learners know that at any time they will be asked to write surprise short tests on any topic that they have already done. That works well, because the learners keep on practising every day for these types of surprise tests.<br><br>I also give them controlled tests, assignments, examinations and so on. | Class work and homework on a routine daily basis. Short tests on a weekly basis, assignments, projects and case studies once a term. Examinations at the end of mid-year and at the end of the year. | I give my learners tests, assignments, case studies, projects and 3-hour examinations. |
| 21 | Do you think that a language barrier exists which makes it difficult for learners to understand ML in a multicultural society? | Yes. I have already mentioned it in question 16. A language problem exists and it is a crucial challenge. But my opinion is that the language of teaching and learning should continue to | Yes. Language plays a vital role in successful quality teaching and learning. Language barriers exist in a multicultural society, where English is not the first | Yes. It happens in any society where the home language and the language of teaching, learning and assessment are not the same.<br><br>Therefore, I can say that a |

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| | Explain your opinion. | be English. This is because we are creating tomorrow's citizens, not only for South Africa but also for the entire world. Our citizens must go out and serve in other countries as well. | language for everybody. | language barrier exists for South African learners, especially in rural schools. |

| | | Respondent 4 | Respondent 5 | Respondent 6 |
|---|---|---|---|---|
| 1 | Age | 35 | 46 | 62 |
| 2 | Gender | Female | Female | Male |
| 3 | Qualifications | B. Sc (Maths); M. Sc (Maths); B. Ed | B. A; HDE;B. Soc. Sc; Honours; M. Soc. Sc. | B. Sc; B. Ed; ACE; B. Ed Honours. |
| 4 | Experience | 10 years | 25 years | 30 years |
| 5 | Have you been trained to teach ML at the FET level? | No, but I am professionally qualified to teach Mathematics and that is why | No, I Studied Mathematics at university level. I have taught Mathematics for many years. | Yes, ACE Mathematical Literacy and B. Ed Honours Mathematical Literacy. |

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| | Give details | I am able to teach ML. | I have attended OBE, NCS and CAPS workshops for ML | |
| 6 | Have you ever participated in an ML teacher development programme?<br><br>Give details | Yes, in 2013 I attended the CAPS workshop for Grade 11 Mathematical Literacy in the East London District. | Yes, OBE, NCS and CAPS workshops. And other short department workshops and subject meetings. | Yes, I attended a week-long NCS workshop in 2007. I have also attended short workshops and seminars. |
| 7 | Do you find the CAPS curriculum for ML challenging?<br><br>Please explain. | No, not for me, because Mathematical Literacy in the CAPS includes only some sections of the pure Mathematics which I studied in my training for teaching. But the learners find it challenging because of long question papers in English, which is not their first language. | No, Some topics are different, but not challenging. | Yes, Challenging for learners, because most of the learners' backgrounds in Mathematics are weak. The language is also a barrier. |

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| 8 | Do you have textbooks and study guides available to teach ML at your school?<br><br>What other resources do you require? Give an Idea. | Yes, I would also like to have a bathroom scale, measuring tapes, city maps and road maps, a kitchen scale and calculators for each learner. | Yes, but not enough textbooks for each learner to have his or her own. Teachers usually have only one set to be shared by all classes. We need a textbook for each learner and enough photocopy paper to roll off past question papers and memos. | No. There is a lack of audio-visual facilities to show model classes from experts on various topics, workbooks, charts, tables, conversion tables, units of measurement and so on. |
| 9 | Do you think that the resources which you do have are assisting you to improve your learners' ML results?<br><br>How? | Yes, in Mathematical Literacy CASS assessments, learners have to calculate BMI or Body Mass Index and measurements of roads and cities. For measurements they are in need of metre rulers and kitchen scales. | No, We need a textbook for each learner so that learners can study on their own at home and photocopied notes from teachers are not enough. | Yes, if they are available, they will definitely assist to make the topics interesting and understandable for learners. |
| 10 | Do you think that the | Yes, teaching should always | Learners do projects, | Yes, because Mathematical |

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| | current learner-centred approach is appropriate for teaching ML at the FET level?<br><br>Explain. | be learner-centred, so that teachers can give most of the responsibilities to the learners. The teacher becomes a passive role player. | assignments and investigations that help them to discover information, themselves, that would normally not be covered by a teacher in a classroom situation. | Literacy topics are practical and life-oriented. So it is very much related to their own environment. So it is alright, this approach. |
| 11 | Would you appreciate it if you attended more workshops and in-service training to develop your teaching skills in ML?<br><br>Why? | Yes, learning is a life-long process. Teachers should be educated in the use of new technologies in teaching so that they can understand the learners effectively. Teachers are always getting new techniques of teaching from the workshops. | Yes, any workshop or in-service training will help develop teaching skills, even if it is just to consolidate skills the teacher already possesses. | .Yes, It will certainly give more ideas, knowledge and methods of teaching various topics. |
| 12 | Do you think the current assessment system, especially the continuous | Yes, because some Mathematical Literacy learners are not good at | Yes, CASS enables learners to do projects, assignments and investigations in ML | Yes, it is an on-going process to assess learners' performance. |

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| | assessment (CASS), is relevant for ML at the FET school level?<br><br>Why? | performing in exams only, it would not be a correct assessment .So CASS work is allowed some duration to complete and they can do it at their own pace. But most learners try to copy the work of others. | which is a good way to improve ML marks, instead of just writing tests and examinations. | |
| 13 | Do you think that the revision or upgrading of the content of the ML syllabus in South Africa is necessary?<br><br>Why? | No, it is not necessary, but it would be nice if we could review the curriculum every 5 years to accommodate the needs of the present and the future. | No, we had NCS ML and now CAPS ML. Upgrading it would serve no purpose. The purpose of ML is to make pupils Maths Literate, but it still won't enable them to go and study for a B. Com or a Medicine degree, so why bother? | Yes, to be up to date with current ideas and developments, revision of the syllabus is necessary. The upgrading of topics is also necessary because of the latest developments in the field of Mathematics. |
| 14 | Can the Annual National Assessment (ANA) assist teachers and learners to | Yes, teachers are finding extra time to teach Mathematics, but the | Yes, if teachers strive to get their learners to the level where the ANA tests them | No, it helps only to find out the levels of learners. It does not provide any coaching or |

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| | improve the standard of numeracy in teaching and learning in South African public schools?<br><br>How? | standard of the learners for Mathematics is not improving. We are getting a true report of what is happening in the lower grades 3, 6 and 9. | and learners are successful in the test, then the ANA would have served its purpose: to improve the standard of numeracy in teaching and learning. | any other kind of assistance. |
| 15 | How do teachers conceptualise or understand Mathematical Literacy at the FET level? Explain. | The 5 key elements in Mathematical Literacy are the use of elementary mathematical content, authentic real-life contexts, solving problems which are familiar and unfamiliar, decision-making and communication and the use of integrated content or other skills to solve problems.<br><br>ML content is needed to make sense of real-life | Mathematical Literacy is for learners who are not mathematically-inclined.<br>Those learners would have been the ones who would have chosen History or Consumer Studies, instead of Mathematics, if ML had not been compulsory if Mathematics was not chosen. | Mathematics in a contextualised situation is Mathematical Literacy. It does not teach pure Mathematics. |

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| | | contexts, enabling the learner to become a self–managing person and to cope with the responsibilities of adult life. | . | |
| 16 | What are the challenges which teachers encounter when teaching Mathematical Literacy, especially in the context of implementing the CAPS? | As ML involves the use of mathematical content, the lack of basic knowledge of arithmetic among learners is a major challenge. Even though the learners are allowed to use calculators, most of them can't afford a calculator, so they just borrow one on the day of | Not enough textbooks for learners and other study materials. ML textbooks are very colourful and feature illustrations such as multiple bar graphs. If learners do not have enough textbooks and use photocopies in black and white instead, there is a challenge, especially for the | Learners have no foundation at the primary school level. They are not familiar with many topics. So when it comes to certain topics, they show a negative attitude. The topics that they don't understand, they also don't try to understand, ultimately because of a negative |

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| | | the examination and don't know what to do with this instrument. Most of the learners have no basic knowledge of different unit systems and how to convert a quantity into different units, such as grams to kilograms, metres to centimetres and hours to minutes and seconds. The third challenge in ML is the poor understanding of English questions of second language learners. Most of the time they don't answer the questions because they couldn't understand them. It means that they are aware of how to solve the questions, but they cannot | teacher, to explain differences in graphs. | attitude to Mathematics. It becomes so difficult to change their mindset. |

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| | | decide what to do or what the question is. The most difficult challenge for a teacher is the lack of interest in learning among learners, absenteeism, non-submission of work and so on. Learners lack interest because of the language problem and poor arithmetic skills. | | |
| 17 | Do you think that the methods which are used to teach ML can improve the results which are possible at the FET level?<br><br>How? | Yes, of course. If a teacher uses only the lecturing method for his teaching, the learners won't give their full attention. If you change your method of teaching by mixing lecturing with more practical lessons, such as creating a day-to-day life situation in the classroom, | Experienced teachers must teach ML using methods that are understandable for learners.<br><br>Teachers who teach in a monotonous way will bore the children, and the children might not be interested enough to listen to the | Yes, different teachers use different methods. But, when it comes to the level of understanding of learners, it really helps the learners. Various methods can be tried. It will enable the lessons to become more interesting to learners as well. |

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| | | like the examples of till slips and VAT or municipality bills and so on. As the learners can see the immediate application of their learning in their daily life, they will be motivated and more learning will result in an improvement of results at the FET level. The use of technology in teaching will also motivate the learners to learn and they will be able to solve the problems in their lives. | teacher. | |
| 18 | How do you teach ML to learners? Describe a model ML lesson. | At the beginning of the lesson, I introduce the topic by describing a similar day-to-day life situation in which we apply this topic to Mathematical Literacy. To get attention and interest | I explain the topic of the lesson, for example scales, explain what we mean by scales and the different types of scales. Then I show the learners an example such as how to determine an actual | Introduce some contextual terms in relation to the topic involved. We discuss it to see how much the learners understand about it. Then introduce the topic and give some simple work and solve |

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| | | from learners, I ask them to give their own examples related to the topic under discussion. I ask them about the importance of the topic in their daily lives when they become adults. I show them documents related to the topic, for example municipality statements, till slips, road maps and so on, and ask them about the importance of the topics in their daily lives. I also ask them the types of questions that could be asked in the examination. Then I give them class work from the topic and homework. | distance using a scale if a measurement on a map is given. I would do 2 or 3 examples on the board. Then I allow time for questions from the learners. The learners are encouraged to write examples on the board. I give them an exercise to start in the class and complete at home. I always try to let kids enjoy the lesson by making a maths-related joke between lessons and explanations. | it. Then proceed from the simple to the complex.. |

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| 19 | How do you know when you have delivered a successful lesson? Describe the feelings and reactions that you have when you get the sense that you delivered the lesson well. Give some examples of how you feel. | As a teacher I am satisfied with my teaching when I have prepared my lesson thoroughly and given enough work for the learners and when I see the happiness and confidence in the faces of the learners. Then I am sure that I have delivered a successful lesson. When I feel this I am proud of what I am doing, making a change in the lives of future citizens. In the beginning of the lesson I can see the curiosity and eagerness to learn from the learners' faces. By the end of a successful lesson I usually | The only way for me to assess whether the kids have understood the work is when I mark the exercise the next day with them and they give me the correct answers. I feel good when I know that I have delivered a successful lesson. | When the learners get the answers right and they get the solution right. They say it and express it verbally. You can tell from their verbal expressions and their body language. When they get it right they are very happy. So then you get satisfaction. |

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| | | see happiness and confidence among the learners, because now they are capable of solving problems in similar situations. The learners can also see the importance of education. | | |
| 20 | Which assessment strategies have you used most to assess your learners? Describe your experience of using these strategies. | Most of the time we use tests, assignments, projects and investigations to assess the performance of the learners. Assignments, projects and investigations are given to the learners in advance with a due date for submission. Because the learners often try to copy the work, most of the time the assessments will not be accurate, but it can be | First, by marking homework with learners and having they give me the answers. This is followed by a test, as per the CAPS requirements, and then by setting an assignment or an investigation.<br><br>I think that these strategies work. I don't use peer assessment, as it wouldn't guarantee whether peers will | I use formal tests, assignments, homework, case studies, and, in some cases, research work also. |

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| | | helpful for a hardworking learner with a low IQ. He or she may not perform well in a test, as tests are given in a controlled situation. These learners do not engage in any bad practices such as copying and they will answer the questions based on their own knowledge, so the assessment can be accurate and trustworthy. As the learners are all assessed using similar criteria, such as the same question paper, fixed times and so on, the assessment will be accurate. | mark correctly. The best assessment strategy would be for the teachers to mark learners' homework every day, but, owing to obvious time constraints, that is not possible. | |
| 21 | Do you think that a language barrier exists | Yes, as English is the language of teaching and | Yes. Language is one of the problems for the learners in | The learners have difficulty in understanding the questions. |

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| | which makes it difficult for learners to understand ML in a multicultural society?<br><br>Explain your opinion. | learning and our learners find it difficult to cope with the situation. Remember English is not the Home language of most of our learners. In ML we take daily life situations and these examples are explained in the form of stories, scenarios, case studies and so on. The challenge comes from the fact that our learners often fail to understand the situations, as a result of language and become underachievers. | their poor performance in the examinations. High school learners struggle to understand questions when they write examinations. Moreover, when they are asked to write comments on a specific point they battle to narrate. In some cases, the learners don't understand the teachers who do not use "code–switching".<br>(Translating from English to the mother tongue of the learners) | The language is definitely a problem for many learners. |

## 4.3 Perceptions gained from the interviews

- Of the 6 respondents in the interviews, 3 of them were in their forties, one was in her fifties, one was in her thirties and another was in his sixties.
- Of the 6 participants, 2 were males and the other 4 were females.
- All of the respondents had degrees.
- Of the participants, 4 had ACE qualifications in Mathematical Literacy, which is recognised as the basic qualification to teach Mathematical Literacy at the FET level. The other 2 had qualifications in Mathematics and experience in teaching Mathematical Literacy.
- With the exception of a single respondent who had 10 years of teaching experience, all of the others had more than twenty years of experience.
- All of the participants had attended workshops or seminars in Mathematical Literacy.
- Although the CAPS curriculum was not perceived to be challenging for the educators, all of the participants believed that it was challenging for the learners.
- All of the participants were of the opinion that they do not have sufficient study materials in the form of textbooks and study guides at their schools.
- The participants all acknowledged that the study materials promote the performance of learners in the examinations.
- All of the respondents believed that the learner-centred approach to teaching ML is effective and suitable, as ML deals with real-life situations.
- All of the respondents felt positively disposed towards attending more workshops in order to improve their ability to teach the subject.
- All of the respondents felt that Continuous Assessment (CASS) was relevant to teaching and learning ML at the FET level.
- All of the participants but 1 believed that the upgrading and revising of the syllabus at certain intervals was necessary for improving the standard of education in South Africa and drawing level with international standards.
- The respondent who did not share this belief maintained that it was difficult to comment, as she felt that the syllabus, as it is at present, is a difficult one for the learners.

- Two thirds or 4 of the respondents were in favour of Annual National Assessment (ANA), while the remaining 2 were opposed to it.
- All of the respondents had a comprehensive understanding of the concept of ML.
- All of the respondents agreed that language presented one of the major challenges to the successful teaching of the subject and was one of the main factors influencing the poor performance of learners. The content gap between GET and FET was perceived to present another significant challenge in the form of a weak foundation of numeracy.
- All of the respondents concurred that the teaching methods and the individual teaching styles of teachers could contribute towards achieving better results.
- Each educator appeared to have his or her own style of introducing lessons and approach to teaching the subject.
- The assessment strategies which are used at present align with the CAPS and CASS.

## 4.4 Analysis of data and findings according to themes

(Refer to 4.4.1 with sub-sections 4.4.1.1 to 4.4.1.4)

As was covered extensively in chapter 3, a qualitative approach was adopted in order to investigate the perceptions of teachers of teaching Mathematical Literacy at the FET level. The interpretation of the data is the stage at which a researcher connects the dots between the collected data and the research question (Mouton, 2004; Mouton, 2010). Analysis, interpretation and the drawing of conclusions was carried out within the framework of the research questions. The analysis was broken down into 3 main themes, namely, teaching, assessments and the management of resources. In order to interpret the data and make recommendations, some of the researcher's own teaching experience was incorporated into the study.

### 4.4.1 Teaching

### 4.4.1.1 The nature of teaching Mathematical Literacy

All six respondents commented on ML as a teaching subject. The DoE (2006a, 2007b) defines Mathematical Literacy as a subject which will help learners to think critically and enable them to deal with mathematical information in real-life contexts.

Throughout the conducting of the research the teachers proved to be very aware of the fact that they needed to introduce real-life contexts into their teaching. A few examples provided by the teachers of the ways in which they used real-life situations are provided below

At the beginning of the lesson the teachers recall related topics from previous grades and examples from the real-life situations of the learners. As an example, in order to explain the concept of VAT, one teacher asked the learners about their experiences of shopping. She asked them whether they had noticed that some items had been recorded as having a zero VAT rating on the cash slips. She went on to ask whether the learners knew the actual percentage at which VAT is levied in South Africa at present. She also wanted to stress to the learners the difference between zero ratings and VAT-exempted status.

Another teacher asked learners about their experiences of banking and explained the functions of banks to them. The learners were quick to identify banks as institutions which are concerned with the lending and borrowing of money, but the teacher went on to explain the interest rates which are paid on investments such as on fixed deposits and those which apply to mortgage bonds.

The educators all recognised that the value of the subject lies in learners believing that they are able to use their skills in numeracy to improve their lives. Learners need to feel that they could add value to their lives by studying Mathematical Literacy. The educators also realised that Mathematical Literacy can be taught effectively only by using real-life concepts and examples with which the learners are familiar and which they feel could be of use to them in the future.

According to the PISA, mathematical literacy as a skill or an ability is “the capacity to identify, understand and engage in mathematics, and to make well-founded judgements about the role that mathematics plays in an individual's current and future private life, occupational life, social life with peers and relatives as a constructive, concerned and reflective citizen" (OECD, 2003, p.24; Gerber, 2011, p.101)

Teachers of Mathematical Literacy need to be conversant with and knowledgeable about a vast array of topics and to be able to understand a great many matters and activities which pertain to everyday situations, such as accounts, building calculations, pyramid schemes and so on, in order to make learners aware of how they are dealt with in real life. In this sense educators are teaching a life skill, in which the practical intelligence of learners is developed in order to enable them to cope with the abstract concerns of real life. Teachers also need to have the ability to relate the curriculum to the contexts of the lives of the learners, with respect to their backgrounds and frames of reference. Learners, in turn, need to realise the importance of being mathematically literate and how it could benefit them in real life (Gerber, 2011). All six respondents alluded to the importance of real life contexts when teaching ML

## 4.4.1.2 An inclusive Mathematical Literacy classroom

Inclusive education is an emerging discipline, which aims to create equal educational opportunities for learners from diverging racial, ethnic, class, cultural or demographic groups (Banks, 2001; Gerber, 2011, p. 102). Conflicts may arise as a result of family traditions, social structures, contexts of schooling, competencies in Mathematics, the backgrounds of teachers and learners and the planning and organisation of teaching. Successful mathematical literacy is shaped by taking into account and incorporating the patterns of understanding, reasoning and mathematical thinking of the societies of which the learners are members (Alro, Skovsmose and Valero, 2005; Gerber, 2011).

*Diverse for me is to use examples, in my classes, from all walks of life and cultures and to use examples and scenarios that my students can relate to* (Respondent 2).

*Getting feedback from students is also important and teaching at their level, taking their frame of reference into account* (Respondent 4).

*Depending on the topic, I try to vary my approaches as much as I can to accommodate the different learning styles of my diverse learners* (Respondent 5).

An inclusive classroom can also indicate demographic diversity, such as age differences among the learners. The researcher is able to confirm that this phenomenon is definitely prevalent in his own classes and could possibly also be the case in other schools. During the interviews the educators all acknowledged the existence of a language barrier, which made the transfer of knowledge all the more difficult. Group work is used extensively, as it helps to group weaker learners with stronger ones. This practice helps to overcome the language barrier, to a certain extent, and it embodies the fundamental principle of the learner-centred approach which lies at the heart of outcomes-based education.

If the work is difficult, a more advanced learner can be asked to explain in a language which the others can understand. As the command of English of most rural learners for whom English is a second language is not good, educators are placed under increased pressure. As the subject entails a great deal of reading and interpretation, the language of instruction and learning becomes a serious problem for most learners whose first language is not English.

Mathematical Literacy involves a large amount of information which has to be read in order to form an understanding of the questions or problems contained in examination question papers. Gerber (2011) succinctly articulates the plight of learners whose progress is hindered by the language problem by saying that “If learners are struggling with the language, it is inevitable that they will not form an understanding of the problem and therefore be unable to come up with solutions” (Gerber, 2011). The respondents validated Gerber’s claim about language.

A problem regarding the mathematical competence of learners was also identified and some of the teachers maintained that basic knowledge was lacking. Although most of the work is theoretical, with practical aspects, in the lower grades in which Mathematical Literacy is taught, because the knowledge of basic Mathematics of the learners is so poor, most of the time is spent on trying to catch up with what they do not know, leaving little time for practical exercises, such as measuring, weighing and so on. Sometimes the learners are grouped together to enable the learners who are more knowledgeable to help the weaker ones. Usually the teacher will have to explain most concepts from the very beginning, owing to the great disparities in the relative levels of knowledge in a single class.

*I have to spend so much time on teaching them the basics, which they should know by now* (Respondent 3). *Learners have come to me and told me that they are finding what we are doing very interesting, but that they struggle to do the mathematics. The struggling, it seems, stems from the fact that the mathematics taught or learned at the primary schools has been very minimal. However, I soon realised how very weak the learners are who come from the primary schools to the high schools. This has made me aware that I cannot assume that students know something, for example, fractions. I have really had to dig deep to find methods to teach students basic calculations very quickly* (Respondent 6).

It appears that the lack of basic mathematical competence of learners influences the amount of time which is spent on the various different topics. Statistics from the Department of Education (DoE, 2008) seem to reflect the problem in the form of weak results. It is of crucial importance that learners should be taught in their mother tongue, in order to construct knowledge in an effective way. In practice this is not always possible, as multicultural classes are made up of learners from different language groups. The fact also remains that examinations are set and written in English and Afrikaans only, leaving no scope for learners from other language groups to participate in their mother tongue (Rutherford and Ahlgren 1989; Gerber, 2011).

At present it may only be speculated why the mathematical competence of many learners is as weak as it is when they arrive at the high school level. The teachers who participated in this study have noticed that the learners struggle to cope with very basic mathematical concepts, necessitating the bulk of class time being spent on revising the basics .Although for weak learners revising the basics presents a means of trying to overcome their fear of numbers and failure, for more advanced learners it can be a very boring exercise (Gerber, 2011; Botha, 2011).

### 4.4.1.3 Teaching strategies

Teaching can be either teacher-centred or learner-centred. While a teacher-centred classroom is driven by the teacher (Musslewhite, 2006), the teachers who were interviewed for this study all used a learner-centred approach, as Mathematical Literacy is a life-driven subject.

*Generally, the teacher would do a few examples of new work together on the board and then give them a few to do for homework. The next day the teacher will call on a few learners to do the sums on the board, helping and correcting, where necessary. If a problem still exists, more exercises are given* (Respondent 4).

*For me, compiling workbooks for my learners and organising their learning material before the academic year starts has been a very good experience. This is why I know my students know exactly what they will be doing and what expectations I have of them* (Respondent 5).

*My own classes are mostly teacher-centred, otherwise I would not be able to complete the curriculum in time and prepare my learners for the examinations. Too much time is used on catching up on the basics, which leaves little time for the learners to direct what should be taught in class* (Respondent 6).

Tomlinson (2000) maintains that the interests of learners, learning styles and the circumstances of their lives can dictate the kind of learning which takes place in the classroom. Learners are encouraged to communicate with one another. Cooperative learning, including problem-based learning, is part of the learner-centred approach (Musslewhite, 2006).

Mavuagara-Shava (2005) has supplied some effective strategies for teaching Mathematical Literacy. Those which were also used by the respondents were:

- The use of real-life problems.
- Overt mathematical communication, which includes both oral and written work.
- The use of multiple approaches to problem-solving.
- Connecting mathematical concepts and skills to other subjects.

Mavuagara-Shava (2005) recommends using extended projects and investigations to enhance the teaching of Mathematical Literacy. Planning and reflection are important factors for making teaching and learning effective.

The more prepared a teacher is for his or her lessons, the better the lessons will flow, and, as a result, confidence grows. The experience conferred by the passage of time and constant self-evaluation enables diligent teachers to improve particular aspects of their teaching (Gerber, 2011).

As all of the respondents who took part in the research had formal qualifications, they were all conversant with the subject content for Mathematics and Mathematical Literacy and the planning of lessons. The Department of Education encourages teachers to further their studies and to obtain professional teaching qualifications.

#### 4.4.1.4 Professional development

Although the Department of Education could provide suitable avenues for teachers to improve their knowledge of teaching Mathematical Literacy, teachers, in turn, also need to be willing to sacrifice private time in order to improve their teaching skills.

### 4.4.2 Assessments

Teachers followed the Assessment Guidelines for Mathematical Literacy supplied by the Department of Education. The Assessment Guidelines (DoE, 2007b) require teachers to use a range of methods of assessment, including controlled tests, assignments, projects, case studies, the writing of reports in the case of some subjects, practical classes in the case of many scientific subjects and summative examinations such as mid-year examinations, trial examinations and year-end examinations. All of the respondents performed all of these types of assessments.

### 4.4.3 Availability of resources

All of the participants indicated that they did not have adequate quantities of teaching and learning materials such as textbooks, study guides, workbooks, data projectors, computers, scales and so on. Shortages of this sort can have only negative implications for the effective teaching and learning of the subject.

## 4.5 Findings of the research study

The findings of the research study are summarised as follows:

- All of the respondents had formal qualifications in Mathematical Literacy.
- All of the teachers who participated in the study had sufficient experience in teaching Mathematics or Mathematical Literacy.
- All the respondents had attended teacher development programmes within the area of specialisation of Mathematical Literacy
- The respondents believed that the CAPS curriculum was challenging for the learners and attributed their difficulties, in part, to their lack of foundational knowledge in Mathematics and the basic skills which are needed to perform elementary mathematical operations.
- The respondents felt that insufficient teaching and learning aids and inadequate support materials adversely affected their ability to teach the subject, which inevitably compromised the performance of the learners.
- The respondents all believed that the learner-centred approach to teaching Mathematical Literacy was appropriate, as it encourages collaboration, discussion and the development of problem-solving skills and creativity among the learners to cope with the types of mathematical problems which are significant to their daily lives.
- All of the respondents believed that more workshops and in-service training could help to develop their content knowledge and teaching skills.
- All of the respondents believed that Continuous Assessment (CASS) was relevant to Mathematical Literacy at the FET school level, as it enables teachers to evaluate how learners are coping or understanding the content before the final examination. In this sense CASS provides a means of determining the mathematical abilities and skills of learners.
- Some of the participants favour the revision and upgrading of the syllabus at regular intervals. This process has the potential to serve as a platform for teachers of Mathematical Literacy to discuss concerns and considerations

which influence the content of Mathematical Literacy and to generate ideas for improving the methodologies for teaching and learning the subject.

- Some of the respondents were not in favour of the Annual National Assessment (ANA). These respondents believed that ANA does not help to improve the standards of Mathematics in South Africa. They tend to perceive the ANA as a means of providing a statistical survey, which they believe in turn discourages learners from taking the ANA tests seriously. These respondents maintained that ANA tests should become a component in the decisions pertaining to whether or not learners are to be promoted at the end of the year.
- All of the respondents were quite conversant with the concept of Mathematical Literacy.
- The respondents all perceived language as the fundamental problem encountered by the learners in their inability to understand mathematical concepts and the difficulties which they experience while trying to understand and interpret questions in tests and examinations, as English is not their mother tongue. Consequently, the terminology and conceptualisation of Mathematical Literacy presents great challenges for learners.
- The respondents agreed that teaching methods can influence the class environment and the results which learners achieve in the subject. It was found that each of the teachers interviewed had his or her own methods of teaching and approaches to the subject.
- It could be concluded that a lack of basic knowledge of Mathematics among the learners is responsible for the high failure rate in Mathematical Literacy at the FET level in the schools. Although all of the teachers who took part in this study were found to have adequate content knowledge to teach Mathematical literacy, the failure rate remains high.

The chief marker’s report also substantiated the assessment of the participants that the language problem and a poor basic foundation of Mathematics are responsible for the general dismal performance in Mathematics and Mathematical Literacy in the National Senior Certificate Examination.

To conclude, the findings of this study align with the theoretical framework upon which it was based, the problem statement and the research questions, as they showed that the teachers perceived the teaching of Mathematical Literacy as being relevant to the lives of learners, which justifies the decision to make it a compulsory subject for those learners who do not choose Mathematics as a subject. Also of great significance was the finding that the teachers are aware of the need for more and regular training, in order to develop teachers who are sufficiently competent to teach the subject in the manner in which it is intended to be taught and for the purposes envisaged by the Department of Education. Although the effects of the lack of sufficient suitable teaching aids and resources and the language have already been covered extensively, the researcher believes that the language problem is further exacerbated by teachers being required to teach in English when it is not their home language. Also noteworthy was the finding that all of the teachers of Mathematical Literacy in the sample were qualified to teach the subject and had a great deal of experience, apart from having taken part in courses designed to develop the ability of teachers to teach Mathematical Literacy. These findings ably support the contention that an understanding of the social learning theory which provided the theoretical framework upon which the study was based is essential for teachers to develop their pedagogical knowledge, skills and attitudes, to improve their methods of teaching and to understand the importance of developing Mathematical Literacy as a social skill, in which collaboration, discussion and team work are promoted through encouraging peer-based learning.

# Chapter 5

# Conclusions and Recommendations

## 5.1 Introduction

This chapter will present the conclusions which were drawn from the findings of the research and offer recommendations on the basis of them.

## 5.2 Objectives of the study

### Main Objectives:

- To determine the perceptions of teachers teaching Mathematical Literacy at Gr 10, 11 and 12 level.

### Sub Objectives

- To understand the challenges that ML teachers experience using the CAPS Curriculum document
- To determine if resources are adequate when teaching ML
- To present evidence that language plays a significant role when teaching ML

## Contextualisation of Mathematical Literacy

Chapter 1 of this study provided an introduction and sketched the background of the research problem, which was followed by a historical overview of Mathematical Literacy as a subject at the FET level in South African schools. The study found that although the teachers who took part had received training in teaching Mathematical Literacy, they all felt the need for more training, both in the content of the subject and in teaching methods, in order to cope with the challenges presented by the new CAPS curriculum. It has been found throughout South Africa that many of the teachers who were appointed to teach Mathematical Literacy came from teaching sectors which were unrelated to either Mathematics or Mathematical Literacy (Mbekwa, 2006). Chapter 1 also provided a discussion of the results for

Mathematical Literacy in the National Senior Certificate Examinations of recent years, a statement of the research problem, the research question and sub-questions and explained the significance of the study.

## 5.3 Literature review: Mathematical Literacy

Obtaining sufficient background material for the study presented no difficulties, as the researcher found that there was an abundance of information available regarding the implementation of Mathematical Literacy at the FET level in schools in South Africa. From all of this information, Chapter 2 was able to provide a comprehensive overview and history of Mathematical Literacy in South Africa and the various ways in which mathematical literacy is conceived, both in South Africa and in other countries throughout the world. The ways in which social learning theories can be used to teach Mathematical Literacy effectively were also covered extensively. A core concern of these theories is the idea that a more knowledgeable peer can assist individuals to construct meaningful learning. Teachers, too, can make use of more experienced colleagues to help them cope with the demands of teaching Mathematical Literacy (Gerber, 2011). During the conducting of the research it also became apparent that teachers make use of this process when teaching in their classroom, by grouping more advanced learners with weaker ones, in order to facilitate the transfer of knowledge at a less formal level than the one entailed by the normal teacher to learner relationship. This strategy draws on the community practices which develop when people share common interests, crafts or professions (Lave and Wenger, 1991). When Mathematical Literacy was first introduced, the educators who were given the task of teaching the subject became a new community of practice and the study found that, in the course of their teaching, teachers often relied on the support of colleagues who teach Mathematics and Mathematical Literacy, apart from taking part in workshops, when they are offered, in order to improve their ability to teach the subject.

## 5.4 Research design and methodology

Chapter 3 was devoted to a detailed discussion of the methodology and the research design which was adopted in order to conduct the study. A qualitative approach was adopted, as it provided the researcher with the best option for capturing the lived experiences of the teachers who took part in the study. The research design took the form of a case study. Data was collected through the use of semi-structured interviews from a research sample which had been purposively selected. All of the respondents answered the same set of questions. The data was analysed and interpreted by transcribing the interviews and identifying the trends which emerged. The data obtained from the participants was corroborated by analysing relevant documentation. The ethical standards of professional research were scrupulously adhered to, both in fulfilment of the moral obligations of the researcher towards the participants and in order to ensure the validity and trustworthiness of the results of the research.

# 5.5 Conclusions and recommendations

The conclusions which have been drawn and the recommendations which are offered in order to assist educators to create an environment which is conducive to learning and teaching are provided below.

- Educators need to familiarise themselves with the curriculum before they are able to teach Mathematical Literacy effectively. By doing so they need not only to know the content, but, more importantly, they need to be able to relate the content to the contexts in which the subject is to be taught. Educators need to make use of real-life examples which are familiar to the diverse group of learners in their classes (Rutherford and Ahlgren, 1989). Connecting life experiences to learning is an important component of creating effective educational experiences. Learners will be more likely to engage with their learning when it is connected to real-life situations (Musslewhite, 2006).
- In the South African context, it has been found to be difficult for learners to construct knowledge if they are not being taught in their mother tongue. Consequently, it is of great importance that there should be less reliance on textbooks and more emphasis placed on practical experience (Rutherford and Ahlgren, 1989). This assessment was confirmed by the findings and articulated by most of the respondents in Chapter 4.
- Planning ahead for the next year is of great importance. By reflecting upon a lesson, an educator is able to plan ahead for the next year, making adjustments where they are necessary. Teaching activities should be

planned well in advance in order to ensure inclusivity. Planning also needs to be monitored in order to ensure the quality of the processes by means of which knowledge is to be transferred.

- The researcher gained the impression that most of the educators who took part in the study did not feel adequately prepared to teach the Mathematics Literacy curriculum. Accordingly, it is suggested that when the Department of Education embarks upon the implementation of new learning areas, time and effort need to be given to an advocacy campaign to inform and prepare educators for the reforms in question. Once educators understand the principles and purpose of a new learning area, they will become more open to the change and the implementation should be much easier and smoother than it would be if they are plunged, underprepared, into a new learning area.
- Educators need to maintain their own development as teaching professionals in order to keep up to date with new teaching methods and changes in the curriculum. Networking with colleagues and Mathematical forums can provide an important support system for educators. The DoE would be well advised to empower educators to take part in professional development activities, such as encouraging staff to study further and to attend workshops and in-service training.
- It is the responsibility of educators to take an active part in their own professional development and it is the duty of the DoE to encourage educators to take part in activities of this sort. The DoE could provide opportunities for educators to improve on both the professional and the personal levels.
- In order to create environments in the schools which are conducive to both teaching and learning, adequate supplies of teaching resources such as textbooks, study guides, data projectors, computers and so on need to be provided.
- Sufficient number of teachers with proper qualifications to teach the subject is necessary.
- Need to receive attention and priority from the DoE as specialists in the subject.

- A variety of teaching strategies needs to be used to ensure effective teaching and learning (Mavuagara-Shava, 2005; Gerber, 2011). This research study has shown that educators believe that learners have different abilities and learning styles. As classes are multicultural, educators need to be aware of the need to ensure inclusivity in their classes, which needs to be reflected in the planning and preparation of their lessons.
- .Assessments need to be moderated internally, in order to ensure that the quality of the tasks which are set and the marking are up to the required standard.
- There should be an assessment plan available in every school, in order to guarantee transparency, and time frames need to be laid down in order to ensure that the assessment takes place consistently according to either a national or provincial time frame.

The DoE needs to improve delivery with respect to LTSM in order to improve availability of textbooks and stationery in the schools. The department also needs to assist the schools in the use of 21st century technologies, such as computers, data projectors and tablets, in order to speed up the teaching process.

# 5.6 Limitations of the study

As the scope of the research was limited to teachers of Mathematical Literacy in 6 FET schools in the East London Education District, the findings of the study may not necessarily be able to be generalised to include schools whose circumstances are significantly different.

# 5.7 Further recommendations

- Steps need to be taken to overcome the language barrier which hinders the effective teaching and learning of ML at present.
- After the completion of Grade 12, the marks achieved in Mathematical Literacy do not carry the same weight as those obtained in other subjects at tertiary institutions when learners apply for admission. This perception is a disappointing one for educators and learners alike, as it tends to belittle the importance and significance of 3 years of teaching and learning. Consequently, the DoE and the tertiary institutions need to arrive at criteria

which enable performance in Mathematical Literacy to be assessed realistically with respect to other subjects.

- There has been talk of discarding Mathematical Literacy at FET schools. The researcher feels that this would not be a wise step, as the reasons for introducing Mathematical Literacy at our schools still exist. As a substantial section of the population of learners in South Africa is unable to study Mathematics successfully, it would be doomed to grow up as numerically illiterate, thereby perpetuating the effects of Bantu Education which the new curricula had sought to eradicate.
- The syllabus can be streamlined or revised to make the depth of the content of Mathematical Literacy equivalent to that of other subjects.

Nowhere in the literature has Mathematical Literacy been referred to as a specialised subject. Instead, it tends to be regarded as specialised knowledge or a competency or skill, embedded in the subject Mathematics. According to Hope (2007), Mathematical Literacy requires an appropriate pedagogy to be used in the teaching of Mathematics. As Mathematical Literacy, with its focus on skills in using and applying mathematical knowledge, forms a part of Mathematics, the focus of teaching Mathematics should be on the knowledge and the development of skills which enable learners to solve real-life problems through the application of mathematical concepts and principles. The conceptions and perspectives mentioned in this study are wide and theoretical and attempting to provide only one internationally applicable definition of mathematical literacy is not viable, as the significance of the concept depends primarily on particular social practices, perceptions and contexts, which is made evident in both the literature from South Africa and that emanating from other countries throughout the world.

## 5.8 Recommendations for future studies

Mention has been made of the central role played by the voices of teachers of Mathematical Literacy in this study. Future studies could be undertaken using a research sample comprising a greater range of different schools with respect to geographic locations, socio-economic status and so on, in order to develop a social and cultural variety of voices which reflect the great diversity of South African society.

## 5.9 Conclusion

This research study focused upon the perceptions of teachers of Mathematical Literacy of what the subject entails and the challenges which are perceived to hinder its successful implementation at the FET level in South African schools. The negative perceptions of the subject of learners, tertiary institutions and the general public have also been examined. Suggestions have been made that the subject should be dropped from the FET curriculum. However, it needs to be stressed that perceptions and suggestions of this sort are short-sighted in the extreme, particularly in view of the importance accorded by the world at large to mathematical literacy as an ability and a set of skills which are of vital importance to any individual. South Africa took the unique step of introducing Mathematical Literacy as a compulsory subject for all learners who elected not to study Mathematics in Grades 10, 11 and 12, in order to ensure that it would no longer be possible simply to abandon Mathematics in any form during the final years of school, which had been possible in pre-1994 South Africa. Although the implementation of Mathematical Literacy in the schools should be seen as a work in progress, rather than as a subject whose pedagogy has attained the stage of maturity, it is of the utmost importance to acknowledge that its implementation represents a sincere concern, on the part of the Department of Education, for all South Africans to become numerically literate. This initiative needs to be placed alongside the great drives to achieve literacy in nations such as the Soviet Union and the People’s Republic of China, in order to modernise their societies and lift their populations from the status of illiterate peasants to that of citizens who are able to cope with the demands of the modern world.

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## APPENDIX A: ETHICAL CLEARANCE

**University of Fort Hare**
*Together in Excellence*

## ETHICAL CLEARANCE CERTIFICATE
## REC-270710-028-RA Level 01

| | |
|---|---|
| Certificate Reference Number: | GAL041SPIL01 |
| Project title: | **Teachers' perceptions on teaching Mathematical Literacy at the further education and training level** |
| Nature of Project: | Masters |
| Principal Researcher: | Sivarama Pillai |
| Supervisor: | Prof G Galloway |
| Co-supervisor: | |

On behalf of the University of Fort Hare's Research Ethics Committee (UREC) I hereby give ethical approval in respect of the undertakings contained in the above-mentioned project and research instrument(s). Should any other instruments be used, these require separate authorization. The Researcher may therefore commence with the research as from the date of this certificate, using the reference number indicated above.

Please note that the UREC must be informed immediately of

- Any material change in the conditions or undertakings mentioned in the document
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research

The Principal Researcher must report to the UREC in the prescribed format, where applicable, annually, and at the end of the project, in respect of ethical compliance.

**Special conditions:** Research that includes children as per the official regulations of the act must take the following into account:

Note: The UREC is aware of the provisions of s71 of the National Health Act 61 of 2003 and that matters pertaining to obtaining the Minister's consent are under discussion and remain unresolved. Nonetheless, as was decided at a meeting between the National Health Research Ethics Committee and stakeholders on 6 June 2013, university ethics committees may continue to grant ethical clearance for research involving children without the Minister's consent, provided that the prescripts of the previous rules have been met. This certificate is granted in terms of this agreement.

The UREC retains the right to

- Withdraw or amend this Ethical Clearance Certificate if
    - Any unethical principal or practices are revealed or suspected
    - Relevant information has been withheld or misrepresented
    - Regulatory changes of whatsoever nature so require
    - The conditions contained in the Certificate have not been adhered to

- Request access to any information or data at any time during the course or after completion of the project.

- In addition to the need to comply with the highest level of ethical conduct principle investigators must report back annually as an evaluation and monitoring mechanism on the progress being made by the research. Such a report must be sent to the Dean of Research's office

The Ethics Committee wished you well in your research.

Yours sincerely

G de Wet

**Professor Gideon de Wet**
**Dean of Research**

17 February 2015

**APPENDIX B: APPLICATION FOR THE CONSENT FROM PARTICIPANTS**

**UNIVERSITY OF FORT HARE**

**<u>EAST LONDON</u>**

**Enquiries: S. P.  M.  PILLAI**
**Mobile: 072 015 8333**

**<u>APPLICATION FOR THE CONSENT FROM THE PARTICIPANTS.</u>**

To: …………………………………………

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Dear Sir/ Madam

**Re: Respondents/Participants consent**

This serves to kindly inform you that I am a student at University of Fort Hare, doing M.  Ed.My study is based on teachers' perceptions on the teaching of Mathematical Literacy at Further Education and Training level (FET).As part of my study and for the purpose of completing my thesis, I need to collect some Mathematical Literacy teachers' views on teaching of Mathematical Literacy in the form of an interview.

I am intending to select you as one of my respondents in this research.
I promise you that it will not be a tedious task and I hope that you will enjoy it.

Yours Sincerely
………………………..  (S. P.  M. PILLAI)

**APPENDIX C: APPLICATION FOR CONSENT FROM PRINCIPALS**

University of Fort Hare
Together in Excellence

**UNIVERSITY OF FORT HARE**
**EAST LONDON**

**Enquiries: S. P. M. Pillai**
**Mobile: 072 015 8333**

**APPLICATION FOR THE CONSENT FROM THE PRINCIPAL**

To: The Principal

……………………………………………..

Dear Sir/ Madam

**Re: Principal's consent to carry out the research**

This serves to kindly inform you that I am a student at University of Fort Hare, doing M. Ed.My study is based on teachers' perceptions on the teaching of Mathematical Literacy at Further Education and Training level (FET).As part of my study and for the purpose of completing my thesis, I need to collect some Mathematical Literacy teachers' views on teaching of Mathematical Literacy in the form of an interview.

I am intending to select your School as one of my sample school.I will choose your Mathematical Literacy teacher as one of my respondents in this research.I promise you that it will not be a tedious task and I hope this study will assist in improving the Mathematical Literacy teaching in our country.

Thanking you in advance
Yours Sincerely

……………………….. (S. P. M. PILLAI)

**APPENDIX D: APPLICATION FOR THE CONSENT FROM DISTRICT DIRECTOR**

University of Fort Hare
*Together in Excellence*

**UNIVERSITY OF FORT HARE**
**EAST LONDON**

**Enquiries: S. P. M. Pillai**
**Mobile : 072 015 8333**

**APPLICATION FOR THE CONSENT FROM THE DISTRICT DIRECTOR**

To: The District Director

Department of Education, EAST LONDON

Dear Sir/ Madam

**Re: Application for the approval of conducting a research from selected schools in the East London District.**

This serves to kindly inform you that I am a student at University of Fort Hare, doing M. Ed.My study is based on teachers' perceptions on the teaching of Mathematical Literacy at Further Education and Training level (FET).As part of my study and for the purpose of completing my thesis, I need to collect some Mathematical Literacy teachers' views on teaching of Mathematical Literacy in the form of an interview.
I am intending to select your school as one of the sample schools.I will choose your Mathematical Literacy teacher as a respondent in this research.I promise you that it will not be a tedious task and I hope this study will assist in improving the Mathematical Literacy teaching in our country.

Yours Sincerely
……………………….. (S. P. M. PILLAI)

## APPENDIX E: CONSENT FORM FOR MR SPM PILLAI’S RESPONDENTS

**I …………………………………………………………………………………………….**

Fully agree that I will be the respondent of Mr Pillai’s research study.I promise that I will provide her with the necessary information which will be of help to her study.I am fully aware that I will be bound by the ethics of this research exercising confidentiality as required by this study.

Signed at…………………………………………………………………………on

This ………………………………………………..day ………………………..2015

Signature of Respondent

……………………………………………………Date……………………………..

Signature of the researcher

………………………………………………………Date………………………………

## APPENDIX F: INTERVIEW SCHEDULE

**BIOGRAPHICAL DATA OF THE RESPONDENT**

**Surname** ………………………………………………………………

**Other names** ………………………………………………………………

**Gender** ………………………………………………………………

**Date of Birth** ………………………………………………………………

**Age** ………………………………………………………………

**Qualifications** ………………………………………………………………

**Experiences** ………………………………………………………………

**Name of school** ………………………………………………………………

**INTERVIEWS QUESTIONS**

**QUESTIONS (A) Please circle your answer, (b) Please provide an explanation for your answer.**

1. Have you been trained for teaching Mathematical Literacy at FET level?

Give details

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2. Have you ever participated in Mathematical Literacy teacher development programme?

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3. Do you find the CAPS curriculum for Mathematical Literacy challenging?

Explain

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4. Do you have text textbooks study guides available to teach Mathematical Literacy at your school?

What other resources do you require? Give an idea.

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5. Do you think the above resources are assisting you to improve your learners' Mathematical Literacy results?

   How?

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6. Do you think that the current Learner Cantered Approach is appropriate to teach Mathematical Literacy at FET level?

   Explain

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7. Would you appreciate it if you attended more workshops and in-service training to develop your teaching skills in Mathematical Literacy?

   Why?

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8. Do you think the current assessment system especially the continuous assessment (CASS) is relevant for ML at FET school level?

   Why?

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9. Do you think that the revision of upgrading for Mathematical Literacy contents (Syllabus) in South Africa is necessary?

   How?

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10. Can the Annual National Assessment (ANA) assist teachers and learners improve the numeracy standard of teaching and learning in South African public schools?

   How?

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11. How do teachers conceptualize/understand Mathematical Literacy at Further Education and Training level? Explain

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12. What are the challenges that teachers encounter in Mathematical Literacy teaching, especially in the context of CAPS implementation?

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13. Do you think that Mathematical Literacy teaching method can improve results possible at FET level?

How?

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14. How do you teach Mathematical Literacy to students? Describe a typical Mathematical Literacy lesson.

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15. How do you know when you have delivered a successful lesson? Describe the feeling/ reactions that you have when you get the sense that you delivered the lesson well. Describe those initial reactions/ feelings/ behaviours? Give some examples of what you felt.

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16. What assessment strategies have you used most in assessing your learners? Describe your experience in using these strategies.

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17. Do you think that the methods which are used to teach ML can improve the results which are possible at the FET level?

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18. How do you teach ML to learners? Describe a model ML lesson.

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19. How do you know when you have delivered a successful lesson? Describe the feelings or reactions that you have when you get the sense that you delivered the lesson well. Give some examples of how you feel.

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20. Which assessment strategies have you used most to assess your learners? Describe your experience of using these strategies.

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21. Do you think that a language barrier exists which make it difficult for the learners to understand ML in a multicultural society? Explain your opinion.

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## APPENDIX G

**The Editor** Editorial Services

(043) 726-4829 gailfrank@nahoonreef.co.za

08 - 06 - 2016

TO WHOM IT MAY CONCERN

This is to certify that the language of the thesis titled “The Perceptions of Teachers of the Teaching of Mathematical Literacy at the Further Education and Training Level: a Case Study Conducted in the East London Education District” by Sivarama Pillai has been edited by David Masters. Should anyone require clarification of any points of grammar, my home telephone number is (043) 726-4829 and I may be reached by e-mail at gailfrank@nahoonreef.co.za.

David Masters