PERCEPTIONS OF THE NOTION OF MATHEMATICAL LITERACY AS A COMPETENCE AND AS A SUBJECT

By

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DECLARATION

I declare that this dissertation is my own work, and is being submitted as partial fulfillment of the requirements for the degree of **Master of Education** in ***Mathematics Education specialization*** in the School of Science, Mathematics and Technology Education at the University of KwaZulu-Natal.

Ethical clearance was granted for this project by the University of KwaZulu-Natal Research Office, and the Ethics Clearance number is HSS/O6148.

This report represents the author's original work/study and has not been submitted in any form for any degree or examination to any tertiary institution.

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ABSTRACT

Given the controversy surrounding the theoretical concept of mathematical literacy within mathematics education community around the world and, in particular, its introduction as a new subject of study in the South Africa's FET curriculum as part of a social transformation process, it seemed necessary and appropriate that a study of this nature had to be undertaken. Thus the study explored perceptions of the notion of 'mathematical literacy' as a competence and as a subject of study. It focused on a group of first-year in-service teachers who were part-time students in the faculty of education at Edgewood Campus in the University of KwaZulu-Natal, as well as the documentary analysis of some of the South African curriculum policy documents. The guiding research questions for this study were: (a) what understandings or notions of mathematical literacy are evident in the South African curriculum documents? (b) What are mathematics educators' perceptions of the competencies of a mathematically literate person? (c) What are their perceptions of, beliefs and views, and initial experiences about mathematical literacy as a subject of study? (d) How do these perceptions and/or understandings play out in the implementation of the new Mathematical Literacy curriculum? In an attempt to answer these questions, I began by, first, exploring the wider theoretical perspectives (both locally and internationally) in extant literature within the domain of mathematics education, and which underpins the debate about mathematical literacy and its related terms as well as informing the recent curriculum change, particularly in South Africa. In the process I discussed the different connotations that were used to describe mathematical literacy and its related terms, as well as the arguments in favour of and against its introduction as a subject of study. Secondly, I explored teachers' understandings of the concept of mathematical literacy both as a competence and as a subject of study in relation to the NCS documents, as well as the problems associated with its implementation and the importance of understanding the interplay between content and context used for its development. It is argued, however, that re-framing of 'mathematical literacy' as a subject of study rather than a competence proves to be problematic in terms of the distinction that could be drawn between epistemology and pedagogy. Finally I have discussed the implications which the findings of this study have for policy and practice, and for further research.

Data on the understandings and teachers' perceptions about mathematical literacy as a competence and a subject of study were obtained using both qualitative and quantitative styles of research as a mixed-mode approach. The major findings of this study are that (1) teachers generally perceived mathematical literacy as a subject of study (2) the South African curriculum documents portray ML as a subject, and therefore framed as such; (3) teachers generally consider a person mathematically literate if that person could do basic arithmetical calculations in everyday life (4) from the international perspective, there are variations on the interpretation of ML, and finally (5) the study has revealed that teachers had difficulties pertaining to their own pedagogical content knowledge of the new subject. Based on these findings it can be concluded that there is need for a sustained monitoring of the implementation process, reviewing of policy documents, and professional development of teachers involved with the teaching of mathematical literacy.

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ACKNOWLEDGEMENTS

No any scholarly written report or book can be considered the exclusive work of a single person, nor can the ideas expressed therein be considered the exclusive thoughts of that person. This dissertation is no different. On the one hand, the ideas, the experiences, the expertise, and the knowledge of other people are reflected in this report. On the other hand, my own experiences and conversations with participants and much dialogue with various texts are reflected throughout the pages of this dissertation. It is, therefore, with my utmost gratitude that I acknowledge the contributions of all the people who have helped in the realization of this intellectually challenging task of undertaking an educational research study. In a special way I would like to thank the practitioners, in particular, who participated in this study. Their involvement and participation has been so valuable, and has contributed immensely towards helping me to broaden my perspective on the various conceptions, notions, beliefs and views about mathematical literacy as a theoretical concept.

I would like to deeply express my sincere appreciation to my supervisor S. Hobden whose guidance and contribution throughout this research project have made it possible for me to complete the write-up of this report. And not forgetting Professor Iben M. Christiansen for her substantial contribution and valuable advice in the design and construction of the questionnaire. Furthermore, my sincere appreciation to everybody else in the faculty of education at the Edgewood Campus who has encouraged and supported me emotionally and spiritually throughout this painstaking journey into the landscape of academic pursuit.

Finally, and above all, I give glory to God the Almighty for His unending loving kindness, that He has been with me through thick and thin all the days of my life. His Word has been a ‘lamp unto my feet’, and His Spirit, a fountain of knowledge and understanding without which the conceptualization and operationalization of this research project would not have been possible.

DEDICATION

To my family: Lucy my wife, and our only three sons Kopano, Ogone and Gape. I thank you for the patience and moral support you have availed to me when I have been away from you for three years, and may God reward you for your steadfastness in all things throughout eternity. Amen.

In loving memory of my mother through whose inspiration I have, thus far, been able to succeed in my educational and academic pursuits.

Notes on the stylistic conventions used in this report

The writing style conventions adopted in this report are as follows:

Citation conventions

There are many direct quotations contained in this report which had been recorded as either participant's actual (verbatim) words from the interview or questionnaire or as from extant literature. In the case of quotations from participant's speech, these are written (in all cases) in italics within the text; whereas if the source of quotes is extant literature or curriculum documents, then the quotations are presented using quotation marks with indentation on both the left hand and the right hand sides and in the same font size as in the rest of the report.

Special phrases or words

There are special phrases/words/terms that have been used frequently throughout the report, and most of these are related to the notions of mathematics and mathematical literacy. Such words are, in most cases presented or written using single quotation marks. Otherwise where the researcher sought to show/indicate emphasis, some words have been written or presented in italics.

CHAPTER ONE INTRODUCTION

1.1 Background and Context to the study

In its transformation process the new democratic government of South Africa has made some radical changes to its education system since 1994. The transformation process has been particularly aimed at addressing issues of social injustice as perpetuated by the previous apartheid government, and as part of this process the education system has been overhauled with the aim of introducing a new school curriculum that is aimed at bringing about social transformation in the new political dispensation (Department of Education, 2003). Of particular interest to me in the new education system has been the introduction of Mathematical Literacy as a subject of study in the Further Education and Training (FET) phase of schooling whose implementation started in the beginning of the year 2006, while there was still a controversy or confusion both locally and internationally about the meaning of the theoretical concept of mathematical literacy. Interestingly, the implementation of this subject was to start at a time when, seemingly, there was not adequate human resource capacity to teach the new subject, and when at the same time there seemed to have been serious disagreement within mathematics education community for a common definition of the concept ‘mathematical literacy’. For this reason therefore, this study was mainly concerned with exploring perceptions of the notion of mathematical literacy as a competence and as a subject of study both within the South African curriculum documents and amongst mathematics educators in order to determine if there were any variations or contradictions in their perceptions and conceptions about this concept. My thesis is that a shared common understanding of the meaning of this concept is crucial to the successful implementation of the curriculum and the fulfillment of its purpose.

As a result of my exposure to “Current Issues and Frontiers in Mathematics Education” module where I first learnt about the idea of ‘mathematical literacy’, and coming from a country (background) where such an idea has not yet been mooted, I developed an interest in broadening my knowledge about mathematical literacy as a concept. Hence I decided to undertake this study in order to further develop my understanding through an exploration of local curriculum documents and mathematics educators' perceptions of the notion 'mathematical literacy' as well as more information on the existing body of knowledge. Being a teacher educator myself, I was particularly interested in, amidst the international and national controversy surrounding the meaning of this concept, finding out what teachers' perceptions of and their notion of mathematical literacy as a competency and as a school subject were; their beliefs and views, as well as their experiences of teaching it as a new subject.

It is worth noting that this study was conducted at a time when "mathematical literacy" as a subject in the Further Education and Training (FET) phase (grades 10 to 12) of schooling had just been introduced. Also, the participants of this research project were in-service teachers who were part-time students in the faculty of education at the University of KwaZulu-Natal, Edgewood Campus. The participants were three cohorts of 70 in-service teachers with a wide range of backgrounds not only in mathematics but also in other subject areas or disciplines, and some of them had no tertiary mathematics background, yet they enrolled for the Advanced Certificate in Education (ACE) course in mathematical literacy with the aim of getting prepared or trained to teach the new 'subject' called 'mathematical literacy' that had just been introduced (in 2006) in all South African high schools.

1.2 Focus and Purpose of study

The introduction of mathematical literacy as a new curriculum subject will, without doubt, pose great challenges to many of the mathematics educators who currently do not have the appropriate training and pedagogical knowledge to implement such a programme. Clearly, this means that the need to equip these teachers with appropriate teaching and assessment strategies to enable them to teach mathematical literacy is an imperative. To this end the government has made arrangements for the education and training of teachers in mathematical literacy. However it is interesting to note that some (if not most) of these teachers have no thorough mathematics qualifications, and therefore, it makes one wonder as to the implications of this in terms of not only their pedagogical content knowledge but also the status of this subject, and how their (teachers) understandings of the concept 'mathematical literacy' will play out in their efforts to implement the new curriculum. Also, it has been in the interest of this study to find out how teachers' perceptions of mathematical literacy related to different notions and conceptions which appear in extant literature. It was against this background that this study set out to explore how mathematics educators perceive the concept 'mathematical literacy', and to find out what beliefs and views of their experiences of studying and/or teaching it were.

The purpose of this study was therefore to explore what teachers' perceptions and beliefs about the notion 'mathematical literacy' were. It was therefore focused on in-service teachers who were being retrained in Advanced Certificate in Education (ACE) course in Mathematical Literacy, ACE General Education and Training (GET) course in Mathematics, and Bachelor of Education (Hons) course in Science and Mathematics Education in the University of KwaZulu-Natal (UKZN), South Africa. It is hoped that this study will lead to a fruitful academic discussion of the idea of mathematical literacy that will ultimately result in a shared understanding of the concept, as well as valuable knowledge production; and the findings will hopefully help teachers and students of mathematical literacy to clarify and develop their understanding of the purpose, the general aims, and in particular, the essential principles of the NCS document. And finally, the findings from this study have the potential to provide policymakers with necessary information that will further help to guide them in matters pertaining to the successful implementation and monitoring of the new curriculum.

1.3 An Overview of Perspectives and Trends in Mathematical Literacy Debate.

There is a growing body of literature within the mathematics education arena whose discussion highlights that there is a growing concern that the formal mathematics curriculum (or traditional school mathematics as it is commonly known) does not prepare and equip learners with the necessary skills in order for them to be mathematically literate. It has been argued (and strongly, especially in America) that the current system of mathematics education does not adequately prepare learners in mathematical literacy to enable them to deal with the quantitative and mathematical demands of everyday life (Madison, 2004; Steen, 1999; Wallace, 2000). For this reason, many authors now advocate for a new (contextualized) curriculum that (it is hoped) they claim will address what is perceived to be the inadequacies of the traditional (abstract) mathematics curriculum by making mathematics more relevant to contemporary society. As a result there have been a lot of debates as to the form the new curriculum should take if it is to bring about improvements in the development of learners' mathematical competencies (competencies needed for mathematical literacy) that go beyond proficiency in pure, theoretical mathematics.

There are contrasting views and varied perspectives concerning the theoretical concept of mathematical literacy expressed by various authors through extant literature and also shown or reflected in some research studies as well. The different authors have rather different ideas about the concept of mathematical literacy and how it should be defined and what should be the appropriate name/label for it. Some authors equate it to quantitative literacy and hence also label it as such (Madison, 2004; Mathematical Council of the Alberta Teachers' Association (MCATA), undated; Organization for Economic Co-operation and Development (OECD) (ed.), 2000; Wallace, 2000) while others refer to the same concept as numeracy (Hobden, 2004; International Adult Literacy Survey (IALS/ALL), 1995; Steen, 2001). As a result of the various names given to this concept, there have been also a variety of interpretations and definitions also used to describe the same concept. Also, the concept has been perceived as either a competency or a subject of study within the international mathematics education community (see Chapter 2).

There are those who assert that the new concept of mathematical literacy (which they prefer to call quantitative literacy) is friendlier to teach and learn than formal mathematics because it can be practiced in multiple contexts. They however argue that the envisaged subject is different from traditional mathematics and cannot be taught in the current educational environment using prevailing pedagogical practices since the current secondary school teachers have not been trained to teach for it (Madison, 2004; Sfard & Cole, 2003; Wallace, 2000). There seems to be an implicit suggestion and an allusion here that in order to teach for mathematical or quantitative literacy, there should be a coordinated integration of and/or interdisciplinary teaching/learning of mathematical/quantitative concepts across the curriculum as well as a move towards effective contextual teaching practices. Also, we can discern from this argument that mathematical/quantitative literacy is viewed as both a school subject and as a competency (Department of Education, 2003; Hobden, 2004; Niss, undated; Wallace, 2000).

These debates have led to further explorations of various ways to the goal of imbuing learners with quantitative habits of mind in addition to conveying mathematical facts and procedures. And as a result of such explorations by various authors, there has been an emergence of terminology differences in terms of what the new curriculum subject should be called, thereby leading to a further debate resulting from differences in emphases on definitions and interpretations of the concept of mathematical literacy. The discussion has focused on the different views about this concept and how differently it is being perceived by different authors across the international mathematics education community (DoE, 2003; Jablonka, 2003; Kilpatrick, 2002; Madison, 2004; MCATA, undated; Sfard & Cole, 2003; Steen, 2001). And it is mainly for this reason that my research project seeks to conduct a study on these kinds of debates and specifically address and further explore mathematics educators' perceptions of the notion 'mathematical literacy' and the beliefs they hold about the concept.

Thus my study is a result of the foregoing trends in the academic conversation regarding the concept 'mathematical literacy' and its relatives, and seeks to further explore the nature of this concept through an evaluation of mathematics and mathematical literacy student teachers' perceptions and views about what it really means to be 'mathematically literate' and why they think a person should be 'mathematically literate' in this modern society. For this reason therefore, this study will address issues of whether or not there are different perceptions of the notion 'mathematical literacy' and whether or not there are contradictory conceptions of the notion 'mathematical literacy' within the mathematics education community in KZN and how these relate to the debate which appear in the extant literature as mentioned earlier.

1.4 Objectives of the Study

The research project discussed here looks at the final outcomes of the exploration of the South African (and in particular, in KZN) mathematics educators' understandings or perceptions of the concept 'mathematical literacy' and especially their perceptions regarding the different notions of this concept as a competency and as a school subject. The study is also aimed at finding out if there are any variations in teachers' perceptions of the concept 'mathematical literacy', and these will be explored in relation to the information obtained from extant literature about its different conceptions, as well as in relation to the background information that was gathered from the teachers who were included in this study.

It is my hope that the knowledge gained and insights emanating from undertaking this study would thus help me to make valuable contribution in the determination of the goals and structure of mathematics education in my home country; and the findings may also help mathematics educators reflect on their classroom practices as a result of a better understanding of the concept 'mathematical literacy'.

This study, it is hoped, will answer the following research questions:

Overarching Question – What are mathematics educators' perceptions of the notion 'mathematical literacy' as a competency and as a school subject?

Critical Questions

1. What understandings/notions of mathematical literacy are evident in the South African curriculum documents?
2. What are mathematics educators' perceptions of the characteristics/competencies of a mathematically literate person?
3. What are mathematics educators' beliefs, conceptions and views about mathematical literacy as a curriculum subject?
4. How do these perceptions and/or understandings play out in the new Mathematical Literacy curriculum implementation?

The existence of and/or variations or lack thereof of mathematics educators' perceptions of the notion 'mathematical literacy' as a competency and as a school subject will be explored using a questionnaire and an interview schedule. The data that will be produced will be analyzed by coding and using SPSS (Field, 2005; Muijs,

2004) in the case of quantitative data type (Kranzler, 2003); and by developing a classification system using codes and themes (coding and thematizing) with the aim of identifying topics and patterns of meanings to generate categories from the qualitative data (McMillan & Schumacher, 2001). And this procedure (coding and thematic analysis) will be applied to both the open-ended questionnaire item responses and the interview transcriptions. The perceptions of the 70 in-service teachers who are enrolled for the professional development courses in mathematics and science will be correlated with other background variables due to the nature of the sample being composed of subgroups (cohorts or stratified groups) of participants who come from different backgrounds and with varying experiences, and thus comparisons could be made across subgroups within the sample. The other background variables will be explored and also included in the analysis model as outlined earlier to help address all the research questions.

1.5 The Research Approach

For the purpose of this research project an exploratory mixed-methods approach (Kemper et al., 2003; Tashakkori & Teddlie, 2003) which is informed by an interpretive theoretical framework/paradigm (Lincoln & Guba, 2000; Henning et al., 2004; Schwandt, 2003) was considered as the most appropriate approach in conducting this study due to the use of a mixture of both qualitative and quantitative techniques that have been employed in data production (Johnson & Turner, 2003; Sandelowski, 2003). These techniques make use of both intra-method and inter-method mixing strategies so that the combination may help to elucidate convergent and divergent aspects of the phenomenon being studied. The study has been designed to utilize a mixture of survey (method) questionnaires and semi-structured interviews, supplemented by document analysis as chosen methods of data collection with a view to adding vigour, breadth, and depth to the exploration, thereby securing in-depth understanding of the phenomenon being studied (Holland & Campbell, 2005; McMillan & Schumacher, 2001). The utilization of these complementary research methods was meant to facilitate the accommodation of disparate views and opinions from the various subgroups that form the main sample of the participants of this study.

According to Mouton and Marais (1990) exploratory studies may have various aims some of which are (a) to gain insight into the phenomenon, and (b) to explicate the central concepts and constructs. Furthermore, they highlight that these studies emphasize the use of three methods:

1. a review of related social science and pertinent literature,
2. a survey of people who have had practical experience of the problem to be studied, and
3. an analysis of "insight-stimulating" examples.

As they point out: "Because exploratory studies usually lead to insight and comprehension rather than the collection of accurate and replicable data, these studies frequently involve the use of in-depth interviews, the analysis of case studies, and the use of informants" (Mouton & Marais, 1990, p. 43). Hence the research design and methodology that I have considered and applied to this study have tended to (a) follow an open and flexible research strategy (mixed-methods and pragmatic approach), and (b) use methods such as literature reviews and documentary analysis, interviews, survey questionnaire, and informants, which may lead to insight and comprehension of the studied phenomenon. This, I believe, is in line with the exploratory and descriptive goals of my research project, as well as the mixed-mode approach (Kemper et al., 2003; Mouton & Marais, 1990) which happened to be cross-sectional (Fink, 2006; Huysamen, 2001).

The mixed-methods approach employed a combination of a mixed questionnaire, which gathered "…data at a particular time (cross-sectional) with the intention of describing the nature of existing conditions…." (Cohen et al., 2000, p. 175), and consisted mainly of open-ended questions with one set of Likert-type closed question items included, as well as the use of semi-structured interviews and documentary analysis. The open-ended question items in the questionnaire were included as a way to capture perspectives that would later be verified by qualitative data that followed from the interviews that were conducted as a follow-up to the administration of the questionnaires. A pilot study or pre-testing of the research instruments was conducted within the campus using a group of 4th Year (undergraduate) Mathematics teacher specialist trainees and a group of mathematics teachers in a neighbouring high school in the Marianhill area of Pinetown.

The semi-structured interview schedule used in the collection of data covered some of the categories of questions which have been used here for the survey questionnaire method, and were mainly related to teachers' perceptions of the notion 'mathematical literacy' as a competency and as a subject of study, of their beliefs and views about mathematical literacy, and of their experiences of the challenges of teaching it. This was considered necessary and convenient as it gave the researcher an opportunity to gain insight into participants' perceptions on the theoretical concept of 'mathematical literacy' and to allow individual teachers to freely express their subjective perspective of and initial experiences of the implementation of the new curriculum.

1.6 The Organization or Structure of the Report

Mathematical Literacy as a theoretical concept is understood differently by various scholars within mathematics education community. While some authors argue that mathematical literacy is a human attribute or habit of mind (Jablonka, 2003; Kilpatrick, 2002; Sfard & Cole, 2003), others contend that it can also be a school subject separate from formal mathematics (Madison, 2004; Steen, 2001; 1999; Wallace, 2000). This controversy hinges much on the interpretation of the term or phrase 'mathematical literacy' and how it relates to formal mathematics. Given the various connotations used to describe mathematical literacy and its related terms, together with lack of shared understanding on this concept, it seems appropriate that I view this study as exploratory. It is exploring mathematics educators' perceptions of the distinction between the notion 'mathematical literacy' as a competency, and as a subject of study; and hence attempts to direct us to a shared common understanding of this theoretical concept through a discussion of each of the chapters as outlined below. In an attempt to explore mathematics educators' perceptions of the notion 'mathematical literacy' within the South African context, this study has explored and presented the various perspectives surrounding the theoretical concept of mathematical literacy as indicated in the next chapters.

There are six chapters in this report. Chapter One introduces the study by giving background information to the research project, and further gives the context for the study. This chapter is divided into five sections. The first section gives a somewhat brief background and contextual information about the study. In this section I highlight a number of key issues of interest relating to the research problem. The second section presents the focus and purpose of the study, while in the third section I give an overview of perspectives and trends surrounding the debate on the concept of mathematical literacy. In the fourth section I discuss the objectives of this study, and present the main research question together with critical questions that help to answer it. I also, in this section, state the types of data collection instruments used and the data analysis software that has been employed. The last section of the chapter looks at the research approach that has been used, and gives a brief discussion of the justification for employing such an approach in this study and the reasons for the chosen data collection methods.

In Chapter Two, I look at extant literature related to this study and give detailed discussion of both international and national perspectives, as well as trends pertaining to the controversial debate about the concept of 'mathematical literacy' and its related terms. The chapter comprises seven sections (with intermittent subsections). After a brief introduction, the first section presents an outline of the conceptual framework that informs this study. The second section (including its subsections) presents a review of the relevant literature and is centered around the discussion and presentation of the various perspectives dealing with the definitions and different connotations used by different authors to describe the term 'mathematical literacy' and its related terms. This section also looks into the origin of the debate on mathematical literacy, and also into the questions: "What is mathematical literacy?" and "Why mathematical literacy?" The third section presents a discussion relating to the issue of whether or not there is a relationship between 'mathematics' and 'mathematical literacy'. In the fourth section, I present a discussion of some of the views relating to the distinction made between the notions of mathematical literacy: as a 'competency' and as a 'subject of study'. The fifth section looks at the relationship between the terms 'mathematical literacy', quantitative literacy, and numeracy. In this section, an attempt is made to answer the question: Is mathematical literacy synonymous with quantitative literacy and/or numeracy? And I argue that these three terms are not the same, thereby offering some important distinctions as a basis for my argument. The sixth section offers some concluding remarks, and the last but not the least section, is a summary of the key issues in this chapter.

Chapter Three is divided into eight sections. The first section serves as an introduction to the chapter, and points to the theoretical framework (paradigm) which has been used in the research sense-making and meaning-making, and the methodological dimension of the study which outlines the procedures and the strategies that have been applied in this research project. In the second section the research design is discussed, thereby giving a detailed research process as has been carried out in this study concerning sampling methods, research instruments, piloting of instruments, data production and analysis methods, reliability and validity issues, Issues of gaining access, ethical considerations, and limitations and delimitations of the study. Chapter Four presents the findings of the study, and further gives the interpretation and discussion of the results with minimal comments in-between. It consists of nine sections. The first section gives the order in which the rest of the sections are presented and discussed. In the second section perceptions of mathematical literacy as evident in curriculum documents are also presented, leading to a discussion of my personal observations of how these documents highlight such perceptions with particular emphasis on the relationship between the cognitive styles of mathematics and the social life of the learners. The third section looks at participants' perceptions of the competencies and/or characteristics of a mathematically literate person. In this section, I present and discuss participants' responses and the findings thereof. In the fourth section, participants' beliefs, conceptions and views about mathematical literacy as a subject are presented and discussed. It is in this section where comparisons between the various cohorts are made to highlight any differences in beliefs about the notion 'mathematical literacy' as a subject by way of computing the mean agreement with each of the 12 beliefs. The fifth section discusses participants' personal understandings of the distinction between mathematical literacy as a competence and as a subject. In the sixth section I present and discuss participants' understandings of the relationship and/or differences between mathematics and mathematical literacy. The seventh section deals with participants' perceptions of the necessity, usefulness and purpose of mathematical literacy as a competence and as a subject within the Further Education and Training

(FET) phase of schooling. In the eighth section I present and discuss participants' perceptions of and their initial experiences with the teaching of Mathematical Literacy as a curriculum subject. The ninth section (which is the last) gives a summary of what has been presented and discussed in all the previous sections of this Chapter and concludes the chapter by giving brief overall findings of this study.

Chapter Five serves to draw conclusions and, in the process, a discussion of the implications of the results of the study for policy and practice is presented in the intermittent sections. There are four sections in this Chapter.   The first section discusses the summary of the main findings. In the second section I look at the implications of the findings of this study for policy and practice, and make recommendations. The third section deals with issues pertaining to possible further research in the area of mathematical literacy. I have highlight a number of important issues that, I believe, will assist in bringing about a better understanding of the concept of mathematical literacy; thereby helping to address some of (if not all) the issues and/or problems obtaining from the findings of this study.   The fourth section is the last one, and gives an overview of the previous sections by presenting a summary of what has been discussed in this Chapter. Finally, in Chapter Six the limitations of the study are discussed together with researcher's reflection and reflexivity on the research process. This is done in three sections. The first section looks at the limitations of the study. In the second section I discuss issues relating to reflexivity in the research process and, in particular, highlight the importance of recognizing the centrality of the researcher's subjectivity and biasness to the generation and presentation of ethnographic knowledge. Finally, I have made my personal reflections on this study in the last section of this Chapter.

CHAPTER TWO CONCEPTUAL FRAMEWORK AND LITERATURE RIVIEW

There is a growing number of reports and articles written and referring to the terms 'mathematical literacy', 'quantitative literacy', 'numeracy', 'mathematical proficiency', and 'mathematical competence'. And these terms seem to have been conceived differently despite each term aiming to describe a measure of mathematical knowledge and skills in relation to their wider uses in people's lives. Some examples of research reports and theoretical discussions that have been considered include: Kilpatrick et al, 2001; Kilpatrick, 2002; Steen, 2001; Madison, 2004; Wallace, 2000; Jablonka, 2003; MCATA, undated. Much of this literature highlights debates and disagreements that exist within the international mathematics education community regarding the meaning of the concept 'mathematical literacy'. The literature further shows that there are two distinct 'notions' of mathematical literacy: as a competency and as a subject of study. Furthermore, a review of literature reveals that despite the prevailing controversy about the meaning of 'mathematical literacy', there are a few countries (including South Africa) which have embraced this concept and have even introduced it as a subject of study in the mainstream curriculum (Department of Education, 2003; MCATA, undated). Thus this review presents a conceptual discussion of the notion 'mathematical literacy' and its related terms (facets), and further discusses perspectives relating to the development of these terms and their definitions. Accordingly, the references used here are not that comprehensive but have been restricted to the discussion of the concept 'mathematical literacy' and its relatives that seem to have been used as a synonym for mathematical knowledge (covering the period from 1995 – present). However, due to the perceived multi-faceted and distinctive nature of the concept of mathematical literacy, it would not be wise, in my view, to group the views of the various authors since the definitions that are offered seem to be also different.

Much of the literature that has been reviewed and is related to this study was found, in addition to a few readings obtained from lectures, largely through Google and Yahoo web searches using the key concepts 'Mathematical literacy', 'Quantitative literacy', 'Numeracy', 'Mathematical Proficiency', and 'Mathematical Competence'. The search was also extended to mathematics education journals and there were few journals found which specifically dealt with the origin and elaborated views of the concept of ‘mathematical literacy’. However, some of the articles that were obtained from these searches dealt with the definitions of the concept of ‘mathematical literacy’, while others dealt with the reasons for incorporation of ‘mathematical literacy’ as a subject in the mathematics education curriculum. In general, all the articles that have been found show that not only are there different conceptions of ‘mathematical literacy’ but also that the concept is given different labels by different authors (Madison, 2004; Kilpatrick, 2002; Steen, 2001a; MCATA, undated). There are debates about the meaning of ‘mathematical literacy’, and the controversy centers around two main questions: What is mathematical literacy? and Why mathematical literacy? Existing literature, both locally and internationally, on this concept shows that there are many different interpretations or definitions of the concept of ‘mathematical literacy’, and the authors (mathematics educators), especially in the United States and in Europe, are divided as to what the correct terminology or label should be used to convey the same concept (AMESA, 2003; DoE, 2003; Jablonka, 2003; Kilpatrick et al., 2001; Madison, 2004; MCATA, undated; Sfard & Cole, 2003; Steen, 2001a; 1999; Wallace, 2000). For example in the UK it is called ‘Numeracy’; in the US it is called ‘Mathematical Literacy’ or ‘Mathematical Proficiency’; and some authors elsewhere prefer to call it ‘Quantitative Literacy’. The problem with these terms, therefore, is that they seem to convey different concepts that are associated with various images, notions and connotations; that people in different parts of the world perceive these terms in quite different ways, and that these terms are used, rightly or wrongly, to convey all kinds of things (de Lange, 1996; Niss, undated; Steen, 2001a).

On the basis of the foregoing it is imperative that this study [literature review] is conducted with the aim of gaining personal understanding as well as to contribute to public understanding of the concept of ‘mathematical literacy’. This will be particularly important for all mathematics educators because the successful implementation of Mathematical Literacy curriculum in several countries where the idea has been adopted will depend fundamentally on teachers’ system of beliefs, in particular on their perceptions of the nature and meaning of mathematical literacy which, to a greater or lesser extent, influence their classroom practices (Fennema & Franke, 1992).

2.1 Conceptual Framework

I locate my account of the debate on the meaning of the theoretical concept of mathematical literacy within a framework recently advocated by Jablonka (2003). In her framework Jablonka (2003) highlights the fundamentally situated nature of the concept of mathematical literacy, and she argues that mathematical literacy is linked to social and cultural practices. She asserts that it is difficult to say what the different meanings of the terms 'numeracy' (or 'quantitative literacy') and 'mathematical literacy' are, especially when there seems to be a variety of interpretations from different authors within the mathematics education community regarding the distinction between the notion 'mathematical literacy' as a subject or area of study, and as a competence, habit of mind or a social practice. I draw especially on her categorization of the different perspectives presented in her chapter about mathematical literacy to look at what other extant literature and mathematics educators have to say regarding the meanings or definitions of 'mathematical literacy' and its related terms; as well as teachers' perceptions of and beliefs about 'mathematical literacy' as a relatively new concept.

Recently there has been a growing interest within the mathematics education community on the subject of what it really means to be mathematically literate, and whether or not there are any differences between 'mathematical literacy' and 'numeracy' (or 'quantitative literacy'); and how the concept of mathematical literacy relates to mathematics (DoE, 2003; MAA, 1998; Madison, 2004; MCATA, undated; Steen, 2001a). More importantly, a move towards the development of mathematical literacy is underway in a number of countries despite the different connotations used to describe the same concept. For example, Alberta curriculum in Canada lays out the mathematics standards needed to address and provide a solid base for mathematical literacy (MCATA, undated). Similar changes (that is, including mathematical literacy in mathematics) are underway also in the US, France and the Netherlands (Hoogland, undated). In response to the debate on the theoretical concept of 'mathematical literacy' as a result of the different connotations and nomenclature used to describe it, Jablonka (2003) provides a critical account of different perspectives on this concept. As she puts it, "The central argument is that it is not possible to promote a conception of mathematical literacy without at the same time – implicitly or explicitly – promoting a particular social practice" (Jablonka, 2003; p. 75).

Thus this assertion suggests that there are different perspectives on mathematical literacy, and these perspectives vary according to value systems as framed by the stakeholders (politicians, policy makers, and curriculum developers) who promote it. It also can be inferred from this comment that 'mathematical literacy is, in fact, a competency. On the basis of this Jablonka classifies the different approaches into five categories (each of which relates to expected human behaviour or habit of mind) as follows, and concludes that the differences in approach are linked to the goals of mathematics education pursued in individual countries (and are aimed at promoting different social practices):

- Mathematical Literacy for Cultural Identity;
- Mathematical Literacy for Social Change;
- Mathematical Literacy for Environmental awareness;
- Mathematical Literacy for Evaluating Mathematics;
- Mathematical Literacy for Developing Human Capital (Jablonka, 2003).

Jablonka (2003) discusses each of the categories in such a way as to highlight the various conceptions of mathematical literacy in relation to how the relationship between mathematics, cultural setting, and the curriculum is being differently perceived in the international mathematics education community. And the following is a synopsis which reflects each of the approaches as has been discussed by Jablonka (2003) and also summarized by Kees Hoogland (undated):

Mathematical Literacy for Developing Human Capital. This approach focuses on equipping people with the mathematical tools to be able to interpret and organize their everyday lives, and the assumption here is that all kinds of problems can be modeled with mathematics and can subsequently be solved with mathematical techniques. These are problems from day-to-day life as well as problems in the work place and problems at a global level. This is the same approach that was used by OECD's Programme for International Student Assessment (PISA), and is echoed in its definition which claims that such a definition is cross-cultural because mathematics is not culture-bound and is free from value judgment and therefore globally comparable (OECD (ed.), 2000; Clarke, 2003; DoE, 2003).

Mathematical Literacy for Cultural Identity. This approach has been more pronounced in the developing countries where there seems to be a serious mismatch between the mathematics the students have to learn at school and the (informal) mathematics they use in their everyday lives and which they use to solve everyday problems. The approach serves as argument to give this informal mathematics a more important place in the curriculum, and thus seem to reflect the socio-cultural embeddedness of this kind of mathematics, which is now commonly referred to as 'ethnomathematics' and is regarded as a form of mathematical literacy. However, it is worth noting that from this perspective there is opposition to the translation of curricula and learning support materials from other countries and cultures, because it has the negative psychological effect on teachers and learners that mathematics is something that comes from outside as opposed to something that is inextricably linked with their own world, something that does not fit in with their cultural identity. This approach is therefore at odds with the view that everywhere in the world mathematical literacy has to involve the same kind of mathematics (Hoogland, undated).

Mathematical Literacy for Social Change. This is the critical pedagogics perspective in which mathematical literacy is seen as a capacity to view reality differently and to change it. From this perspective, mathematical literacy needs to lead primarily to critical citizens (see DoE, NCS for Mathematical Literacy, 2003). The approach strongly criticizes school mathematics, which only leads to continued inequality in knowledge, social class and sex. In this perspective the teaching and learning of mathematics should focus mainly on the critical consideration of socially and politically meaningful issues, especially if they are associated with statistics. And as Jablonka says, "….One important function of mathematics within this vision of mathematical literacy refers to the use of basic statistical data and statistical questions to deepen one's understanding of particular issues and to change people's perceptions of those issues (Jablonka, 2003, p. 85).

Mathematical Literacy for Environmental Awareness. This approach contends that mathematics provides a useful and beneficial contribution to industrialization and science and therefore to the improvement of living conditions and the level of welfare of the population. Hence it seems to have a wide support all over the world. However, supporters of this approach seem to be also agitated by the recognition of the dangers that advanced technologies bring along as a result of applying mathematics in technological developments. They would like to see how mathematics can contribute to analysis of global environmental problems so as to make all kinds of people much more aware of this role of mathematics because they believe that mathematical literacy involves an attempt to change people's perceptions of mathematics (see also Hoogland, undated).

Mathematical Literacy for Evaluating Mathematics. In this perspective, mathematical literacy is viewed as learning to identify as well as being able to critically evaluate mathematics and the role that mathematics plays; and this is however rarely found in school mathematics. This form of mathematical literacy learning requires a great deal of discussion and dialogue during mathematics lessons. In view of the fact that mathematics is used explicitly and implicitly (in the school subject of Maths; in all kinds of political discussions involving figures; in models and graphical representations; and in technology) throughout society, this approach aims to prepare learners to become mathematically literate so as to enable them to "interpret information presented in a more or less scientific way" (Jablonka, 2003, p. 89), such as use of condensed measures and indexes, and use of models; be aware of applications of such uses of mathematics, and be able to critically evaluate those measures and models that are often not accompanied with the relevant social or political background. Awareness of the danger of relying fully on ready-made or compiled figures (inflation, consumer confidence, productivity, price index, etc) and the critical use of models, as well as the consciousness of the limits of reliability of mathematical models, according to this approach, should be seen as some of the characteristics of a mathematically literate person (Jablonka, 2003).

In her conclusion, Jablonka (2003) makes a number of conclusions about mathematical literacy some of which seem most relevant to mathematics education at upper secondary school level. And the following are some of such conclusions:

Firstly, there are many different ways to analyze the relationship between the mathematics taught in schools and that used outside school and the various definitions of mathematical literacy revolve around this relationship because they relate to an individual's capacity to use the mathematics that should be learnt at school. Secondly, the ability to understand the mathematical aspects of everyday situations and to make a judgment about them forms an important part of mathematical literacy. Thirdly, the capacity to evaluate critically is not in itself mathematical by nature and neither is it a result of a high level of mathematical thinking. And lastly, introducing critical discussions implies bringing in a great deal of classroom discussion about mathematics. This will lead to well-informed citizens dealing with mathematics outside of school in a new way.

In essence, Jablonka's categorization and the conclusions she draws (although not giving a direct definition of mathematical literacy) seem to suggest that mathematical literacy can be perceived both as a competence or a behaviour and as a subject of study, depending on the various cultural settings within which it is being promoted. Also, it is implied from the explanations or descriptions on each category that mathematical literacy is more of a behaviour, an ability or a habit than a subject of study, in that all such descriptions place much emphasis on what learners should be able to do (as an end-product) in terms of the skills that will have been acquired through the learning of formal mathematics; thereby empowering them to be able to critically face all of the socially and politically meaningful issues they meet in their everyday lives in this modern society. This, of course, essentially, also suggests that mathematical literacy is a direct 'by-product' (so to speak) of successful mathematics teaching and learning which necessarily should aim at making learners aware of real world applications of mathematics. Hence her conclusions essentially suggests that mathematical literacy is a competence since the various definitions that have been offered by various authors only serve to reflect how the mathematics that should be learnt at school could be used by individuals once they leave school.

2.2 Literature Review

In the following sections, an exploration of the origin of the debate on the theoretical concept of mathematical literacy is presented, leading to a discussion of extant literature pertaining to the development of mathematical literacy as a new concept, as well as perspectives on its various definitions.

2.2.1 The Origin of the debate on the concept 'mathematical literacy'

Between January 1998 and June 2001, amid the dispute about standards-based reforms and as a result of a major concern raised by policymakers around the world regarding the effectiveness of schools in preparing learners (particularly in mathematics) for work and life, a study committee of experts (in the US) in classroom practice, mathematical sciences, cognitive science, business, and mathematics education was appointed to conduct a study about mathematics learning and then provide recommendations for best practice in the early years of schooling (Kilpatrick et al., 2001). In its main responsibility of synthesizing research, the study committee was also charged with the task of defining and describing the context of the study with respect to what is meant by 'successful mathematics learning' (Kilpatrick, 2002; Kilpatrick et al., 2001). And this prompted the need to discuss the definition of 'successful mathematics learning', and the committee, recognizing that it needed some way of characterizing such learning, considered many possible terms, and among them were 'mathematical literacy', 'numeracy', 'mastery of mathematics', and 'mathematical competence' (Kilpatrick, 2002). However the committee felt that, although each of these terms captured what it means to learn mathematics successfully, none of them seemed suitable enough. Hence they finally decided to adopt the term 'mathematical proficiency', defining it in terms of the five strands as developed and outlined in the *Adding it Up: Helping Children Learn Mathematics* final report by National Research Council (Kilpatrick et al., 2001). The report described mathematical proficiency as the integrated attainment of 'conceptual understanding', 'procedural fluency', 'strategic competence', 'adaptive reasoning', and 'productive disposition'. The study committee believed that 'mathematical proficiency' was the most appropriate term that could be used to define learning goals for all students and that at any age or grade students' proficiency or lack of it could be judged according to those goals. Kilpatrick (2002) argues that the term ‘mathematical literacy’, though it was not adopted for the aforementioned report, equally characterizes ‘successful mathematics learning’ just like the term ‘mathematical proficiency does, and therefore also portrays and fits the study committee’s view of mathematical proficiency very well. Hence the term ‘mathematical proficiency’ has since been adopted especially that (according to the study group’s review of literature on mathematics learning) no use of such a construct had been made before (Kilpatrick, 2002).

However, the current debates concerning the definitions of the concept of mathematical literacy and its related terms have been going on for several decades, and yet there seems to be a wide agreement that a well educated citizen in this 21st century should have some significant proficiency in mathematical thinking and in the most useful elementary techniques that go with it. Overall, it seems there is a growing awareness (despite disagreements over definitions used to describe mathematical literacy) of the inadequacy of traditionally defined mathematics skills in preparing individuals to operate powerfully (Madison, 2004; MAA, 1998; Wallace, 2004; Steen, 1999; MCATA, undated; Kilpatrick et al, 2001; Kilpatrick, 2002).

2.2.2 What is Mathematical Literacy?

Before trying to answer the main research question about mathematics educators’ perceptions of the notion ‘mathematical literacy’, it is necessary first to consider what extant literature has to offer in terms of the definition of this theoretical concept. It has been noted that the term mathematical literacy has been given a variety of different names such as quantitative literacy, numeracy, mathematical proficiency, mathemacy, or critical mathematics education; and consequently the same terms have been given a variety of interpretations which have led to a controversy over the definition of the term ‘mathematical literacy’ by different authors. This debate, which is comprehensively reviewed by Coben et al (2003), not only concerns itself with the definition of the concept, but also its relationship to mathematics itself. Table 2.1 provides definitions of mathematical literacy and its various related terms from the 1995 IALS/ALL study (OECD, 1995) to the 2006 definition arising from the PISA study (OECD, 2006) which appears to have gained acceptance. Some of the definitions are discussed in the following sections.

Table 2.1 Definitions of Mathematical Literacy and its related terms.

Date	Source	Term	Definition
1993	National Adult Literacy Survey	Quantitative Literacy	The knowledge and skills required to apply arithmetic operations, either alone or sequentially, using numbers embedded in printed materials (e.g. balancing a checkbook, completing an order form)
1995	International Adult Literacy Survey	Numeracy	The knowledge and skills required to effectively manage and respond to the mathematical demands of diverse situations.
1997	OECD; International	Quantitative Literacy	The knowledge and skills required to apply arithmetic operations, either alone or sequentially, to numbers embedded in printed materials, such as balancing a checkbook, figuring out a tip, completing an order form, or determining the amount of interest on a loan from an advertisement.
2000	ILSS: International	Quantitative Literacy	An aggregate of skills, knowledge, beliefs, dispositions, habits of mind, communication capabilities, and problem solving skills that people need in order to engage effectively in quantitative situations arising in life and work.
2000	OECD (PISA): International	Mathematical Literacy	The capacity to identify, to understand and to engage in mathematics and to make well founded judgments 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.
2000	Evans: England	Numeracy	Numeracy is the ability to process, interpret and communicate numerical, quantitative, spatial, statistical, even mathematical information, in ways that are appropriate for a variety of contexts, and that will enable a typical member of the culture or subculture to participate effectively in activities that they value.
2003	Department of Education: South Africa	Mathematical Literacy	Mathematical Literacy provides learners with an awareness and understanding of the role that mathematics plays in the modern world. Mathematical Literacy is a subject driven by life-related applications of mathematics. It enables learners to develop the ability and confidence to think numerically and spatially in order to interpret and critically analyze everyday situations and to solve problems.
2006	OECD(PISA): International	Mathematical Literacy	An individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments 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.

2.2.3 Why mathematical literacy?

In this section, different views regarding the development of mathematical literacy as a new concept are discussed, with some of the definitions and nomenclature that emerged to describe mathematical literacy being presented; and in the process will be a discussion of the arguments advanced in favour of the various terms and definitions associated with the notion 'mathematical literacy', and most importantly, in favour of mathematical literacy as both a theoretical concept and a social practice. Furthermore, a critical discussion of the notion 'mathematical literacy' as a competence and as a school subject is presented, and the distinction thereof (if any) will be drawn.

In the following sections, I will in the process argue that 'quantitative literacy' and 'numeracy' (and all other related mathematical terms/phrases) are, essentially, elements or expressions of mathematical literacy (de Lange, undated). Thus I will further argue that quantitative reasoning and number sense (or numeracy) are dimensions of mathematical knowledge; hence they are inseparable from mathematical literacy as content is inseparable from context, both of which are linked to the diverse socio-cultural practices of today's increasingly advancing technological world (Guberman, 2004; Stolp, 2005; Department of Education, 2003). Consequently, and contrary to earlier assertions from many of the arguments highlighting some similarities between mathematical literacy on one hand, and quantitative literacy and numeracy on the other hand, I will also argue that quantitative literacy is different from numeracy, and that mathematical literacy *must* not (and should not) be perceived as a subset of formal mathematics or even another discipline that can be equated to mathematics subject.

Recent years have seen a growing dialogue about the goals and impact of mathematics education, and various arguments have been brought forward to support a broadening of the conceptions regarding mathematical knowledge and skills that school graduates should possess. The concern about ways of improving mathematics teaching and learning, apparently, has been the driving force behind growing international interest to transform mathematics curricula in ways that would ensure proper development of mathematical literacy in all learners (Kilpatrick, 2002; Madison, 2004; Wallace, 2004; Steen, 1999). As such, mathematics educators around the world have at various levels engaged with the idea of defining learning goals for all students with a view to providing them with all the necessary mathematical knowledge and skills to prepare them for the socio-economic and political challenges of this modern civilized society (Steen, 2001a; MCATA, undated). The description of learning goals in the NRF Mathematics Learning Study *Adding It Up* describes five strands of mathematical proficiency as defined in the report. This definition of learning goals is what was to characterize a 'successful teaching and learning of mathematics' so that students at any age could be judged mathematically literate or not according to those defined goals (Howson, 2002; Kilpatrick, 2002). However this characterization has actually brought controversy regarding the definitions of mathematical literacy and its related terms, and whether or not these are perceived in the same way within the international mathematics community (Evans, 2000; Jablonka, 2003; Kilpatrick, 2002; Steen, 2001a; 2001b).

According to existing literature there are many different conceptions of 'mathematical literacy'. Although the study is focused on South African context, it is important that this concept is discussed drawing on/from the international perspectives in order to have a thorough exploration of the issues around this topic. The concept 'mathematical literacy' has been not only variously defined but different names/labels have been used differently both nationally and internationally to refer to or to convey the same idea (Madison, 2004; Gal cited in Hobden, 2004; Sfard and Cole, 2003; DoE, 2003; AMESA, 2003; Kilpatrick, 2002; MCATA, undated; Steen, 2001a; OECD 2000; Wallace, 2000; Evans, 2000; Steen, 1999).

2.2.4 Perspectives on the various definitions of mathematical literacy

This section looks at both international and national perspectives on the various definitions of mathematical literacy as described by the different authors in extant literature, as well as the arguments in favour of and against its development within mathematics education curriculum.

International Perspective: Mathematical Literacy or Quantitative Literacy?

Madison (2004) in his article *Two Mathematics: Ever the Twain Shall Meet?* asserts that there are two kinds of mathematics: formal (real) mathematics and trivial (useful) mathematics. He calls the two mathematics, *Formal Mathematics* and *Quantitative*

Literacy respectively. Madison defines *Quantitative Literacy* (QL) as "the ability for citizens to deal with the quantitative demands of everyday life" (Madison, 2004, p. 9). He argues that today's mathematics curriculum (at least in America) is dominated by a hurried and linear sequence of geometry, algebra, trigonometry, and calculus (GATC, for short) which, in his view, is ineffective in teaching for Quantitative Literacy. Madison's argument clearly suggests that there is a difference between mathematics and what he calls Quantitative Literacy. However, he does not seem to have any problems referring to quantitative literacy also, as *mathematical literacy* since he uses the two terms interchangeably.

Madison (2004) further argues that teaching and learning for quantitative literacy (or mathematical literacy) requires a different approach to both the curriculum and pedagogy, and this should involve looking at bringing together QL and formal mathematics through more contextual teaching (using multiple contexts). As he says, "……Quantitative Literacy is a habit of mind….developing habits of mind requires practice in a variety of contexts. Mathematics alone cannot teach QL…" (Madison, 2004, p.11). Changes should also include coordinated integration of quantitative literacy (QL) concepts across the curriculum by other disciplines. And more importantly, as he claims, there is lack of understanding about QL and how to achieve it and that is why there are fears that teaching contextualized mathematics will water down the mathematics (compare with Steen, 2001a; 1999; Wallace, 2000); and that not many students will choose to learn formal mathematics needed for science and engineering. Finally, Madison (2004) argues against the perception that QL is for lower-class students and points out that this is what has led some people into favouring formal mathematics for everyone.

It seems clear from Madison's (2004) arguments that there is very little difference (if any) between mathematical literacy and quantitative literacy. Most importantly, Madison's assertions, especially from his definition, seem to suggest that ML/QL should be viewed both as a competency and as a subject of study. This is evident in his phrase that, "…….QL is a habit of mind….." (p.11). Also, by classifying QL as trivial mathematics, suggests that Madison views it as a subject of study. Hence I am inclined to conclude that, according to him, there are two notions of the concept 'mathematical literacy': as a competency and as a subject of study. And by arguing that formal mathematics and trivial mathematics (quantitative literacy) could be brought together is indicative of his conviction to the idea of integrating mathematics into other subjects of the curriculum if the teaching of learning for 'mathematical literacy' is to be achieved (see also Adler et al., 2000). This, he believes, can be achieved through what he calls contextualized teaching of mathematics by well trained teachers who have been adequately prepared to teach or educate learners for 'mathematical' or 'quantitative' literacy .

Steen (1999) in his article *Numeracy: The New Literacy for a Data-Drenched Society* argues for the need to develop the teaching and learning of mathematics with a view to enhancing mathematical skills of learners at all levels of the education system. He also is of the view that numeracy (which he also calls *quantitative literacy*) has come to mean different things to different people across the world (see also Niss, undated). Steen (1999) asserts that there is confusion within the mathematics education community about the nature of quantitative literacy or numeracy and especially about its relation to mathematics (see also Madison, 2004). And he argues that it should not be considered as 'basic skills', 'elementary statistics', 'logical reasoning', or 'advanced mathematics' because, according to him, none of these by itself gives a holistic meaning of numeracy. He further asserts that as a result of this confusion the teaching of mathematics in various institutions differs widely in terms of the requirements that will lead to quantitatively literate graduates (see also Wallace, 2000). Although he does not define numeracy, Steen (1999) makes a claim that numeracy is more than mathematics, and therefore is the gateway to understanding the modern data-drenched society. However, he points out that: "The test of quantitative literacy……is whether a person naturally uses appropriate skills in many contexts" (Steen, 1999, p. 12), which seems to imply that numeracy or mathematical literacy is in fact a competence.

Thus it seems clear that Steen (1999) believes that teaching for numeracy can best be achieved through use of multiple contexts as well as teaching/learning of mathematics as an integrated subject (see also Madison, 2004; AMESA, 2003; DoE, 2003). However he still does not make it clear how he defines numeracy. This is even compounded by his use of other terms like 'mathematical literacy' and 'quantitative literacy' in his article when he refers to numeracy. For example, he says:

"…..national and international studies show that most U.S. students leave high school with far below even minimum expectations for mathematical and quantitative literacy…"(my emphasis)(Steen, 1999, p. 8). This, unlike in the cases of Kilpatrick (2002) and Madison (2004), does not make it clear whether or not there are any differences in these terms especially that no definition(s) have been offered by him. However, it is clear from his argument that he views mathematical literacy or numeracy as more of a *competency* than a subject of study. This is evident from the phrase/expression "…teaching for numeracy…" which he uses throughout his discussion. Finally, however, Steen (1999) suggests that Mathematical and/or Quantitative Literacy (which he calls Numeracy) must be taught across the curriculum in high schools, and that teachers of every subject must use students' numeracy skills – especially in the natural, social, and applied sciences where the need for Mathematical and Quantitative Literacy is compelling – in order to enhance the central issue of reinforced learning for Numeracy. Thus Steen is also of the view that 'numeracy' can be achieved through contextualized teaching of mathematics as an integrated subject. This perception of numeracy clearly portrays it as a competency.

Wallace (2000) argues that if mathematics knowledge is dispersed widely throughout the population, no matter what exactly the content is, we can be sure that the opportunities for a child to learn to fear mathematics will decrease. He, however, is also of the view that not every learner pursues a career in mathematics; so it is not necessary for everybody to do it as a standardized course of study, but offering a wide variety of interdisciplinary courses in which students study a specific topic in depth might satisfy society's larger and more pervasive needs in this twenty-first century. He goes on to suggest that the individual should be free to pursue his/her own ends, including along the way many parts of mathematics that are relevant to those ends. The goal should be for everyone to have a solid grasp of particular parts of mathematics, with specific content varying widely throughout the population. In other words, he is advocating for the teaching of a contextualized and relevant kind of mathematics in service for quantitatively literate modern society.

Madison (2004), Wallace (2000) and Steen (1999) are of the view that the development of quantitative literacy can best be achieved through contextualized teaching and learning practices using multiple contexts. Furthermore, they assert that it is important to educate citizens of any democratic nation for quantitative literacy or numeracy if they are to be ‘mathematically’ or ‘quantitatively’ literate. Although these authors, in principle, seem to express similar sentiments, Steen (1999) does not make mention of the term mathematical literacy in his arguments. But, from the way he presents his arguments, one can infer that the three authors are using their respective terms to describe what others (e.g. Kilpatrick, 2002; Department of Education, 2003) refer to as mathematical literacy. Again, we can discern from Wallace’s (2000) argument that he views ‘mathematical literacy’ as a competency which develops out of a particular way of presenting mathematics to learners. This point is actually corroborated by Kilpatrick et al’s (2001) idea of ‘mathematical proficiency’, and both of them seem to emphasize more or less the same thing; and that is, the mastery of mathematics.

Stoessiger (2003) points out that numeracy is not the same as arithmetic (as has traditionally been thought). He describes numeracy as a set of “mathematical skills needed to function in everyday life, in the home, workplace and community” (Stoessiger, 2003, p. 2). Furthermore, Stoessiger (2003) takes the discussion of numeracy to another level and talks about the idea of *critical numeracy* which he says, “….is a focus on the ways in which practical mathematical situations are implicated in the power relationships and face-to-face politics of everyday life……..a focus on how numeracy in all its forms is involved in our relationships to each other and the world” (Stoessiger, 2003, p. 2). He also highlights that practical uses of mathematics in the world (the domain of numeracy) demonstrates the importance of numeracy in people’s everyday lives. Hence he defines numeracy as follows:

> “To be numerate is to have and be able to use appropriate mathematical knowledge, understanding, skills, intuition and experience whenever they are needed in everyday life” (Stoessiger, 2003, p. 2).

This conception of numeracy sounds much broader and is similar to that of Steen (1999) and Wallace (2000) whose arguments also characterize numeracy as having important application in people’s lives because the emphasis in both cases is on the practical or everyday uses of mathematics. Stoessiger (2003), however, does not state whether or not numeracy is related to quantitative or mathematical literacy but, from the definition, one can discern that there are similarities between these concepts. For this reason therefore, I would like to conclude that the authors are talking about the same “animal” despite the different names they have used. Hence the authors’ conceptions fit well into Jablonka’s framework (see *Mathematical Literacy for Developing Human Capital* and *Mathematical Literacy for Social Change*). Stoessiger (2003) further argues that numeracy is a social practice, and so it has an influence in the power relationships between individuals and social groups. He also points out that the teaching of critical literacy involves various ways through which “students learn how to use mathematics in the world” critically, thereby empowering them in different ways one of which is to see themselves as “creators of mathematics for their own purposes”…… (Stoessiger, 2003, pp. 4-5). As he puts it:

> “[….], critical numeracy is about critique; it is about helping students develop a healthy skepticism about the use of numbers, graphs, statistics and measurement. …….it is also about empowerment” (Stoessiger, 2003, p. 4).

Finally, and probably most importantly, Stoessiger (2003) points out that critical numeracy is characterized by the following four major aspects:

- Being able to critique or make critical interpretations of mathematical information;
- Being able to unpack, interpret or decode mathematical situation;
- Using mathematics in a self-reflective way;
- Using mathematics to operate more powerfully in the world.

This conception of numeracy characterizes it as functional mathematics which can empower citizens with the necessary skills to be able to engage in socially and politically meaningful issues (compare with Steen, 1999; Steen, 2001 and with DoE, 2003; PISA, 1999 on Mathematical Literacy). Clearly, Stoessiger’s (2003) argument resonate well with Jablonka’s framework (see ‘Mathematical Literacy for Social Change’, Jablonka, 2003).

IALS/ALL (1995) argue that Numeracy should be viewed as different from knowing school mathematics, and that it is broader than Quantitative Literacy (compare with Madison, 2004; Steen, 1999). It further asserts that some definitions and perspectives on the meaning of numeracy contain emphasis on the practical or functional application of mathematical knowledge and skills; and as a result the study (IALS/ALL, 1995) offers the following definition to illustrate such a perspective:

> "Numeracy is the mathematics for effective functioning in one's group and community, and the capacity to use these skills to further one's own development and of one's community" (IALS/ALL, 1995, p.2).

This conception of numeracy clearly reflects some resemblance to what has been discussed concerning mathematical literacy and quantitative literacy by other authors (see Stoessiger, 2003; Jablonka, 2003) in terms of practical uses or functional application of mathematics in real life situations. Another perspective that has been offered about numeracy is as follows:

> "To be numerate is more than being able to manipulate numbers, or even being able to 'succeed' in school or university mathematics. Numeracy is a critical awareness which builds bridges between mathematics and real-world, with all its diversity" (Johnston cited in IALS/ALL, 1995, p.2).

This is another illustration of the conception of numeracy that shows the relationship between numeracy and mathematics (and about the concept of critical numeracy as discussed by Stoessiger, 2003) in terms of how mathematical knowledge, skills and understandings can actually be put into practice as shown and discussed elsewhere by other authors (see Steen, 1999; Department of Education, 2003). However, in the definition given above there is no explicit indication that numeracy has the same meaning as mathematical literacy or quantitative literacy but the description leads to that conclusion.

Steen (2001a), in the NCED report, makes a distinction between 'quantitative literacy' which stresses the use of mathematical and logical tools to solve common problems, and 'mathematical literacy' which stresses the traditional tools and vocabulary of mathematics, and highlights the differences in terms of the topics found on each of these ‘subjects’ in order to explain their different definitions (see also MAA, 1998). In conclusion, the article asserts that Quantitative Literacy is driven by issues that are important to people in their lives and works, not by future needs of the few who may make professional use of mathematics or statistics. As pointed out in the report: “In the teaching of Quantitative Literacy, content is inseparable from pedagogy and context is inseparable from content. And because Quantitative Literacy is everywhere, there are good opportunities to teach it across the curriculum” (Steen, 2001a, p. 9) (see also Madison, 2004; Wallace, 2004 and Steen, 1999). Again, this argument suggests that QL is a competency that can be achieved through contextual teaching of mathematics in an integrated manner, and not as a separate subject of study. The emphasis here is in its connectedness to people’s lives and work. However, the differences between ‘quantitative literacy’ and ‘mathematical literacy’ expressed here clearly contradict earlier assertions made by Madison (2004) and Steen (1999) that the two concepts mean the same thing. On the other hand numeracy is defined differently from mathematical literacy or quantitative literacy by other authors (de Lange, undated; IALS/ALL, 1995; OECD (ed.), 2000; Steen, 2001b). It is these kinds of contradictions that are at the core of this academic debate regarding the term ‘mathematical literacy’ and its facets/relatives.

Levels of Mathematical Literacy – proficiency or competency?

Kilpatrick et al (2001) in their report *Adding It Up: Helping Children Learn Mathematics* give a view of what they consider to be a successful mathematics learning and their conception of what it means to be mathematically proficient. The discussion describes the kinds of cognitive changes that need to be promoted in learners in order for them to be successful in learning mathematics. They refer to such “successful mathematics learning’ as “mathematical proficiency”, and this is defined in terms of the following five interwoven components or strands:

- Conceptual understanding – comprehension of mathematical concepts, operations, and relations;

- Procedural fluency – skills in carrying out procedures flexibly, accurately, efficiently, and appropriately;

- Strategic competence – ability to formulate, represent, and solve mathematical problems;

- Adaptive reasoning – capacity for logical thought, reflection, explanation, and justification; and

- Productive disposition – habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy as a doer of mathematics (Kilpatrick et al, 2001).

The authors of this report point out that these strands are not independent of each other, and that they represent different aspects of a complex whole. It is clearly emphasized that the strands are interwoven and interdependent in the development of proficiency in mathematics. The discussion of the five strands that constitute mathematical proficiency, in particular the strategic competence strand, seem to relate to contextualized mathematics as discussed by Steen (1999) and Madison (2004) and characterizes their notion of mathematical or quantitative literacy.

Also, Kilpatrick et al (2001) assert that to help learners acquire mathematical proficiency there is need for institutional programs that will address all the aforementioned strands. The authors claim that proficiency in mathematics should enable children or learners to cope with the mathematical challenges of daily life and to continue their study of mathematics in high school and beyond (see also Forman & Steen, 2000; Madison, 2004; Wallace, 2000; Steen, 1999). Thus, in general, this conception of mathematical proficiency seems to emphasize and express the claim that valuing of mathematics should be a precondition for the development of mathematical literacy (Kilpatrick, 2002). And this is a conception of 'mathematical proficiency' that emphasizes the utility value of mathematics and the need to connect it to people's everyday lives. Even though the report has so far not used or adopted the term 'mathematical literacy' or 'quantitative literacy' as defined elsewhere, it is clear that the characterization used to describe successful mathematics learning as discussed in the report fits very well some of the views expressed in such definitions (Kilpatrick, 2002; Kilpatrick et al, 2001).

Kilpatrick et al (2001) conclude their discussion by pointing out that:

- Proficiency develops over time. Each year they are at school, students ought to become increasingly proficient. To become proficient, they need to spend sustained periods of time doing mathematics – solving problems, reasoning, developing understanding, practicing skills – and building connections between their previous knowledge and new knowledge;

- Proficiency cannot be characterized as simply present or absent. Every important mathematical idea can be understood at many levels and in many ways;

- Goals for mathematics instruction for proficiency need to be set in full recognition of the differential access students have to high-quality mathematics teaching and the differential performance they show; and

- For students to be able to compete in today's and tomorrow's economy, they need to be able to adapt the knowledge they are acquiring, learn new concepts and skills, and view mathematics as a useful tool that must be constantly sharpened. In short, they need to be mathematically proficient (Kilpatrick et al, 2001).

Kaiser and Willander (2005) in their empirical study to evaluate the development of mathematical literacy have identified and adapted Bybee's work on scientific literacy to suggest five levels of mathematical literacy. They distinguish them as follows:

- The lowest level is illiteracy – the ignorance of basic mathematical concepts and methods;
- The second level is nominal literacy – the individual's minimal understanding of mathematical concepts, topics or terms characterized by the usage of naïve theoretical explanations and misconceptions;
- The third level is functional literacy level – this means that individuals can use scientific and technologic vocabulary, but their use is often confined to a particular activity or need, such as defining a term on a test;

- The fourth level is the conceptual and procedural literacy – these dimensions of literacy consist of developing understanding of the way conceptual parts of a discipline relate to the whole discipline; and
- The highest level is multidimensional literacy – this level goes beyond vocabulary, conceptual schemes, and procedural methods to include other understandings about science and contextual understanding of mathematics, as well as incorporating philosophical, historical, and social dimensions of mathematics. In this level, learners are able to make connections within mathematics and between mathematics (Kaiser & Willander, 2005, pp. 49-50).

It is quite evident from the distinctions made in the levels of mathematical literacy that the authors perceive the notion 'mathematical literacy' as a competency that can be developed through proper teaching of mathematics. This is also clearly indicated in their expression "Development of mathematical literacy", which is the title for their paper. The word "development" actually suggests an improvement on an individual's ability or skill or competency to perform a task. The idea that mathematical literacy as described here by Kaiser and Willander (2005) is a competency also has some similarities with the one by Kilpatrick et al (2001), which also in a more or less similar manner features five mathematical abilities (conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition) which they believe are necessary in the development of proficiency in mathematics. This, I believe, is in line with Jablonka's framework (see 'Mathematical Literacy for Evaluating Mathematics' and 'Mathematical Literacy for Developing Human Capital').

Kaiser and Willander (2005) also point out that there are differences between mathematical literacy and quantitative literacy or numeracy although they have not discussed them due to, as they claim, lack of space. However they have also alluded to the fact that although there is no consensus about the differentiation, it is generally agreed that all of these terms focus on the functional application of mathematics to people's lives and work; sentiments that are also expressed in PISA's definition.

Mathematical Literacy: competency or subject of study?

The Mathematics Council of the Alberta Teachers' Association (MCATA) describes Mathematical Literacy as "a way of conveying meaning through and recovering meaning from the form of representation in which it appears", and also refers to it as Numeracy (MCATA, undated, p. 1). The Association says Mathematical Literacy is about:

- Connecting mathematics with the world;
- Using mathematics appropriately in a variety of contexts;
- Communicating using the richness of the language of mathematics;
- Synthesizing, analyzing, and evaluating the mathematical thinking of others;
- Appreciating the utility and the elegance of mathematics; and
- Understanding and being conscious of what has been learned mathematically.

MCATA (undated) believes that one key element of mathematical literacy is to understand the pervasiveness of mathematics in contemporary society. This can be achieved, the Association claims, through teaching Mathematical Literacy across school curricula or across subjects (see also Madison, 2004; Wallace, 2000 and Steen, 1999). Furthermore, the Association suggests the following as some of the important aspects of a mathematics programme that will develop Mathematical Literacy:

- Giving opportunity for learners to justify processes and answers;
- Encouraging flexible thinking and strategy selection;
- Focusing on developing conceptual understanding;
- Assessing learner understanding, and not just procedures and skills; and
- Connecting school mathematics and real life mathematics. Enabling and encouraging learners to recognize mathematics in their world (MCATA, undated).

These aspects seem to echo similar sentiments to the five strands of Mathematical Proficiency as outlined in the *Adding It Up report* by Kilpatrick et al (2001). In other words these aspects actually portray Mathematical Literacy as a *competency* but not as a *subject* of study, and seem to emphasize both its utility value and contextual connectedness (see Jablonka's category on 'Mathematical Literacy for Human Development'). And, unlike in the NCS for Mathematical Literacy where this concept is perceived as a school subject rather than a competence, MCATA's description of the term 'mathematical literacy' implies that it is a competence. This is evident in their new proposed mathematics curriculum, and also in their assertion that the key element of mathematical literacy is to understand the pervasiveness of mathematics in contemporary society; and further claim that this can be achieved through teaching mathematical literacy across school curricula or across subjects.

Sfard and Cole (2003) address the issue of the meaning of the concept 'mathematical literacy' by considering two ideas separately: 'mathematical discourse' and 'literacy'. First, they define 'literacy' (in the context of mathematical literacy) as "the ability to use secondary discourses", and secondly, they argue that within the communicational framework, there are two types of discourses: 'everyday *or* colloquial mathematical discourses' and 'literate mathematical discourse'; and "mathematics is seen as a special type of discourse"… and that… "unlike spontaneously acquired everyday discourses, secondary discourses require deliberate teaching". So that "a discourse count as 'mathematical' if it deals with mathematical objects such as quantities and shapes (Sfard & Cole, 2003, p. 3). The differences between the two types of discourses are as follows:

- Unlike everyday (colloquial) mathematical discourses, literate mathematical discourse does not develop spontaneously;
- Literate mathematical discourse is taught, whereas everyday mathematical discourses are not;
- Literate mathematical discourse is visually/symbolically mediated, whereas everyday mathematical discourses are predominantly physical;
- Literate mathematical discourse is characterized by the distinctive use of words and their unique routines which derive from, and build on, the symbolic and recordable nature of the discourses; and

- Literate mathematical discourses are general-purpose, whereas everyday mathematical discourses are specialized and highly limited in their applicability (Sfard and Cole, 2003, p. 7).

On the basis of this clarification about the two types of mathematical discourses, Sfard and Cole (2003) offer the following definition for the concept 'mathematical literacy':

> "[..]…being mathematically literate means to be a skillful and proactive participant of literate mathematical discourse. The term proactive means that the mathematically literate person has a general disposition toward using the literate mathematical discourse in a broad range of situations, including situations much different from the one in which this discourse was originally learned" (Sfard and Cole, 2003, p. 5).

Furthermore, the authors assert that to be regarded as mathematically literate, a person has to know both the 'how' and the 'when' of literate mathematical discourse. That is, the person has to be able to use this discourse both when the initiative comes from others and on his/her own accord in any situation in which the discourse can be helpful. The two abilities – '…the command of the literate discourses and the ability to use it…' – are dialectically interrelated (Sfard and Cole, 2003, p. 7). In conclusion the authors assert that development of mathematical literacy is in fact a direct result of the way mathematics teaching/learning is being practised in schools. And as they say:

> "…..when it comes to the poor results in developing mathematical literacy, the school is found to be the culprit" (Sfard and Cole, 2003, p. 10). Finally, the authors point out that successful teaching and learning of mathematics for the purposes of promoting literate discourses can best be achieved by changing school practices such as "discontinuing the practice of using mathematics as a tool for measuring human potential" (Sfard and Cole, 2003, p. 10).

Thus the aforesaid argument generally views 'mathematical literacy' as a competency that can be developed through proper teaching of mathematics. There seems to be no suggestion by the authors that the notion 'mathematical literacy' can be perceived as a school subject of study. Hence, I understand the argument to be expressing similar sentiments to those raised by Steen (1999) and MCATA (undated) that development of mathematical literacy is a product of good teaching of mathematics (see also Kilpatrick et al, 2001).

The Organization for Economic Co-operation and Development (OECD) Programme for International Student Assessment (PISA) describes ‘mathematical literacy’ in terms of the utility value of mathematics and its connectedness to people’s lives (OECD cited in Clarke, 2003). And thus PISA later defined ‘mathematical literacy’ as follows:

> “An individual’s ability to identify, understand, to make well-founded judgments about, and to act towards the roles that mathematics plays in dealing with the world, as needed for that individual’s current and future life as a constructive, concerned, and reflective citizen” (OECD, 2006, p. 12).

This definition portrays ‘mathematical literacy’ as a competency, and shows some overlap and consistency with the conceptions of mathematical literacy and quantitative literacy as adopted and described by other authors mentioned earlier. However, there seems to be some contradictions between PISA’s understanding of the notion ‘mathematical literacy’ and that of other authors. These include the following:

- The PISA document, on one hand, seems to define ‘mathematical literacy’ in terms of how learners understand, use, and apply mathematical skills learned from formal mathematics as well as how they mathematize problems that are related to what they study in formal mathematics (end product). In which case, in my view, this suggests that ‘mathematical literacy’ is viewed as a competency rather than as a subject of study and is different from quantitative literacy and numeracy. On the other hand, other authors in their discussions, seem to suggest that ‘mathematical literacy’ can be both a competency and a subject of study (process); and it is the same as quantitative literacy and numeracy as well as mathematical proficiency (compare with Wallace, 2000; Madison, 2004; Steen, 2001; Stoessiger, 2003; DoE, 2003).

- PISA document's conception suggests that 'mathematical literacy' is a measure of learners' mathematical knowledge that can be determined through some kind of formal assessment, whereas contrary conceptions suggest that 'mathematical literacy' and its relatives can be taught as subjects of studies with the goal of providing learners with opportunity for the development of their critical thinking skills (see Madison, 2004; Stoessiger, 2003).

It should however be noted that PISA's view of 'mathematical literacy' stems from a philosophical standpoint which is rooted on fundamental underpinnings about assessment based on assumptions about what it really means to know math or be able to do math in a schooling context. Thus the definition assumes that it is legitimate to determine an individual's mathematical literacy by assessing mostly formal knowledge of what was learnt in schools as an end-product, whereas the contrary view seems to assume that 'mathematical literacy' as a competency can only be developed through the teaching of mathematical literacy as a subject of study, despite that the two opposing views, in one way or the other, seem to converge at one level. That is, on the issue of 'mathematical literacy' being a competency, and diverges at another level, as being a subject of study. Again, and more strongly, PISA's definition seems to place more emphasis on application of mathematics in real world contexts if mathematical literacy as a competency is to be supported, thereby developing competencies needed for work and life.

PISA, however, seem to argue for a much broader definition of mathematical literacy that would encompass most of what other authors refer to as "quantitative literacy". The definition (which has been given above) suggests to me that 'mathematical literacy' is more than 'quantitative literacy', and is more a competency than it is a subject of study. This is born out of the fact that the other definitions, although implicitly referring to mathematical knowledge and skills, their apparent emphasis is on 'quantity' and therefore 'narrower', whereas mathematical literacy as defined by PISA seems to go beyond the ability to apply quantitative aspects but to include knowledge of mathematics in the broadest sense. These various interpretations and labels, in my view, highlight some of the contradictory conceptions of mathematical literacy that exist within the international mathematics education community. And

Mogens Niss (undated), in a paper entitled 'Quantitative Literacy and Mathematical Competencies' alludes to this when he says… "…the variation is mainly a matter of how *narrowly* the word quantitative is to be understood, vis-à-vis the involvement of numbers and numerical data. Some use the word in a much broader sense than numbers and data only…" (Niss, undated, p. 215).

National Perspectives: mathematical literacy or numeracy?

Department of Education (2003) documents describe mathematical literacy as "a subject that is driven by life-related applications of mathematics", and has the potential to provide learners with an awareness and understanding of the role that mathematics plays in the modern world (DoE, 2003, p. 9). The department also makes the claim that, "….The inclusion of Mathematical Literacy as a fundamental subject will ensure that our citizens of the future are highly numerate consumers of mathematics" (DoE, 2003, p. 9). Furthermore, the department believes that Mathematical Literacy will enable learners to "…develop the ability and confidence to think numerically and spatially in order to interpret and critically analyze everyday situations and to solve problems" (DoE, 2003, p. 9) (compare with Jablonka, 2003). First, this approach clearly points to Jablonka's category of "Mathematical Literacy for Developing Human Capital" since the emphasis seem to be on the 'consumers' of mathematics. Secondly, the use of the word 'numerate' seems to suggest that the terms *mathematical literacy* and *numeracy* mean the same thing. Yet, on the contrary, the term numeracy has been given multifarious interpretations which are reflective of disagreements about a common understanding of the concept by different authors. This clearly shows that there are some contradictory conceptions of the term 'mathematical literacy (see also Jablonka, 2003; IALS/ALL, 1995).

Furthermore, it is the view of the department that Mathematical Literacy can provide learners with the necessary mathematical skills which will enable them to become self-managing persons who can be critical when analyzing situations and solving everyday problems that are mathematical, and which are usually presented in the media and other platforms. As the Department puts it: "[..]…., Mathematical Literacy, should enable the learner to become …..a contributing worker and a participating citizen in…… a democracy" (DoE, 2003, p. 10).

It is clear also up to this point that this conception of mathematical literacy is in line with Jablonka's category of "Mathematical Literacy for Social Change" whereby the teaching and learning of mathematics should focus on producing critical citizens. However, there seems to be a problem here because, as I understand it, the department's view seems to express mathematical literacy as a subject, whereas Jablonka's idea suggests that it is a competency. Therefore this is clearly another indication of contradictory conceptions of the theoretical concept 'mathematical literacy', despite that the idea of introducing the FET subject, Mathematical Literacy, seems to be underpinned by socially and politically meaningful issues as suggested in Jablonka's framework (see also Vithal, 2006).

Another interesting point to note is that the Department of Education emphasizes the importance of 'contexts' in developing mathematical literacy in learners, and argue that this can be achieved "…through engaging learners in situations of a mathematical nature experienced in their lives…" (DoE, 2003, p. 42). This is a similar view of the importance of "contextualized mathematics" in the development of mathematical literacy raised by other authors (see Madison, 2004; Wallace, 2000; Steen, 1999). However, Clarke (2003) on the contrary argues that there will never be any *contexts* that will be *familiar* and *relevant* to all learners in any given social practice, even within any school system. This then implies that even the efforts to implement the assessment standards relating to the learning outcomes as outlined in the NCS document become problematic.

It is further argued by the Department of Education that:

> "Being literate in Mathematics is an essential requirement for the development of the responsible citizen, the contributing worker and the self-managing person. Being mathematically literate implies an awareness of the manner in which Mathematics is used to format society and enables astuteness in the user of the products of Mathematics such as hire-purchase agreements and mathematical arguments in the media – [….]" (DoE, 2003, p. 43).

An analysis of this statement begs two questions: (1) how is Mathematics "used to format society?" and (2) what is the relationship here, of mathematics and mathematical literacy? It seems to me that the phrase "Being literate in Mathematics" is used here to mean 'at homeness' with Mathematics as a discipline or subject of study, and the phrase 'mathematically literate' is being used to express a person's ability to deal with mathematical arguments using skills acquired from learning Mathematics. In which case then, this implies that mathematical literacy is a competency but not a subject of study, and a product of the teaching or learning of Mathematics, hence the relationship. Yet the department regards it as a fundamental subject of study (compare with Sfard and Cole, 2003).

AMESA (2003) in its submission to public hearing has also made its contribution in the debate about the notion 'mathematical literacy' arguing that the idea has not been properly conceptualized for it to be introduced in all of the FET schools in South Africa. The AMESA document makes a claim that there is still lack of understanding in South Africa about the notion mathematical literacy (see also Madison, 2004; Wallace, 2000; Steen, 1999), and hence argue that contrary to popular belief, Mathematical Literacy is not (a) watered down Mathematics (b) standard grade Mathematics (c) trivial Mathematics, or (d) "Easy" and/or applied Mathematics.

The AMESA document makes the suggestion that Mathematical Literacy is related to but different from Mathematics although it has not shown what the differences are. By implication from the following statement, it seems to be suggested that mathematical literacy is a competency:

> "If literacy is the ability to read and write, then Mathematical Literacy should be the ability to read, write, and engage with information and situations that are numerical in nature and mathematical in structure. While the mathematically literate person may draw on mathematical algorithms or knowledge, their mathematical literacy is reflected in habits and behaviours and ways of engaging with problems and situations" (AMESA, 2003, p. 2).

Thus, it seems, mathematical literacy is viewed and portrayed as a competency or embodiment of knowledge, skills, competencies, and other attributes that enable an individual to engage in meaningful social and political issues that are mathematical. Hence it is characterized as having application and usefulness in everyday lives of people. However it is noted that, despite this concept being discussed here by AMESA as both a competency and a subject of study, the view held by AMESA can be associated with Jablonka's categories of "Mathematical Literacy for Human Development" and "Mathematical Literacy for Social Change" due to its emphases on the person's 'habits and behaviours'.

Vithal (2006) in a paper presented at Brunei Conference addresses the question about the notion 'mathematical literacy' from a critical perspective. Firstly, she observes that in the two new curricula reforms for grades 0 to 9 and grades 10 – 12 "mathematical literacy features as a competence to be acquired by all learners"….(p. 2), while at the same time it is to be taken as a subject of study by some students while others take mathematics. This is quite interesting (and seems contradictory) because the author clearly points out that mathematical literacy is in fact a *competency*. Secondly, and drawing on socio-critical perspectives in mathematics education, she argues that mathematical literacy can be realized or developed through project work.

Vithal (2006) points out that project work, due to its flexibility and diversity to provide a teaching and learning environment for interdisciplinary approach, carries the potential for the development of mathematical literacy in learners. This is because, as she says, it "opens real possibilities for linking mathematics in authentic ways to other subjects…." (Vithal, 2006, p. 7), thereby bring the mathematics to be learned into context in an integrated way (see also Wallace, 2000; Steen, 1999). This, I believe, makes it even more succinct that 'mathematical literacy' is viewed here as a competency rather than a subject of study.

2.3 Mathematics and Mathematical Literacy – are the two concepts related?

Although there are contradictions in the way mathematical literacy is portrayed as opposed to formal mathematics, it seems there is general agreement, both internationally and nationally, that there should be split streams of Mathematics and Mathematical Literacy despite that there is a dilemma in deciding on the relationship between the so-called ‘two mathematics’ (Madison, 2004; Stoessiger, 2003; Steen, 1999; De Lange, undated). Furthermore, there is evidence that there are various understandings (within mathematics education community) of what mathematical literacy, really is; and therefore to choose to have the two mathematics as separate subject brings an issue of status whereby the notion of mathematical literacy as a subject is trivialized as a ‘watered-down’ version of mathematics (see AMESA submission, 2003; Mbekwa, 2006; Niss, undated). It appears that the various understandings fall within the following categories: (a) the functionalist view which regards mathematical literacy as that type of mathematics that finds application in people’s lives, (b) the status view which regards mathematical literacy as a simplified/easier (watered-down) version of traditional school mathematics, and (c) the inter-disciplinarity view which regards mathematical literacy as a competency that develops as a result of an integrated and contextualized teaching and learning of formal mathematics within other subjects. In most of the arguments, both locally and internationally, the former and the latter views seemed to predominate. It is also clear that all evidence from extant literature and from the participating teachers point to the absence of a mathematically-based human attribute (i.e. mathematical literacy) which should be a by-product of sound mathematics education that is related to the cultural setting within which mathematics is practiced. Hence, indeed there seems to be a relationship between mathematics and mathematical literacy; and that is, mathematical literacy is a by-product of good teaching and learning of mathematics subject. On the basis of the foregoing, therefore, one cannot escape from the conclusion that, much as there is recognition (both internationally and nationally) for the importance and necessity of mathematical literacy in today’s societies, it is also important to recognize the need for much closer ties (in service for mathematical literacy) between the mathematics curriculum and the culture in which it is taught or practiced (Jablonka, 2003; Guberman, 2004).

2.4 Mathematical Literacy – a competency or a school subject or both?

In AMESA's conception, and from the definitions extensively discussed as argued by the different authors who used the term 'mathematical literacy', it is clear that this term refers to a competency which is a direct result of a sound mathematics education that takes place in the compulsory schooling curriculum, rather than a subject of study. Sfard and Cole (2003) also corroborate this conclusion by arguing that being mathematically literate means to "…be a skillful and proactive participant of literate mathematical discourse…" (Sfard & Cole, 2003, p. 5) (see also MCATA, undated). Furthermore, AMESA also asserts that…"while the mathematically literate person may draw on mathematical algorithms or knowledge, their mathematical literacy is reflected in habits and behaviors and ways of engaging with problems and situations…" (AMESA, 2003, p. 2). So that, this conceptualization makes it clear that mathematical literacy is perceived here as a competency, and this suggests that, essentially, there are three interconnected key elements inherent in the phrase 'mathematical literacy': the 'content' (i.e. the mathematics), the 'context' (i.e. the life-related applications, the everyday situations, the problems) and the 'abilities and behaviours that a mathematically literate person has to exercise' (confidence, thinking, interpreting, analyzing and solving); and that these elements are interrelated since in the development of such an human attribute, content is inseparable from pedagogy as context is inseparable from content (see also Fosnot & Dolk, 2005; Stolp, 2005).

2.5 Is Mathematical Literacy synonymous with Quantitative Literacy and/or Numeracy?

Having discussed and presented the various connotations used to describe the term 'mathematical literacy, and having highlighted the different views and perspectives associated with it, I would now make an attempt to answer the question "Is Mathematical Literacy synonymous with Quantitative Literacy and/or Numeracy?", with a view to making some helpful distinctions between these three terms. I also, in the process, will try to build an argument that there is need for a consensus on what constitutes *basic* mathematical literacy as distinct from *advanced* mathematical literacy (see Kaiser & Willander, 2005; Sfard & Cole, 2003).

To understand the notion of mathematical literacy as a theoretical concept, we first need to understand what constitutes mathematics as a discipline or a science. And this is not intended or meant to offer a deep philosophical treatment of the mathematics subject but rather to help us understand that the whole idea of acquiring mathematical knowledge and applying it in our everyday situations is, in itself and by itself, a form of literacy. Hence, the seemingly universal agreement/convention to accept school mathematics as being constituted by the following learning areas or strands/topics: arithmetic, algebra, geometry, and calculus which are normally arranged to form the curriculum: first arithmetic, then simple algebra, then geometry, then more algebra, and finally, calculus (Steen, 2001; 1999; 1990). And this listing of topics is common in almost all the countries of the world which follow similar mathematics education system. It is through the learning of these strands that we develop or invent mathematical concepts, structures, and ideas to be used to organize phenomena in the natural, social, and mental worlds. And once this has been achieved, it is then assumed (rightly or wrongly) that the teaching of mathematics (together with the informal development of intuition along the multiple strands/roots of mathematics) as a discipline and its practical applications within a context epitomizes the development of mathematical literacy as a competency. Hence the definition of "mathematical literacy" as offered by PISA which, in my view, sounds broader and also mathematical.

On the basis of the foregoing explanation, therefore, I now look at the relationship between numeracy, quantitative literacy and mathematical literacy. I must hasten to point out that mathematical literacy is neither synonymous with quantitative literacy nor with numeracy. However, the three terms are related but distinct. Mathematical Literacy as a human attribute is characterized by the following elements or 'competencies': mathematical thinking and reasoning, mathematical argumentation, modeling, problem posing *and* solving, representations, symbols, and tools *and* technology (Steen, 2001; Niss, undated). To be mathematically literate, individuals need all these competencies, though at varying degrees. Quantitative Literacy is an expression of mathematical literacy, and is characterized by a cluster of phenomenological categories: quantity, change and relationships, and uncertainty. Numeracy is, also, an expression of mathematical literacy (and does also fit directly into quantity), and is characterized by an individual's ability to handle numbers and data and to evaluate statements regarding problems and situations which involve mental processing and estimating in real-world contexts (de Lange, online). Thus mathematical literacy can be thought of as the overarching literacy that comprises both quantitative literacy and numeracy (including spatial literacy). Hence a visual representation to reflect this relationship can be made as shown below.

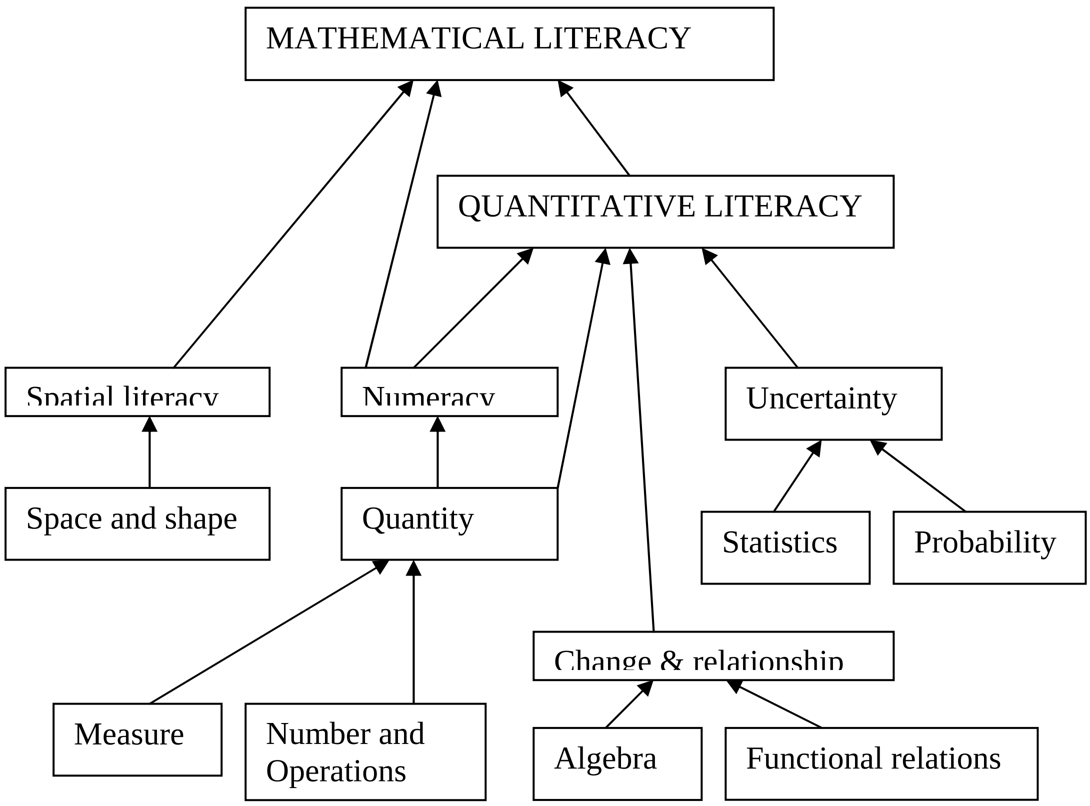

Figure 2.1 Illustration of the relationship between Mathematical Literacy, Quantitative Literacy and Numeracy.

Adapted from de Lange (undated).

Having made the important distinctions among the aforementioned terms and their relationship clear, it seems now appropriate to reiterate that there are different levels of literacy within the field of mathematical literacy, and that these fall into two categories: (1) basic mathematical literacy (BML), and (2) advanced mathematical literacy (AML) (see Kaiser & Willander, 2005; de Lange, undated; IALS/ALL, 1995).

In which case, therefore, being mathematically literate can be described in terms of these levels, and varies according to educational practice as may be defined in a given society. On one hand, basic mathematical literacy may be thought of as a level expected of all learners up to a certain school-going age as determined by a particular society according to its needs. On the other hand, advanced mathematical literacy can be thought of as relating to the use of mathematics in everyday life and the workplace. Hence the need to know the different levels of mathematical literacy and to understand how these relate to the aforementioned categories is an imperative. Furthermore, I believe it would help if, in an attempt to develop mathematical literacy in learners, we structure our mathematical activities according to aforementioned categories, taking cognizant of each individual learner's capabilities and specific interests in terms of topics she or he wishes to study (see Madison, 2004).

2.6 Concluding Remarks

The literature review that has been presented here on mathematical literacy is not exhaustive but serves to highlight the contradictory conceptions that exist within the international mathematics education community concerning the theoretical concept of mathematical literacy. It is evident from the extant literature that there is little common consensus on the definition of the term 'mathematical literacy', and that the term has been given a variety of names, thereby leading to a variety of debated interpretations and conceptions by different authors. The debate about the meaning of the terms 'mathematical literacy', 'quantitative literacy', 'mathematical proficiency' or 'numeracy' brings to the fore the framing of the concept as a 'subject' or area of study, rather than an ability, behaviour or a social practice. Yet the focus is on defining what a mathematically literate person does, rather than what collection of topics, skills and contexts mathematical literacy could be thought to consist of.

Madison (2004) defines quantitative literacy as "the ability for citizens to deal with the quantitative demands of everyday life" (p. 9). In a somewhat similar way Steen (2001) refers to quantitative literacy as the "capacity to deal effectively with the quantitative aspects of life" (p. 12). Wallace (2004), although he does not define the terms, suggests that quantitative literacy (which he also calls numeracy) is a competency, and that it is the same as numeracy. Nowhere in Madison's definition or

Wallace's statement is any indication made of a relationship (of any form) between mathematical literacy and quantitative literacy. Steen (1999) also, because of his interchangeable use of the two terms, suggests that quantitative literacy is the same as numeracy. However, on the contrary, Steen (2001a) points out that quantitative literacy, on one hand, stresses the use of mathematical and logical tools to solve common problems, while mathematical literacy, on the other hand, stresses the traditional tools and vocabulary of mathematics. Conversely, the NCS for Mathematical Literacy offers the following definition, which frames 'mathematical literacy' as a 'subject' rather than a competency, behaviour or a social practice:

> "Mathematical Literacy is a subject driven by life-related applications of mathematics. It enables learners to develop the ability and confidence to think numerically and spatially in order to interpret and critically analyze everyday situations and solve problems" (Department of Education, Mathematical Literacy, 2003, p. 9).

This is clearly a contradiction in the definition of the same term which has not only been defined differently but also given a variety of labels seemingly emanating from their different understandings of this concept. Again, this definition (in my view) is not different from all that have been given before because its focus is also on defining competency, a behaviour or habit of mind, rather than a subject (i.e. a collection of topics and skills).

At another level it seems IALS/ALL (1995), Steen (1999), and Stoessiger (2003) use the term 'numeracy' in a much broader sense than other authors, and therefore this suggest that they view it much the same as mathematics with utility value and contextual problem solving relevance both of which can empower learners to be critical and proactive participants in a democracy (i.e. as a competency). As Kees Hoogland succinctly states:

> "Mathematical Literacy is in fact mainly about the functional aspect of mathematical knowledge. It is about individual competencies to use mathematical knowledge in a practical, functional way; mathematical

> literacy in order to…… or mathematical literacy for….” (Hoogland, undated, p. 2).

In the light of the foregoing, it becomes clear that despite the different connotations and the different labels used to describe mathematical literacy and the personal preferences authors may have regarding the definitions and nomenclature, one thing certain is that all the authors, for all intents and purposes, are advocating for a mathematics education curriculum that will result in the attainment of mathematical literacy as a competence or behaviour with a view to equipping all learners with the necessary mathematical skills and techniques to be able to engage with information and situations that are numerical in nature and mathematical in structure. Hence it is quite evident, from the definitions in Table 1 and from earlier discussions herein, that mathematical literacy (regardless of the different labels given to it) is a human attribute linked to behaviour or human attribute resulting from successful teaching and learning of formal mathematics within the compulsory schooling curriculum, and not a subject of study.

2.7 Summary

There are several important issues that have emerged which reflect significantly different perspectives on what exactly mathematical literacy is and how it should be taught or developed. From the perspectives discussed above, it has been observed that some definitions focus on an individual’s capacity to use quantitative tools, while others focus on the abilities of individuals to understand and appreciate the use and applications of mathematical and quantitative methods in day-to-day human affairs. Some put emphasis on basic skills (such as number sense and number operations – arithmetical/computational manipulations), others emphasize higher-order thinking (‘well-founded judgments’). In the following list I give a brief summary of some of the themes and perspectives that emerged:

- Mathematical literacy means different things to different people;
- There is need for the inclusion of mathematical literacy in mathematics;

- Mathematical literacy is a competency that can be developed through contextual and interdisciplinary teaching of mathematics (integration);
- Major changes to both curricula and pedagogy are needed to ensure proper teaching/development of mathematical literacy;
- Mathematical literacy is perceived differently, as a competency and/or as a subject of study;
- Some people within mathematics education community view mathematical literacy as a watered-down version of mathematics;
- Mathematical literacy guarantees liberty for individuals and society in a democracy;
- Teaching/developing mathematical literacy ensures that learners are empowered to cope with everyday situations; and
- Mathematical Literacy is viewed by some people as a subject of study, therefore should be incorporated into the mainstream curriculum as a separate subject.

All the definitions of the theoretical concept of mathematical literacy and its relatives that have so far been explored seem to assume a contextualized mathematics, with each definition seemingly having the intention to describe (though at varying degrees) some measure of quantitative and mathematical knowledge and skills in relation to their wider uses in people's everyday lives. Thus the definitions provided in the literature link the idea of mathematical literacy to how mathematics should be used in real life situations (functionality and utility values of mathematics). Furthermore, it seems that the central argument is that 'mathematical literacy' is different from mathematics and that its development in learners can best be achieved through contextual teaching practices by well trained teachers. Mathematical Literacy is also seen not only as an individual's display of mathematical knowledge and skills (competencies) but also as a very important communication tool which empowers citizens to be proactive participants in any democracy.

CHAPTER THREE RESEARCH METHODOLOGY

In this chapter I discuss the research methodology that has been used in this study designed to explore Mathematics educators' perceptions of the concept 'mathematical literacy' in KZN province. The chapter gives an outline of the specific methods used in the collection of the qualitative and quantitative data, the process of data collection, the sample used in the study, and the process of analyzing data. This study adopted an *interpretive* philosophy of knowing and followed a *descriptive* research methodology which utilized both qualitative and quantitative approaches (with minimal quantitative style through intra-method mixing) and methods to explore mathematics educators' perceptions of the notion 'mathematical literacy' as a competency and habit of mind, and as a subject of study. Interpretive paradigm, by its nature, is concerned with meaning, and therefore usually gives descriptive analyses of the social phenomena for the sole purpose of emphasizing deep understanding of the subjective world of human experience through the mental process of interpretation (Cohen et al., 2000; Henning et al., 2004; Wellington, 2000; Anderson, 1990).

According to Henning's explanation of interpretive theory, construction of knowledge is not only through "observable phenomena" but also "by descriptions of people's intentions, beliefs, values and reasons, meaning-making and self-understanding" (Henning et al, 2004, p. 20). It is for this reason that this study seems to, naturally, follow an *interpretive* theoretical framework, and a *descriptive* methodological approach to the research project.

3.1 Research Design

In this research a mixed mode approach which took the form of a descriptive and an ethnographic survey was considered the most convenient approach to use in conducting this study. This approach utilized both qualitative and quantitative strategies to explore mathematics educators' perceptions of the concept 'mathematical literacy'. For this reason, therefore, I call this approach a mixed-mode approach; and also because it combines both an ethnographic and descriptive survey methodologies in seeking to obtain information about people (Morse, 2003; Picciano, 2004). Hence in this research I adopted a mixture of both reconstructed logic and logic in practice approaches to research whereby questionnaires and in-depth interviews follow from a survey method, and a document study (content analysis), both of which clearly reflect a mixed-mode orientation (Creswell et al., 2003; Holland & Campbell, 2005; Johnson & Turner, 2003; McMillan & Schumacher, 2001; Neuman, 2006). The small-scale survey was conducted over a period of three days from 3rd July 2006 to 6th July, 2006. Content analysis was done through analysis of documents and related literature (e.g. NCS document, Mathematical Literacy text-books) in order to be able to gather information relating to how the concept of 'mathematical literacy' is being defined, and hence provide a full description of teachers' perceptions, beliefs, and experiences about the notion of 'mathematical literacy' and how these relate to its different conceptions that appear in extant literature.

According to Cohen et al (2000) a survey is meant to gather data at particular points in time by asking respondents who constitute a population or sample of a population, questions (for exploratory purposes) with the intention of describing the nature of existing conditions. A survey typically involves one or more of the following data-production methods: structured or semi-structured interviews, self-completion or postal questionnaires, standardized tests of attainment or performance, and attitude scales (Cohen et al., 2000; Denscombe, 2003; Huysamen, 2001; Neuman, 2006). There are different types of survey all of which attempt to gather data from a sample of individuals selected from a finite population. In this research, however, I have used mixed-methods survey of the cross-sectional type, whereby information was obtained from the respondents at a particular point in time (Fink, 2006; Rosier, 1988), with the purpose of exploring and then describing the situation (and estimating frequencies rather than to establish causal patterns) as it pertained to teachers' perceptions of the studied phenomenon. Mixed-Methods survey studies have been used for educational research purposes before, and continue to be used. For example, Lee and Abd-El-Khalick (2006) used a mixed-method survey to obtain data relating to teachers' perceptions of the introduction of socio-scientific issues into the science curriculum in Korea. Similarly, Julie and Mbekwa (2005) and Monyatsi et al (2006) also, respectively, used a multi-methods (mixed-mode) survey strategy in a study dealing with the issues and situations that learners would prefer to deal with in mathematics in South Africa, and another study dealing with teacher perceptions of the effectiveness of teacher appraisal in Botswana. All these studies had a mixed-methods orientation due to what is currently believed to be methodological approach which characterizes such studies (Knight, 2002; Morse, 2003; Neuman, 2006; Sandelowski, 2003).

My study focused on teachers (mathematics educators). And this means therefore that it is an ethnographic study which seeks to explore and investigate teachers' perceptions about an educational concept by identifying, studying, and then synthesizing the data to provide an interpretive description of the seemingly many various perspectives about the theoretical concept of mathematical literacy. According to Wiersma, ethnography, put in the context of education, can be defined as "The process of providing scientific descriptions of educational systems, processes, and phenomena within their specific contexts" (Wiersma, 1991, p. 17).

Thus it seemed reasonable to use what Neuman (2006) refers to as a *bricolage* technique, which combined ethnographic survey method with document analysis to gather data for this research about the studied phenomenon. Through this kind of approach, it is hoped that this study will be successful in its endeavor not only to contribute to the debate about the theoretical concept of mathematical literacy, but also towards efforts to reform mathematics education with a view to better addressing the needs and aspirations of the modern society. This is born out of the belief that "the complexity of educational phenomena and their entrenchment within broader socio-cultural milieus are revealed consistently in ethnographic accounts" (Goetz & LeCompte, 1984, p. 32).

3.1.1 Sampling of mathematics educators

The research was conducted in the University of KwaZulu-Natal's faculty of education at Edgewood Campus, South Africa; with mathematics educators who were doing their first years of Advanced Certificate in Education (ACE) and Bachelor of Education (B.Ed Hons) professional development courses, respectively, in the year 2006. The sample comprised a total of 70 in-service teachers of whom 27 were Bachelor of Education (Hons) students specializing in science and mathematics, 25 were ACE students specializing in GET mathematics, and 18 were ACE students specializing in FET Mathematical Literacy (see Appendix K). Of the 27 Bachelor of Education (Hons) students, six were teaching mathematical literacy in their respective schools, and only 6 of the 18 ACE Mathematical Literacy students were actually teaching this subject in their respective schools.

In selecting research participants for this study, my major consideration was not so much about the setting (context) but rather it was about getting the relevant people (what Henning calls a theoretical population) who could ‘travel’ with me on the journey towards more knowledge about the topic, and are not necessarily representative of the population (Henning et al, 2004). Hence the 70 teachers (postgraduate part-time students) who were included in the survey were selected using a procedure that employed a combination of convenience sampling strategy and a stratified purposive sampling strategy (non-probability sample) due to their easy accessibility (convenience sample) and, in particular, their relevance to my research topic. Also, this was in anticipation of the quality and richness of the information that would derive from the sample in order to address the research question through careful examination of patterns of meaning which emerge from data itself (Henning et al, 2004; Neuman, 2006). Non-probability sampling allows the researcher to use some criteria or purpose to select participants to a research project (Neuman, 2006; McMillan & Schumacher, 2001; Cohen et al, 2000), “with an underlying focus on intentionally selecting specific cases that will provide the most information for the questions under study” (Kemper et al., 2003, p. 279). For this reason therefore, a combination of both convenience and purposive Sampling strategies was employed in this study.

Purposive sampling is used here to mean that the researcher uses his judgment to select appropriate participants (cases or subgroups that constitute the sample) that are especially informative (Kemper et al, 2003; Henning et al, 2004). This kind of sampling is particularly valuable when used in exploratory research such as in this study (Neuman, 2006). Convenience sampling is used here to mean that the group of participants for this study was selected on the basis of being accessible (McMillan & Schumacher, 2001). Kemper et al (2003) states that: “Stratified Purposive sampling involves dividing the purposefully selected target population into strata…..with the goal of discovering elements that are similar or different across the subgroups” (Kemper et al, 2003, p. 282). Kemper et al (2003) also regard convenience sampling as a form of purposive sampling technique.

Thus in this study the participants were purposefully sampled according to the nature of their respective subject specializations as well as their teaching experiences (i.e. B.Ed Hons Science and Mathematics course, ACE (FET) Mathematical Literacy course, and ACE (GET) Mathematics course) to enable comparisons of perceptions across subgroups because one of the key issues of the study was to differentiate between the perceptions of those participants who had actually been involved with the teaching of mathematical literacy and the perceptions of those who had not. For this purpose, self-completed questionnaires and semi-structured interviews were used to explore teachers' perceptions, beliefs and experiences with regard to their understandings of the theoretical concept of mathematical literacy both as a competency and as a subject of study. The profiles of the participating teachers who responded to the questionnaire and to the interview appear in Appendix K. From these data, one can see the varying experiences and degrees of individual teacher's professional and teaching qualifications.

The ACE Mathematical Literacy group comprised 18 teachers who had a wide range of teaching experiences ranging from 2 years to 14 years, with a mean of 4 years. Out of the 18 teachers, 11 teachers (61%) taught mathematics in their respective schools, and only 6 (33%) were involved in the teaching of Mathematical Literacy. Eight (44%) teachers out of the eighteen indicated that they came from rural schools which were poorly resourced, and two of these teachers were involved in the teaching of Mathematical Literacy. Another eight (44%) teachers out of the eighteen indicated that they came from urban schools but did not say whether the schools had poor or good resources, and three of these were involved in the teaching of Mathematical Literacy, while the rest who also indicated that they came from schools with poor resources did not mention whether such schools were in the rural or urban area(s).

The ACE (GET) Mathematics group comprised 25 teachers with teaching experiences ranging from 1 year to 25 years, with a mean of 5 years. Of the 25 teachers, only 20 (80%) teachers were teaching mathematics, and the rest did not indicate whether or not they were involved in the teaching of mathematics. Ten (50%) teachers out of the twenty who were teaching mathematics indicated that they came from rural schools but did not say whether or not such schools had good or poor resources, and only three mentioned that the schools they came from were poorly resourced. Only two

(8%) teachers indicated that they came from urban schools but did not say whether the schools had poor or good resources.

The B.Ed(Hons) group comprised 27 teachers, and 20 (74%) of these teachers were teaching mathematics and had a range of experiences ranging from 3 years to 20 years, with a mean of 6 years. Out of the 20 teachers, only 5 (25%) were involved in the teaching of Mathematical Literacy in their respective schools. Fourteen teachers (70%) out of the twenty that were teaching mathematics indicated that they came from rural schools which were poorly resourced despite that they (the schools) were government funded, while the rest (30%) mentioned that they came from urban schools with good resources. Only two (10%) of the fourteen teachers who taught mathematics were also involved in the teaching of Mathematical Literacy in their respective schools.

It can also be seen that of the 18 (25%) teachers who are studying the ACE course for mathematical literacy, there are six (33%) teachers who are currently involved in teaching it. The rest (about 9%) come from the B.Ed(Hons) mathematics and science education course. Another striking revelation is that the majority of the participating teachers who were involved in the teaching of the new subject have qualifications in mathematics ranging between STD and HDE (see Tables 2a, 2b and 2c). Of the 70 participants, 5 (7%) teachers had a Primary Teachers Diploma (PTD) qualification, 14 (20%) had a Secondary Teachers Diploma (STD) qualification, 12 (17%) had a Higher Diploma in Education (HDE) qualification, 13 (19%) had a variety of Bachelors' degree qualifications (e.g. B.Paed, B.A., B.Tech., B.Ed), five (7%) had a Further Diploma in Education (FDE) qualification, and 21 (30%) had other qualifications different from the ones already mentioned. Seemingly the latter group is the one that did not have any mathematics teaching experiences (see Appendix K).

Of the 70 in-service teachers included in this study, only six agreed to be interviewed. Two were from ACE (FET) Mathematical Literacy, three were from B.Ed Hons, and one was from ACE (GET) Mathematics. In two instances, two groups of two participants in the form of focus groups chose to be interviewed individually. In effect, out of the 70 teachers who were included in this study, only 12 were involved in the teaching of mathematical literacy in their respective schools. Easy access to all the participants at the university during their contact sessions was the only justification for the choice of the cohort that made up the sample that was used in this study. It has been convenient for me, on one hand, to use the group as participants because it was easier to get access to the group since they were teachers who were enrolled as part-time students in graduate studies in the same university as me. On the other hand I purposefully chose to select this group of teachers because I knew that they were better placed to provide relevant information (hopefully) to enable me to address the purpose of this research project since they were, in addition to having registered to study one of the mathematical science courses, either teaching mathematics or mathematical literacy in their respective schools. Thus, I used questionnaires, semi-structured interviews, and document analysis for data production.

Initially I had planned to use a focus group interview, but on realizing that most participants were not willing to be interviewed while already on the site, I decided to resort to individual interviews. The six teachers who were interviewed volunteered to come for the interview after I had made a plea two days after the administration of the questionnaires.

3.1.2 Construction of the Questionnaire

The construction of the questionnaire was one of the most daunting tasks I ever experienced as a novice researcher. It took me, I think, about three weeks before I could (with the help of the supervisor) manage to formulate questions that were related to my critical research questions. After the first draft was written, it took us about another week revising it and making lots of changes in an attempt to align the question items to both the main research question and the critical questions. Eventually, however, and after extensive discussions and careful examination of all possible aspects of the main research problem (which also had been rephrased several times) we noticed that, in fact, there were two major aspects that needed to be addressed by the study. The first aspect of the main research question was to do with the notion of the concept of 'mathematical literacy' as a competence; and the second aspect of the main research question was to do with the notion of this concept as a subject of study. Hence, in the construction of the questionnaire these two aspects (or notions) were the major consideration. Based on this, the questionnaire was then divided into four main parts (parts A, B, C and D) which guided the formulation of the kinds of question items that were selected to answer the four research (critical) questions. Part A was meant to gather data relating to the participants themselves (biographical data), and about the profiles of the schools where they taught. In Part B there were two questions concerning competencies of and ideas about a mathematically literate person, and were aimed at answering the second critical question: What are mathematics educators' perceptions and understandings about mathematical literacy? Part C was basically meant to explore participants' beliefs, conceptions and views about mathematical literacy as subject of study and also how they construct the enactment of their understandings in the implementation of the ML curriculum; and was therefore aimed at answering the third and fourth critical questions: What are mathematics educators' beliefs, conceptions and views about mathematical literacy as a curriculum subject? How do these perceptions and understandings play out in the implementation of the new ML curriculum? Part D was the last one, and was generally intended to find out about participants' initial experiences of teaching mathematical literacy as a subject of study. This part of the questionnaire raised a wide range of issues including purposes of the curriculum, differences between mathematical literacy and mathematics, resources for teaching mathematical literacy, and a comparison of the teaching strategies between mathematical literacy and mathematics, as well as the strategies that were used by the participants in the teaching of the subject Mathematical Literacy. Thus, although this part was aimed at answering both the second and third critical questions, its main thrust was on the notion of mathematical literacy as a subject of study. Table 3.1 provides a summary of questionnaire items into main domains (according to the aforementioned parts) and their relationship with the research critical questions.

However, it must be noted that although the questionnaire design took the form of the description mentioned above, the individual question items were not arranged according to the order of the research questions. Due to the nature of the study and the methodology that was adopted the question items were designed so as to target specifically the two aforementioned aspects of the main research question (with emphasis on making a distinction between the two notions of mathematical literacy), and to spread across almost all the parts of the questionnaire. Furthermore, the arrangement of the different parts and the emphases on various issues inherent in the question items was deliberately designed for identifying the different groups which formed the sample of this study for analysis purposes.

Table 3.1 Summary of questionnaire items into main domains (clusters of question items).

PART	Domain (Main Categories/Themes)	Item(s)	RQ
A	Biographical Data	1-7	
B	Perceived competencies of and ideas about a mathematically literate person.	*8a , 8b.*	**2**
C	Beliefs, views and conceptions about Mathematical Literacy	*09*	**2**
C/D	Understandings of the relationship or differences between 'mathematical literacy' and 'mathematics'	*10, 16*	**2**
C/D	Understandings of the different notions of ML	11, 14	**1**
C/D	Perceptions of the necessity and usefulness of ML as a competence and as a school subject	*12, 15.*	**3, 4**
C/D	Perceived ways of developing/teaching ML as a competency and as a school subject	*13, 17, 18, 19.*	**3, 4**

3.1.3 Research Instruments/tools

A mixed self-completed questionnaire (although predominantly qualitative) consisting of mostly open-ended questions with only one fixed-response question item, and a semi-structured interview schedule were used in this study as data production instruments. The interviews were recorded using two digital voice recorders used simultaneously, in case there was a technical problem with any one of the recorders (Brown & Dowling, 1998; Neuman, 2006). The mixed questionnaire was used with the aim of bringing a balance between the main sources of measurement error from both the open-ended and fixed-response questions (Gorard, 2003).

Johnson and Turner (2003) indicate that there are two major ways of method-mixing which they refer to as 'intra-method mixing' and 'inter-method mixing'. Intra-method mixing is the concurrent or sequential use of a single method that includes both qualitative and quantitative components. An example of this mixing is when open-ended and closed-ended items on a single questionnaire are used concurrently or when an open-ended questionnaire and a closed-ended questionnaire are sequentially used in a single study. Inter-method mixing, on the other hand, is the concurrent or sequential mixing of two or more methods such as using questionnaires and interviews in a research study (and my study is such an example). Similarly, McMillan and Schumacher (2001) state that there are three types of mixed-methods that are commonly conducted (complementary, developmental, and expansion), and that these can take the following forms: 'simultaneous' use of both qualitative and quantitative techniques, 'sequential' ordering of both qualitative and quantitative techniques, and 'parallel' use of both methods/techniques to address different questions in the same study. In this study, however, I used both intra-method mixing and inter-method mixing strategies. Thus open-ended self-completed questionnaires and semi-structured interviews were used to explore and capture teachers' opinions, knowledge and beliefs (or perceptions) about the studied phenomenon. These strategies have been used in this form (complementary and simultaneous) so as to complement each other (Kemper et al, 2003; McMillan & Schumacher, 2001), as well as for validation purposes (Cohen et al, 2000).

3.1.4 The Pilot Phase

For the purposes of reliability and validity of the instruments (Cohen et al, 2000; Huysamen, 2001), a self-completed questionnaire and an interview schedule were developed and pilot-tested. The questionnaires were pre-tested on 20 fourth-year undergraduate students studying Mathematics course in the University of KwaZulu-Natal at Edgewood Campus. Ten were sent to a neighbouring high school through a colleague to give them to mathematics educators in that school. All of the 20 questionnaires that were administered to the undergraduate students were completed and returned, whereas none of those given to the neighbouring high school were returned. The questionnaire was also discussed with one mathematics education expert whose advice has been valuable and quite helpful in the development of the final instrument.

A lot of changes (as per advice) had to do with the design of the questionnaire. The initial questionnaire had the bulk of the items being closed-ended questions with very few open-ended questions. This was modified to include mostly open-ended items. The criticism was that with too many closed-ended questions the respondent would not be allowed enough freedom to formulate their own responses and express their feelings or opinions, but rather they would be 'channeled' into giving responses that the researcher asked of them by way of largely fixed- or forced-response questions (Huysamen, 2001; Gorard, 2003). However, Gorard (2003) cautions that, in as much as closed-ended questions contribute to measurement error from the respondent, open-ended questions contribute to this measurement error from the researcher as well. Therefore, since research studies have shown that there is little similarity between responses to closed-ended and open-ended questions, it has been perhaps advisable to mix these types of questions in this instrument. This, in fact, presupposes the mixed-mode notion of intra-method mixing technique (Johnson & Turner, 2003).

The response rate from the pilot questionnaires was 100% because they were personally administered by the researcher. On analyzing the responses it was discovered that only 3 respondents did not answer questions 13, 15, and 18. All other participants had responded to all the questions and the responses generally indicated that there were not any serious problems with the clarity of the items in the instrument. However, as a result of the comments (feedback) that came from the experts in research, there were necessary changes that were done to the original questionnaire to accommodate the changes that were suggested (that is, in terms of the structure and format). Thus the final instrument resulted in having the bulk of the items being open-ended with far less closed-ended ones (only one section). And due to time constraints the modified instrument resulting from this pre-testing was never piloted again since it was felt that the changes that were suggested did not warrant another piloting.

The interview schedule was also pre-tested with one mathematics education expert who pointed out that some of the participants might have problems answering some of the questions that particularly dealt with the teaching of Mathematical Literacy since most of them were not teaching the subject. So in preparing the final instrument I made sure that there was a balance of items that dealt with the concept both as a 'competency' and as a 'subject of study', and the rest of the questions were to be used as prompts. In the overall, piloting seems to have significantly helped me reveal inherent weaknesses of the original research instruments which had to be addressed before the study began.

3.1.5 Data Production Methods

This research is an exploratory and descriptive study of mathematics educators' perceptions of the notion 'mathematical literacy' aimed at exploring their perceptions and/or beliefs as teachers of Mathematics and Mathematical Literacy subjects in their respective schools, as well as being students of the mathematics and mathematical literacy courses at the university of KwaZulu-Natal in 2006. For the purpose of this study, administration of self-completed questionnaires, standardized open-ended interviews (semi-structured and tape-recorded), and document analysis were the only research methods that were used for data production (see Neuman, 2006 and Fink, 2006). The reason for choosing these methods was that they were found to be most appropriate for a survey study such as this one. These methods were chosen due to the descriptive (which is one of the key aspects of the interpretive paradigm) nature of the research question (Maykut & Morehouse, 1994; McMillan & Schumacher, 2001; Miles & Huberman, 1994), and were mixed as a way of method triangulation for the purposes of validation (Delamont, 1992; Hopkins, 1993). Johnson and Turner also point out that,… “Methods should be mixed so that they have complementary strengths and non-overlapping weaknesses” (Johnson and Turner, 2003, p. 316). On the contrary, Sandelowski (2003) argues that mixed-methods approach (if not carefully articulated) can be problematic as a research design because it tends not to allow for fair representation of the various target audiences. She further cautions that researchers who decide to use mixed-methods approach in their studies must ensure that such approaches are employed not only as appeals to validity but should also appeal to mixed audiences of researchers and readers in terms of objectivity or truth. As she puts it:

> “Mixed methods studies engender a crisis of representation all their own as they mandate that researchers/writers communicate across entrenched divides often separating writers from readers, in general, and qualitative from quantitative writers and readers, in particular” (Sandelowski, 2003, p. 321).

However, I have chosen to use mixed method approach because I felt it was the most appropriate one for this study. Hence, both administration of questionnaires and interviewing in the form of a ‘sequential inter-method mixing’ (or triangulation) were used to collect data from the participants (Kemper et al, 2003).

The first method of data production that was employed in this study was the use of self-completed questionnaires to collect data from the participants. Since the mode of inquiry employed for this study was a mixed-methods or mixed-mode approach, intra-method mixing technique that used a self-report data production instrument (mixed questionnaire) which was to be filled by all participants was employed (Kemper et al, 2003). This technique employs the use of both qualitative and quantitative data type questions (intra-method mixing) in the same questionnaire to collect data from participants. The mixed questionnaire consists of mixture of both open-ended and unstructured (qualitative) questions whereby respondents provide the answers in their own words, and closed-ended and structured (quantitative) questions whereby respondents are provided with the possible responses from which they must select (Neuman, 2006; Kemper et al, 2003).

The use of a mixed questionnaire with largely qualitative question items is a useful strategy because it helps to ensure that the views of respondents are well-represented (Neuman, 2006; Kemper et al, 2003; Cohen et al, 2000). And as Kemper et al argues, "In many cases, the mixing of qualitative and quantitative methods will result in the most accurate and complete depiction of the phenomenon under investigation" (Kemper et al, 2003, p. 299). Furthermore, Cohen et al argue that the open-ended questions (if used in a questionnaire) can "catch the authenticity, richness, depth of response, honesty and candour which……are the hallmarks of qualitative data" (Cohen et al, 2000, p. 255). Thus I chose to use this type of questionnaire for the purpose of this study so as to be able to capture teachers' responses in the manner that make them feel free to express their beliefs and convictions concerning their perceptions about the concept 'mathematical literacy' without being too much 'channeled' by the researcher into responding only in a certain way (Huysamen, 2001). And since all the participants were on campus during their contact session over a period of two consecutive weeks in the months of June and July 2006, questionnaires were administered to all of them in their respective lecture rooms at various times over a period of two consecutive days.

3.1.6 Interviewing

Following the administration of the questionnaire, the second method of data production that I used for this study was the interviewing. Interviewing is a method that employs questioning as its principal technique for data production (Neuman, 2006; Henning et al, 2004; Kemper et al, 2003; Huysamen, 2001; McMillan & Schumacher, 2001). Neuman (2006) asserts that: "The interview is a short-term, secondary social interaction between two strangers with the explicit purpose of one person's obtaining specific information from the other" (Neuman, 2006, p. 304).

Thus and for the purposes of this study, interviewing was employed as one of the data production methods with a view to explore teachers' general perceptions of the notion 'mathematical literacy' and their individual personal views and beliefs related to this concept; and which might give insights into the study. As a data production method, the interview may, on one hand, vary from those that are completely unstructured to those that are completely standardized and structured, on the other hand (Johnson & Turner, 2003; McMillan & Schumacher, 2001; Cohen et al, 2000; Neuman, 2006).

Seidman (1998) points out that the basis of interviewing is the desire to understand other people's experiences and what they make of such experiences. He says:

> "At the root of in-depth interviewing is an interest in understanding the experience of other people and the meaning they make of that experience. [……] If the researcher's goal is…..to understand the meaning people involved in education make of their experience, then interviewing provides a necessary, if not always completely sufficient, avenue of inquiry" (Seidman, 1998, pp. 3 - 4).

However, for the purpose of this study I chose to use a semi-structured and standardized open-ended interviewing method because I felt this was a powerful way of gaining insight into educational issues, and hence would give both the researcher and the respondents opportunity to explore and discuss issues together face-to-face (Johnson & Turner, 2003; Neuman, 2006; Seidman, 1998; McMillan & Schumacher, 2001). This type of interviewing is in line with sequential inter-method mixing technique (or method triangulation) which is in keeping with the mixed-methods approach/mode that has been employed throughout this study (Johnson & Turner, 2003; McMillan & Schumacher, 2001).

Henning et al (2004) describes standardized interview as a data production method in which the interviewer is to control the process so as to ensure that the interviewee does not wander off the topic, yet allowing the respondent(s) to "freely" give subjective answers (that yield information that represent reality more or less as it is through the response of the interviewee) to the questions posed by the interviewer. Thus the interview method employed in this study took the form of a standardized open-ended interviewing which used semi-structured questions (see also Johnson & Turner, 2003; McMillan & Schumacher, 2001; Neuman, 2006). And all the interviews were guided by a set of questions, and were recorded using digital voice recorders and later transcribed.

The interviews were semi-structured and conducted with a sample of 6 participants. Of the 6 interviewees, 5 were female teachers who were actually involved with the teaching of Mathematical Literacy in their respective schools, and 1 was teaching Mathematics at the high school GET level.

3.1.7 Conversational Interviewing (Individual/paired group interviewing)

According to Neuman (2006) and Johnson & Turner (2003) focus groups are a variation of an interviewing method comprising a homogeneous group of about 6 to 12 people to discuss a research topic or issue for the purpose of obtaining a better understanding of a problem or idea by interviewing a sampled group rather than each person individually. This technique is qualitative in nature, and can be used in inter-method mixing approach as a sequential mixed-method strategy to aid a better understanding and interpretation of information and findings emanating from earlier use of other data collection method(s) (see also McMillan & Schumacher, 2001; Holland & Campbell, 2005). For this reason I initially planned to use focus group interview as one of the data production method for this study.

It was initially planned that the subgroup (about12 teachers) of teachers who were involved with the teaching of Mathematical Literacy in the FET phase would constitute a focus group to be included in the group discussion on the topic of study. However, this was not possible as the concerned teachers, when approached by the researcher, were not willing to come forward. As a result I had to change the strategy and resorted to approaching them as individuals to ask them to participate in the interviews that were to be arranged later. Out of some stroke of luck I managed to get two groups of two participants each, who agreed to be interviewed as a pair (paired group interview) and two more participants who preferred to be individually interviewed. So, altogether there were six participants (three from B.Ed Hons Science & Mathematics, two from ACE Mathematical Literacy for ACE, and one from GET Mathematics for ACE) who were interviewed or involved in the conversational interview. Dates for the interviews with these “small groups” were arranged and fixed. Thus the interviews were scheduled for the first week of July, 2006. There were four separate interviews that were conducted altogether, two of which were group interviews and the other two were individual interviews. The first interview was conducted on the 3rd July, 2006 with the ACE Mathematical Literacy group of students; the second interview took place on the 4th of July, 2006 with one B.Ed (Hons) student; the third interview took place on the 6th of July, 2006 with two

B.Ed(Hons) students; and the last interview was also conducted on the 6th of July, 2006 with one GET Mathematics student.

Thus, instead of using focus group interview as was initially planned, I used a combination of face-to-face small discussion group and face-to-face individual standardized open-ended interviews for the purposes of achieving my research plan and also to confirm the findings of the self-completed questionnaire method that I earlier used (Neuman, 2006; McMillan & Schumacher, 2001; Holland & Campbell, 2005).

3.1.8 Document Study/Analysis

Official documents such as the FET National Curriculum Statement (Grades 10 – 12) for Mathematical Literacy, and the learning support materials (that is, textbooks) which have been produced since the inception of the new curriculum reforms, were used as another source of data from which to search for perspectives concerning the theoretical concept of mathematical literacy, through the use of both *content* and *discursive* analysis methods. Henning et al (2004) point out that documents can also be used as a method of data collection along with other methods, and are also, just like all texts, open to discursive analysis. Reflectively I found that official documents saliently provided context and background with regard to curriculum issues relating to Mathematical Literacy and thus I selected and incorporated the aforesaid documents as part of my methodical approach for data capturing (see also Hammersley & Atkinson, 1995; Knight, 2002; McMillan & Schumacher, 2001; Neuman, 2006).

3.2 Data Reduction and Analysis Methods

In the light of the interpretivist orientation of this study, data analysis took the form of both an inductive process/approach whereby topics are developed from data itself to generate categories using an open coding procedure, and a deductive process/approach which uses predefined codes and categories (Henning et al., 2004; McMillan & Schumacher, 2001; Onwuegbuzie & Teddlie, 2003) that emanated from literature reviews concerning the concept of mathematical literacy, and related to teachers' perceptions of the characteristics/competencies of a mathematically literate person, of their beliefs about mathematical literacy, and of their experiences of teaching mathematical literacy. The inductive process involves reading through the entire data sets with the aim of identifying possible groupings of codes that can be categorized according to different segments or units of meaning (Henning et al, 2004). This process is referred to by Maykut and Morehouse (1994) as 'unitizing' the data (see also Cohen et al, 2000); whereas deductive process uses categories that the researcher will have decided in advance as derived from either the research questions or relevant literature. The coding and categorization process (which Henning et al refer to as 'thematic organization') entails several cyclical phases which eventually lead to the extraction and construction of themes from the categories, thereby allowing for synthesis and interpretation (McMillan & Schumacher, 2001; Cohen et al, 2000).

For the qualitative data, the free responses (open-ended) were typed out verbatim, and were analyzed manually using codes and categories, together with all the other qualitative data (interviews) from the particular participants. An attempt was made to use N-vivo software programme on the source documents, in this case participants' interviews and additional comments from the questionnaires, but it was not easy (much of the coding was done manually due to lack of experience with the programme on the part of the researcher). The analysis used in the project was done based on the codes and categories that I derived from the text itself – i.e. both from data and extant literature (Miles & Huberman, 1994; Neuman, 2006). Codes are labels attached to text (from single words to whole paragraphs or documents) for allocating units of meaning to the information collected in a study. The codes can be created in two main ways: either by creating a provisional start list from the theoretical framework for the study, the research questions and key variables prior to the fieldwork and adding to this as necessary once the data has been collected (deductively), or by waiting for the data and creating codes as they arise from the text (inductively). Both ways were used in this study.

The analyses of the qualitative part (open-ended items) of the questionnaire together with the interviews have been done using what Henning et al (2004) refer to as 'qualitative content analysis' which involves organizing data into codes and categories; and the ensuing categories were named inductively using the data as a guide throughout the analysis process. This organization of data into codes and categories is both an interactive and iterative process which brings in issues of data reduction, display, and of conclusion drawing/verification that help the researcher to construct themes that can be used in the final synthesis and interpretation (Henning et al, 2004; Miles and Huberman, 1994), and as a basis for an argument in the discussion around such themes.

However, due to the different types of data collected in this study, the data analysis methods are discussed according to the mixed-methods (*qual* + *quan*) approach that informs this study (Kemper et al, 2003). The quantitative data from the 12 Likert-Scale items were coded numerically on a scale of -2 for “strongly disagree” to 2 for “strongly agree.” In addition to the relative frequency of each aforementioned category, a mean score was computed. A mean greater than zero points to a positive response from the groups overall, with all the usual caveats of outliers unduly influencing the means. All quantitative data from the questionnaires were captured according to a detailed codebook (see Appendix H) drawn up according to guidelines suggested by Piper (1996) and Oppenheim (1992). Accordingly, numerical values were assigned to each variable’s values in the categorical data items such as gender, and to missing responses. Items such as age, and experience in teaching mathematics were self-coding since the responses themselves formed the numerical codes. Each participant in the study was given a unique reference number and a master data spreadsheet created with the biographical data for each particular participant. This allowed for subsequent disaggregating of the data according to all the biographical factors such as gender, school location or school resources, cohort, and/or funding. Once all the data were entered, a process of data cleaning was undertaken. These was done by visually scanning the data set for gaps, and by producing frequency tables for each individual variable to check for values that were obvious errors of coding or recording (see Appendix F). Data were disaggregated by cohort and a one-way ANOVA test was administered to check whether there were any significant differences within and between cohorts. If any differences were found, then a *post hoc* Scheffe test was performed to indicate which pair of cohorts had statistically significant differences. Specifically, the participants’ responses on the quantitative part of the questionnaire have been analyzed using SPSS to generate descriptive statistics (see Appendix K) for the Likert-type item(s) (Field, 2005; Kranzler, 2003; Muijs, 2004).

In this study therefore, the whole process of the analyses of both the questionnaire responses and the transcribed interviews has been supported by making use of computer software suited to the management and analysis of qualitative and quantitative data which were found most appropriate to my analysis plans and to the structure of my data sets (Bazeley, 2003; Weitzman, 2000).

The use of exploratory factor analysis to reduce the data was initially investigated. Exploratory factor analysis was performed on the items from the section concerning participants' beliefs (item 9, part C of the questionnaire) to see if related variables (beliefs) within the section could be identified to form groups/components of factors. However this was finally abandoned due to lack of any clear differences or similarities between the components emanating from such analysis (see Appendix G).

3.3 Reliability and Validity Issues

As a novice researcher, I found myself faced with the daunting task of ensuring that, throughout the research process, issues of reliability and validity were addressed. Cohen et al (2000) point out that these data-verification measures are important and can be applied to any type of research (qualitative, quantitative, or naturalistic). Hence they suggest several ways in which different types of reliability and different types of validity can be addressed, all of which must be based on or be considered in the light of the purposes of research, the time scales and constraints on the research, the methods of data collection and analysis, and the methodology of the research. In which case therefore, given the sample and design of this study, an attempt to address issues of reliability and validity in both the questionnaire and the interview schedule was made through pilot-testing of research instruments and method triangulation or use of multiple method approach (Fink, 2006; Neuman, 2006; Cohen et al, 2000). Also, as an attempt to reduce bias and/or address issues of reliability and validity, the questionnaire and the interview schedule were given to two separate reviewers, whose advice was used to modify both instruments (and in particular the questionnaire) to make them much more open-ended.

3.4 Gaining Access

Some of the crucial issues I needed to attend to at the initial and later stages of this research project was to seek permission from all the relevant authorities before I could conduct my study. After my research proposal was passed and my ethical clearance application was approved, I made an application to the coordinator of the Advanced Certificate in Education (ACE) programme at the Edgewood Campus, in the University of KwaZulu-Natal's faculty of education for permission to survey the in-service teachers, who were enrolled in professional development courses, in my study during one of their contact sessions in the months of June and July, 2006. I was given access to these sessions and allowed to administer the questionnaires. The participants did not seem to have any problems accepting me into their lectures especially that I had officially been introduced by their tutor, and they all completed the questionnaires in my presence during the 20 minute period of time that was allocated for that purpose. I used the first 5 minutes of this time to explain to the teachers the purpose and origin of my research project.

However, even with this acceptance and seemingly willingness (on the part of participants) to participate in the study, I later realized that the teachers were generally reluctant to be interviewed. Only two female Indian teachers came forward at the end of the lecture and volunteered to give me an interview. This was scheduled, and later on in the course of the first week, four more teachers came along and offered me some interviews which were also accordingly scheduled. All the six teachers who granted me interviews were those who were involved in the teaching of Mathematical Literacy subject in their respective schools.

3.5 Ethical Considerations

In view of the ethnographic nature of this study, it was necessary that issues of ethics that related to methodological approach should be considered and heeded before and during engagement in the research. Cohen et al succinctly point out that: […], the researcher will frequently find that methodological and ethical issues are inextricably interwoven in much of the research we have designated as qualitative or interpretive (Cohen et al, 2000, p. 66).

For this reason therefore, I made sure that participants' consent was sought before the study proceeded, through making a provision on the questionnaire for them to sign as an indication of their agreement to give their consent and to participate in this research project. It was also explained on the questionnaire and during the interviews, to the participants, that all information they provided would be treated confidentially, and that they were free to withdraw their consent and data if they so wished at any time (see Neuman, 2006; Fink, 2006; Cohen et al, 2000).

3.6 Delimitation of the Study

The three cohorts of teachers who formed the sample for this study were the 2006 in-service teachers studying for Advanced Certificate in Education (ACE) in Mathematical Literacy program, Advanced Certificate in Education (ACE) in General Education and Training (GET) Mathematics program, and Bachelor of Education (B.Ed, Hons) in Mathematics and Science Education program at Edgewood Campus Faculty of Education, in the University of KwaZulu-Natal. The analysis is, therefore, restricted to a single teacher education institution in a single province of KwaZulu-Natal. For this reasons, the findings need not necessarily be generalized to other teachers or mathematics educators in other provinces in South Africa and elsewhere since they are limited in scope and may not necessarily resonate with perceptions of the rest of the broader mathematics education community, either due to forming an unrepresentative sample or incorrect analysis and/or interpretation or incorrect data.

CHAPTER FOUR RESULTS: PRESENTATION AND DISCUSSION

This chapter focuses on analysis of policy documents and on the ideas which emerged from the analyses of data that were collected from the interviews with participants, and the questionnaire which comprised 12 open-ended items and with a set of 12 beliefs of a five-point Likert-type scale each (see Appendix G), as well as policy documents. The sample from which data have been gathered comprised three cohorts of teachers, two of whom studied for an Advanced Certificate in Education (ACE) in FET Mathematical Literacy and GET Mathematics, while the other cohort (combined group) studied for B.Ed(Hons) in Mathematics and Science Education. This sample was made up of 18 teachers who were being retrained in mathematical literacy course, 25 teachers who were studying for a General Education and Training (GET) course in mathematics, and 27 teachers who were studying for Bachelor of Education (B.Ed Hons) course in science and mathematics education. Altogether there were 70 teachers who made up the sample and participated in this study. Of the 70 participants, only six out of the 18 teachers were involved in the teaching of mathematical literacy; and only five out of the 25 teachers from the B.Ed(Hons) group for mathematics and science education course were involved in the teaching of mathematical literacy as a subject in their respective schools, while the rest were not.

This study set out to explore mathematics educators' perceptions of the notion 'mathematical literacy' as a competence and as a subject of study. Its main purpose was to find out from teachers what their understanding of mathematical literacy was and whether they regarded it as a subject of study or as a competency. From the findings of this study, it has been revealed that participating teachers were not acutely aware of the international controversy surrounding the different connotations used to describe 'mathematical literacy', and the distinction drawn between its two notions of 'competency' and 'school subject'. A large majority of participants believed that mathematical literacy was a school subject that is not very different from formal mathematics except that its teaching requires presentation of relevant contexts in which learners will have the opportunity to see and experience uses and applications of mathematics. Most participants also believed that being mathematically literate is about the ability to deal with numbers (or number and quantity) and data handling. However, participants did not explicate on the important distinction between mathematical literacy as a competency, and as a school subject. At best, most participants (especially during the interviews) expressed lack of confidence to handle mathematical literacy due to lack of either content knowledge or pedagogical knowledge. In an AMESA submission paper, it has been noted that, "……There are simply not enough well qualified or trained teachers……current teachers are not adequately prepared to teach Mathematical Literacy. Current teachers, in the main, lack the capacity both to connect their mathematics to real contexts and struggle to see the internal connections between mathematical concepts…." (AMESA, 2003, pp. 3-4). Overall, the results seem to indicate that, by comparison, the three cohorts had different beliefs about and conceptions of 'mathematical literacy' all of which point to the fact that these groups had different perceptions regarding the two *notions* of mathematical literacy. A large majority of teachers believed that mathematical literacy was a subject of study, while only a few thought it was both a competency and a subject of study.

4.1 Findings

In the following sections, analysis of document study is presented and discussed. Next, teachers' perceptions of the notion of mathematical literacy are discussed and compared with the literature according to the following categories: teachers' perceptions of the competencies of a mathematically literate person; teachers' beliefs and views about mathematical literacy as a subject; teachers' understandings of the relationship between 'mathematics' and 'mathematical literacy'. Furthermore, participants' notions of ML as a competence and as a school subject are included as well; teachers' perceptions of and their experiences of developing/teaching ML as a competence and as a school subject are also discussed. Finally, participants' understandings/perceptions of the important distinction between mathematical literacy as a competence and habit of mind, and as a subject of study, are discussed. Appendix J provides a summary of participants' responses to open-ended question items regarding their perceptions according to these categories.

All the responses to the open-ended items of the questionnaires and the interviews were analyzed for themes and categories relating to educators' perceptions of competencies of a mathematically literate person, their beliefs and conceptions of ML as a subject, their initial experiences of developing/teaching ML, as well as what their notion of and how they understood ML as a theoretical concept.

4.2 Perceptions of Mathematical Literacy evident in curriculum documents.

This section presents data which informs Research Question One: What understandings/notions of mathematical literacy are evident in the South African curriculum documents? As mentioned earlier on in Chapter Three concerning methodology, this section is a culmination of documents analyses which have been conducted as part of data collection using the NCS document Grades 10-12 (General) for Mathematical Literacy, Subject Assessment Guidelines for Mathematical Literacy document, NCS document for Mathematics Grades 10-12 (General), NCS Grades 10-12 (General) Learning Programme Guidelines for Mathematical Literacy, and Mathematical Literacy Learner's book (Grade 10). Hence, in this section I present my observations of these documents with regard to how their authors perceive the notion 'mathematical literacy,' and in the process, I will also discuss how the documents highlight the relationship between the cognitive styles of mathematics and the social life, under five headings, which highlight five issues that have emerged as a result of the content and discursive analyses.

4.2.1 The definition of Mathematical Literacy

With regard to ML, the NCS document offers the following definition:

> "Mathematical Literacy is a subject driven by life-related applications of mathematics. It enables learners to develop the ability and confidence to think numerically and spatially in order to interpret and critically analyze everyday situations and to solve problems" (DoE, Mathematical Literacy 2003, p. 9)

This statement, in my view, is not really a definition but rather a description of what Mathematical Literacy (ML) is and what it can do to learners. Thus, it seems to me that this definition is deliberately aimed at reframing mathematical literacy as a school subject, rather than a human attribute deriving from practicing mathematics as a discipline. Hence, although the Department of Education have adopted this as a definition, I find it difficult to accept it as such because the first sentence of the statement clearly expresses it as a "subject" proper, while the second sentence expresses what the results of teaching/learning of such a "subject" can do to learners. This is because, in my understanding, the words "ability" and "confidence" are human attributes or habits of mind that explain what a person is capable of doing. In contrast, the use of the term "subject" and the phrase "applications of mathematics" suggest that the 'entity' being referred to as 'Mathematical Literacy' in this context is perceived as a subject and not a competence/competency or a habit of mind; and this is problematic. This entity we call 'mathematical literacy' cannot, in my view, be a *subject* (as we traditionally know what is meant by a subject) and at the same time assume the status of being a habit of mind or social practice.

Perhaps it is necessary that I point out that the word "literacy" in and of itself implies an ability to perform, which is a result of being taught or trained (Kaiser & Willander, 2005; Sfard & Cole, 2003; Vithal, 2006). Literacy is a dynamic entity situated within the social and power dynamics of a society and is much broader than just the skills of reading and writing. It involves a reframing of one's reality through conscientization (see Jablonka's categories of 'Mathematical Literacy for Human Development' and 'Mathematical Literacy for Social Change'). As Paulo Freire once said:

> "To acquire literacy is more than to psychologically and mechanically dominate reading and writing techniques. It is to dominate those techniques on terms of consciousness; to understand what one reads and to write what one understands; it is to communicate graphically. Acquiring literacy does not involve memorizing sentences, words or syllables (or *mathematical symbols* -**my addition**) – lifeless objects unconnected to an existential universe – but rather an attitude of creation and re-creation, a self-transformation producing a stance of intervention in one's context" (Freire cited in Cohen-Mitchell, 2000, pp. 148-149).

Clearly, this statement echoes similar sentiments as of those who assert that to be literate is more than just reading and writing. I would similarly (and in particular) consider mathematical literacy to be more than to "psychologically" and "mechanically" dominate mathematical "reading and writing" skills and techniques.

The above quotation clearly shows that "literacy" is understood to be a human condition that reflects a person's behaviour. It is for this reason that I cannot escape the conclusion that "mathematical literacy" (a phrase derived from the idea that a person is literate or has expertise in mathematics) is a competency which can be taught, and not a subject of study (see Niss, undated; de Lange, undated).

Hence, I would argue that, just like all the other literacies (such as computer literacy, English Language literacy, etc), mathematical literacy is a competence/competency (and is not and cannot assume or convey any other meaning save for the different levels or degrees of literacy) or habit of mind which is a by-product of proper teaching and learning of the subject mathematics as a discipline (Kaiser & Willander, 2005; Sfard & Cole, 2003; Kilpatrick, 2002).

Furthermore, in terms of the language and tone however, one cannot escape the conclusion that the NCS document for ML (together with ML textbooks) is oriented towards more everyday (contextualized) mathematics. Although this sounds a good approach, it could also be problematic because emphasis on contextualized mathematics teaching does not necessarily guarantee learners' success in generalizing out of the context, and thus restricts them to remain in either the colloquial (everyday) mathematical discourse or the literate (secondary) mathematical discourse (Sfard & Cole, 2003). Also, there is the highest possibility that the chosen context(s) may not be relevant or appropriate to all learners of different social origin (that is: class, race, ethnicity, etc.) due to their previous socialization experiences (Cooper, 1992; Rowlands & Carson, 2002). This will invariably have practical implications on what teachers might be expected to do in order to try and help all the learners in their classes, especially since in great majority of South African schools the disadvantaged learners from seriously impoverished learning environments seem to be lacking in the necessary formal mathematical knowledge.

4.2.2 The Mathematical Literacy curriculum

I have already mentioned that the international debate around 'mathematical literacy' as a concept reflects different connotations used to describe this term and how it is being perceived. Now, an examination of the definition of 'mathematical literacy', which is offered by NCS document, reveals that this term or phrase has been framed as a subject.

The definition (as stated above) claims that there are three key elements of the *subject* Mathematical Literacy, and have been used to justify its inclusion in FET schooling curriculum. These are: the *content*, the *context*, and the *abilities* and/or *behaviour*s that a mathematically literate person is to display. However, there seems to be a problem with this definition (in my view), because the very elements that have been outlined seem to point to what school mathematics and its end results should be rather than what mathematical literacy as a subject consists of as this does not make it different from mathematics. Also, it is not clear exactly how those three elements should play out together in the Mathematical Literacy classroom differently from mathematics discourses such as the mathematizing notions of ‘realistic mathematics’ and ‘mathematical modeling’ (ICMI Study, 1996; Vos, 2002) which are themselves illustrations of *everyday* and *workplace* applications of mathematics. The central idea of ‘realistic mathematics’ and ‘mathematical modeling’ is that mathematics is best learnt from a concrete, realistic situation (or a model) that appeals to learners; thus the problems in these situations are mathematized by being transferred to a more or less mathematical problem which can be analyzed with mathematical tools.

In contrast for the NCS, despite that the concept has been framed as a subject, it is clear that the idea is a remodeling of the standardized Mathematics curriculum couched under a new nomenclature whose connotation is in keeping with what it means to be mathematically literate. Hence it can be concluded (and I think, rightly so) that the NCS view of mathematical literacy as a subject, rather than a competency, is problematic because it does not clearly make an important distinction (by definition) between a competence and a subject. Furthermore, it can be argued that the way mathematics is currently taught in schools is what fails the development of mathematical literacy in learners and not the way the subject (mathematics) is structured. In other words, it is the teaching and/or the learning approach to mathematics that should be improved in order to produce mathematically literate learners. As has been rightly pointed out in the curriculum: “The approach that needs to be adopted in developing Mathematical Literacy is to engage with contexts rather than applying Mathematics already learned to the context” (DoE, NCS for

Mathematical Literacy, 2003, p. 42). This is the proper way (approach) to the teaching and learning of mathematics that, I believe, is being echoed from research studies within mathematics education. However, I do not think that inappropriate way of teaching/learning of mathematics is enough justification for the reframing of 'mathematical literacy' concept to become a subject of study. My thesis is that contexts are meant to bring to life mathematical concepts and ideas that learners may not be familiar with. Therefore, I find it difficult to understand what "…to engage with contexts rather than applying Mathematics already learned to the context" mean, because I cannot imagine how learners would be able to understand the mathematical structure embedded in the very contextual problem they are to solve without some basic mathematical knowledge. For this reason, therefore, I will argue that "to engage with contexts" does not necessarily suggest that one learns from the concrete or from the context. Rather, it could mean that you either have the tools to solve a mathematical problem in real-life situations or you still need to acquire such tools through exposure to real-world problems that need to be solved. The former suggests that you already have the tools while the latter suggests that one is yet to learn. If we take school to be a place where learning/teaching occurs, then it follows that development of mathematical literacy (which is a habit of mind) has to start at school, and it is highly possible if teachers are themselves mathematically literate. In which case, there is absolutely no need to have another subset of mathematics called 'mathematical literacy. All that is needed is to train teachers to be well grounded in mathematics content knowledge, and the rest will follow. Otherwise the NCS document for ML seems to predominantly follow Jablonka's framework (see 'Mathematical Literacy for Developing Human Capital', 'Mathematical Literacy for Evaluating mathematics', and 'Mathematical Literacy for Social Change') which is, in fact, the essence of mathematics enterprise.

4.2.3 The difference(s) between 'Mathematics' and 'Mathematical Literacy'

Analysis of the content of the Mathematical Literacy curriculum reveals that the curriculum has been divided into four outcomes using the same content-based divisions as the Mathematics FET curriculum. Yet the international debate around mathematical literacy seemed to suggest a strong thread that discussed the distinctions between mathematics and mathematical literacy with its related terms (Madison, 2004; Steen, 2001a). For example, in his paper "Mathematics and Numeracy: Two

Literacies, One Language", Steen (2001b) reviews a US report on what work requires of schools. He notes that the report reflects differences between mathematics and numeracy (or mathematical literacy). Steen (2001b) observed that mathematics conveys the power of abstraction, whereas numeracy/mathematical literacy conveys the power of practicality. And it is this 'power of practicality', in my view, which portrays 'mathematical literacy' as a competence rather than a school subject. However, this explication does not give a clear and important distinction between the notions of 'mathematical literacy' as a competence and as a subject of study or social practice.

In contrast, the South African Mathematical Literacy curriculum, although it does seemingly reflect an attempt to have split streams of formal mathematics and mathematical literacy in order to illustrate the differences between the two, does not explicate such a re-framing in terms of the content for such a 'subject', as can be seen in the Learning Outcomes:

The Learning Outcomes for the Mathematical Literacy Curriculum are:

Learning Outcome 1: Number and Operations in Context
Learning Outcome 2: Functional Relationships
Learning Outcome 3: Space, Shape and Measurement
Learning Outcome 4: Data Handling

The Learning Outcomes for Mathematics FET Curriculum are:

Learning Outcome 1: Number and Number relationships
Learning Outcome 2: Functions and Algebra
Learning Outcome 3: Space, Shape and Measurement
Learning Outcome 4: Data Handling and Probability

A comparison of the Learning Outcomes of the two curricula (Mathematics and Mathematical Literacy) reveals that the two are more or less the same. Also, it is difficult to view Mathematical Literacy as defined by the Curriculum documents, as different from 'watered-down version of Mathematics' looking at some of the choices of mathematical content. For example, in Grade 10 the curriculum states that, in terms of functional relationships, ‘linear, inverse proportion and compound growth in simple situations’ are included, and in Grade 11 the list is expanded to include ‘quadratic functions’ (DoE, 2003, pp. 20-21). For this reason therefore, one would argue that the two documents (in terms of content) are not entirely different from each other except for the inclusion of functions like piece-wise defined functions or step functions (and exclusion of algebra) which provide mathematical models for real-life situations through which the idea of *context* that the ML curriculum makes is emphasized. Furthermore, it is quite clear that by putting emphasis on “context”, the ML curriculum gives leverage to educators to decide on and choose what they deem to be appropriate context for learners; and this is problematic since not any one context will be relevant to all the learners at any given time and space (see also Clarke, 2003; Cooper, 1992; Rowlands & Carson, 2002). Not only that, but the idea that the teacher brings *contrived* ‘contexts’ into the classroom is in itself problematic since it does not provide learners with *real* real-life situations (see Stolp, 2005; Schifter, 2005; Fosnot & Dolk, 2005). Hence my assessment of the two curricula leads to the conclusion that, despite the painstaking efforts by the authors of ML curriculum to portray mathematical literacy as a subject rather than a competence, the curriculum or the syllabus looks too much like that of Mathematics. It must also be noted that the exclusion of algebra from the ML curriculum suggests that the formal mathematics subject (as we know it) has been reduced in terms of the number of its strands that have traditionally been used to define it. Hence it sounds a legitimate argument to say that Mathematical Literacy is a ‘watered-down version’ of mathematics.

Furthermore, analysis of the NCS Learning Programme Guidelines (LPGs) for Mathematical Literacy (with particular reference to the four important abilities which are: *using mathematics to solve real world problems*, *understanding information represented in mathematical ways*, *critically engaging with mathematically based arguments in real life situations*, and *communicating mathematically*, p. 8) clearly shows that Mathematical Literacy is, in fact, a competency; and that its development is predicated in the way mathematics is taught and learned. This is evident in the statement that, “The most noticeable change in the approach to the teaching and learning of mathematics in Mathematical Literacy is the delaying of formal methods (algorithms) in favour of extended opportunities to engage with mathematics in diverse contexts" (DoE, Learning Programme Guidelines, 2007, p. 8). This statement, however, seems to suggest two things; (a) that Mathematical Literacy is different from mathematics, and (b) that mathematics is a subject incorporated within Mathematical Literacy subject. First, I think the first suggestion is questionable because earlier on in the ML curriculum it was argued that *content* cannot be separated from *context*, and therefore to suggest that ML is different from mathematics implies that the two are neither the same nor related; which cannot be true. Secondly, the second suggestion is also questionable because, contrary to my considered opinion and explication about the concept, it implies that ML is a subject of study, yet I have argued (and I think convincingly) that it is and should not be perceived as such (compare with Jablonka, 2003).

Although the aforementioned quotation suggests that ML is a subject of study and not a competency, what seems to be clearly revealed or implied from the statement concerning the purpose of mathematical literacy, in my view, is that mathematics and mathematical knowledge are inextricably bound; and that mathematical literacy is an automatic consequence of knowing mathematics. Hence, I argue that ML does not, itself, develop any abilities (as the NCS document claims) but rather, it is characterized by such main abilities as stated in the Learning Programme Guidelines because it is (by definition) a competency and not a subject of study. And as I have alluded to elsewhere, it is important to recognize that the 'four main abilities' reflect not only the importance and relevance of mathematics applications to real-life situations but also the interplay between content and context, as well as the interconnectedness of mathematics itself to the real world. On the basis of the foregoing, therefore, it is my thesis that the Learning Programme Guidelines would better be suited to the development of mathematical literacy as a competency in a reformed mathematics education curriculum which recognizes mathematics as a subject, and takes cognizance of the fact that the teaching/learning practices that go with it are essentially geared towards producing mathematically literate learners across the whole spectrum of the educational system. For this reason, there seems to be no need for another 'subject' called Mathematical Literacy since the dichotomous split to have two 'mathematics' as put forward internationally and locally, in my view, is not convincing enough for as long as the strands or topics in both are more or less the same.

4.2.4 The interplay between content and context.

One of the hotly debated issues that have been faced in mathematics education is that in order to mathematize a context one needs to have a good understanding of the content. This poses greater challenges (both curricular and pedagogical) for teachers, since (as alluded to elsewhere) treatment of 'real contexts' for mathematics is highly likely to take different forms and approaches which are not necessarily relevant to all the learners. Mathematical Literacy teachers are not only required to understand mathematics, but also a host of all the contexts that will be relevant to all learners. Similarly, Mathematical Literacy learners will have to develop a good grasp of these contexts; and this is where a host of problems lies. For example, the Mathematical Literacy curriculum has a focus on personal finances. The topics that learners are expected to deal with range from basic budgeting to compound interest, and proceed from the effect of changing interest rates on mortgage repayments to comparing different retirement options. However, in planning the teaching of these topics teachers cannot (given the South African context) just assume that all learners in South Africa have adequate experience of banks, let alone an understanding of interest or of notions of risk and return in investments. If mathematical literacy learners are expected to be able to use mathematics "to interpret and critically analyze everyday situations" (DoE, Mathematical Literacy, 2003, p. 9), then they have to have adequate familiarity with the situations or develop sufficient understanding of the situations in order to use their mathematical knowledge to analyze them. Unfortunately, as has been alluded to elsewhere, it is very unlikely that teachers will be able to provide *all* the relevant contexts within their classes for all learners to manage them, let alone the large amount of teaching time required to meet just one example listed under one assessment standard in the curriculum.

The Subject Assessment Guidelines for Mathematical Literacy released by the Department of Education (2005) makes the following statements: "On the one hand, mathematical content is needed to make sense of real-life contexts; on the other hand, contexts determine the content that is needed," and that "When teaching Mathematical Literacy, teachers should avoid teaching and assessing mathematical content in the absence of context. At the same time teachers must also concentrate on identifying in and extracting from the contexts the underlying mathematics or 'content'. That is avoid teaching and assessing contexts without being deliberate about the mathematical content" (Subject Assessment Guidelines, Mathematical Literacy, 2005, p.7).

What does not seem to be coming out clearly from these statements is whether or not 'mathematical literacy' and 'mathematics/mathematical content' are the same/related; and it is not made clear what the differences (if any) are. The suggestion that teachers must "concentrate on identifying in and extracting from the contexts the underlying mathematics or content" clearly implies that mathematical literacy cannot be separated from the mathematics subject. Furthermore, it is clear from the statements that the teacher is significantly more in control of the learning situation than the learners. Hence it is not difficult to see that this kind of approach to developing 'mathematical literacy' suggests that contexts are created by the school. In which case, therefore, they are not real 'real-life' or 'real world' problems but rather they are *contrived* problems. The question now is: how can these imagined contexts exactly match out-of-school settings in order to clearly show substantial evidence of learners' abilities to transfer learning from in-school to out-of-school settings? Furthermore, it seems to me that the two statements quoted above are contradictory. On one hand, the first statement is suggesting that mathematics content is necessary "to make sense of the contexts", on the other hand, the second statement suggests that content cannot or should not be taught out-of-context. In other words, the two (content and context) should go together during the process of teaching mathematics for the development of mathematical literacy. But how does the development of mathematical literacy occur without mathematics? And by 'content', does it refer to content of mathematics subject or mathematical literacy subject? The very fact that situations to which teachers are expected to expose learners are mathematical suggests that the basis for learning is the context, but what has to be learned is the mathematics content and not mathematical literacy. Mathematical Literacy becomes the by-product, with the learner becoming mathematically literate as an end-product of the teaching and learning of mathematics subject.

Furthermore, I take the view that mathematical content (or mathematics) is the key thing here, and that this content-context interplay leads to acquisition of mathematical competencies that form the basis of what is called 'mathematical literacy' which is a by-product of mathematics education resulting from a compulsory schooling curriculum. It therefore follows that the contexts from which the content develops are supposedly determined by the social and cultural settings within which an individual learner exists, and that such contexts vary from culture to culture where the mathematics (or content) is being practiced. In which case, therefore, the role of context is mainly to aid in the teaching and learning of the content (mathematics) but not mathematical literacy, as it were (see NCTM cited in Goba, 2004). And for this reason therefore, it means that teachers will have to be quite adept in the art of teaching. Also, it seems quite clear that teachers, under time pressure in the classrooms, and aware of the need to teach what will be examined, are faced with enormous challenges and are in a serious dilemma to be able to fulfill the requirements of the new curriculum.

The assessment standards and the learning outcomes in the Mathematical Literacy curriculum do not provide a framework that gives clear guidance on how the content-context interplay can be achieved. This, in my view, could be a result of failure on the part of the curriculum authors to foresee the implications of isolating 'mathematical literacy' from mathematics on the basis of 'contexts' as a major determinant, and therefore not to get a clear and thorough understanding of the underlying meaning of the concept of 'mathematical literacy' and how it should be seen as different from or related to formal mathematics.

4.2.5 Learners' textbook as a didactic material.

It is widely accepted that didactic material plays a very important role for the learners to engage in mathematical activities. And thus for this reason, it seems rather difficult to imagine any teaching and learning of mathematical concepts without any didactic material. Teachers/educators use didactic material as a means for setting ideas and intentions into practice. Also (and in the process), new didactic materials which are meant to improve the practice of mathematics education are developed as another aspect (e.g. teachers' guide, etc.). Hence, my task here is to analyze the Mathematical Literacy Grade 10 Learner's textbook (Goba et al, 2005) with a view to assessing how it is intended to be presented in the classroom, as well as to look at the mathematical activities that learners are expected to perform on it, and to compare these to the respective learning outcomes as outlined earlier. My view is that, the didactic material does not (by itself) provide the 'realness of 'real-world' contexts that may be relevant to all learners in the classroom. For this reason, therefore, we cannot expect that, by engaging in the mathematical activities (provided by such contexts), which their teachers have prepared, the learners will somehow miraculously develop mathematical knowledge which will necessarily make them literate in all mathematical situations.

A closer look at the grade 10 learner's textbook shows that an attempt has been made to provide examples of mathematical activities that the writers of the book considered appropriate to the development of mathematical literacy in all prospective learners in the FET phase of schooling. For example, in each chapter throughout the textbook we see the headings of such chapters (e.g. *Earning a Living*, *Business and Services*, etc) as depicting the relationship between everyday and mathematical reasoning given or illustrated within the mathematical activities under each chapter. However, the given examples of situations which supposedly are aimed at presenting required contexts, do not differ from those that are used in 'mathematical modeling' or 'realistic mathematics', as it were. Hence, it seems problematic (contradictory) that, although the textbook is entitled "Mathematical Literacy" as a new 'subject', the given activities are clearly grounded on the formal mathematics content, and therefore portrays the concept of mathematical literacy as a competency, rather than a school subject. It remains to be seen, however, whether teachers will be able to use this text as it ought to. As Gellert (2004) argues:

> "Mathematics teachers cannot adopt a newly developed didactic material. They always adapt it to the ends they pursue; they fit the use of didactic material into existing routines for mathematics instruction. Since this process of adaptation is governed by the cognitive style of routines, the new and the challenging may easily be ignored in order to continue with the teaching practice that teachers feel comfortable with" (Gellert, 2004, p. 171).

Clearly, this comment shows that teachers do not always employ didactic materials to the full satisfaction of the designers of such materials. It therefore follows that even for this new learner's textbook, not all learners will use it in ways that their teachers (or even the designers) foresee. However, it must be noted that didactic materials can be used to support the process of change (such as the South African new curriculum transformation), depending on the willingness (or readiness) of the users of such didactic materials to adapt them in the classroom discourses. As Maxine Greene succinctly once said:

> "We do not ask that the teacher perceive his existence as absurd; nor do we demand that he estrange himself from his community. We simply suggest that he struggle against unthinking submergence in the social reality that prevails. If he wishes to present himself as a person actively engaged in critical thinking and authentic choosing, he cannot accept any "ready-made standardized scheme" at face-value……How does a teacher justify the educational policies he is assigned to carry out within his school? If the teacher does not pose such questions to himself, he cannot expect his students to pose the kinds of questions about experience which will involve them in self-aware inquiry" (Greene cited in Stolp, 2005, pp. xi-xii).

It therefore becomes clear that this textbook (which is a didactic material) should be seen as a mediator between the aims of mathematical instruction and its outcomes: mathematically literate learners. Hence, the book should illustrate (for all intents and purposes) the connection between mathematics and being literate, focusing on the value of mathematics and mathematical activities in the development of learners' mathematical literacy. However, the use of the term 'Mathematical Literacy' as the title for the textbook (in my view) is inappropriate because the emphasis in the activities (just like in the Learning Outcomes of the NCS curriculum for ML) is on both the *content* and the *context* (the two key aspects of the element of *competence*) whose deliberate aim is to produce a mathematically educated and well-informed individual. In other words, the activities in this textbook do not make it much different from the formal mathematics textbook (since their respective modules are the same), except for the many examples drawn from simple everyday situations as is implied in the chapter titles. For this reason, one may argue that it was really not necessary to introduce 'mathematical literacy' as a subject separate from the mathematics discipline in the first place.

4.3 Participants' perceptions of the competencies of a mathematically literate person.

In this section data relating to Research Question Two: What are mathematics educators' perceptions of the characteristics/competencies of a mathematically literate person? is presented and discussed. Participating teachers were asked to list as many mathematics knowledge and skills as they thought were necessary for a person to be considered mathematically literate, as well as to give a brief description of their idea of a mathematically literate person. In this section, therefore, I present and discuss their responses and the findings thereof. The most seemingly prominent theme in participants' perceptions of a mathematically literate person was the notion of an understanding and possession of basic mathematical knowledge and skills such as being able to work with numbers and data handling. Most of the respondents indicated that they considered someone to be mathematically literate if that person has the knowledge of the four basic number operations and can do the mental and/or calculator-aided calculations accurately. For instance, when asked to list some of the necessary mathematical skills, one respondent mentioned that: *You need to have the knowledge of basic maths and skills such as mathematical operations, addition, subtraction, division and multiplication…….You also need to be able to calculate the sums involving interest rates in context.*

Similarly, many of the respondents also noted that there are other mathematical knowledge and skills necessary in order for a person to be considered mathematically literate. For example, one teacher described competencies of a mathematically literate person as follows: *The skill of collecting raw data and be able to (i) synthesize it (ii) be able to use it or apply it in its context. The skill of knowing how to work with numbers/numerals and its operations (addition, subtraction, division and multiplication). The ability to use mental calculations in the absence of machines/electronic calculators. Being able to use scientific calculators where applicable and use it appropriately/effectively. The skill of being problem solvers in day to day world of stats or numerical stats…..*

Thus it appears that most of the respondents (57%) consider mathematically literate people to be able to do basic arithmetical calculations. In other words they seem to suggest that mathematical literacy is the ability to solve simple everyday problems involving number as well as dealing with data. This suggestion seems too narrow since it does not encompass knowledge of other areas of mathematics such as algebra, shape, space and functional relationships which are in fact part of the NCS Mathematical Literacy curriculum. However, another theme which emerged from the interviews was the respondents' belief that one has to have basic knowledge of mathematics (as opposed to arithmetic) in order to be mathematically literate. One interviewee, for example, argued that: *[….] You have to have knowledge of mathematics in order to be mathematically literate. You have to have knowledge of numbers….eeh….in terms of being mathematically literate, perhaps relate those numbers to physical quantities…..*

Many of the participants, when asked about their idea of a mathematically literate person, suggested that it is enough for such a person to be able to reproduce mathematical facts and techniques. Table 3 (which is a summary count of major themes) shows that 40 respondents (57%) felt that facility with number and the four basic number operations is sufficient for someone to be considered mathematically competent, while 36 (51%) felt that the ability to apply mathematics to real life problems is the necessary skill needed to be displayed by a mathematically literate person. Furthermore, 19 (27%) respondents felt that the ability of an individual to do arithmetical calculations mentally as well as with the aid of a calculator in daily life is the necessary skill for mathematically literate people. It is clear from this that a considerable number of respondents (57%) felt that fluency with number and the four basic number operations is a necessary skill for someone to be considered mathematically literate, compared to those (51%) who expressed the view that it was the application of mathematics to real world problems that makes one to be considered mathematically literate.

Table 4.1. Major themes in participants' perceptions of a mathematically literate person.

Competency	Frequency	%	Illustrative Quote
Basic arithmetic or facility with number and the four basic operations.	40	57.1	*Basic knowledge of addition, subtraction, multiplication and division.*
Being able to apply maths to real life problems such as those involving personal finances and business issues.	36	51.4	*A person who is able to cope with real life situation and use maths skills.*
Mental and calculator-aided calculation skills.	19	27.1	*A mathematically literate person must be able to do basic calculations needed in our daily lives.*
Possession of critical and problem solving skills.	14	20	*You need to be able to solve real life problems that deal with numbers in order to be considered math literate.*
Being able to collect and present data, analyze and interpret them.	13	18.6	*Being able to handle data.*
Knowing the language of maths, and being able to translate real problems into mathematical language.	11	15.7	*Interpret maths language*
Ability to deal with mathematical information encountered in real life situations.	7	10	*Able to interpret the truth in the newspaper articles when figures are given.*

Furthermore, 14 (20%) respondents indicated that one of the characteristics of a mathematically literate person is the ability to critically evaluate mathematics and the role it plays in people's lives. This, it seems, is consistent with one of Jablonka's (2003) categories about mathematical literacy. 11 (15%) respondents mentioned *knowing the language of maths* and *being able to translate real problems into* *mathematical language* as some of the characteristics of a mathematically literate person. Seven (10%) respondents stated some of the characteristics of a mathematically literate person as *the ability to deal with and interpret mathematical information encountered in real life situations* as well as *being able to understand and analyze data in everyday life*. Of the 11(15%), only three (about 4%) respondents mentioned the idea of "being able to understand the language of mathematics and being able to use it as a communication tool" as one of the characteristics of a mathematically literate person. Finally, it became clear that some (15 of the 70) respondents, in their attempt to answer the question about a description of their idea of a mathematically literate person, just repeated some the things they had earlier listed as competencies and, therefore wrote the same responses as the ones they had given in the first question item. However, there were five (about 7%) respondents who gave a more elaborate description. For example, one respondent from the ML group responded by saying: *A mathematically literate person is someone who is able to apply maths in real life situations to solve problems.*

4.4 Participants' beliefs and views about mathematical literacy as a subject.

This section deals with data that informs Research Question Three: What are mathematics educators' beliefs, conceptions and views about mathematical literacy as a curriculum subject?

In this section participants' awareness of and strong feelings toward mathematical literacy are discussed, and comparisons between the various cohorts are made to highlight any differences in teachers' beliefs about the notion 'mathematical literacy' as a school subject. The first step in the analysis of the quantitative data type (that is, data from the 12 Likert Scale items) from participants' responses to item 9 of the questionnaire was to compute the mean agreement with each of the 12 beliefs (see Figure 1) for all the 70 respondents as a group. Secondly, the data was disaggregated by cohort and a one-way ANOVA test administered to check for differences in mean agreement between cohorts. The computation of the means for the 12 beliefs was performed statistically (see Figure 1 and Figure 2); and the results seemed to show some interesting differences in beliefs amongst the various cohorts.

After the computation of the means for each item on all the participants as a group, it has been revealed that, on average, there was on one hand, an overall agreement by all the respondents on beliefs 1, 2, 3, 4, 5 and 7, and an overall disagreement by all the respondents on beliefs 6, 8, 9, 10, 11 and 12 on the other hand (see Figure 1). In other words, on average, the respondents, on one hand, agreed that:

- ML will help to improve the levels of literacy in the country (belief 1);
- ML is more about habits and ways of behaving than about mathematics content (belief 2);
- ML is an opportunity to develop new skills in our modern society (belief 3);
- ML is necessary because it will enable learners to solve real life problems (belief 4);
- Learners who study mathematics to Grade 12 will automatically become mathematically literate (belief 5); and
- A strong mathematical background is necessary for effective teaching of ML (belief 7).

On the other hand, the respondents on average disagreed that:

- ML is for those who are academically too weak to continue with mathematics beyond Grade 9 (belief 6);
- ML is introduced because mathematics educators are failing to make students pass mathematics (belief 8);
- The introduction of ML will deny many disadvantaged learners the opportunity to proceed to tertiary education (belief 9);
- ML is a watered-down academic mathematics (belief 10);
- ML should not be taught by the mathematics teachers as they have more important work to do (belief 11); and
- ML is not necessary since learners who have reached Grade 10 have sufficient basic mathematical skills for their everyday living (belief 12).

When data were disaggregated by cohort and the one-way ANOVA test administered (together with a *post hoc* Scheffe test) as was discussed in Chapter Three, the ANOVA test showed significant differences between cohorts in beliefs 2, 5, 6, and 9; while the Scheffe test showed (on the same beliefs) which pair was significantly different (see Appendix N). And these differences (together with other beliefs), are discussed below, starting with the ones which showed statistically significantly large differences between cohorts:

Belief 2: *Mathematical Literacy is more about habits and ways of behaving than about Mathematics content.*

Overall, the mean agreement with this statement was 0.4 indicating a slight agreement. The frequency table shows that 24% of the respondents were neutral, and only 13% chose to agree or disagree strongly. This could point to uncertainty about the issue, or uncertainty regarding the meaning of the statement. Disaggregating the data however shows some interesting differences between the various cohorts. One way ANOVA testing indicated that cohort was a significant grouping variable. Although the Scheffe test did not show a significant difference between any two cohorts, observation of the means indicates that the mean for the B.Ed(hons) students was 0 (a neutral response) while the other two cohorts had means closer to the positive score of 1. This statement is in line with the philosophy of mathematical literacy which could have been more familiar to the maths teachers than the science teachers who formed part of the B.Ed (Hons) cohort.

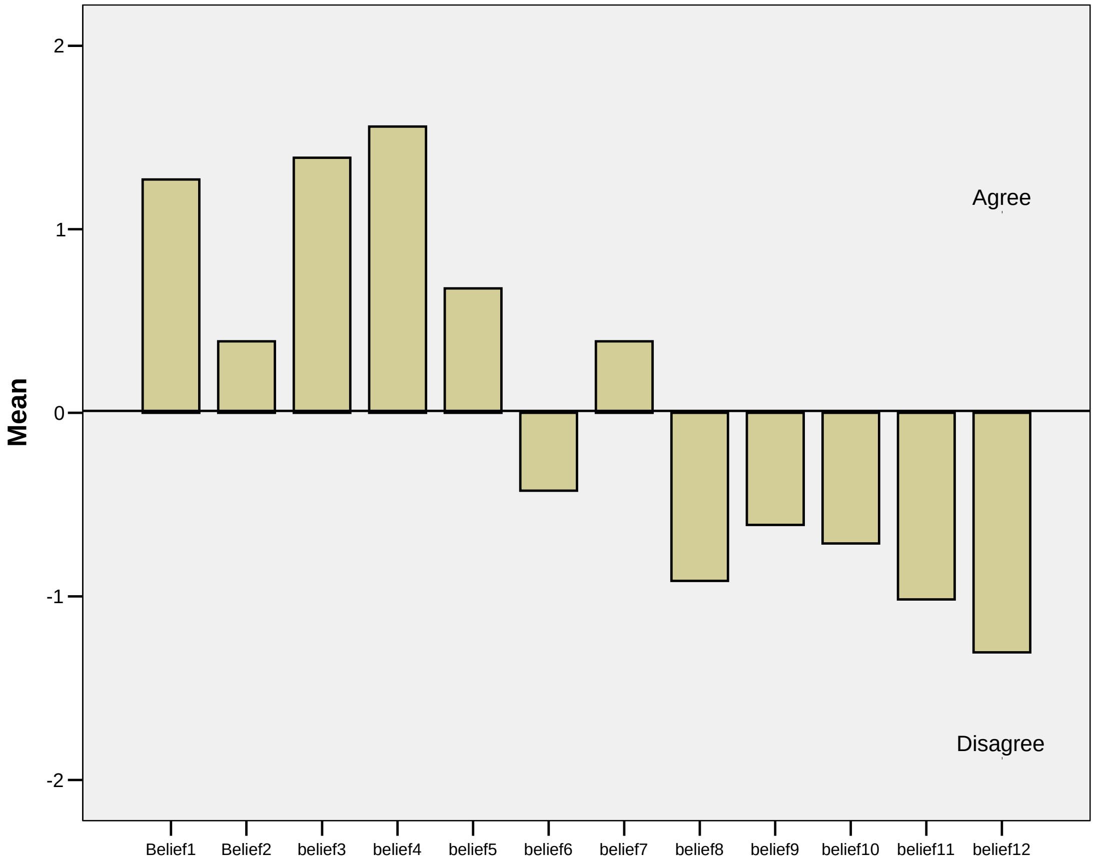

Figure 4.1: Mean agreement with each belief for all the participants as a group.

Belief 5: Learners who study Mathematics to Grade 12 will automatically become mathematically literate.

While there was moderate overall agreement with this statement, the maths literacy cohort disagreed. In other words, while the teachers retraining to teach ML on average do not agree that mathematical literacy is an automatic result of studying mathematics to a Grade 12, the cohorts not directly involved in ML on average do agree. Viewing the means of the three groups reveals that the mean of the ML cohort (M= -0.44) is much less than those of the other two (M=1.08; M= 0.70). It's clear that these two means are statistically significantly different from the other one; thereby confirming that there was moderate overall agreement with this statement by the two groups with means closer to 1. Furthermore, a post hoc analysis reveals that the ACE (GET) Maths group's mean is significantly larger than that of the others. This variation could probably be due either to the perception that mathematics is not different from mathematical literacy or lack of general understanding of the important distinction between ‘mathematical literacy’ as a competency or habit of mind, and as a school subject.

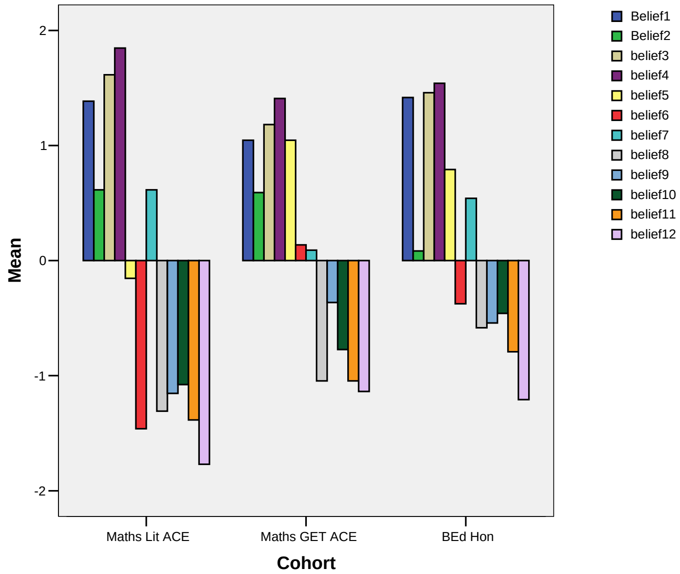

Figure 4.2 Mean agreement with each belief by the various cohorts.

Belief 6: *Mathematical Literacy is for those who are academically too weak to continue with Mathematics beyond Grade 9.*

Although the ACE (FET) Mathematical Literacy and the B.Ed(Hons) cohorts, on average, disagreed with this statement (M = -1.44; M = -0.33), there were teachers especially from the ACE (GET) Mathematics cohort who agreed slightly (M = 0.13). The ANOVA test showed that, overall, there was no significant difference amongst the cohorts. The Scheffe test, however, showed the difference between ACE (GET) Maths cohort and both the others to be significant. This in one way or the other implies that while the other two cohorts (Math Lit. and B.Ed) generally disagreed, because they both had means less than zero (M = -1.44 and M = -0.33), that mathematical literacy is for those who are academically too weak to continue with mathematics beyond Grade 9, teachers in the ACE (GET) Maths cohort on average agreed slightly. This statement reflects the perception which is held in some quarters within the mathematics education community (particularly those who have not been retrained in the teaching of ML) in South Africa that mathematical literacy is an easier and watered-down mathematics. Furthermore, this highlights a strongly held view that formal mathematics is too abstract and difficult to many learners to cope with (see Madison, 2004; Wallace, 2000).

Belief 9: The introduction of Mathematical Literacy will deny many disadvantaged learners the opportunity to proceed to tertiary education.

The mean agreement with this statement was -0.66 indicating that there was, on average, an overall disagreement by the participants from all the three cohorts. As evident from the frequency table for this belief, 43 respondents (63%) disagreed, with only nine respondents (13%) choosing to agree; whereas 16 (24%) respondents remained neutral. The one-way ANOVA test indicated significant differences between the various cohorts, and the Scheffe test indicated that there was a significant difference between ACE (GET) Maths and B.Ed(hons) students (M = 0.55), but very little difference between ACE (FET) Maths Literacy and ACE (GET) Maths students (M = 0.027). This could be suggesting that there were mixed feelings amongst the groups regarding the truth or substantive-ness of the statement.

Belief 1: Mathematical Literacy will help to improve the levels of literacy in the country.

The mean agreement with this statement was 1.26 indicating that, on average, there was an overall agreement by all the respondents as a group. This is also confirmed by the frequency table which shows that about 89% of the participants generally agreed that Mathematical Literacy will help to improve the levels of literacy in the country, with only 4% of the respondents choosing to disagree, with only 6% of the respondents remaining neutral (see Appendix H). Furthermore, disaggregating the data revealed that there was an overall agreement with this statement by all cohorts with means above positive one (see Figure 2).

Belief 3: I see Mathematical Literacy as an opportunity to develop new skills in our modern society.

There was an overall agreement with this statement by all the respondents as is clearly evident from the frequency table (see Appendix H). A large majority of respondents (91%) chose to agree that they saw Mathematical Literacy as an opportunity to develop new skills in our modern society. Observation of the means from both Figure 1 and Figure 2 does not indicate any significant differences between cohorts. And therefore, on average, all the cohorts showed agreement with this statement.

Belief 4: Mathematical Literacy is necessary because it will enable learners to solve real life problems.

There is, clearly, on average, an overall strong agreement with this statement by all the respondents as is indicated by a mean closer to 2 (see Figure 1); and also by comparatively insignificant differences in the means of the three cohorts (see Figure 2).

Belief 7: A strong mathematical background is necessary for effective teaching of Mathematical Literacy.

Observation of the means of all the beliefs as shown in Figure 1 indicates that, on average, there was on average a slight agreement with this statement. Furthermore, the frequency table shows that 53% of the respondents agreed with this statement, and only 26% disagreed, while 13% chose to remain neutral. However, disaggregating the data revealed that the ACE (GET) Mathematics cohort's mean is significantly smaller than those of the others, indicating less agreement with this statement.

Belief 8: Mathematical Literacy is introduced because Mathematics educators are failing to make students pass mathematics.

The frequency table shows that about 75% of the respondents disagreed with the statement, while about 16% chose to agree, and only 9% were neutral. Overall, the mean agreement with this statement is -0.9, indicating that, on average, there was indeed an overall disagreement with this statement by all the cohorts.

Belief 10: Mathematical Literacy is a watered-down academic Mathematics.

Figure 1 shows that, on average, there was an overall disagreement with this statement. This suggests that all the respondents disagreed that Mathematical Literacy was a 'watered-down' academic Mathematics. However, while there was overall disagreement with this statement, the ACE (FET) Mathematical Literacy and the ACE (GET) Mathematics cohorts seemed to have slightly disagreed (see Figure 2).

Belief 11: Mathematical Literacy should not be taught by the mathematics teachers as they have more important work to do.

The mean agreement with this statement was -0.99, indicating that there was, on average, a disagreement by the respondents from all the cohorts. The frequency table shows that at least 83% of the respondents disagreed with this statement, and only 10% were neutral. Furthermore, observation of the means does not indicate any statistically significant differences between the various cohorts, thereby suggesting that either all the three cohorts believe that mathematics teachers should also teach Mathematical Literacy, or that they do not consider the work more important.

Belief 12: Mathematical Literacy is necessary since learners who have reached Grade 10 have sufficient basic mathematical skills for their everyday living.

Observation of the histograms from both Figure 1 and Figure 2 shows on average there was disagreement with this statement. Also, the frequency table shows that at least 90% of the respondents disagreed with this statement, thereby confirming that there was overall disagreement by the large majority of respondents. These results seem to strongly suggest that; overall, the respondents believe that Mathematical Literacy is a necessary subject.

4.5 Participants' personal understandings of the distinction between mathematical literacy as a competence and as a subject to study.

In this section data also relating to Research Question Three: What are mathematics educators' beliefs, conceptions and views about mathematical literacy as a curriculum subject? is presented and discussed.

In this section, the teachers' perceptions of the notion of mathematical literacy as a competence and as a subject, and the distinction thereof are discussed. In one of the open-ended questions the respondents were asked to explain what they understood by the two statements, '*We teach for mathematical literacy*' and '*We teach Mathematical Literacy.*' The purpose for the inclusion of this kind of question was to try to find out what the term "mathematical literacy" meant to them in the context in which it had been used. Thus it was expected that their perceptions of the notion 'mathematical literacy' as a competency and as a school subject, and the distinction thereof, as well as their general understanding of it as a theoretical concept that has currently been debated within the mathematics education community, would be made.

It has, however, become evident that participants held different notions and/or understandings regarding the distinction between mathematical literacy as a competency and habit of mind, and as a school subject (although majority of them perceive it as a subject of study). There were some who could not see the difference in the two statements as mentioned above, and others were able to clearly see the difference as was intended in asking such a question. For those who could not see the difference between the statements, it became evident that there was some confusion which led them to conclude that the term 'mathematical literacy' can only mean or refer to a school subject; whereas those who held the contrary view indicated that the notion 'mathematical literacy' as used in the aforementioned statements refers to both a school subject, and a competence and habit of mind. This distinction is expressed (in various ways) and reflected in most of the responses from the participants. For example, one respondent explained the statements (a) and (b) in item 11 as follows, respectively: *This means we teach so that people become mathematically literate* and *This means that Maths Lit just as any subject is taught regardless of whether people become mathematically literate or not.*

Clearly the difference that can be drawn between the two responses is that, the first one suggests that mathematical literacy is a competence or a habit of mind, while the second response states that it is a subject of study.

Furthermore, other participants, in their responses to the interviews also expressed similar perceptions about the notion 'mathematical literacy'. Two teachers (in the interview) have highlighted their understandings of the notion 'mathematical literacy' as indicated below.

The first one explained that: *To my mind mathematical literacy is a language of numbers. Eeh….and how numbers, numeracy relates to lives of students. Probably understanding numbers, making sense of numbers…….; being able to interpret the numbers in terms of the context that is given…[…].*

The second one further stated that: *Having studied the NCS document, having gone to the workshops, the basic understanding of mathematical literacy is to give the learner, to give the learner a fair understanding of mathematical concepts; working more with numbers rather than the algebra and the abstract, right. There is a little bit of algebra, but working more with numbers, and trying to create a link……with their everyday life and the things that have maths in their daily lives.…[…]. So, in other words you want to develop the person…..eeh…, to be successful…..with working with numbers and the operations related to numbers, basically. That….that is my understanding of mathematical literacy and what it is meant for.*

These comments are indicative of the participants' similarities of how they perceive the notion 'mathematical literacy' as a theoretical concept. And as I have earlier on mentioned, these are not the only participants with such views; there were many of them but because of space, I would not give all the responses as part of this report as I believe that the above comments suffice to give evidence to my assertions. However, the major theme that seems to come out clearly from both comments, and is seemingly emphasized, is the perception that mathematical literacy is both a skill (competence) and a subject of study, and that it is more to do with number sense or quantity. This is evident from some of the expressions that appear in the above comments, such as ‘understanding numbers, making sense of numbers’ and ‘to give the learner a fair understanding of mathematical concepts,’ as well as ‘working more with numbers rather than the algebra and the abstract.’

With regard to question item 14, there were only 10 (about 14%) teachers who attempted to respond to it, and six of these came from the ML cohort while the rest of them came from the B.Ed (Hons.) group. What emerged from these responses as a general theme is that teachers seemed to understand the expression “highly numerate consumers of mathematics” to mean that future citizens should have the ability to use numbers in everyday life. In other words, it appears as if what they wanted to say is that future citizens should be people who will be capable of using mathematics to solve their everyday problems that are mathematical in nature. This is illustrated in the following excerpts as stated by two respondents from the B.Ed (Hons.) group. The first respondent stated that: *Mathematical Literacy will focus on dealing with numbers and how to work with them and use them in real life.* The second respondent also expressed similar sentiments by saying: *I agree, the lives of the consumers in S.A. are largely dependent on Maths.- making groceries, paying bills, transport fares; all these sphere require numeracy mathematics.*

Similarly, two respondents from the ML cohort seemed to have had the same understandings. The first respondent explained that: *It means they must use mathematics to the fullest. Use numbers in solving their everyday problems.* The second one stated that: *Basically this means that people in any society should be at “home” with numbers. Presently there are individuals who avoid anything to do with numbers.*

Clearly these quotations, despite their seemingly lack of proper semantic, are expressing the idea of people’s functional use or applications of mathematics to day to day business of their lives. From these responses, one can conclude that there is evidence to suggest that the respondents had a somewhat hazy understanding of the purpose of the inclusion of ML as a subject in the FET curriculum.

4.6 Participants' understandings of the relationship or differences between 'mathematics' and 'mathematical literacy'.

This section presents and discusses data that informs both Research Questions Three and Four: What are mathematics educators' beliefs, conceptions and views about mathematical literacy as a curriculum subject? How do these perceptions and/or understandings play out in the new Mathematical Literacy curriculum implementation?

In this section, participants' responses to question items 10 and 16 which asked for the differences between mathematics and mathematical literacy, are presented and discussed. The respondents described some of the differences between the two subjects as follows:

1. Mathematical Literacy is informal/concrete and more contextualized, whereas Mathematics is too formal/abstract;
2. Mathematical Literacy involves solving real life problems, whereas Mathematics is highly abstract and involves theorems and formulae;
3. Mathematics is difficult and challenging, whereas Mathematical Literacy is about basic knowledge of mathematics and its application to real life problems and their solutions;
4. Mathematical Literacy is less advanced than Mathematics, and is for weaker learners;
5. Mathematical Literacy is easier than Mathematics, and is needed by everyone to be able to solve daily life problems because it's more relevant to people's lives than Mathematics.

These differences seem to fall into three major themes: content/context-based nature of the subjects, level of difficulty of the subjects, and mathematical literacy being an automatic consequence of knowing mathematics. The following discussion focuses on these themes that emanated from teachers' understandings of the differences and/or the relationship between the two subjects.

The first theme (as was implied in response 1) seems to suggest that Mathematical Literacy is more important because it relates to learners' experiences. As one respondent pointed out: *Mathematics is content based with little relevance and application to daily life. Mathematical Literacy is context based therefore it would be within the experience of the ordinary person. The context will enable them to make financially sound decisions, assist in managing their daily lives, e.g. working through area in terms of houses which are within the experience of the learner.*

So, this quotation shows that this respondent views mathematical literacy as a more relevant kind of mathematics, and believes that it is rather contextualized and real than what pure mathematics is traditionally believed to be. The comment also seems to make the suggestion that mathematical literacy is a subject of study rather than a competency.

The second theme which emerged from the interviews was the respondents' view that one has to have good knowledge of mathematics (supposedly pure mathematics) in order to be mathematically literate. One interviewee, for example, pointed out that: *[….] You have to have knowledge of mathematics in order to be mathematically literate. You have to have knowledge of numbers….eeh….in terms of being mathematically literate, perhaps relate those numbers to physical quantities…..*

This comment does make it clear that mathematical literacy could be achieved or developed from successful teaching/learning of pure or traditional mathematics. Also, it does come out clearly from the responses (at least at this stage) that mathematical literacy should be regarded as a competence. Thus it is implied that the perception here is that of the notion 'mathematical literacy' being a competence derived from mathematical knowledge. This could be due to the way the question had been asked as well as the multifarious ways that the concept of mathematical literacy has been understood within mathematics education community.

The third theme that emerged from both the questionnaire responses and the interviews was participants' view that there is a difference between mathematics and mathematical literacy, yet the two are related. Some participants, on one hand, felt that mathematics is too difficult for most of their learners to cope with due to its abstract nature, and therefore not really needed by many of those learners. On the other hand, others felt that there was very little difference between the two subjects in that some topics which seemed difficult for learners had been left out from the NCS Mathematical Literacy curriculum; thereby making the subject (ML) much easier than pure mathematics. Otherwise it still is mathematics. Furthermore, they point out that one of the differences between the two subjects is that ML is context-based, whereas Mathematics is content-based. As one interviewee puts it when quizzed about her experience with studying and teaching ML: *I guess for me it has not been too difficult because I have been teaching mathematics so I know the mathematical concepts. Eeh…, so studying this course hasn't been difficult because the new thing that we are only using is the context; the mathematics is still the same.*

Similarly, another interviewee argued: *I also find the mathematics content manageable. But what is really interesting is the real life context in terms of the mathematics because supposedly what was abstract before has now real life relevance…., and that is what makes it more interesting and perhaps it could be a bit more accessible to students, I think, in future…[…..].*

It seems, from these statements, that there is a general sense that what makes ML different from Mathematics is the approach on how it is taught rather than what is taught in terms of content. However, no clear-cut distinction between mathematical literacy as a competence and as a school subject is made, save for the suggestion that it is also mathematics; except that the mathematics is now contextualized and has relevance to learners' experiences.

Clearly the responses from both the open-ended questions and the interviews demonstrate that teachers have different views about their understanding of 'mathematical literacy' and how it relates not only to learners' experiences but also to formal mathematics. Some of the teachers, on one hand, believe that mathematical literacy is a simplified/easier version of mathematics and that it will be good for the academically weaker learners if they are given the option to do it as a school subject. Thus, in my view, these teachers suggest that they view ML as a school subject. However, on the other hand, other teachers argued that ML (as both a competence and a subject) is important to learners as it provides them with opportunities to relate mathematics to real life situations since it is context-based. Also, they argue that the teaching/development of mathematical literacy will provide welcome opportunities to break away from the undue emphasis in teaching mathematics the traditional way of memorization of facts and algorithmic problem solving without helping learners to apply their understandings of mathematical concepts to real life situations. Finally, the view that mathematical literacy should be integrated within other subjects and also developed through contextualized teaching/learning practices, suggest to me, that it can be both a competency and a subject of study, as has seemingly been highlighted or suggested in the extant literature (e.g. Madison, 2004; Steen, 1999; Wallace, 2000).

Participants' perceptions of the notion 'mathematical literacy' have been echoed in their responses to both the questionnaire and interview questions. The major themes evident in participants' responses to these questions reflecting their various understandings or conceptions of and views about 'mathematical literacy' can briefly be categorized into the following three major areas:

(1) 'Functional' view, which regards 'mathematical literacy' as a more contextualized and applied type of mathematics, which is even more relevant to people's lives. And as one teacher put it: *Yes Mathematical Literacy is within context. The learner carries out the task with understanding and will therefore be able to apply it in their daily life. They will be competent with the skills that they have learnt and will prepare learners for the challenges that they experience in the outside world.*

(2) 'Status' view, which regards 'mathematical literacy' as a 'simplified/easier' version of mathematics which is very basic, and is meant for academically weak learners to do it at school. However, other teachers during the interviews argued that 'mathematical literacy' is not a watered-down kind of mathematics. One interviewee says that: *I don't agree with that. I really don't agree with that. I suppose,….eeh…, coming from the previous system, with…, learners have to choose courses at Grade 10 level. There were certain courses with the, for example, the science courses, you have to have the mathematics; so students who are interested in the sciences have to do mathematics. And there were certain non-mathematics courses. So this connotation of being watered-down is perhaps,….eeh…., because the old*

system….(inaudible)…within, we had students who were not doing mathematics and they were, supposedly, academically weaker. So we have this idea that we can push the 'mathematical literacy' to them so that they can have the strong foundation, but the mathematical literacy that we are seeing in terms of syllabus and curriculum, the mathematics literacy curriculum, is not watered-down at all.

(3) 'Inter-disciplinarity' view, which regards mathematical literacy as both a competence and a subject to study, which should be developed through integration within other disciplines or subjects and through contextualized teaching/learning practices. This view is held by majority (38 out of 70) of the respondents whose responses to the question (from the questionnaire), 'In which way, *as an integrated subject* or *as a separate subject,* would you like mathematical literacy to be developed,' indicated that it would be best if mathematical literacy is developed through teaching/learning of mathematics by integrating it with other subjects.

4.7 Participants' perceptions of the necessity, usefulness and purpose of ML as a competence and/or as a subject in the FET curriculum.

This section also presents and discusses data relating to Research Questions Three and Four: What are mathematics educators' beliefs, conceptions and views about mathematical literacy as a curriculum subject? and How do these perceptions play out in the new Mathematical Literacy curriculum implementation?

The necessity, usefulness, and purpose of mathematical literacy as a subject of study have been echoed by almost all the respondents in their responses to open-ended and interview questions. Indeed, in one form or another, almost all participants pointed out that it was necessary and useful to include mathematical literacy into the FET curriculum as a separate subject to study because, as one respondent put it: *It is very useful because it will help people with life's challenges when they leave school. It will give them skills to lead their lives financially and make informed choices.*

In the same vein, another respondent suggests that: *It is useful, and I would suggest that everybody must learn Mathematical Literacy because everyone needs to be open-minded in terms of finances and country's economy*.

Clearly, participants' belief in the need to include mathematical literacy in the FET curriculum seems to be anchored in an associated set of perceived benefits for learners. It thus follows that participants' belief in the need to introduce mathematical literacy as a subject separate from mathematics also suggests that learners will in the process be empowered to critically face the moral issues and/or social and political challenges that are mathematical. But whether or not this will meet the intended purposes is another issue, given not only the different social backgrounds and cultural settings from which learners come, but also the lack of confidence and pedagogical content knowledge on the part of the teachers to handle the new curriculum.

Furthermore, when asked (in question item 15) if they thought ML would meet all its stated purposes, respondents expressed their opinions in various ways some of which were positive, while others were negative. For example, one respondent from the ML group had this to say: *It will ultimately but not at this initial stage. Once educators are well trained and learners change their attitude towards the subject, it will meet its stated purpose. This could take 5 years from now.* Another one respondent clearly indicated that ML as a subject would not meet all its stated purposes by saying: *No – manipulation of formulae is sometimes beyond the capabilities of the learners. Those learners who are doing ML are not learners who are competent in mathematics.*

It seems quite clear from the first comment that the respondent felt that for as long as educators were not adequately trained to teach the subject, it would require substantial amount of time and effort to ensure that the new subject achieves its stated purposes. Furthermore, the respondent makes a very interesting point that learners needed to 'change their attitude towards the subject.' I suspect, by 'attitude' he meant or was referring to negative attitude. In which case, this seems to suggest that many of the learners whom he was teaching, might not have been interested in the new subject. And if this is true, then it certainly indicates some of the challenges that the educators would face in the initial stages of the implementation process. On the contrary, the second response clearly shows that the respondent did not think that ML will achieve the stated purpose because she felt that learners who opted for this new subject were not competent in mathematics, and therefore they probably would not be able to cope with it. I guess what this implies is that knowledge of mathematics is a prerequisite for one to be able to cope with the study of Mathematical Literacy as a subject.

In somewhat a similar vein, but on a positive note, two respondents from the B.Ed(Hons) group expressed a seemingly strong feeling that Mathematical Literacy would certainly achieve its stated purposes when they said: *Definitely, if the Dept. of Education continues to train and retrain educators.*
Yes, learners are enjoying it, they are putting sense to it. I feel it will meet the stated purpose.

All these responses are, indeed, indicative of some of the mixed feelings about the new subject; and similar opinions and/or misgivings have also been expressed elsewhere about Mathematical Literacy from a similar study conducted by Graven and Venkatakrishnan (2006).

4.8 Participants' perceptions of and experiences with developing/teaching ML as a subject.

In this section, data relating to Research Question Four is presented and discussed: How do these perceptions and/or understandings play out in the new Mathematical Literacy curriculum implementation?

There seemed to be some differing ideas (real or perceived) amongst participants in this study regarding the teaching of mathematical literacy as a subject (see Table. 4). This apparently stems from the fact that many of the respondents who participated in this study had very little or no teaching experience at all with regard to teaching of mathematics (see Appendix K). In particular, many of the participants did not seem to perceive themselves as having either the content knowledge or pedagogical expertise needed to teach mathematical literacy effectively. They pointed out that they had had insufficient background in mathematics (and also have not had enough training in the teaching of the new curriculum), and therefore their understandings of the NCS mathematical literacy as a subject were modest. For example, when quizzed about the challenges faced in teaching mathematical literacy and whether or not they were getting any support to teach the subject, one interviewee pointed out that: *The first one will be that….eeh the department delayed to train the teachers, or to workshop the teachers on maths literacy. So it's ….according to my view, it was, it was long overdue, it was supposed to be done maybe a year before it was implemented. The teachers would have been developed a year or two years before,…..before it was implemented. So we are learning in the same time we are teaching the kids…...[…..].*

Another one said that: *[…..], I will say I don't have support from the department. Individually me, I don't have support because I haven't seen a specialist in mathematical literacy. I haven't seen….no one has visited my school to see what am I doing, to see if I am on the right track, what is the workload?* Also, the other respondent indicated that teaching the new subject was quite interesting despite that it was also a challenge: *It's ok……it's interesting……it's an interesting thing……..and also challenging because each time you have to introduce a concept, you must think of the real life situation….yes, related to that……*

Furthermore, other participants complained about lack of adequate and relevant support materials and they also have highlighted the dilemmas they faced and expressed low confidence in their abilities to develop materials pertaining to teaching about mathematical literacy. This was evident from some of the responses to the open-ended and interview questions, when one interviewee stated that: *And sometimes different books have different information. So we don't know exactly what to do or otherwise……The structure….., the structure of the worksheet…..of the work plan, sorry. Like from here you go to there, from here you go to there, this is what is going to come up in the first paper; this is what is going to come up in the second paper…..we don't have something of that sort. As……she is saying, we go to workshops, we discover that no, we taught something wrong, I was supposed to have done……Or maybe you have already done something that you are supposed to do after…second term…..two months or what……*

This was further corroborated by another respondent in stating that: *Well it is difficult, it's tough-going, in terms of having to find resources; but because it's a new thing….eeh,….your…..learner-teacher support materials are not really developed, and the schools are not,….eeh,…going and buying a variety of books and so on….[…]. Resources is a problem but…eeh,….as I said, you have to adapt and move on, you can't go on complaining…..[…..]*

Also, it was quite evident from the responses to some of the interview questions that teachers experienced lots of problems in teaching mathematical literacy. For example, some interviewees noted that: *[….]…it's not easy to find relevant context, eeh.., and to find the various assessment standards to go with it; it requires lots of planning, and on the part of the educator, lots of understanding of the content that we need to work with to apply to the context that the learner….(unclear)….; so it's difficult….[…].*

Clearly, these comments illustrate the kinds of challenges and experiences that teachers seem to face in the implementation of this new curriculum for mathematical literacy. They serve to show the kinds of differing perceptions and/or misconceptions about some of the factors mediating the enactment in actual instructional practices of teachers' views about curricular priorities in terms of their content knowledge and their pedagogical expertise as implementers of the new NCS for Mathematical Literacy.

On one hand, however, some teachers (about 25%) [that is, those who perceive ML as a subject] felt that mathematical literacy should be developed or taught as a separate subject but could not clearly state the reasons for their position; while on the hand, other teachers (47%) felt that it should be integrated with other subjects. The rest did not respond to both parts of the item 13. Many of those who made attempts to respond to that questionnaire item did not further give any reasons for their position, and where few of them did, they could not clearly explain why. Overall, it seems the majority of the participating teachers (about 47%) felt that the development of mathematical literacy could be achieved through an integrated approach whereby the teaching of mathematical concepts is spread across other related disciplines or into other subjects.

Table 4.2 Participants' perceptions of and their experiences of teaching Mathematical Literacy as a subject (open-ended items).

Responses	Frequency	%
There is need to integrate the teaching of Mathematical Literacy into other subjects.	33	47.1
Mathematical Literacy should be developed and taught as a separate subject for learners who dislike and find Mathematics difficult.	18	25.7
There are vast differences in the ways in which the available textbooks approach the teaching of Mathematical literacy.	5	7.1
The way Mathematical Literacy is taught is not different from how Mathematics is taught. The teaching/learning aids and teaching/learning strategies used for each are the same.	3	4.3
The way Mathematical Literacy is taught is hard and the teaching and learning resources for it are not easy to find.	4	5.7
The teaching and development of Mathematical Literacy requires well trained educators and well resourced schools.	7	10

However, there are also some teachers (about 26%) who felt that mathematical literacy should be taught and developed as a separate subject for the sake of those learners who dislike and/or find formal mathematics difficult for them. Furthermore, some teachers (about 6%) felt that teaching mathematical literacy proved too hard for them to cope with since (according to them) it was not easy to find relevant teaching and learning resources for it. It seems that few participants (about 4%), especially those who were interviewed, were viewing mathematical literacy, on one hand, through rather traditional epistemological lens well suited to addressing "regular" mathematical concepts; and on the other hand, through a rather traditional pedagogical lens not well suited to addressing the new mathematical literacy curriculum. First, some of the responses to the interview questions indicated that these interviewees perceived mathematical literacy curriculum to have been more or less framed just the same as Mathematics FET curriculum in terms of the concepts that ought to be covered as content within the FET curriculum. Secondly, they felt that the way mathematical literacy is or should be taught is/should not be different from how formal mathematics is taught since the teaching/learning aids needed and the teaching/learning strategies used in both areas are more or less the same (see Table 4.2).

Furthermore, there was also (especially from the interviews) the view that background knowledge of and good foundation in mathematics is a prerequisite for the acquisition of mathematical literacy. And as such it is not possible for someone to be able to do mathematical literacy as a subject without adequate mathematical knowledge, and consequently be able to understand the mathematical concepts that go with it. As one respondent commented on his experience of studying mathematical literacy for teaching: *When tutoring the mathematical literacy, I would suggest that tutors must bear in mind that not all students have done mathematics up to Grade 12. So, they must not use maths terminology. On the other hand, all important equations must be taught so that educators will be able to approach and solve any problem that may be encountered.*

Clearly, this is an indication of the frustration that some of the teachers who are teaching and also training for mathematical literacy may also be going through. In which case, therefore, it is quite evident that mathematical knowledge should be the basis for a proper successful teaching and learning of mathematics in schools.

Another respondent, in an interview, noted that it was important that learners (not only educators) taking the mathematical literacy option should also have good knowledge of mathematics: *[….] So, when you are teaching mathematical literacy you have to go backwards, you got to first go to the content..(**the mathematics content**.. my addition), teach them the content, understanding the content; then you will have to go to the context, to make it relevant to the child. So without mathematical knowledge, it's extremely difficult; it's not…..sometime we could say is not difficult than actual mathematics because children are expected to manipulate* *formulae; and a person who does not have maths knowledge will not be able to manipulate the formulae. So they must have mathematical knowledge, otherwise it could become extremely difficult to work with the mathematics.*

Hence, it is clear from these comments that content knowledge of pure or formal mathematics forms a basis for the development and/or teaching of mathematical literacy since this seems to be a relevant way of not only teaching mathematics, but also connecting it with real life contexts. This, as other interviewees agreed, is how the development of mathematical literacy in the teaching and learning of mathematics content curriculum should be framed if it is to achieve the desired outcomes. Second, while teachers' concern with context seems to have some merit, the concern reflects naïve views about contextual teaching/learning practices and the novel teaching strategies which need to be employed (Gellert, 2004). In a sense, some teachers seemed to believe that providing a "context" would automatically help learners understand the needed mathematical concepts, thereby equipping them with the necessary competencies or mathematical skills to face everyday problems. This position, in my view, disregards or ignores the multicultural diversities which exist in mathematics classrooms in the various schools within the country. As one interviewee (confirming my concern) argued: *[…..] And what has to be realized is that a context for me, is not……may be relevant to me, but not to the next child. So, in that classroom, your context is not applicable to all children, so that can become another major block because, they have no idea as to what you are talking about,…..[….].*

In addition to the problems already mentioned, and linked to the teaching/development of mathematical literacy using relevant contexts, some teachers who were interviewed cited language literacy as a major stumbling block to their efforts towards that end. When further pressed about the challenges they faced in teaching the new subject, one respondent explained that: *[…]…; So before we go and actually determine the context of mathematical literacy, is it at the level of my kids, is it not at the level of my kids? I am questioning as an educator. Is my student not able to answer my question because he has a language comprehension problem? Or is my student not able to answer my question because he has a mathematics language comprehension problem. That's a major stumbling block for me at the moment.*

Another respondent further indicated that language was a serious problem by saying that: *And eeh…, if you look at…eeh.., language…if they don't understand particular terms, then they won't be able to answer the question. If they don't understand the mathematics, it's doubly compounded. So…the language is hindering the progress. So we need to….eeh, and we cannot put in a context without a language…[..].*

In addition to these problems, responses to open-ended questionnaire items and interview questions revealed a set of situational factors that seemed to impact negatively on participants' efforts to effectively implement the new NCS for Mathematical Literacy. Some of these factors were not different from those relating to the introduction of new curricular materials or implementation of novel teaching strategies often voiced by teachers. These included (a) large class sizes; (b) lack of readily available and relevant/appropriate support materials; (c) teachers' higher workload, especially in light of the difficulties associated with having to teach other subjects alongside ML; (d) Learners' negative attitude towards ML; (e) lack of enough funds to buy the necessary resources due to some learners defaulting in payment of school fees; and (f) the difficulties associated with determining relevant contexts in which appropriate teaching strategies could be employed to make the mathematics content more realistic.

Still other teachers referred to the lack of readily available support materials for ML and to the teachers' higher workloads resulting from shortage of teachers, and the difficulties associated with that, by pointing out that: *There.., there isn't, there wasn't much available at the beginning of the year. So, you are working with one textbook kind of situation….[…]. But, eeh.., we need much more than that. And eeh.., the thing is, we are not teaching only mathematical literacy in school; we're teaching other subjects.*

Furthermore, another teacher expressed similar concerns and stated that: *[…]…, if I could just add, even with the, in terms of resources, even with the textbooks that we received for mathematical literacy, I thought there was no commonality in terms of levels. Too much of discrepancy; certain textbooks they are giving you information at a certain level; in another textbook, it is at another level….[….].*

This comment, I believe, clearly illustrates some of the problems that (as alluded to earlier) may be posed by didactic materials. The problem becomes even more compounded if, as in this study, teachers or users of such materials do not have the subject content knowledge and the necessary pedagogical content knowledge (Calderhead, 1987).

There were not too many responses from the participants regarding the issue of strategies they used for the teaching/learning of mathematical literacy since there were only 11 teachers who indicated that they were involved in this new subject in their respective schools. Of these, four respondents stated that they preferred using group discussion approach; only three respondents mentioned that they used whole-class approach, and three other respondents stated that they preferred using individual study strategy. Only one respondent mentioned the use of both whole-class and independent study strategies as her preferences. Although these teachers responded to the question that was asked, it seems some of them did not make any effort to provide other example of their own except to just select from the list of strategies that were given as examples in the question. However, many of them (8 out of 11 teachers) made somewhat fair attempts to provide explanations for their preferences. The following are vignettes of some of the various responses that were commonly offered, despite that some of them were not grammatically well written: The first respondent indicated a preference for 'group-work' strategy by stating that: *Learners work in pairs/groups as well to assist each other along due to large class sizes. Independent tasks are given to identify whether the learner has grasped the concept.* The second respondent also echoed similar sentiment by saying: *I started teaching with 'whole-class teaching' method. However, I recently found that teaching/learning has been extremely effective using the 'Group-Discussion' method where learners are allowed to air their views/ arguments while learning with/from their friends.* This was corroborated by the third and fourth respondents when they stated, respectively, that: *Group work helps learners create the link between information and the required calculations. Individual work also assists learners and helps learners to make meaning for themselves. Group work –Learners share their experiences and make the most of the learning situation.*

These comments clearly show that, generally there was, of course, some preference by some teachers towards the "group work" method, but whether or not what they reported was exactly what was taking place during their classroom discourses is another issue. However, there is an interesting difference in the first two comments. In the first comment the respondent seems to be suggesting that her inclination to pair/group work is a result of the dictates of the circumstances (large class sizes) that she finds herself in rather than a preference. Moreover, it appears that her choice of the other method only acts as a complementary strategy to assess learners' level of understanding in the process. On the other hand, in the second comment the respondent clearly shows her enjoyment of using 'group-work' as her preferred method. This apparently is ascribed to her discovery of the seemingly ineffectiveness of the method that she used before (i.e. the whole-class approach).

Furthermore, there are other respondents who stated that they preferred using 'Independent study' and 'Whole-class methods', respectively; and the following excerpts illustrate this: *Independent study: This is where learners learn to be on their own. Whole-class teaching/learning: – pupils don't want to work on their own, they prefer whole class.*

These two comments clearly show the kinds of diverse perceptual and traditional pedagogical tendencies that are seemingly prevalent amongst the respondents despite current reform efforts towards novel curricula and teaching practices by both the Department of Education and the teacher education programmes. This, however, is not meant to suggest that these two methods are by any means not relevant, but, given the nature of the new curriculum and the South African context, it is very unlikely that such methods of teaching/learning will be effective, especially in the initial stages of the curriculum implementation. Again, it is important to note that choice of teaching/learning strategies depends very much on the topic to be taught and the caliber of learners that the subject is to be presented to. In which case, therefore, a combination of strategies that are learner-focused, I believe will be more appropriate than a single approach in such socially and multi-culturally diverse classrooms such as in South African high schools.

4.9 Conclusion

In this chapter I have presented the findings of this study and discussed teachers' perceptions of the notion 'mathematical literacy' as a competence and as a subject of study according to following categories: analysis of policy documents on the concept of ML, teachers' perceived characteristics of a mathematically literate person, their beliefs and views about mathematical literacy as a subject of study, teachers' understandings of the relationship or differences between mathematics and mathematical literacy, teachers' perceived usefulness or necessity of ML as a competence and as a subject of study, and teachers' initial experiences of teaching ML. The findings have indicated that participating teachers' beliefs about ML between cohorts differed significantly. Furthermore, the findings have also indicated that participants generally perceived 'mathematical literacy' as a subject of study. However, there were some participants (though fewer) who strongly felt that the time was not yet ripe for the introduction of this new curriculum on mathematical literacy. Some of the reasons they advanced included (a) lack of knowledge about the new subject on the part of mathematics educators; (b) unavailability of well-trained mathematical literacy educators who can implement the new curriculum; and (c) lack of knowledge and understanding on the part of the Department of Education Officers about what mathematical literacy is all about. I have also, in the process of analyzing policy documents, found that ML and Mathematics curricula are essentially the same in terms of content. Lastly, I have pointed out that the findings of the study revealed three major themes about the concept of mathematical literacy: functional view, status view, and inter-disciplinarity view.

Overall, it seems most of the participants regard mathematical literacy as a subject of study that is an "easier version" of mathematics. There is also a general sense that mathematical literacy content is not different from that of formal mathematics content except for the emphasis on context in terms of the former. Furthermore, many of the participants have expressed their lack of confidence in teaching the subject, highlighting inadequate support materials and their lack of pedagogical content knowledge as some of the main factors that militated against successful implementation of the new curriculum. Finally, there was a feeling amongst some of the participants that teaching of mathematical literacy is difficult due to learners’ poor English language literacy skills.

CHAPTER FIVE SUMMARY AND CONCLUSIONS

In this chapter, a summary of the key findings from the results of the study (Chapter 4) is discussed, leading to a presentation of the link between the main issues in the literature (Chapter 2) and the findings, and then to a further discussion of the contradictions and gaps therein. Finally, a summary of the main responses or themes which address the main research question is given; thereby highlighting the challenges that lay ahead for the mathematics educator community, and also offering some recommendations for policy and practice, as well as for further research.

5.1 Summary of main findings

The study of the participating educators' perceptions of the notions of mathematical literacy (as a competency, and as a school subject) in KwaZulu-Natal area has offered a picture of teachers' beliefs and views of their experiences about the implementation of the new NCS for Mathematical Literacy in South Africa. It has also attempted to explore how educators construct their understandings of the two notions of 'mathematical literacy'. The analysis of teachers' perceptions emphasized the meaning or definition used to describe the term 'mathematical literacy', and also what teachers understood or viewed to be a distinction between mathematical literacy as a 'competence' and mathematical literacy as a 'subject of study'. The study was focused on teachers or educators who were enrolled in the Advanced Certificate in Education (ACE) course in Mathematical Literacy offered in the University of KwaZulu-Natal, at Edgewood campus, as well as those who were also studying for Bachelor of Education (B.Ed-Honours) in Mathematics and Science education courses. As a result, the study seem to have highlighted a number of issues that were central to the implementation of the new Mathematical Literacy curriculum, as well as pointing out the different perspectives held within mathematics education community about the concept of mathematical literacy. From the information gathered, there seems to be enough evidence to suggest that, indeed, participating teachers within and across cohorts generally had differing perceptions about the notion of mathematical literacy as a competence and as a subject of study, as well as different beliefs and views of their experiences about the concept of mathematical literacy, thereby leading them to have differing states of readiness (in terms of both their professional and technical competence) to implement the new curriculum.

Based on the discussions of the arguments advanced (in extant literature) against and in favor of increased attention to mathematical literacy, it is evident that there is indeed a controversy surrounding the notion 'mathematical literacy' and some of its definitions, as well as the related terms that have been used to describe it. Furthermore, an examination of the main issues raised by the participating teachers shows that (in general) there is no shared understanding (in the South African context) of the concept of mathematical literacy amongst the educators; hence the different beliefs and views within and between the cohorts. However, there are some common themes running through many of the arguments and issues that have been raised, and link both the international and local perspectives together, as well as some of the participating teachers' beliefs and views about mathematical literacy. One is the need for the integration of mathematics with other subjects in service to mathematical literacy. This is consistent with what Madison (2004) and Wallace (2000) have both argued for, and have further advocated for curricula and pedagogical changes that would see effective articulation between various disciplines in teaching the use of mathematics in numerous contexts (see also Adler et al, 2000). Similarly, some of the participating teachers have also expressed misgivings towards the introduction of mathematical literacy as a separate subject from mathematics. Instead, they felt that it should not have been introduced since it proved to be difficult (compared to the traditional mathematics) for many learners. Another important theme is the need for changes in curricular and teaching practices (in terms of the curriculum priorities and the pedagogical approaches) geared towards proper teaching and learning of mathematics if development of mathematical literacy in all learners is to succeed.

Furthermore, it has been revealed that, although teachers vary in their understandings of what constitutes mathematical literacy, a majority of them view it as a subject of study rather than a competency. This is, perhaps, attributable to the fact that it has been declared so by the curriculum designers, as well as, maybe, the way the curriculum itself has been designed or even framed. That aside, the study has generally revealed that:

- Participating teachers (especially the ML cohort) perceive mathematical literacy as a subject that is different from formal mathematics. They have highlighted, as the major element that is key to the difference between the two 'subjects', the *abstract* (as opposed to the *concrete* nature of ML) nature of formal/academic mathematics;
- Learners who choose ML option seem to have serious English language (both spoken and written) literacy problems which seemingly frustrate their efforts to cope with the subject;
- Teachers without good foundation or background in formal mathematics seem to be having serious difficulties with teaching mathematical literacy;
- Linking teaching/learning of academic mathematics with everyday life situations through use of relevant contexts seems to be a big challenge for many educators; and
- There is not enough support to help teachers with the implementation of the new curriculum;
- The workshops that were run by the department of education were not adequate to fully prepare teachers to implement the new curriculum for mathematical literacy.

The study has also identified a number of issues and/or factors that would seemingly impede the development/teaching of mathematical literacy: learners' lack of basic mathematical concepts, their difficulties in English language communication, and their negative attitudes towards the new subject (ML). Also, teachers highlighted a number of factors that they felt were some of the impediments to the teaching of the new subject: teachers' lack of confidence to teach mathematical literacy; their lack of pedagogical content knowledge, their conceptions and beliefs about the nature of mathematics; high workloads; the large class sizes; the lack of appropriate and sufficient teaching and learning support materials; lack of uniformity in the types of textbooks used for instruction; lack of support from the department of education by way of frequent in-service training workshops; lack of funds to buy the necessary resources for instructional purposes; and the difficulties associated with finding or deciding on relevant contexts, as well as implementing effective instructional approaches relating to the development of mathematical literacy.

However, there seems to be some contradictions and serious gaps in some of the arguments in the existing literature, not only in terms of the connotations used to describe the concept of mathematical literacy, but also in terms of the relationship that is being made between this concept and formal mathematics; further leading to confusion about the nature of mathematics as a discipline and its utility. For example, Steen (1999) asserts that numeracy/quantitative literacy is more than mathematics and is synonymous with 'mathematical literacy, yet mathematical literacy is not synonymous with quantitative literacy or numeracy. On the contrary, de Lange (online) argues that these terms or concepts are not the same. In other words, neither numeracy nor quantitative literacy are synonyms of mathematical literacy. Furthermore, no similarities or relationships between these terms have clearly been made in many of the arguments or discussions around the description of the concept of mathematical literacy insofar as they relate to mathematics subject. Nonetheless, generally, the overall response from the participating teachers seems to indicate that mathematical literacy is a subject that can be studied and therefore should be incorporated into the FET phase of schooling in South Africa despite the many challenges that may come with the introduction of such an innovation.

Based on the present findings it can be concluded that:

- Through a sustained monitoring of the implementation process, reviewing of policy documents, and professional development of those involved with teaching mathematics and/or mathematical literacy, educators can gain increased pedagogical content knowledge and skills which will ultimately enhance their performance in their daily classroom discourses;
- The different conceptions of mathematical literacy are due to the multifarious ways in which the relationship between school mathematics and out-of-school mathematics has been analyzed and constructed, but not due to any differences between these two aspects of mathematics as a discipline;
- There is a relationship between school mathematics as a subject and mathematical literacy as a competency. This relationship is merely a consequence of knowledge of mathematics because it reflects an individual's capacity to use the mathematics that is supposed to be learnt at school; and

- The problem of perceived differences between school mathematics and mathematical literacy could be overcome or resolved by incorporating ethnomathematical practices or ordinary everyday indigenous knowledge into school mathematics rather than to have split streams.

It is perhaps important at this stage (in the light of the foregoing) to consider what the implications of these results are, given that the new curriculum has already been introduced and has to be implemented. As the results have shown, most participating teachers viewed mathematical literacy as a subject, and as such have highlighted their concerns relating to its introduction and implementation. Furthermore, the results showed that many of the issues or factors that have been raised are related and interdependent in some ways. Hence, in the following sections I will discuss these findings in terms of their implications for policy and practice, as well as for further research.

5.2 Implications for policy and practice

Given the complex ways in which the factors mentioned herein are interdependent, it is important that they are grouped into categories and then discussed in terms of their implications for policy and practice, as well as for further research. There are three categories that can be formed from the issues and factors that have been raised: Teachers' low levels of readiness to teach ML, curricular and pedagogical issues, and learners' inadequacies or lack of readiness to meet curricula demands.

5.2.1 Teachers' low levels of readiness/professional bases to teach ML

The first category of factors has to do with those that are related to teachers themselves. It has been revealed that most of the participating teachers lacked confidence to teach mathematical literacy. This could mean two things: either they did not have adequate content knowledge and understandings of mathematical concepts or they lacked the pedagogical content knowledge of the subject. This, therefore, will mean that there is an immediate need for an ongoing professional development support to help them acquire the necessary skills needed for effective teaching of mathematics content in service for the development of mathematical literacy, especially at the initial stages of the implementation of the new reforms in the

South African high schools. This is particularly important given that almost all the present mathematics educators in South Africa were trained during the time when traditional approaches to teaching and learning were predominant; in which case then it is understandable that they may find it very difficult to use the novel teaching strategies that are in line with the spirit of OBE which forms the foundation for the curriculum in South Africa. There are two important areas of professional development that need due attention. First, there is need to strengthen the current teacher education programs by structuring them so as to provide student-teachers opportunity to examine and reflect on their own beliefs and conceptions about mathematics, and also to learn more about the history of mathematics. Secondly, there is need for all mathematics educators to be formally retrained in line with the current curricular and pedagogical reforms especially in the light of the OBE innovation which stresses the importance of constructivist perspective. Furthermore, there is need for an ongoing professional support that will help mathematics educators to experience for themselves how teaching for the development of mathematical literacy is like. Most of the participating teachers complained about not having been adequately trained for the teaching of mathematical literacy, and thus they did not have ideas on how to conduct such instruction in the context of the FET classrooms. This, therefore, suggest that teachers need to undergo and experience (from the perspective of a learner) a training that brings together the content knowledge and the pedagogical knowledge, as well as the habits of mind, all of which should provide opportunity for them to reflect on such experiences from the perspective of mathematics educators. It is also important, as a way of helping educators on the issue of providing relevant contexts, to train teachers on how they can use ethnomathematics as a tool in the mathematics classroom to help learners make connections and develop deeper mathematical understanding (Masingila & King, 1997). This is, in fact, what mathematical literacy is all about.

The suggested professional development efforts, I believe, can help to address specifically the issues of lack of adequate content knowledge of mathematics and lack of confidence to teach the subject, thereby helping teachers to be able to subsequently handle the issue of the interplay between content and context in their classrooms. It must be noted, however, that teachers' beliefs and conceptions of mathematical literacy are invariably linked to mathematics subject, and in one way or the other, this may have practical implications for their teaching practices (see Thompson, 1996). For this reason, therefore, it should be expected that efforts to undo old practices through these kinds of professional development activities should be a major undertaking which will render the whole exercise to be costly both in terms of time and financial resources.

Furthermore, it is important to recognize that in the process of implementing mathematical literacy, teachers need help in understanding the concept of 'mathematical literacy' itself and what it entails in terms of how teachers should plan the mathematical activities for learners and how to reconcile the interplay between content and context within such activities and within their classroom diversities. Teachers may, given the large class sizes that they are handling, also need support to reconcile the demands of introducing mathematical literacy activities with classroom management demands. Finally, it is also important to encourage mathematics educators, in the process, to conduct thorough and honest evaluation that will help them to confront their own practices, throughout the initial stages of the implementation period (which should be at least the first five years). These efforts (and all that have been alluded to earlier), I believe, can make a difference in terms of helping teachers to appraise their professional thinking.

5.2.2 Curricular and Pedagogical issues/factors

The second category relates to curricular factors or elements, and includes macro- and micro elements. On the micro level, there is an immediate need to develop instructional resources that are pertinent to proper development of mathematical literacy. As has been pointed out earlier, many of the participants were not involved in the teaching of the new subject (let alone in the acquisition of adequate mathematics qualifications); and for those who were involved, they were not quite confident to handle it. And even as they were struggling to teach it, they simply could not do it satisfactorily due to (a) the high workloads resulting from the many classes and other different subjects that they were expected to teach, and (b) lack of adequate mathematical content knowledge. As a result it was very difficult for them to develop relevant instructional materials or even to prepare appropriate teaching aids. To address this, a crucial first step would be to have carefully constructed instructional materials readily available for teachers. These materials should have three major characteristics: First, if they are to reflect a commitment to the widely held argument that mathematics provides tools to help us come to understand the world (and, more specifically, it prepares us for citizenship in an increasingly technological world), their primary thrust should be on mathematical activities that make use of mathematical models to help learners understand realistic problems that they might conceivably encounter in everyday life or in the workplace, and that draw on and reinforce learning about mathematics concepts and topics (including abstractions) central to the required FET mathematics curriculum; secondly, they should integrate and sufficiently provide illustrations of appropriate pedagogical approaches so that teachers with the least modicum of confidence in the new teaching approaches feel that they can also use the materials in their classrooms to teach mathematics. (We should remember that many of the mathematics educators we have in South African schools have been trained in the traditional teaching and learning approaches; hence they are likely to find it difficult to embrace the new reforms); and thirdly, the materials must be designed in a student-centered approach (i.e. with more emphasis on project work) to the teaching and learning of mathematics. Implementing this curricular recommendation, of course, will entail cyclical developments and refinement, in addition to monitoring and investigating the extent to which the developed materials, as used by teachers, affect classroom instruction and student learning. This also suggests that, invariably, there will be no need for prescribed learners' textbooks which are often recommended for schools.

On the macro level, there should be *medium-* and *long-term* mechanisms put in place and aimed at improving (making necessary changes to) the curriculum, as well as to ensure that materials do not easily fall out of favour and use. It was quite evident from the results of this study that almost all the participating teachers were unhappy with adequacy or supply of teaching and learning support materials, and also the professional support they expected from the department; and this should be seen as an indication of the need for a sustained micro curriculum development and macro curricular changes aimed at modifying overall curricular goals, priorities, and emphases directed towards helping teachers to cope with the overall aims and principles of the National Curriculum Statement for Mathematical Literacy.

5.2.3 Learners' inadequacies to meet curricular demands

The third category (which is the last but not the least) of factors has to do with those that are related to learners. It has been revealed from the results of this study that many high schools in South Africa are facing financial problems resulting from learners' failure to pay school fees. Consequently this leads to many of the schools not affording to buy appropriate and relevant prescribed textbooks and other related resource materials needed for instruction. To address this problem, there is need for the government to rethink its policy relating to school fees so as to make education accessible to all children, as well as enabling schools to facilitate the successful teaching and learning in mathematics education. The other two crucial factors here are learners' difficulties with the language of instruction and their lack of adequate knowledge of mathematical concepts. The results of this study showed that some of the participants indicated/asserted that most learners (especially the black learners) in their classes had serious difficulties in understanding the mathematical concepts because of the English language problem. For this reason teachers also find it difficult to present the mathematical ideas in the way that is intelligible to all learners, thereby making their attempts at providing relevant contexts almost impossible. Furthermore, given the reality of the South African context, where learners taking the option of Mathematical Literacy are those who will have not passed Mathematics at Grade 9, the issue of English language (or mathematical language) problem in the teaching of mathematical literacy will remain as one of the greatest challenges to teachers. Although it seems like there is very little that can be done to address this language problem, given its association with larger cultural and political factors, Rowlands and Carson (2002) remind us that it would be a big mistake to "…assume that some pupils by virtue of their language use or the colour of their skin have an intrinsically different conceptual approach to maths…..'' (p. 96) (see also Setati cited in Goba, 2004). In other words, they seem to suggest that language is not really the only problem when it comes to the learning of mathematical concepts (compare with Pillay, 2005). This is a challenge for educators to rethink their pedagogical approaches to the teaching of mathematics or mathematical concepts if they are to succeed in producing mathematically literate learners.

5.3 Issues for further research

As already noted earlier, the present results from this study showed that the three groups or cohorts of in-service teachers who formed the sample for this research project had different perceptions of and beliefs about the *notion* of mathematical literacy as a school subject. However, the relevancy (to all learners) of the range of contexts that teachers have used and the extent to which such contexts assist in the development of mathematical literacy is not clear. For this reason, therefore, there is need for further research in this area. Furthermore, there is need to carry out research relating to the extent to which mathematics educators and/or mathematical literacy educators are able to assess the relevance and appropriateness of the current learners' textbooks for mathematical literacy at the FET level. This, it is hoped, will assist policy-makers to make necessary efforts towards offering teachers and/or educators in-service professional development activities that will culminate in addressing the issues and factors that have been raised, and also to evaluate the success or failure of the new curriculum implementation. Finally, I think the following are some of the very important issues that require further research:

1. the extent to which the ACE program helps to prepare and empower in-service teachers or educators for the teaching of mathematical literacy;
2. an exploration of FET mathematical literacy learners' experiences about and attitudes towards the new curriculum;
3. the extent to which learners are motivated to learn 'mathematical literacy';
4. the extent to which 'mathematical literacy' assessment tasks promote critical thinking skills in learners; and
5. an investigation of the relationship between teachers' perceptions of 'mathematical literacy' and their classroom practices.

5.4 Conclusion

In this chapter, I have presented and discussed a summary of the key findings of this study and, in the process, have highlighted some of the challenges faced by mathematics educators, as well as implications for policy and practice, and for further research. I have also looked at any existence of a relationship between issues raised in extant literature and the key findings, and have concluded that much as there are a variety of perspectives within the international mathematics education community about the notion of mathematical literacy, there are variations also within and between the three cohorts of in-service teachers who participated in this study. However, the present results have mainly shown that many of the participating teachers perceived the notion 'mathematical literacy' as a subject, rather than a competency. Although much of existing literature has shown that there was an increasing attention towards and an interest in developing learners' mathematical understanding at all levels of education, it is evident that the various perspectives and the conclusions drawn from the findings do present some serious challenges to both the policy makers and the mathematics educators not only in South Africa, but also in the rest of the world where reforms in mathematics education directed towards development of mathematical literacy have been undertaken.

Finally, it has been concluded that, despite the differences in interpretations (definitions) and names given to the theoretical concept of mathematical literacy by different authors within the international mathematics community, it seems there is a general consensus that there is need for effective preparation of each nation's citizens for work and life, and that to achieve this goal, major changes to both the curricula and pedagogy (see Gates, 2003; Madison, 2004; Wallace, 2000; Vithal, 2006) aimed at the development of mathematical literacy in learners, are needed. In particular, there is a general perception that mathematical literacy is necessary in these technologically advancing modern societies, and therefore there is need for effective approaches to mathematics and mathematics education that will promote its development. In essence therefore, it is clear that most of (if not all) the definitions resonate well with Jablonka's categories which (in a much elaborative way) portray the theoretical concept of mathematical literacy as a competency rather than a subject of study.

CHAPTER 6 LIMITATIONS, REFLEXIVITY AND REFLECTIONS

6.1 Limitations of the Study

In view of the cross-sectional nature of this small-scale ethnographic survey, and the fact that it was not easy for the researcher to do thorough pilot-testing of the instruments due to time constraints, it was not possible to expose all the seemingly inherent weaknesses in the research instruments. The sessions lasted for only two weeks, and three days of each week were used to conduct the study, both the administration of the questionnaires and the interviews. Given that there were 70 questionnaires altogether to analyze, and four interviews (of about 40 minutes each) to transcribe, it proved difficult (in the interim) to "work out" the data in time for the researcher to be ready for the second phase of the study which was initially planned for mid September, 2006. It was thought that there was insufficient time to carry on with data collection, and hence the plan was abandoned to give more time for the analysis of the data that had already been collected and to the writing of the first draft of the report despite that it was significant that, if there was sufficient time to repeat the study in the second phase, the results would probably have been different.

Furthermore, it is quite evident from this research report that a theoretical study, rather than an empirical study, would have been a better choice for this research project since the unit of analysis was much more to do with the meaning of a *theoretical concept* than with the ontological and phenomenological discussion of a particular curricular subject matter. Hence, I am of the view that if this study was to be repeated, it would be more appropriate to use an analytical research approach in the form of a theoretical study. This is because I do feel that, since the notion of mathematical literacy is new within mathematics education, participants were not quite conversant with the issues around it and therefore limited in terms of being able to provide fuller explanations about their understandings of this concept.

6.2 Reflexivity

The issue of reflexivity has become a debatable and contested area in the landscape of educational research (Goodley et al, 2004; Pink, 2001), and there seems to be a general agreement, though, within the research community that it is of central importance to the research process (see also Cohen et al, 2000; Cole & Knowles, 2001; Lincoln & Guba, 2000). Critical to this debate is how researchers should continually and critically examine their practice/process of research to reveal its assumptions, values, and biases so as to find ways to deal with all possibilities and/or categories of the selves inherent in the research process (Fine et al, 2003; Maanen, 2002). Bias and subjectivity are the two major issues warranting reflexivity in the research process. The idea, ultimately, should be to recognize the centrality of the subjectivity and biasness of the researcher to the generation and presentation of ethnographic knowledge. Lincoln and Guba point out that:

> "Reflexivity is the process of reflecting critically on the self as researcher….It is a conscious experiencing of the self as both inquirer and respondent, as teacher and learner, as the one coming to know the self within the process of research itself……Reflexivity forces us to come to terms not only with our choice of research problem and with those with whom we engage in the research process, but with our selves and with the multiple identities that represent the fluid self in the research setting" (Lincoln & Guba, 2000, p. 183).

Thus reflexivity demands us to interrogate and continually examine our practices/process of research and become aware of the fact that our subjectivities do influence our understanding of reality, and as such we also need to be aware of the interplay of the relationships between the subjectivities of researcher and researched that produces a negotiated version of reality (Goodley et al, 2004; Moore, 1999; Usher, 1996). Reflexivity is therefore tied to the issues of inter-subjectivity as well as the importance of acknowledging one's position as researcher. Usher (1996) and Cole and Knowles (2001) remind us that being aware of reflexivity must not only be about being skeptical and personal as regards researcher's own identity as an individual, but should also include developing and operating from an ethic of care for research informants. In this way then reflexivity is seen as more than just "enabling researchers to be more 'upfront' about the 'subjective' elements, including the values of the researcher, that cannot simply be ignored or banished from research" (Usher, 1996, p. 36), but also leading to "heightened awareness of self, other, and the self-other dialectic" (Cole & Knowles, 2001, p. 30). Researchers need to be also conscious of how different elements of their identities such as gender, age, class, race, ethnicity, etc become significant during research in the way they (researchers) are situated and situate themselves in the research settings (Pink, 2001). Cole and Knowles (2001) assert that the visibility and acknowledged presence of a researcher in a research account is one of the standards of good research.

Having briefly discussed the notion of reflexivity, I now use this to analyze how, as a researcher, I addressed my relation to the research setting, the participants/informants, and issues of bias and/or subjectivity. I may not be a very good judge of myself, but it is evident from the methodology and the methods that have been used for data collection and analysis that I was operating from the usual traditional perspective of a research relationship where the participants/informants assume a passive role, giving consent to participate and providing data to the researcher. I, just like in many of the previous research studies (compare with Jita & Vandeyar, 2006; Mbekwa, 2006), assumed all the responsibility in terms of decision-making about how the research proceeded. And I believe this is typical of most, if not all, research. It has not been easy, I must admit, given the nature of the methodology I chose, to allow a more relaxed and reflective relationship that blurs the boundaries between the researcher and the researched and that which would be guided by mutual interest as Cole & Knowles (2001) suggest. It therefore follows that, although participants were given the freedom to choose whether or not to participate in the study, they did not have any input in the decision-making in the writing process despite that they were interviewed. However, I must point out that every attempt, as far as was humanly possible, was made to facilitate the conduct of this study, especially with regard to issues of participants' consent, confidentiality, and gaining access.

Furthermore, it should be recognized that, as a researcher, much as I may have tried (or failed) to be ethical, it is likely that I may not have succeeded in addressing all issues relating to my subjectivity and biasness in this research process. But I believe that, as a novice researcher, I have contributed immensely to the current academic conversation by the generation and presentation of ideas and findings around the theoretical concept of mathematical literacy.

6.3 Reflections

I can still vividly remember how difficult it was for me to make sense of my first few attempts to read around the concept of 'mathematical literacy' during our lectures on *Current Issues and Frontiers in Mathematics Education* module in 2005. It did not make much sense to me at the time, more so that it was a new idea not only to me but to the rest of my colleagues in that group of students. As we read through the few handouts we got from the lecturer, I could not see the difference between the lines of argument that were presented by various authors as to why there was so much debate, and what exactly was the idea of 'mathematical literacy' all about. We were given an assignment about which we were to search for more literature concerning the concept of mathematical literacy and why it was important to introduce it as a separate subject in the FET phase of schooling in South Africa. I searched for more literature and tried to read but still, it was not easy to come to grips with the meaning of that phrase, especially that there was so much controversy over its definition and many interpretations which led to many labels given to it as well.

However, after much dialogue with various texts and people, reflection, and immersing myself into research 'communities of practice' and by constructing representations of my understandings of the concept, I now feel I have improved on my knowing of the concept of 'mathematical literacy' and the many various definitions that are used to describe it. I now have a greater sense of the richer 'cloud of baggage' I have developed around some of the concepts and terms that have been used within mathematics education community. This cloud has been enriched by multiple approaches to understanding – mainly by reading and by writing and re-writing, by working extremely hard alone and finally by writing this report. I now feel I have a deeper understanding of the meaning of the theoretical concept of mathematical literacy and how it relates to mathematics subject, and I believe I can now be more critical of texts in terms of the author's background, and social situations in terms of the environment and participants. To this end, I believe the knowledge I have acquired, to some greater degree, has been used in the writing of this report, both in the philosophical and the methodological orientations.

From writing this report, I have a better feel for the value of educational research in using theory to inform practice. I also have a better feel for the value of a reflective account of one's experiences, as well as the value of reflexivity in the research process.

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APPENDICES

APPENDIX A: Letter to request permission from Department of Research and ECMIS to conduct research.

University of KwaZulu-Natal
Edgewood Campus
Yellow-wood Flat 2
Private Bag X03
Ashwood
3605

20 February 2006

Mr. S.R. Alwar
Department of Research, Strategy, Policy Development and ECMIS
Private Bag X05
Rossburg
4072

Dear Sir

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN KZNED SCHOOLS

I am a 2nd year student and pursuing a Master of Education (M.Ed) degree at the above-mentioned university, and currently planning a research project for my dissertation which will be part fulfillment of the requirement for the M.Ed qualification.

The title of my proposed research is "AN EXPLORATION OF MATHEMATICS EDUCATORS' UNDERSTANDING OF THE CONCEPT OF MATHEMATICAL LITERACY". This is an ethnographic study which will involve only three high schools and focused on mathematics educators who are involved in the teaching of Mathematical Literacy at Grade 10 in the year 2006.

The purpose of this research is to explore mathematics educators' understanding of the concept of 'mathematical literacy' and how this will impact on the implementation of the new curriculum. My interest in this study stems from, among others, the following reasons:

- The need to understand and know more about 'mathematical literacy' as a concept, as well as a subject of study in the NCS document;
- The need to assess how educators' understanding impact on the programme delivery; and

- The need to see how mathematical literacy educators translate the new curriculum statement into classroom practice.

It is anticipated that the study will take about 4 months, starting from mid-February 2006 to about mid-June 2006. And in the process of data collection, much as I can, I will make every effort to ensure minimal use of school time. This process will comprise 3 lesson observations spread over a period of 3 weeks (with the use of a video camera), and an unstructured interview (lasting for about an hour and a half) subsequent to each observation for the purpose of stimulating a conversation about the video recordings. Also, it is hoped, and be rest assured, that the study will not in any away harm the image of your department, nor violate any laid down rules of conduct expected of the researcher.

Furthermore, every effort will be made to ensure that the anonymity of the concerned teachers, and that of their schools, as well as confidentiality regarding information that will be provided, are maintained. At all times during this study and after, the identity of the teachers involved will be protected. Participation in this study by teachers is voluntary, and if at any point during this research the individual teacher does not feel comfortable to continue as a participant, s\he will be free to withdraw from the study without any negative consequences.

All data collected during this study will be kept confidential until the research is over, and as regards disposal of data materials, we (the researcher and the participant) shall have to discuss and agree on the best and convenient way of doing that.

It is hoped that the findings from this study will help teachers to clarify and develop their understanding of the general aims, and in particular, the essential principles of the NCS document that they will be implementing, as well as to provide policymakers with necessary information that will further help to guide them in matters pertaining to the implementation and monitoring of the new curriculum.

If you would like to query anything about this study, you may contact my supervisor at UKZN, Faculty of Education (Edgewood Campus), Mr. P. Ntenza. His contact details are as follows: Telephone Number: 031 260 3460; e-mail: Hobdens@ukzn.ac.za .

Thank you

Yours faithfully,

Phineas S. Madongo (**Student No. 205518929**)

APPENDIX B: Letter to ACE Coordinator (UKZN) requesting permission to conduct research on ACE students.

University of KwaZulu-Natal
Edgewood Campus
Yellow-wood Flat 2
Private Bag X03
Ashwood
3605

03 April' 2006

ACE Coordinator
School of Science, Mathematics and Technology Education
University of KwaZulu-Natal
Edgewood Campus
Private Bag X03
Ashwood
3605

Dear Sir/Madam

RE: Request for Permission to Use Mathematics ACE teachers to Conduct Research

I am a second year Masters in Education (M.Ed) student in the University of KwaZulu-Natal specializing in Mathematics Education, and would like to ask for permission to use your ACE mathematics teachers to conduct a study about **Mathematics Educators' understandings of the concept of 'mathematical literacy'.** To this end, I will need to make a request for you to allow me the opportunity to meet the teachers during their **sessions** with you this academic year (2006) so that I can conduct my study.

I trust that you will assist me accordingly in order to facilitate this important project at this crucial stage of my studies.

Yours faithfully,

Phineas S. Madongo (**Student Number: 205518929**)

APPENDIX C: Letter to request for Research funding from Educational Attaché (Botswana High Commission).

School of Science, Mathematics and Technology Education
University of KwaZulu-Natal
Edgewood Campus
Private Bag X03
Ashwood
3605

23 February 2006.

Assistant Educational Attaché
Botswana High Commission
P.O. Box 57035
ARCADIA
0007
Pretoria

Dear Sir

RE: Research Project Funding – Mr. Phineas S. Madongo

This letter serves to inform you that Phineas S. Madongo, a student at our university, is about to embark on a research project as part of the requirement for the M.Ed degree qualification that he is currently reading for. To this end, I therefore wish to confirm that indeed he shall require some funding in order that he can conduct his study, and hence support his request for funding.

I trust that you will assist him accordingly so as to facilitate such an important project at this crucial stage of his studies.

Yours truly,

Ntenza P.S. (Supervisor)

APPENDIX D: Copy of the research Questionnaire.

A QUESTIONNAIRE FOR MATHEMATICS EDUCATORS

I would really appreciate it if you could spend some time to complete this questionnaire. The information you provide will be used solely for the purposes of an academic research project for a Masters of Education thesis at UKZN. You will not be identified by name in any report and all information shall be treated confidentially. Please sign to indicate that you have read this and give your informed consent to participate in this research project. You may withdraw your consent and your data at any time.

Many thanks for your co-operation

Phineas Madongo	Mrs. SD Hobden
Student no: 205518929	Project supervisor

I give permission to use the data from this questionnaire for academic research purposes.

I understand that I will not be identified by name in any research report and that I am not under any obligation to give this permission. I may withdraw my permission at a later stage if I so wish.

Signed:______________________________________ Date:__________________

PART A: Biographical Data

1. Gender: ______________

2. Age (in years): __________

3. Highest qualification: _______________________

4. Teaching experience: _______________________

5. How many years have you been teaching mathematics? _________________

6. Tick the description which best fits the school in which you teach.
   6.1 Urban school..( ) *or* Rural school (..)

6.2 School with poor resources ( ) *or* School with good resources ( )

6.3 Private school ( ) *or* Government funded school ( )

7. Are you currently teaching Mathematical Literacy?

7.1 Yes ( ) 7.2 No ( )

PART B: Competencies of a mathematically literate person

8.a. What mathematical knowledge or skills do you think are necessary in order for a person to be considered mathematically literate: Please try to list as many as you can think of.

____
____
____
____
____
____
____
____
____

8b.Write a brief description of your idea of a mathematically literate person.

____
____
____
____
____
____
____

PART C: **TEACHERS' BELIEFS ABOUT MATHEMATICAL LITERACY**

9. Indicate with a tick in the appropriate block, your agreement with each of the following statements about the new subject Mathematical Literacy in the FET curriculum?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Mathematical Literacy will help to improve the levels of literacy in the country					
Mathematical literacy is more about habits and ways of behaving than about Mathematics content.					
I see Mathematical Literacy as an opportunity to develop new skills in our modern society					
Mathematical Literacy is necessary because it will enable learners to solve real life problems					
Learners who study Mathematics to Grade 12 will automatically become mathematically literate.					
Mathematical Literacy is for those who are academically too weak to continue with Mathematics beyond Grade 9					
A strong mathematical background is necessary for effective teaching of Mathematical Literacy.					
Mathematical Literacy is introduced because Mathematics Educators are failing to make students pass Mathematics.					
The introduction of Mathematical Literacy will deny many disadvantaged learners the opportunity to proceed to tertiary education.					
Mathematical Literacy is a watered-down academic Mathematics					
Mathematical Literacy should not be taught by the mathematics teachers as they have more important work to do					
Mathematical Literacy is not necessary since learners who have reached Grade 10 have sufficient basic mathematical skills for their everyday living.					

10. What do you think are some of the major differences between being mathematically literate and knowing mathematics well?

____

____

____

____

____

11. Explain what you understand by each of the following two statements?

- *We teach for Mathematical Literacy*

  ____

  ____

  ____

- *We teach Mathematical Literacy*

12. Can you briefly say why you think it is useful or not useful to have Mathematical Literacy as a subject in the FET curriculum separate from Mathematics?

13. In which of the following ways would you like Mathematical Literacy to be developed, and why?

- *Integrated with other subjects*

- *As a separate subject*

The remainder of this questionnaire is ONLY for those who are currently teaching Mathematical Literacy.

PART D: TEACHERS' INITIAL EXPERIENCES OF TEACHING MATHEMATICAL LITERACY

14. One of the purpose statements of the NCS (Grades 10-12) document says that: **The inclusion of Mathematical Literacy as a subject in the FET curriculum will ensure that future citizens are highly numerate consumers of mathematics**. What do you understand the phrase "highly numerate consumers of mathematics" to mean? Explain why you agree or disagree with this statement?

15. Do you think the Mathematical Literacy curriculum will meet all its stated purposes? Explain.

16. Can you briefly state how you think the subject Mathematical Literacy differs from the subject Mathematics?

17. Do you find that the teaching of Mathematical Literacy differs from the teaching of Mathematics? Explain.

18. What resources/teaching aids (e.g. chalkboard, media articles, etc) have you used /or are using to support your teaching of Mathematical Literacy? Give examples.

19. What teaching/learning strategies (approaches), e.g. whole class teaching/learning, independent study, do you prefer to use? Explain.

Please include any other comments you might have on the blank page at the back of this questionnaire.

APPENDIX E

<u>INTERVIEW SCHEDULE</u>

<u>04 July 2006</u>

Introduction

(The researcher starts off by introducing himself and explaining the purpose of the interview and the origins of his interest in the research topic, and to ask for permission to tape-record the interview as well as giving assurance about confidentiality of information emanating from the interview).

- purpose of interview
- background to the study
- permission to tape-record
- reassurance about confidentiality of information.

1. How long have you been teaching, and which subject(s)?
2. What is your Mathematics background?
3. I learn that you teach Mathematical Literacy. How come you are teaching Mathematical Literacy yet you have never studied it?
4. What evoked your interest in this area?
5. Could you explain to me as clearly as possible your understanding of the term ‘mathematical literacy’?
6. Can you give examples to illustrate your notion of the concept ‘mathematical literacy’?
7. Based on your understanding, is ‘mathematical literacy’ a subject of study or a competency? If it’s a subject, how does it differ from Mathematics? If it’s a competency, why should we have it as a curriculum subject alongside Mathematics?
8. Is it possible or not possible for learners to become mathematically literate without studying mathematics?
9. It is argued that ‘mathematical literacy’ is a result of good mathematics teaching and learning, and therefore it is not necessary to have separate curricula for mathematics and mathematical literacy. What is your comment?
10. Some mathematics educators feel that Mathematical Literacy is a ‘watered-down’ Mathematics. What do you think?
11. What is it like to teach Mathematical Literacy?
12. What are the challenges (if any) of teaching Mathematical Literacy?
13. Is there any support you get to help you in the implementation of the Mathematical Literacy curriculum?

14. As I understand it, learners who do not prove to be good in mathematics at the end of GET phase of schooling are the ones who can opt for Mathematical Literacy, is that correct? If so, what does that say about the status of Mathematical Literacy compared to Mathematics?
15. Are there any further comments you would like to make concerning ‘mathematical literacy’ concept?

APPENDIX F: Frequency Tables showing cohorts' responses to each of the 12 beliefs.

Belief1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2	2	2.9	2.9	2.9
	-1	1	1.4	1.4	4.3
	0	4	5.7	5.8	10.1
	1	32	45.7	46.4	56.5
	2	30	42.9	43.5	100.0
	Total	69	98.6	100.0	
Missing	9	1	1.4		
Total		70	100.0		

Belief2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2	2	2.9	2.9	2.9
	-1	13	18.6	19.1	22.1
	0	16	22.9	23.5	45.6
	1	30	42.9	44.1	89.7
	2	7	10.0	10.3	100.0
	Total	68	97.1	100.0	
Missing	9	2	2.9		
Total		70	100.0		

belief3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2	1	1.4	1.4	1.4
	-1	1	1.4	1.4	2.9
	0	2	2.9	2.9	5.8
	1	34	48.6	49.3	55.1
	2	31	44.3	44.9	100.0
	Total	69	98.6	100.0	
Missing	9	1	1.4		
Total		70	100.0		

belief4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2	1	1.4	1.5	1.5
	0	1	1.4	1.5	2.9
	1	28	40.0	41.2	44.1
	2	38	54.3	55.9	100.0
	Total	68	97.1	100.0	
Missing	9	2	2.9		
Total		70	100.0		

belief5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2	4	5.7	5.8	5.8
	-1	15	21.4	21.7	27.5
	0	9	12.9	13.0	40.6
	1	22	31.4	31.9	72.5
	2	19	27.1	27.5	100.0
	Total	69	98.6	100.0	
Missing	9	1	1.4		
Total		70	100.0		

belief6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2	15	21.4	21.7	21.7
	-1	27	38.6	39.1	60.9
	0	8	11.4	11.6	72.5
	1	13	18.6	18.8	91.3
	2	6	8.6	8.7	100.0
	Total	69	98.6	100.0	
Missing	9	1	1.4		
Total		70	100.0		

belief7

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2	3	4.3	4.5	4.5
	-1	18	25.7	26.9	31.3
	0	9	12.9	13.4	44.8
	1	18	25.7	26.9	71.6
	2	19	27.1	28.4	100.0
	Total	67	95.7	100.0	
Missing	9	3	4.3		
Total		70	100.0		

belief8

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2	24	34.3	35.8	35.8
	-1	26	37.1	38.8	74.6
	0	6	8.6	9.0	83.6
	1	8	11.4	11.9	95.5
	2	3	4.3	4.5	100.0
	Total	67	95.7	100.0	
Missing	9	3	4.3		
Total		70	100.0		

belief9

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2	13	18.6	19.1	19.1
	-1	30	42.9	44.1	63.2
	0	16	22.9	23.5	86.8
	1	7	10.0	10.3	97.1
	2	2	2.9	2.9	100.0
	Total	68	97.1	100.0	
Missing	9	2	2.9		
Total		70	100.0		

belief10

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2	14	20.0	21.5	21.5
	-1	29	41.4	44.6	66.2
	0	14	20.0	21.5	87.7
	1	6	8.6	9.2	96.9
	2	2	2.9	3.1	100.0
	Total	65	92.9	100.0	
Missing	9	5	7.1		
Total		70	100.0		

belief11

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2	20	28.6	29.0	29.0
	-1	37	52.9	53.6	82.6
	0	7	10.0	10.1	92.8
	1	1	1.4	1.4	94.2
	2	4	5.7	5.8	100.0
	Total	69	98.6	100.0	
Missing	9	1	1.4		
Total		70	100.0		

belief12

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2	30	42.9	43.5	43.5
	-1	32	45.7	46.4	89.9
	0	2	2.9	2.9	92.8
	1	2	2.9	2.9	95.7
	2	3	4.3	4.3	100.0
	Total	69	98.6	100.0	
Missing	9	1	1.4		
Total		70	100.0		

APPENDIX G: Factor Analysis of participants' beliefs about Mathematical Literacy.

Pattern Matrix[a]

	Component				
	1	2	3	4	5
Belief1	-.163	.791	.032	-.281	-.064
Belief2	-.216	-.059	-.762	-.045	-.160
belief3	.097	.846	-.094	-.138	.149
belief4	.111	.814	.115	.276	-.010
belief5	-.161	.172	-.038	-.812	-.106
belief6	.218	-.071	-.090	-.708	-.055
belief7	-.240	.090	-.017	.139	.898
belief8	.452	-.094	.082	-.406	.246
belief9	.294	.001	-.769	-.032	.223
belief10	.404	-.170	.096	-.368	.313
belief11	.842	.181	-.298	.065	-.135
belief12	.814	-.074	.167	-.037	-.130

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 24 iterations.

Factor 1

Beliefs 8,11,12

1	2	3	4	5
8, 11, 12	1, 3, 4	2, 9	5, 6,	7

10 does not load sufficiently on any factor

10	Mathematical Literacy is a watered-down academic Mathematics

Factor 1

Mathematical Literacy is introduced because Mathematics Educators are failing to make students pass Mathematics.	8
Mathematical Literacy should not be taught by the mathematics teachers as they have more important work to do	11
Mathematical Literacy is not necessary since learners who have reached Grade 10 have sufficient basic mathematical skills for their everyday living.	12

Factor 2

Mathematical Literacy will help to improve the levels of literacy in the country	1
I see Mathematical Literacy as an opportunity to develop new skills in our modern society	3
Mathematical Literacy is necessary because it will enable learners to solve real life problems	4

Factor 3

Mathematical literacy is more about habits and ways of behaving than about Mathematics content	2
The introduction of Mathematical Literacy will deny many disadvantaged learners the opportunity to proceed to tertiary education	9

Factor 4

Learners who study Mathematics to Grade 12 will automatically become mathematically literate.	5
Mathematical Literacy is for those who are academically too weak to continue with Mathematics beyond Grade 9	6

Factor 5

A strong mathematical background is necessary for effective teaching of Mathematical Literacy.	7

APPENDIX H: Codebook

Question number	Variable description	Variable name	Value label
ID no.	Identity number	IDNUM	self-coding
			99 Missing value
Cohort	Course been studied	Cohort	1 Maths Lit ACE
			2 Maths GET ACE
			3 Maths/Science BED (Hon)
Gender	Gender	GENDER	1 male
			2 female
Age	Age	AGE	self-coding
H Qual	Highest qualification	QUALIF	1 3 year diploma
			2 4 year diploma
			3 ACE
			4 Bachelors degree
			9 missing value
Texp	Teaching Experience	TEACH	self-coding
			9 missing value
Texpma	Teaching Experience Maths	TEACHMA	self-coding
			9 missing value
Schooloc	School location	SCHOOLOC	1 Urban school
			2 Rural school
			9 missing value
Schoolres	School resurces	SCHOOLRE	1 Poor resources
			2 Good resources
			9 missing value
Schoolfund	School funding	SCHOOLFU	1 Private

			2 Government
			9 missing value
Maths lit	Teaching maths Lit	MATHLIT	1 Yes
			2 No
			9 missing value
Beliefs 1-12		BELIEF1-12	strongly disagree -2
			disagree -1
			Neutral 0
			agree 1
			disagree 2
			9 missing value

APPENDIX I: Teachers' profiles

1. ACE Mathematical Literacy students

Teacher	Age (in years)	Highest qualification in maths	Teaching experience (in years)	Number of years teaching maths	Description of school	Currently teaching math literacy
1	36	STD	12	12	Rural, poorly resourced, government funded.	No
2	35	PTD	5	3	Poorly resourced	No
3	29	DE	5	n/a	Rural, poorly resourced, government funded.	No
4	26	DE	7	6	Rural, poorly resourced, government funded.	Yes
5	30	DE	6	n/a	Rural and poorly resourced.	No
6	48	STD	26	4	Poorly resourced	Yes
7	39	HDE	17	2	Urban, well resourced, government funded	Yes
8	44	STD	14	14	Urban, poorly resourced, government funded	Yes
9	56	BA	32	n/a	Urban, well resourced, government funded	No
10	33	SPTD	6	6	Rural, poorly resourced, government funded	No
11	31	STD	3	2.5	Urban	No
12	29	STD	3	n/a	Rural, poorly resourced, government funded	No
13	32		3	n/a	Urban	No
14	38	B. PAED	16	n/a	Urban, well resourced, government funded	No
15	41	B. Paed (Sc)	18	10	Urban	Yes
16	28	Diploma	3		Urban, well resourced.	No
17	44	Diploma	10	2	Rural	No
18	29		6	6	Rural, poorly resourced, government funded	Yes

2. ACE for GET Students

Teacher	Age in years	Highest qualification	Teaching experience	Number of years teaching math	Description of school
1	31	M3	5	5	Poorly resourced
2	27	Diploma	3	1	Rural
3	42	STD	10	10	Urban, poorly resourced, government funded
4	37	Diploma	14	N/A	Urban
5	42	Matric	None	N/A	Urban
6	29	STD	7	N/A	Rural, poorly resourced, government funded
7	-	PTD	3	-	Government funded
8	28	STD	7	7	Urban, poorly resourced, government funded
9	35	STD	10	3	-
10	29	STD	4	4	-
11	49	NPDE	25	25	Poorly resourced
12	40	M3	10	6	Urban
13	33	Diploma	8	8	Urban
14	29	HDE	7	5	Rural, poorly resourced, government funded
15	31	STD	4	4	Well resourced
16	46	STD	20	2	Rural
17	29	DESP	4	3	Rural
18	26	DSE	5.5	None	Urban, poorly resourced, government funded
19	33	DE	3	3	Rural
20	36	M3	5	2	Rural
21	29	Diploma	6	2	Rural, poorly resourced, government funded
22	35	PTD	6	6	Poorly resourced
23	46	B.Teh	19	19	Rural
24	33	SPTD	5	4	-
25	31	DE	5	4	Urban

3. B.Ed (Hons) students

Teacher	Age in years	Highest Qualification	Teaching Experience (in years)	Number of years teaching maths	Description of school	Currently teaching Math Literacy
1						
2	30	M+4	5	5	Rural, poorly resourced, government funded	No
3	43	ACE	7	5	Poorly resourced	-
4	32	B.Ed	4	4	Rural school	No
5	33	M+4	6	6	Rural school, government funded	No
6	32	BSc.	10	-	Rural, Government funded	No
7	48	ACE	12	10	Rural school	No
8	36	-	4	3	Poorly resourced	Yes
9	44	FDE	23	20	Urban, good resources, government funded	Yes
10	49	B.Ed	13	11	Urban, well resourced.	No
11	32	B.Ed	9	9	Rural, government funded	No
12	29	BSc.	5	5	Government funded	No
13	39	FDE	12	12	Rural, poorly resourced	No
14	28	M+4	5	5	Well resourced	No
15	35	ACE	11	6	Rural, poorly resourced	No
16	40	ACE	14	-	Rural school	No
17	38	BA	13	13	Well resourced	No
18	22	B.Ed	4	-	Well resourced	No
19	36	FDE	10	8	Rural school	No
20	33	FDE	13	-	Rural school	No
21	46	FDE	15	15	Rural school	Yes
22	45	ACE	14	10	Poorly resourced, government funded	No
23	29	ACE	7	7	Urban school	No
24	32	B.Paed.(Sc.)	8	-	Rural, poorly resourced, government funded	No
25	30	B.Ed (Primary)	7	7	Urban school	Yes
26	32	M+3	9	9	Rural, poorly resourced, government funded	Yes
27	31	ACE (primary)	10	10	Rural, government funded	No

APPENDIX J: Summary of participants' perceptions of the notion of Mathematical Literacy as a competency and as a subject of study (open-ended items).

PART	Question Item(s)	Summary of responses	Themes
B	**8a , 8b** Perceived competencies and notions of a mathematically literate person.	• Knowledge of basic number operations/arithmetical calculations; • Knowing mathematical language and being able to solve everyday life problems using mathematical techniques; • Being able to apply maths in the workplace to perform mental as well as calculator-aided calculations; • Being able to critically evaluate mathematics and the role it plays in people's lives; • Being able to handle or deal with and interpret mathematical information encountered in real life situations; • Having an understanding of the language of mathematics and being able to use it as a communication tool; • Being able to count and do basic calculations; and • Being able to understand and use numbers and data analysis in everyday life. • A mathematically literate person is someone who is able to apply maths in real life situations to solve problems;	Computational skills Personal and Citizen Empowerment.
C	**10, 11, 16** Beliefs about Mathematical Literacy. Understandings/perceptions of the relationship between mathematics and mathematical literacy	• Mathematical Literacy is informal/concrete and more contextualized, whereas Mathematics is too formal/abstract; • ML involves solving real life problems, whereas Mathematics is highly abstract and involves theorems and formulae; • Mathematics is difficult and challenging, whereas ML is about basic knowledge of mathematics and its application to real life problems and their solutions. • Mathematical Literacy is less advanced than Mathematics, and is for weaker learners; • ML is easier than Maths, and is needed by everyone to be able to solve daily	ML as a subject easier than Maths. Watered-down version of maths

		life problems because it's more relevant to people's lives than Mathematics;	
D	**12, 13, 14, 15, 17, 18, 19** Perceptions of, the necessity of, and purposes of, ML as a competency, and as a school subject in the FET curriculum. Perceptions of and experiences with, the teaching of ML as a school subject.	• ML should be developed as a separate subject for learners who dislike Mathematics; • ML should be integrated with other subjects so as to give every learner opportunity to do basic mathematics; • ML should be included in the FET curriculum so as to provide learners with a basis for subsequent learning of mathematics; • ML requires well trained educators and well resourced schools.	Development and Utility of ML Need for curricula and pedagogical changes.

APPENDIX K: SPSS output on statistical analysis of teachers' beliefs

(a)

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Belief1	Between Groups	1.050	2	.525	.689	.506
	Within Groups	50.255	66	.761		
	Total	51.304	68			
Belief2	Between Groups	7.125	2	3.563	3.787	.028
	Within Groups	61.154	65	.941		
	Total	68.279	67			
belief3	Between Groups	1.249	2	.625	1.133	.328
	Within Groups	36.403	66	.552		
	Total	37.652	68			
belief4	Between Groups	1.940	2	.970	2.170	.122
	Within Groups	29.060	65	.447		
	Total	31.000	67			
belief5	Between Groups	25.252	2	12.626	9.931	.000
	Within Groups	83.907	66	1.271		
	Total	109.159	68			
belief6	Between Groups	26.090	2	13.045	10.364	.000
	Within Groups	83.069	66	1.259		
	Total	109.159	68			
belief7	Between Groups	2.365	2	1.183	.712	.495
	Within Groups	106.351	64	1.662		
	Total	108.716	66			
belief8	Between Groups	5.355	2	2.677	2.067	.135
	Within Groups	82.914	64	1.296		
	Total	88.269	66			
belief9	Between Groups	7.120	2	3.560	3.850	.026
	Within Groups	60.100	65	.925		
	Total	67.221	67			
belief10	Between Groups	2.557	2	1.279	1.269	.288
	Within Groups	62.458	62	1.007		
	Total	65.015	64			
belief11	Between Groups	1.078	2	.539	.540	.585
	Within Groups	65.907	66	.999		
	Total	66.986	68			
belief12	Between Groups	3.836	2	1.918	2.113	.129
	Within Groups	59.903	66	.908		
	Total	63.739	68			

(b)

Multiple Comparisons

Scheffe

Dependent Variable	(I) Cohort	(J) Cohort	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Belief2	Maths Lit ACE	Maths GET ACE	.081	.307	.966	-.69	.85
		BEd Hon	.706	.300	.071	-.05	1.46
	Maths GET ACE	Maths Lit ACE	-.081	.307	.966	-.85	.69
		BEd Hon	.625	.272	.079	-.06	1.31
	BEd Hon	Maths Lit ACE	-.706	.300	.071	-1.46	.05
		Maths GET ACE	-.625	.272	.079	-1.31	.06
belief5	Maths Lit ACE	Maths GET ACE	-1.528*	.352	.000	-2.41	-.65
		BEd Hon	-1.148*	.343	.006	-2.01	-.29
	Maths GET ACE	Maths Lit ACE	1.528*	.352	.000	.65	2.41
		BEd Hon	.380	.316	.490	-.41	1.17
	BEd Hon	Maths Lit ACE	1.148*	.343	.006	.29	2.01
		Maths GET ACE	-.380	.316	.490	-1.17	.41
belief6	Maths Lit ACE	Maths GET ACE	-1.569*	.350	.000	-2.45	-.69
		BEd Hon	-1.111*	.341	.007	-1.97	-.26
	Maths GET ACE	Maths Lit ACE	1.569*	.350	.000	.69	2.45
		BEd Hon	.458	.315	.352	-.33	1.25
	BEd Hon	Maths Lit ACE	1.111*	.341	.007	.26	1.97
		Maths GET ACE	-.458	.315	.352	-1.25	.33
belief9	Maths Lit ACE	Maths GET ACE	-.843*	.305	.027	-1.61	-.08
		BEd Hon	-.547	.298	.193	-1.29	.20
	Maths GET ACE	Maths Lit ACE	.843*	.305	.027	.08	1.61
		BEd Hon	.296	.270	.550	-.38	.97
	BEd Hon	Maths Lit ACE	.547	.298	.193	-.20	1.29
		Maths GET ACE	-.296	.270	.550	-.97	.38

*. The mean difference is significant at the .05 level.

(c)

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Belief1	Maths Lit ACE	18	1.44	.856	.202	1.02	1.87	-1	2
	Maths GET ACE	24	1.13	.900	.184	.75	1.50	-2	2
	BEd Hon	27	1.26	.859	.165	.92	1.60	-2	2
	Total	69	1.26	.869	.105	1.05	1.47	-2	2
Belief2	Maths Lit ACE	17	.71	.985	.239	.20	1.21	-1	2
	Maths GET ACE	24	.63	.711	.145	.32	.93	-1	2
	BEd Hon	27	.00	1.144	.220	-.45	.45	-2	2
	Total	68	.40	1.010	.122	.15	.64	-2	2
belief3	Maths Lit ACE	18	1.56	.511	.121	1.30	1.81	1	2
	Maths GET ACE	24	1.21	.779	.159	.88	1.54	-1	2
	BEd Hon	27	1.33	.832	.160	1.00	1.66	-2	2
	Total	69	1.35	.744	.090	1.17	1.53	-2	2
belief4	Maths Lit ACE	18	1.78	.428	.101	1.57	1.99	1	2
	Maths GET ACE	23	1.43	.590	.123	1.18	1.69	0	2
	BEd Hon	27	1.37	.839	.161	1.04	1.70	-2	2
	Total	68	1.50	.680	.082	1.34	1.66	-2	2
belief5	Maths Lit ACE	18	-.44	1.149	.271	-1.02	.13	-2	2
	Maths GET ACE	24	1.08	.974	.199	.67	1.49	-1	2
	BEd Hon	27	.70	1.235	.238	.22	1.19	-2	2
	Total	69	.54	1.267	.153	.23	.84	-2	2
belief6	Maths Lit ACE	18	-1.44	.511	.121	-1.70	-1.19	-2	-1
	Maths GET ACE	24	.13	1.329	.271	-.44	.69	-2	2
	BEd Hon	27	-.33	1.209	.233	-.81	.14	-2	2
	Total	69	-.46	1.267	.153	-.77	-.16	-2	2
belief7	Maths Lit ACE	18	.72	1.447	.341	.00	1.44	-2	2
	Maths GET ACE	24	.25	1.260	.257	-.28	.78	-2	2
	BEd Hon	25	.52	1.194	.239	.03	1.01	-1	2
	Total	67	.48	1.283	.157	.16	.79	-2	2
belief8	Maths Lit ACE	18	-1.28	.752	.177	-1.65	-.90	-2	0
	Maths GET ACE	23	-.96	.976	.204	-1.38	-.53	-2	1
	BEd Hon	26	-.58	1.447	.284	-1.16	.01	-2	2
	Total	67	-.90	1.156	.141	-1.18	-.61	-2	2
belief9	Maths Lit ACE	17	-1.18	.809	.196	-1.59	-.76	-2	0
	Maths GET ACE	24	-.33	.963	.197	-.74	.07	-2	2
	BEd Hon	27	-.63	1.043	.201	-1.04	-.22	-2	2
	Total	68	-.66	1.002	.121	-.90	-.42	-2	2
belief10	Maths Lit ACE	15	-1.00	1.000	.258	-1.55	-.45	-2	1
	Maths GET ACE	24	-.79	.721	.147	-1.10	-.49	-2	1
	BEd Hon	26	-.50	1.208	.237	-.99	-.01	-2	2
	Total	65	-.72	1.008	.125	-.97	-.47	-2	2
belief11	Maths Lit ACE	18	-1.17	.985	.232	-1.66	-.68	-2	2
	Maths GET ACE	24	-1.00	.834	.170	-1.35	-.65	-2	2
	BEd Hon	27	-.85	1.134	.218	-1.30	-.40	-2	2
	Total	69	-.99	.993	.119	-1.22	-.75	-2	2
belief12	Maths Lit ACE	18	-1.61	.502	.118	-1.86	-1.36	-2	-1
	Maths GET ACE	24	-1.04	.908	.185	-1.43	-.66	-2	2
	BEd Hon	27	-1.11	1.188	.229	-1.58	-.64	-2	2
	Total	69	-1.22	.968	.117	-1.45	-.98	-2	2