AN EXPLORATION OF MATHEMATICAL LITERACY TEACHERS' PERCEPTIONS OF, AND PERFORMANCE IN MATHEMATICAL LITERACY TASKS BASED ON ALGEBRA

By

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ABSTRACT

Mathematical Literacy (ML) has only recently been introduced to learners, and research in South Africa concerning learners' conceptual understanding in ML is not widely available. However an important predictor of learners' success or difficulties in concepts is the success or difficulties that in-service teachers experience themselves. It is therefore important for us as mathematics educators to identify areas in Mathematical Literacy that teachers are struggling to learn and apply. With this in mind, the study sets to explore teachers' perceptions about, and performance in Mathematical Literacy tasks based on algebraic concepts.

This study is located within the principles of the qualitative research case study approach. The combination of data collection techniques has allowed me to identify broad trends across the group as a whole as well as differences within the participants of the group itself. The participants of the study were a class of 17 students who were completing the ACEML programme at UKZN.

Four sources of data were used. Firstly, data was generated from teachers' reflections about certain tasks, the solution of which required the use of algebra. A second data collection instrument was an open-form questionnaire and the third instrument was two unstructured interviews with two teachers. The final instrument was the analysis of the teachers' examination scripts. For this study, teachers from this group were classified along the lines of whether they were qualified to teach mathematics or not.

The theoretical framework for the study was derived from the OECD/PISA (2003) cycle of mathematisation which specifies 5 aspects of mathematisation, together with the theory of reification. For the purpose of this research, a participant was considered as a "mathematics specialist" if s/he studied mathematics up to tertiary level, while a participant was considered as "non-mathematics teacher" if s/he studied mathematics only up to Grade 12 level.

The findings reveal that although the teachers conveyed varying understandings of the ML curriculum, they believed that knowledge of basic algebra was necessary and adequate for them to deal with ML problems. Furthermore the teachers believed mathematical teaching experience contributes to improved problem solving in ML and that ‘practice and familiarity’ helped teachers improve their problem solving skills in ML. They also voiced a concern that the pace of the programme constituted a barrier to their success. Within the group, it was found that Mathematics specialist teachers performed better than the non-Mathematics teachers. All teachers found the mathematisation aspects of solving the mathematical problem and of reinterpreting the mathematical solution to make sense of the real-life problems, challenging, while the non-Mathematics teachers experienced problems with all five aspects of mathematisation.

The findings of the study suggest that teachers need help in moving from lower levels to higher levels of mathematisation. Opportunities for mathematical modeling experiences need to be incorporated in the part-time in-service contact courses like ACEML. Further research is needed to inform education authorities about whether the use of teachers with only grade 12 mathematical knowledge to teach ML is advisable.

DECLARATION

I AUBREY SIFISO VILAKAZI declare that

(i) The research reported in this dissertation, except where otherwise indicated, is my original work.

(ii) This dissertation has not been submitted for any degree or examination at any other university.

(iii) This dissertation does not contain other person's data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

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Mr A S Vilakazi
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Dear Mr Vilakazi

PROTOCOL: Exploring the impact of teachers' understanding of algebraic concepts in Mathematical Literacy
ETHICAL APPROVAL NUMBER: HSS/1009/2010 M: Faculty of Education

In response to your application dated 03 September 2010, Student Number: **202521961** the Humanities & Social Sciences Ethics Committee has considered the abovementioned application and the protocol has been given **FULL APPROVAL.**

PLEASE NOTE: Research data should be securely stored in the school/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

Professor Steve Collings (Chair)
HUMANITIES & SOCIAL SCIENCES ETHICS COMMITTEE

SC/sn

cc: Dr. S Bansilal (Supervisor)
cc: Mr. N Memela

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My sincere gratitude also goes to my mother Elizabeth Ncombi (MaCele) who has always been besides me, encouraging me to continue with the project. Finally, special thanks go to my sister Nokwethemba, and the rest of my family and my extended family members as well, for their continuous support.

ABBREVIATIONS

ML	**Mathematical Literacy**
KZN DoE	**KwaZulu-Natal Department of Education**
UKZN	**University of KwaZulu-Natal**
B Paed	**Bachelor of Paedagogics**
ACE	**Advanced Certificate in Education**
STD	**Secondary Teachers' Diploma**
PTD	**Primary Teachers' Diploma**
HDE	**Higher Diploma in Education**
OECD/PISA	**Organisation for Economic Co-operation and Development/ Programme for International Student Assessment**
MTE	**Mathematics Teaching Experience**
QL	**Quantitative Literacy**
NCS	**National Curriculum Statement**
RAND	**Developing a Strategic Research and Development Program in Mathematics Education**
RQ	**Research Question**
ZPD	**Zone of Proximal Development**
ZT	**Zone of Tolerance**
ZFI	**Zone of Feasible Innovation**
FET	**Further Education and Training**
CME	**Concerned group of Mathematics Educators**

DP	**Duly Performed**
SSMTE	**School of Science, Mathematics and Technology Education**
VAT	**Value Added Tax**
SA	**South Africa**
USA	**United States of America**
UK	**United Kingdom**
S1	**Statement 1**
DH	**Data Handling**
NO	**Numbers and Operations in context**
SAG	**Subject Assessment Guideline**
LPG	**Learning Programme Guideline**
C2005	**Curriculum 2005**

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CHAPTER ONE
INTRODUCTION AND OVERVIEW

1.1 Introduction

This study intends to explore teachers' perceptions with regard to their performances as they engaged with contextualised tasks of ML, and to examine their performance in Mathematical Literacy (ML) tasks based on algebra. The participants in this study were the in-service teachers who were enrolled at University of KwaZulu-Natal (UKZN) for the Advanced Certificate in Education Mathematical Literacy (ACEML) for the 2007 to 2008 academic years.

1.2 Introduction of ML in South Africa

Political changes in South Africa have resulted in reforms particularly, within its Department of Education (DoE). Responding to such reforms, the DoE introduced ML as a learning area in its curriculum. According to Christiansen (2007, p. 92), there are two main reasons to construct a ML school subject for South Africa. The one "was to reach the 200 000 learners leaving Grade 12 every year without mathematics and the 200 000 additional learners who fail mathematics yearly". Added to this was the failure of South African learners in international comparison surveys/tests. Christiansen notes that there are strong indications that adults who are innumerate are seriously disadvantaged in their employment possibilities, as a result widespread innumeracy is of both economic and social concern locally, nationally and globally. The other reason for an ML school subject was to teach learners competencies and knowledge which would be in line with overall intentions of the National Curriculum. According to Christiansen (2007), the intentions of the MLNCS are "proclaimed for improvement of living conditions, social justice and democracy". The following is the South African definition of Mathematical Literacy (ML):

> "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 2008a, p. 7).

The South African focus on equipping its citizens with ML skills is one that is shared throughout the world. Bowie and Frith (2006, p. 29) point out that "this idea that ML is mainly concerned with mathematics used in context is fundamental to all the definitions of mathematical literacy worldwide, whether it is seen as a social practice, form of literacy, a critical approach, or a behaviour (or even set of skills)".

1.3 Implications of ML for teacher training

Curriculum reforms in South Africa have meant that all learners in the FET phase are compelled to take either Mathematics or Mathematical Literacy. The unavailability of teachers, particularly those teachers with the potential to teach ML, compelled the KwaZulu-Natal Department of Education (KZNDoE) to extend an invitation to the teachers who are not qualified to teach Mathematics, but who have completed Mathematics up to Grade 12 as those ones to teach the subject. This has resulted in teachers being recruited for reskilling and retraining, for them to be able to implement this complex ML curriculum appropriately (Bishop & Vithal 2006, p. 2; Frith & Prince 2006, p. 52).

The University of KwaZulu-Natal (UKZN) responded to this call by the KZNDoE of retraining the in-service teachers by offering the ACEML course. This is an eight module course, which is offered over a period of two years (i.e. two modules are offered per semester). This is a part-time course where in-service teachers are expected to attend the compulsory contact sessions in order to meet the government regulations on notional time. Four out of eight modules are content based: Data Handling; Numbers and Operations in context; Functional Relationships; and Shape, Space and Measurement. These modules were offered in the centres of teachers' convenience and proximity viz. Empangeni, Ulundi, Ladysmith, Port Shepstone, etc.

During the process of recruiting teachers to teach ML, I however noted that among those recruited, there were also those who were qualified to teach Mathematics, but who preferred to take a Mathematical Literacy route for unforeseen reasons. That diversity in terms of algebraic experience indeed defined the cohort of ML in-service teachers. It therefore became of interest to observe the teachers' work along the lines of being either qualified or unqualified to teach mathematics.

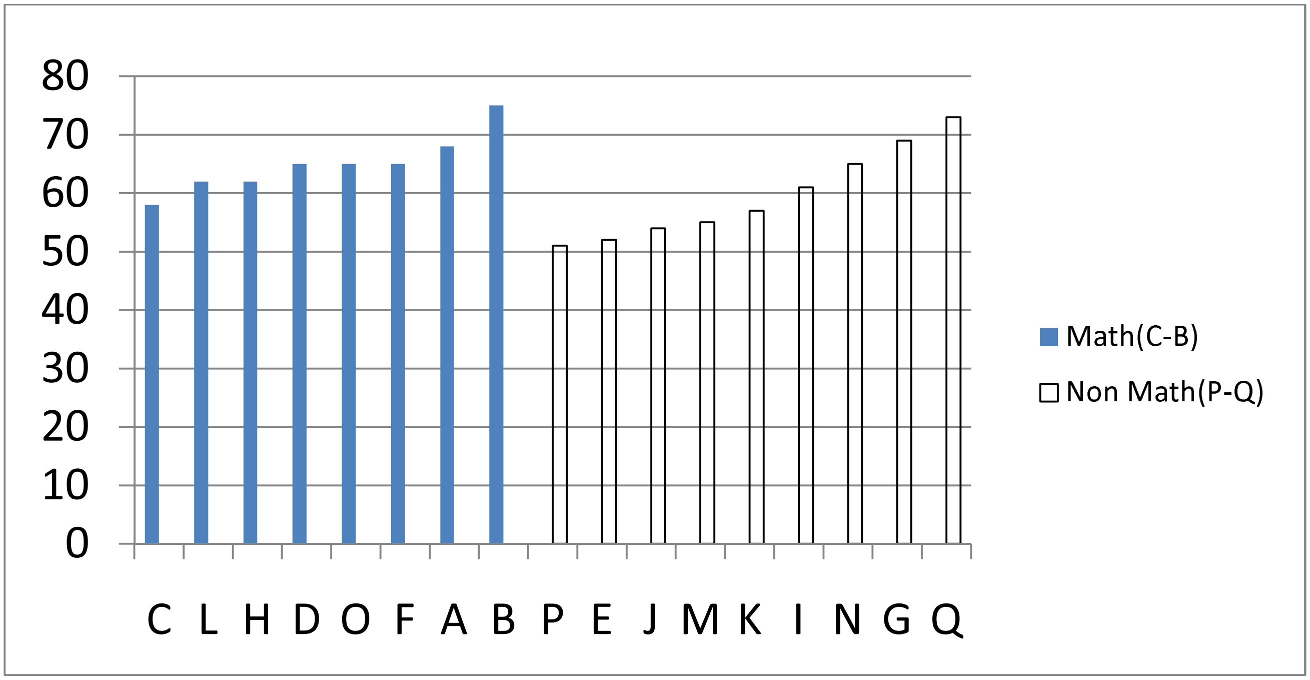
1.4 My personal experience in the project

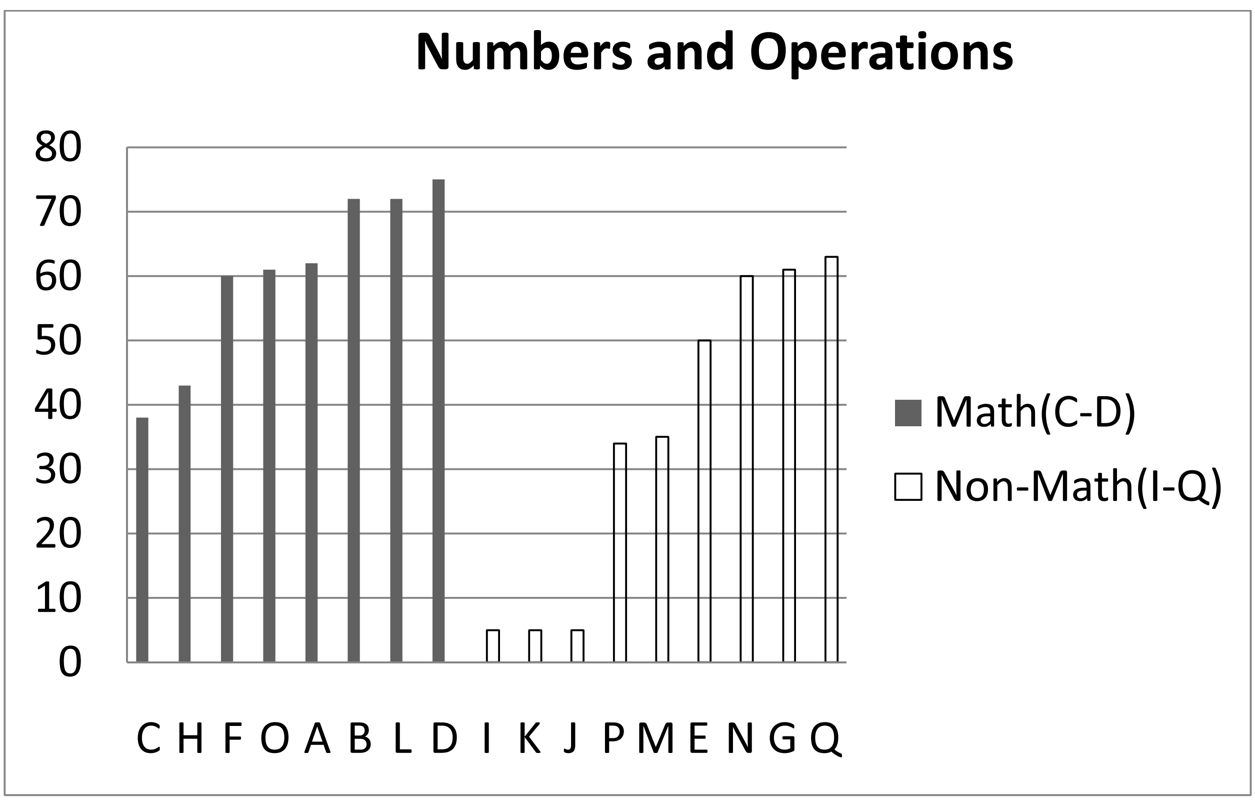
In the beginning of 2007, I was employed by the UKZN School of Mathematics, Science and Technology Education (SSMTE) as a ML tutor for one of the centres. At this time I was also beginning my studies towards the masters degree in Mathematics Education at UKZN. It took me only the first semester before I was moved to another centre. It was during this period where I developed an interest in focusing my research studies on ML as a requirement of the masters degree. I used the opportunity that I had to tutor to research advantage.

As tutors, we were given an opportunity to look at the final marks for all the teachers who were part of the group. I began to realise that some of the teachers did not perform well in the examination of the modules Data Handling; and Numbers and Operations in context, which were offered as the first year first semester modules. I began to explore the teachers' performance by looking at their biographical details, which led me realize that the mathematics specialists were seen to be performing better than the non-mathematics teachers. Table 1 shows the distribution of marks of the two modules Data Handling, & Numbers and Operations in context, where teachers are categorised into mathematics specialists; and non-mathematics teachers respectively.

TABLE 1: Graphical representation of one ACEML class in the modules Data Handling & Numbers and Operations as they appear in APPENDIX B.

Data Handling





From Table 1, one can deduce that mathematics specialists were performing better than the non-mathematics teachers in both Data Handling & Numbers and Operations modules. A question was raised as to what might be the underlying reasons informing such poor performance, especially in the case of the non-mathematics teachers. I began to think that perhaps one of the underlying causes of such poor performance might be the inefficient use of algebra. This I deduced, based on the fact that I had once been exposed to these modules, through the marking process and that they were indeed characterised by the predominant use of algebra.

From my experience as a Mathematics teacher, I have noted that the mathematics curriculum has been characterised and dominated by the use of algebra. This has been the case in the Mathematics Paper One, which is part of the Senior Certificate examination and consists mainly of algebra. In addition, for one to be successful in Mathematics Paper Two, s/he should have a sound background in algebra as well. Such algebraic dominance is no exception with Mathematical Literacy as its Learning Outcomes (LOs): Numbers and Operations in contexts, Data Handling, and Functional Relationships are characterised by the use of algebra as well.

It is now interesting to learn that teachers with just Grade 12 mathematics experience are recruited to teach Mathematical Literacy at the FET phase. It is my concern that in order to train to become an ML teacher (at UKZN); one needs only a Grade 12 background in mathematics. Yet the ML curriculum in school includes Algebra topics such as Linear Programming, which were traditionally not even included in the Grade 12 Standard Grade mathematics curriculum. "Word problems", as they are known in the world of traditional pure mathematics, referring to their nature of being context based, are defined by de Corte, Greer and Verschaffel (2000, p. ix) as "verbal descriptions of problem situations wherein one or more questions are raised, the answer to which can be obtained by the application of mathematical operations to numerical data available in the problem statement". Most problem-solvers - particularly the algebraically inexperienced teachers - were left without confidence in problem-solving. The difficulty was compounded by the fact that mathematics was embedded in the English language statement with the dire need for an educator to interpret the statement algebraically. In order to master such problem solving techniques the level of teacher insight - as well as their exposure, needed to be questioned.

Although many of the contexts used in word problems can be contrived, the skills and techniques used to translate English into Mathematical language (mainly algebraic), remain similar across different problems. I believe that such context-based problems in ML will also require similar techniques. Based on my personal experiences, my hypothesis surrounding the poor performance of in-service teachers in the modules of Data Handling (DH), and Numbers and Operations in context (NO) began to develop.

Teachers of this group emanate from different algebraic backgrounds. Some have been teaching mathematics and have studied mathematics post-Grade 12 (mathematics specialists) and others last studied mathematics during their years of schooling (non-mathematics teachers). I therefore believe those teachers who have been teaching mathematics and have studied mathematics post-Grade 12 should perform better for various reasons. One among many reasons is the fact that the previous mathematics curriculum was not completely non-contextualized - there were some bits of contextualized problems included in certain parts of the curriculum. Hence the mathematics specialists were to some extent exposed to contextualized problems as compared with the non-mathematics teachers.

Christiansen (2007) reasons as to why the SAML fails to perform. She argues that the curriculum is saturated by the myth of mathematics' utility to everyday practices, while the curriculum is largely organized around mathematics, thus pathologising and mythologizing the non-mathematical. She is therefore of the opinion that, "while new teachers of ML are in the pipeline, experienced teachers would have to either teach from what they know-it is most likely that existing mathematics and science teachers would feel positioned to do so- or would require retraining" Christiansen (2007, p. 100). This suggests that the mathematics specialists have an advantage over the non-mathematics teachers.

Furthering her argument Christiansen (2007, p. 101) suggests that "a teacher of mathematical literacy would have to know enough mathematics and enough about applications of mathematics, misuses of mathematics, and effects of using mathematics to further learners' awareness and understanding of the role that mathematics plays in the modern world". These arguments to a certain extent provide a simplistic understanding of why mathematics specialists are performing better than non-mathematics teachers.

This ACEML programme is delivered under tight time frames. This kind of delivery may have an impact on the learning of teachers - as they are adults. One needs to take note of the following considerations pertaining to adult learners, as suggested by Wlodkowski (1999, pp. 18-33). According to him, for teachers to participate meaningfully, one has to consider many issues. Firstly, there is the possibility that short-term memorisation of complex material may take older adults longer because they have to scan large stores of previously stored information to find proper associations. Secondly, older learners are likely to have the most problems with initial learning and subsequent recall when learning activities are fast paced, complex, or unusual. Thirdly, intellectual capacity during adulthood is a multidimensional combination of experience and knowledge that displays its continuing growth and highest potential in culturally relevant, real-life situations.

1.5 The Focus of the Study and the Research Questions

The focus of the study was to explore teachers' perceptions with regard to their performances as well as their actual performance in contextualised tasks of ML, based on algebra. The main question of this research project is "An exploration of Mathematical Literacy teachers' perceptions of, and performance in Mathematical Literacy tasks based on algebra". In trying to address the main research question, I felt the following four sub questions would be essential:

- Research Question One (RQ 1): What are the perceptions of the teachers in the group concerning the role played by mathematical content knowledge, when solving ML problems?
- Research Question Two(a) (RQ 2a): Was there a difference in performance between mathematics specialists and non-mathematics teachers, with respect to ML tasks based on algebraic concepts?
- Research Question Two(b) (RQ 2b): How can this difference in performance of RQ 2a) be explained?

- Research Question Three (RQ 3): What aspects of mathematisation were experienced as challenging by the whole group of teachers?

Further questions were also identified as a way of directly and indirectly addressing the main research question. These questions appeared on both the questionnaire (APPENDIX C) as well as on interviews (APPENDIX K), which are dealt with in chapter three of this research project. Two other contributions in this study were the extension to the taxonomy, and the breakdown of the aspects of mathematisation into skills needed at each stage of the mathematisation process.

1.6 The significance of the Research

There are numerous research findings about learners' difficulties with the various mathematical concepts covered at school level (e.g. Booth, 1990; Barnard, 2002; Alibali, Rittle-Johnson & Siegler, 2001; Bowie, 2000). Because ML has only been introduced to learners, research in South Africa concerning learners' conceptual understanding in ML is not widely available. However, I argue that the findings will not be too different from the findings in Mathematics research.

However, an important predictor of learners' success or difficulties in concepts is the success or difficulties that in-service teachers experience themselves. It is therefore important for us as Mathematics educators to identify areas in ML that teachers are struggling to learn and apply. In acknowledging the initiative by the DoE in reskilling educators, Frith et al., (2006, p. 52) share similar sentiments as they are quoted as saying, "in the same way that a teachers' mathematical content knowledge may be the most important predictor of learning in the mathematics classroom, so the development of mathematical literacy by school learners is likely to be most strongly affected by the availability of teachers who are highly mathematically literate themselves".

A further reason for researching teachers' understanding of the concepts is that, such findings will extend our knowledge concerning the issue of what knowledge teachers need in order to facilitate the learning of ML with their Grade 10-12 learners. With this in mind, the study sets out to explore teachers' perceptions with regard to their performances, and their actual performance in contextualised tasks of ML, based on algebra.

There is a dire need of drawing heavily on algebra due to the fact that in ML, to a greater extent, some contexts are contrived. According to du Fei (2001, p. 2) by contrived contexts he means where "contexts are invented to fit a particular mathematical point, irrespective of how appropriate these situations are to real life". These contexts are contrived because the mathematics used, although essentially straightforward, does not have a ready application in everyday life. This is a great challenge on its own, because some concepts in algebra have been dealt with as if they are context-free. This reality will bring about the great possibility of teachers resisting the shift from a mathematical approach to mathematical literacy approach. This possibility has also been noted by Bowie et al., (2006, p. 31) speaking in a mathematically oriented way – they hint that "the outcomes of ML are divided - it is therefore difficult for teachers who have been educated under a traditional mathematics curriculum (and many of whom may have also taught mathematics curriculum) to break away from the idea of doing some number work, some algebra and some graphs". In emphasizing the use of algebra, Jablonka (2003, p. 81) quoting Banu (1991) points that "mathematics is the most efficient tool to assist in resolving complex problems such as population growth, flood, which affect the day to day life of inhabitants of the country…however we do not have the properly trained teachers who can accept the challenge of the problems of science, technology waiting for mathematical modeling". From the South African perspective, I strongly agree with (Banu) for the following reason: Many of the teachers who opted to teach or retrain to become ML teachers were specialists in other fields. Hence ML will be taught by teachers who last studied mathematics at high school, during their schooling years, some of whom I believe could not continue with their choice of study because of difficulties that they may have encountered in learning mathematics.

I foresee an even bigger challenge of the implementation of ML, since it bases its foundation on the mastering of a basic knowledge of mathematics. I therefore believe that research of this nature has to be conducted in order to benefit both the South African Education Department, in terms of preparing the manpower to implement ML, as well as the community at large, whose citizens will ultimately be transformed to become mathematically literate.

1.7 Major Problems and Issues associated with the Research Project

My purpose is to conduct a study that will explore teachers' perceptions with regard to their performances, as well as their actual performance in contextualised tasks of ML, based on algebra. This is because I believe that such developments are going to dramatically impact on the mathematical literacy landscape that yet holds significant implications for the way in which algebra is utilized. The participants of this study are in-service teachers who are enrolled for the ACEML programme with UKZN. This study is focused on the teachers from group that I tutored. This group consists of the teachers who teach in the rural parts of the KwaZulu-Natal Province of South Africa.

There are however various issues which mark the limitations of this research project. This study focused on the 2.3% percent of the in-service teachers who were enrolled in the ACEML qualification. In fact it focused on one group (that I tutored) of 17 teachers among 25 groups of a total of 752 teachers, all with different tutors. Again, the group of participants has knowledge of one kind of denomination i.e. their knowledge is bound to unicultural experience. Only 17 teachers out of 752, who participated in the: administration of the questionnaires; scripts analysis; and the teachers' reflections. I, as the researcher, have been an ACEML tutor for the participants. The implications on the study of my double role (as tutor and researcher) could have unduly influenced them to say things they wanted me to hear, particularly in the interviews. Another huge limitation is the use of assessment tasks for research purposes. Examination stress might have affected teachers' responses which would not have been the case if they were responding to the research instrument. Even though the test items are designed for assessment purposes, I used it for research purposes as I found them providing the rich source of data.

CHAPTER TWO
LITERATURE REVIEW

2.1 What is Mathematical Literacy?

Throughout the world, there has been a recent thrust towards developing mathematical literacy skills in ordinary citizens so that they can use mathematics to make sense of data and information that appears in everyday life experiences. ML is defined by the Organisation for Economic Co-operation and Development/ Programme for International Student Assessment (OECD/PISA) as:

> "an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen". (Organisation for Economic Co-operation and Development/ Programme for International Student Assessment (OECD/PISA) 2003, p. 24)

According to OECD/PISA (2003, p. 24) citizens in every country are increasingly confronted with a myriad of tasks involving quantitative, spatial, probabilistic or other mathematical concepts. For example, media outlets are filled with information in the form of tables, charts, etc. PISA therefore believes that the subject ML will serve to ensure that once students complete their formal compulsory mathematics learning, they will be able to use their mathematical knowledge and understanding to face these societal demands. This notion of the use of mathematical knowledge is embodied in the term "mathematical literacy" as they suggest that it emphasizes mathematical knowledge put to functional use in a multitude of different situations in varied, reflective and insight-based ways. PISA believes that for such use to be possible and viable, a great deal of fundamental mathematical knowledge and skills are needed. Again, the term "to use and engage with" is meant to "cover using mathematics and solving mathematical problems, and also implies a broader personal involvement through communicating, relating to, assessing and even appreciating and enjoying mathematics". OECD/PISA (2003, p. 25)

In United States of America (USA), Quantitative Literacy (QL) is defined as:

> "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". Madison (2004, p. 10)

Thus, QL in the USA refers to a broad range of skills needed to deal with quantitative demands on its citizens, which were largely driven by the power of computers to amass and analyze data.

In United Kingdom (UK), numeracy is defined as:

> "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". Stoessiger (2003, p. 3)

The driving force is embedded in what they regard as being numerate; which according to Stoessiger (2003) "is to have and be able to use appropriate mathematical knowledge, understanding, skills, intuition and experience whenever they are needed in everyday life".

In South Africa the imperative to develop informed citizens has resulted in the introduction of ML at Grades 10- 12 which is the Further Education and Training (FET) band. The study of ML is deemed to be necessary for those learners who do not study the subject Mathematics in the FET band. For the South African government, ML is defined as:

> "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 2008a, p. 7).

This definition, as with a number of international descriptions of different literacy, specifies three elements: the content (mathematics), the contexts (life-related applications), and the abilities and behaviors that a mathematically literate person will exercise (confidence, thinking, interpreting, analyzing, and solving), as Bowie et al., (2006, p. 30) suggest. This means that these elements are intertwined, particularly the context and content. This mutual dependence of elements may lead to challenges in teaching and learning, the subject ML.

Madison (2004, p. 10) points to the difficulty experienced in the USA with regard to QL of the subject being rooted in its sophisticated uses of elementary mathematics and a concomitant immersion in extraneous, varied, and possibly confusing terminology. He believes using mathematics in multiple and unpredictable contexts require both an understanding of mathematical concepts and practice at retrieving and applying them. Speaking from a United Kingdom perspective, Stoessiger (2003, p. 3) believes that numeracy advocates the practical uses of mathematics. Furthermore, it is necessary to recognise that the ways in which we use numbers - why we use some particular numbers rather than others - as well as the language we surround them with, are both value-laden, dependant on their cultural contexts.

2.2 Training teachers to teach ML

The wide scale implementation of ML led to an associated challenge - that of finding teachers to teach the subject. The unavailability of teachers to teach the new school subject ML, led the education departments to find resourceful ways of dealing with the shortage. The KZN DoE together with the UKZN extended an invitation to the teachers who had studied mathematics up to Grade 12 but were not qualified to teach to be retrained as ML teachers. This re-skilling and retraining would enable them to implement the complex ML curriculum appropriately (Bishop et al., 2006, p. 2 and; Frith et al., 2006, p. 52).

The Faculty of Education at UKZN designed and offered two-year programme ACEML course to practicing teachers who wanted to develop skills that would allow them to teach ML at school level. The ACEML was set up in 2006 and is made up of 8 modules altogether. Two modules are devoted to core generic knowledge dealing with the school and the profession, teaching, learning, context, resources, etc. There are six modules designed and coordinated by the UKZN SSMTE (School of Science Mathematics and Technology Education) related to the teaching and learning of ML. Two of these are ML education modules that are related specifically to issues around the teaching of ML and are based on the philosophy and theories of mathematical literacy and reflective practice. Four other ML education modules are related respectively to the four generic ML outcomes, with the aim of developing the content knowledge of the participants.

The programme utilizes a mixed mode delivery over a period of two years (two modules are offered per semester). There are some points when the in-service teachers are expected to attend the compulsory contact sessions in order to meet the government regulations on notional time. The four content-based modules are: Data Handling; Numbers and Operations in context; Functional Relationships; and Shape, Space and Measurement. These were further divided into centres of teachers' convenience and proximity viz. Empangeni, Ulundi, Ladysmith, Port Shepstone, etc. Part of this study is based on students' responses to examination questions from the module Numbers and Operations in ML.

Programmes aimed at the professional development of practising mathematics teachers are essential for many reasons. Ball and Even (2009, p. 2) outline three reasons why practising teachers need a developed mathematics. Firstly, mathematics students' learning compels attention to teachers, and to what work of teaching demands. Secondly, no effort to improve students' opportunities to learn mathematics can succeed without parallel attention to their teachers' opportunities for learning. The third reason is that the notion of teacher education is rapidly expanding. In teaching reforms in USA, the Developing a Strategic Research and Development Program in Mathematics Education (RAND) Mathematics Study Panel (2001, p. 78) furthers this notion of development by suggesting the following focus areas, if teachers are to be developed for mathematical proficiency:

- develop teachers' mathematical knowledge in ways that are directly useful for teaching.
- develop teachers in teaching and learning skills for mathematical thinking and problem solving.
- and develop teachers in teaching and learning of algebra.

I find these reasons above relevant to this study as it is aimed at exploring teachers' perceptions about, and performance in ML tasks based on algebraic concepts.

There are many challenges experienced by teacher educators who design professional development programmes for practicing teachers. Firstly, the shortage of qualified mathematics teachers was noted by the RAND as a critical impediment towards the initiative of development (RAND 2001, p. xiv). This means that in the USA system of education there were imbalances in terms of the qualifications of teachers. These inequalities in teachers' qualifications mean inequalities in their knowledge base. It is therefore important to address the issue of teachers' knowledge base, because if in the process some teachers have a restricted view of proficiency and are not themselves proficient in mathematics, their efforts to improve their students mathematical knowledge may be limited (RAND 2001, p. 9). This is similar to the situation in South Africa as Clark and Linder (2006, p. 7) contend: "South Africa is a country with a system of educational provision that spans a wide range of contexts, staffed by teachers whose levels of pre-service training differ markedly, and whose experiences (and expectations) of teaching and learning differ in turn by extremes". Rogan (2008, p. 73) quoting Beeby (1966), comments that "in a system where many teachers, through no fault of their own, are either un- or under-qualified, some form of structure is necessary".

Rogan suggests three structures as collaboratively important in any educational change. Firstly, there is Vygotsky's Zone of Proximal Development (ZPD), which is described as "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance". Secondly, there is the Zone of Tolerance (ZT), which is defined as "the latitude or manoeuvability granted (or yielded) to the leadership of the schools by the local community". Critical in this research project is the third structure the Zone of Feasible Innovation (ZFI), which is defined by Rogan (2008, pp. 60-68) as the "structure that is concerned with the appropriateness of the innovation, taking into account the context as a whole, including, but not limited to, the teacher". ZFI is widely used in developing countries, as was the case in the introduction of Curriculum 2005 (C2005) in South Africa. I strongly agree with Rogan (2008, p. 73) as she points out that implementing ZFI in a top down manner has largely been unsuccessful in South Africa. One founding reason is the fact that in most cases, the policy-makers provide this structure (ZFI) while ignoring certain dimensions that come with it.

One important dimension that must be taken into consideration in any professional development programme, is the teachers' beliefs and feelings regarding the implementation. According to Clark et al., (2006, p. 7) when implementing curriculum changes, one needs to acknowledge that a teacher brings "to the task of teaching complex of beliefs, assumptions and experiences that collectively constitutes the 'educational situation' within which change occurs". In illustration of this statement, Johns (2008, p. 4) witnessed recently that the Concerned group of Mathematics Educators (CME) from the Western Cape (South Africa), embarked on action against the implementation of ML. They complained that the DoE should have spent more time and money on training and recruiting mathematics teachers before the implementation of the ML curriculum. This shortsightedness in planning by the DoE led van der Westhuitzen (2008, p. 143) quoting Carrim (2003) to predict that recent government attempts to improve the professional status of teachers through various policies would fail unless teachers' working conditions improved and teachers' sense of professionalism and autonomy "as well as their role to inform and formulate policies as much as their own rights as human beings within a democracy were emphasized". This is of great importance as Hattingh (2008, p. 54) points out that ignoring the local cultural values on which local pedagogical strengths are built will not enhance the reform agenda, especially in rural areas in the developing world.

Any planning of a professional development initiative also has to take note of the following considerations pertaining to adult learners, as noted by Wlodkowski (1999, pp. 18-33). Firstly, there is the possibility that short-term memorisation of complex material may take older adults longer because they have to scan large stores of previously stored information to find proper associations. Secondly, generally, older learners are likely to have the most problems with initial learning and subsequent recall when learning activities are fast paced, complex, or unusual. Thirdly, intellectual capacity during adulthood is a multidimensional combination of experience and knowledge that displays its continuing growth and highest potential in culturally relevant, real-life situations. This I believe may have diverse results, in that, on the one hand a highly experienced and exposed educator may perform better; and on the other the inexperienced teacher may fail to equal the experienced. Finally, this ACEML programme is run within fixed time constraints, that is, it is a conventional academic programme. I believe that any professional development programme must build in sufficient time for revision and the time frames for the delivery must be designed in a manner that allows teachers to consolidate the work that is learnt. In addition, the programme must take cognizance of the teachers' obligations to their jobs, families, social lives and other commitments, which may emanate from their diverse backgrounds.

In a study conducted at Rhodes University by Brown and Schafer (2006, p. 50), teachers were trained based on mathematical modelling and it was observed that "teachers with weaker mathematical skills took considerable longer to master the contexts and skills developed in these activities. This suggests that a teacher's level of mathematical skill is an important determinant of success". They further went on to admit that, "due to the pressure of time on the programme, it was not possible to include consolidation work that was appropriate for the less skilled teachers, for all the contexts considered" (Brown et al., 2006, p.51).

Because the context and content are intertwined in ML, this may present certain challenges. Steen (1999, p. 12) points out that "the test of quantitative literacy, as of verbal literacy, is whether a person naturally uses appropriate skills in many contexts. Teachers know all too well the common phenomenon of compartmentalization, in which skills or ideas learned in one class are totally forgotten when they arise in a different context. Students need to learn numeracy in multiple contexts". According to Steen "all teachers need to help students think of mathematics not just as tasks on school worksheets but as something that arises naturally in many contexts". He also points that "teachers need to broaden their goals to encompass more than just the narrow arithmetic-algebra track that has dominated USA mathematics programs. In particular, they need to vigorously develop several parallel and highly interconnected strands of quantitative thinking".

According to Meaney (2007, p. 1), ML is viewed as a set of ideas involving applications of mathematics to real-world contexts. However, his study reveals that the way in which the task is contextualised does affect the students' mathematical argument and therefore their perceived level of mathematical literacy. This idea is supported by Christiansen (2007, p. 101) as she emphasized that "should the mathematics teachers decide to make integration more relevant, however, they would have to possess a broad range of knowledge from other disciplines and practices". She further argues that, teaching mathematics for critical citizenship and/or in relevant applications as the MLNCS suggests, requires knowledge both in and outside of mathematics.

In a study conducted by Graven and Venkat (2008, p. 7) in Gauteng, three teachers from one school were given a similar ML task. It was however found that all teachers interpreted the task very differently, which is an indication that there exists a tension in relation to the relationship between the content and the context. This is a significant barrier towards the implementation of the subject ML, as some authors even claim that numeracy is "not less than or even part of mathematics, but something more than mathematics" being "the ability to situate, interpret, critique, use and perhaps even create mathematics context" (Bowie et al., 2006, p. 30).

Graven and Venkatakrishnan (2006, p. 5), noted some tensions in the implementation of ML in the South African classrooms. Some of these tensions suggest the difficulties faced by both the teachers as well as students, which are associated with the increased language and comprehension required by ML due to its more applied, contextualized and 'real-life' problem-solving nature. It is important for ML teachers to know about these difficulties which may be a result of certain misconceptions that are carried along from a mathematics perspective into ML. Thus the study seeks to elicit teachers' perceptions of some challenges of engaging with MLtasks. Bansilal and Debba (forthcoming) have identified specific demands related to the use of resources when solving contextualized tasks. These are:

- *context-specific terminology* which refers to phrases which hold a particular meaning within the context.
- *context-specific rules* which are rules that are bound to the context and need to be interpreted by the learner, within the context
- *context-specific reasoning* which is the reasoning, arguments or assumptions made about issues in the context.

Working from this notion, my study will be based on trying to understand some of the teachers' perceptions with regard to the content of ML. In the next section we will look at some of the implications of the wide scale implementation of ML.

Bansilal (2008) carried out a study on ML teachers' understanding of the concept of inflation by analysing the examination scripts of one class from the ACEML. The study revealed that students did not recognize which algorithms were appropriate for certain problems (Bansilal 2008, p. 11). It was also found that certain students may have used the appropriate procedures but were unable to judge whether they had completed the solution or not. This implies that some of the in-service teachers lacked procedural fluency. Bansilal and Debba (forthcoming) point some challenges of working with contextualised tasks. This one aspect of this study is to elicit perceptions of the teachers with respect to engagement with these contextualised tasks.

2.3 Skills and knowledge needed for success in ML tasks

The OECD/PISA (2003, p. 30) provides three components that describe the extent to which the problem-solver in Mathematical Literacy can handle mathematics in a well-founded manner when confronted with real-world problems.

- The first component is the *situations or contexts* in which the problems are located.

The situation is the part of the student's world in which the tasks are placed. In-service educators come to the course with diverse backgrounds of knowledge. Such knowledge might have been acquired either formally or informally. The diversity is also a product of the fact that they hail from diverse upbringings, as some are from rural areas while others are from urban environments. Hence, this diversity may lead to students giving the similar problem different locations. According to Meaney (2007, p. 1) "the context of the task affects what students perceive to be most relevant approaches to use, which are reflected in the arguments they give; this, in turn, affects external judgments of their level of mathematics". This argument also prevails in the study by Kotze and Strauss (2006, p. 44) where it was noted that "there were major differences between the nine provinces; between low and high socio-economic groups and between rural and urban schools. Again, particular characteristics were prevalent in certain provinces as well as differences between various groups emerged from the data". This notion signifies the importance of context at which one emanates towards his/her as Boaler (1993, p. 1) suggests that "the specific context within a mathematical task is capable of determining not only general performance but choice of mathematical procedure". South Africa is a multi-cultural country with culturally diverse classrooms. Such cultural diversity might also have an impact on the way people understand different contexts. Alro, Skovsmose and Valero (2007) share a similar view as they stress that "when students do mathematics, they have different ways of trying to see the meaning of what they are doing. This significance may be instrumental, daily-life life, expected work-practice, socio-political and historical significance as well as significance for critical citizenship". According to Alro et al. (2007), "naturally, we could expect other forms of significance to emerge from the background as well as from the foreground of the students. What might be daily-life significance or an instrumental significance for a group of students might depend on the context of the students" (Alro et al., 2007, p. 165). This cultural diversity will further encourage students to explore the cultures of the others. This is simple because contextual problems are neither culture-free nor culture bound, they emanate from everywhere and anywhere. According to Hall (2002, p. 1), "students in Multicultural Mathematics are expected to not only master the mathematics, but to make comparisons between cultures, to understand the differences between ethnomathematics and academic mathematics, and to explore the historical and cultural role of mathematics in society". Ethnomathematics refers to the type of mathematical thinking that is found outside what is traditionally considered 'mathematics'.

- The second component is the *mathematical content* that has to be used to solve the problems, organised by certain overarching *ideas*.

Mathematical concepts, structures and ideas have been invented as tools to organise the phenomena of the natural, social and mental world. However, in context-based situations, problems do not arise in ways that allow the logical application of content strands as they are in mathematics curriculum (OECD 2003, p. 34). The implication is, for the problem-solver in ML to be successful there is a need for knowledge acquisition in terms of the mathematical content, from within all the walks of life. Speaking from within the South African context, Christiansen (2007, p. 101) is of the same opinion as she suggests that "a teacher of mathematical literacy would have to know enough mathematics and enough about applications of mathematics, misuses of mathematics, and effects of using mathematics….develop in learners the ability to interpret practical situations using mathematical skills transferred from one context to another". This quote emphasises that teachers of ML need to go the extra mile since some contexts may be drawn from outside of the teachers' experiences.

- The third component is the *competencies* that have to be activated in order to connect the real world, in which the problems are generated, with mathematics, and thus to solve the problems.

Mathematical competencies are the mathematical processes that students apply as they attempt to solve problems. According to Kilpatrick (2001, p. 107), for students to be able to compete in a changing economy, they need to be able to adapt the knowledge they are acquiring - they need to be mathematically proficient. Kilpatrick (2001, p. 107) defines mathematical proficiency in terms of five separate but interwoven strands which are:

(a) *conceptual understanding*, which refers to the student's comprehension of mathematical concepts, operations, and relations;

(b) *procedural fluency*, or the student's skill in carrying out mathematical procedures flexibly, accurately, efficiently, and appropriately;

(c) *strategic competence*, the student's ability to formulate, represent, and solve mathematical problems;

(d) *adaptive reasoning,* the capacity for logical thought and for reflection on, explanation of, and justification of mathematical arguments; and

(e) *productive disposition,* which includes the student's habitual inclination to see mathematics as a sensible, useful, and worthwhile subject to be learned, coupled with a belief in the value of diligent work and in one's own efficacy as a doer of mathematics.

Because of the emphasis of this study on the performance of the teachers, it is necessary to consider how performance in ML can be judged. To do this, I examined the OECD/PISA descriptions of levels of proficiency. In assessing the level of achievement, OECD/PISA (2003, p. 54) provides a consolidated three levels of proficiency, where problem-solvers of ML can be located when dealing with context-based problems. The levels of proficiency are described as:

1. *Lowest proficiency level*: "students typically carry out single-step processes that involve recognition of familiar contexts and mathematically well-formulated problems, reproducing well-known mathematical facts or processes, and applying simple computational skills".
2. *Higher proficiency level*: "students typically carry out more complex tasks involving more than a single processing step. They also combine different pieces of information or interpret different representations of mathematical concepts or information, recognizing which elements is relevant and important and how they relate to one another. They typically work with given mathematical models or formulations, which are frequently in

algebraic form, to identify solutions, or they carry out a small sequence of processing or calculation steps to produce a solution".

3. *Highest proficiency level*: "students take a more creative and active role in their approach to mathematical problems. They typically interpret more complex information and negotiate a number of processing steps. They produce a formulation of a problem and often develop a suitable model that facilitates its solution. Students at this level typically identify and apply relevant tools and knowledge in an unfamiliar problem context. They likewise demonstrate insight in identifying a suitable solution strategy, and display other higher-order cognitive processes such as generalization, reasoning and argumentation to explain or communicate results".

Any discussion of mathematical skills and knowledge necessary for success in ML tasks is not complete without a discussion of the role played by algebra in the solution of such tasks. In order to attain mathematical proficiency, the problem solver has to be fluent in various algebraic procedures because algebra is the most commonly used tool employed to solve mathematical problems. Algebra is described as:

> "mathematical language that enables us to express generalisations, to investigate and describe patterns, relationships and procedures by appropriate manipulation. Algebra is also viewed as the language for investigating and communicating most of mathematics. Algebra can also be seen as generalised arithmetic, and can be extended to the study of functions and other relationships between variables" (Vermeulen 2007, p. 15).

Similar sentiments are also shared by Barnard (2002, p. 15) as he proposed that:

> "basically algebra illuminates the workings of mathematics and provides a means of understanding and explaining mathematical phenomena. He (Barnard) uses the analogy that algebra is a language. So, learning rules like $a^5/a^3=a^2$ is part of learning that language, and is as crucial to mathematics as correct spelling and punctuation is to English. Therefore, algebra is a universal language understood by everyone and without which, technology would not work".

Algebra is therefore considered in this study for two particular reasons. Firstly, algebra is regarded as "foundational in all areas of mathematics because it provides the tools (language and structure) for analyzing and representing quantitative relationships, for modeling situations, for solving problems, and for stating and proving generalizations" (RAND 2001, p. xx). The panel further argue that "algebra, and more generally the broad mathematical skills that algebra encompasses, are critical both to mathematical proficiency and to equity in the achievement of proficiency" (RAND 2001, p. 78). However "for years, algebra has created considerable difficulties for students and teachers alike" (Booth 1990, p. 13). I therefore believe that the similar tensions are also going to be experienced in mathematical literacy as well.

Secondly, problems in Mathematical Literacy are largely immersed in **context.** In the previous mathematics curriculum, problems of this nature were simple referred to as 'word problems'. Efficient use of algebra in this research is determined by the level of success of the in-service teachers – due to the fact that they engage with such problems. Engaging with word problems as has been discussed in the previous chapter, demands from the problem-solver a great deal of interpreting within and across different representations. Interpreting in mathematics involves writing, in most cases converting the English written statement into a mathematical statement. According to Ntenza (2004) citing Vygotsky, "writing requires particular demands from the writer who has to engage in the deliberate structuring of the web of meaning. For Vygotsky, this structuring is critical because writing could be seen as an extension of inner speech, which is maximally compact, whereas written speech is maximally detailed. Vygotsky strongly believes that "writing seems to increase the cognitive actions executed by students, and the inner speech is critical in the writing process" (Ntenza 2004, p. 14).

I end this literature review with a brief discussion of the role played by practice in attaining mathematical proficiency**.** According to Alibali, Rittle-Johnson and Siegler (2001, p. 346) "procedural knowledge is the ability to execute action sequences to solve problems and conceptual knowledge is an implicit or explicit understanding of the principles that govern a domain and of the interrelations between units of knowledge in a domain". In order to engage successfully in ML problems that necessitate the attainment of these strands of mathematical proficiency (procedural fluency and, conceptual understanding); I believe a great deal of ‘practice’ has to be encouraged. Van de Walle (2007, p. 69) looks at “practice” as referring to different problem-based tasks or experiences, spread over numerous class periods, each addressing the same basic ideas. He is of the idea that if learners are provided with ample and varied opportunities to reflect on or create new ideas through problem-based tasks, there is an increased opportunity to develop conceptual ideas and more elaborate and useful connections. The work by Chase and Mayfield (2002, p. 105) where they “compared three different methods of teaching five basic algebra rules involving some kind of practice, they found that cumulative practice of component skills is an effective method of training problem solving”. Again, the study conducted by Lovett and Rosenberg-Lee (2006, p. 4) did reveal that pure procedural practice does lead to improvements in conceptual knowledge.

2.4 Theoretical Framework

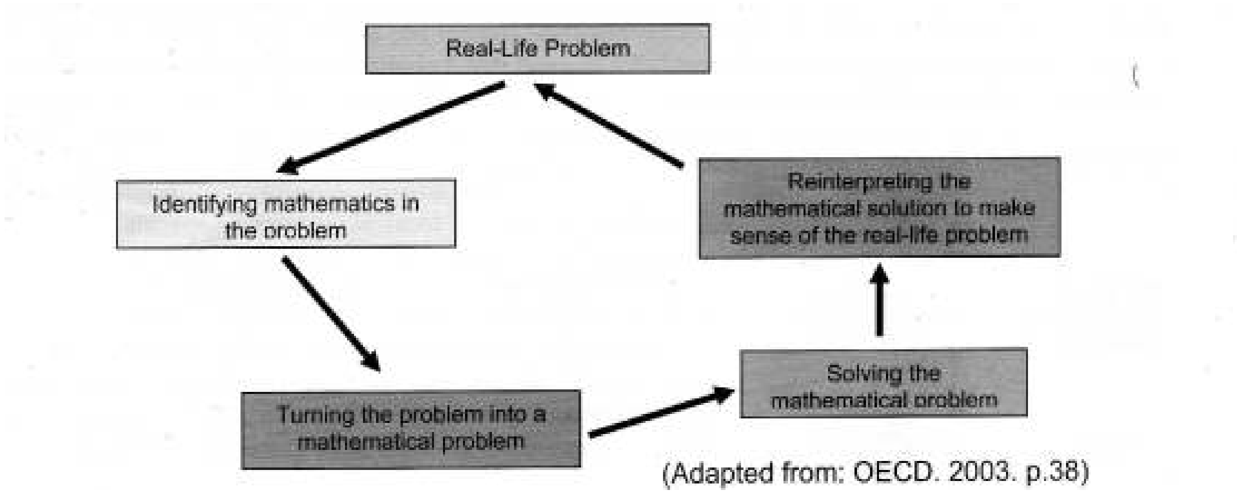
2.4.1 Mathematisation

Solving problems in ML requires a great deal of movement within various representations (verbal, algebraic, symbolic, and graphical). According to OECD/PISA (2003, p. 26) context-based problems can be solved by following the general strategy used by mathematicians, which the PISA mathematics framework - refers to as **mathematizing.** Mathematising can be characterized as having five aspects:

- Starting with a problem situated in reality.
- Organizing it according to mathematical concepts and identifying the relevant mathematics.
- Gradually trimming away the reality through processes such as making assumptions about what are the important features of the problem, generalizing and formalizing, which promote the mathematical features of the situation and transform the real-world problem into a mathematical problem that faithfully represents the situation.
- Solving the mathematical problem.
- Making sense of the mathematical solution in terms of the real situation, including identifying the limitations of the solution.

The way these steps work is explained in section 3.4.1 of Chapter 3 of this research.

Figure 1: Schematic Diagram showing the process Cycle of Mathematisation



Barnes and Venter (2008, p. 7) quoting Gravemeijer, Cobb, Bowers and Whiteneack (2000), define the "verb mathematising or its noun mathematisation as implying activities in which one engages for the purposes of generality, certainty, exactness and brevity". They further define mathematisation into horizontal mathematisation where "learners use their informal strategies to describe and solve a contextual problem; and vertical mathematisation that occurs when the learners' informal strategies lead them to solve the problem using mathematical language or to find a suitable algorithm".

However, they further point out that there is a challenge associated with mathematizing, in that "learning to mathematize occurs as a consequence of building on prior knowledge via purposeful engagement in activities and by discourse with other students". Therefore, in their view "student performance should be judged in terms of whether students are mathematically literate. This means information should be gathered about what concepts and procedures students know with understanding and how students can use such knowledge to mathematize a variety of non-routine problem situations".

It was apparent that the aspects of mathematisation were separate from the skills and demands listed in the SAML taxonomy tabled in Appendix H. I have taken each mathematisation aspect and broken it down into specific demands of the context or the mathematics, respectively. This is the framework we have devised for analysing students' engagement with the tasks. Section 4.5 of

Chapter 4 shows how this combination of skills was used in this study in identifying the strengths and weaknesses/challenges of the teachers. Figure 2 that follows shows how certain aspects of mathematisation are linked to certain mathematical or contextual demands that have to be attended to when working with tasks based on algebra.

Figure 2: Aspects of mathematisation as a process

Number	Aspect of mathematisation	Mathematical or contextual demands of the particular aspect of mathematisation
1	Problem situated in a real life context	Knowing definitions, rules or semiotic representation used in context
2	Organizing it according to mathematical concepts and identifying the relevant mathematics.	Knowledge of relevant mathematical concepts, and conditions under which a concept can be applied
3	Gradually 'trimming away' reality through processes such as making assumptions about what are the important features of the problem, generalizing and formalizing, which promote the mathematical features of the situation and transforming the real-world problem into a mathematical problem that faithfully represents the situation.	Making assumptions to render problem solvable. Identifying relevant process/formula or rule that is suitable. Deciding whether the problem requires a direct, inverse or multi-step approach. Formulating (if necessary) the required model or equations.
4	Solving the mathematical problem.	Carrying out the computation, correct substitution, simplification, algebraic manipulation, obtaining a solution (procedural fluency), conversion of units.
5	Making sense of the mathematical solution in terms of the real situation, including identifying the limitations of the solution.	Interpreting answer within the context, to see if the solution makes sense in the context. Engaging in contextual reasoning.

Due to the emphasis of the study on algebra, theories about concept development in algebra are useful. Accordingly, this study draws on the work of the following theorists – Dubinsky; Sfard; Tall; and Piaget, to help in understanding students' difficulties in algebra. Matos, Powell and Sztajn (2009, p. 168) quoting Little (1993), describe a training model for professional development, as a "model whose focus of activities is placed on the individual and the acquisition of new knowledge". According to Matos et al. (2009) professional development opportunities under the training model fit within what Linchevski and Sfard (1994) call the acquisition metaphor for learning. According to this metaphor, a person who learns something new is acquiring a new concept or procedure, which forms a unit of knowledge that can be "accumulated, gradually refined, and combined to form ever richer cognitive structures". Linchevski et al., (1994, p. 194) describe reification "as the ability of minds' eyes to envision the results of processes as permanent entities in their own right". Under this metaphor 'the permanence of *having* gives way to the constant flux of *doing*' (Matos et al., 2009, p. 169). According to Bowie (2000, p. 3) reification involves a qualitative shift in understanding which occurs when the student is able to detach the notion from the processes that produced it and see it as an object.

Parallel to Sfard's theory of reification, is Dubinsky's model of conceptual understanding (Dubinsky 1991, p. 167; Bowie 2000, p. 3). I am speaking in terms of the contextualised problem being interpreted by the problem solver using algebraic skills. The problem solver is then engaged in a process of manipulating the algebraic data with a view of solving the presented problem, which then leads to a solution which is the object. Finally, all happens to be stored on schema right there in the cognitive structure. There is therefore a certain degree of agreement between the two theories as Linchevski et al., (1994, p. 194) points that "mental entity building through reification of actions, procedures, and concepts into phenomenological objects, can then serve as the basis for new actions, procedures, and concepts at a higher level of organisation". This theory is relevant for this study as the context-based problems are to be solved through the use of algebra.

Tzur (2007, p. 275) takes on the theory by Piaget and von Glasersfeld who postulated that "a new mathematical conception is abstracted via a mental mechanism of reflection on activity-effect relationship". Tzur (2007) points that, this mechanism proceeds from learners' assimilation of problem situations into their available conceptions. In his context of assimilation and accommodation, Piaget speaks of cognitive structures or schema, which is categorised into three: a trigger, an action or reaction, and the consequence of the activity. According to Tzur (2007), "via their activity learners may notice differences between the anticipated result and the actual effects of the activity". Being able to engage in the mathematical processes meaningfully, as Linchevski and Sfard (1994) suggests, demands meaningful action and reaction. Hence the two theories just briefly discussed (reification and assimilation and accommodation) do concur with one another.

This notion of drawing from pre-existing knowledge is also pointed out by Piaget in his theory of constructivism as he proposed that "for intellectual development; knowledge is constructed as the learner strives to organize his or her experiences in terms of pre-existing mental structures or schemes" (Bodner 1986, p. 873). Linchevski et al., (1994, p. 191) share similar sentiments as they point out that, "the nature and growth of algebraic thinking is first analysed from an epistemological perspective supported by historical observations, and eventually, its development is presented as sequence of ever more advanced transitions from operational to structural outlook".

Also of paramount importance when dealing with context-driven problems is the notion of being able to associate between the concepts used in the problem, and the image the problem solver is creating within him/herself.. Tall and Vinner (1981, pp. 152-153) describe a theory on the concept image and concept definition, where the term concept image "describes the total cognitive structure that is associated with the concept, which includes all the mental pictures and associated properties and processes, whereas the concept definition is a form of words used to specify that concept". For each individual a concept definition generates its own concept image. This I believe, might be the case with the ML context, where the context-based problem lends itself to cognitive structures which were shaped from different origins, as Linchevski et al., (1994, p. 194) describe mathematics as a multi-level structure where basically the same ideas are viewed differently from different positions.

Finally, as I have defined the word problems as dominating the ML activities, it is vital that the problem-solver has the mobility of moving within the different representations. Leikin and Levav-Waynberg (2007, p. 350) proposed the theoretical assumption that the essential part of mathematical understanding is subject to the problem-solver's ability of making mathematical connections, including connections between different mathematical concepts, their properties, and their representations. This ideal can only be realised if the students are encouraged to interact with mathematical problems both instrumentally and relationally. The study by Battey, Carpenter, Franke, Jacobs and Levi (2007, p. 260) found relational understanding as a powerful, unifying idea for engaging teachers in conversations that support their use of algebraic reasoning. By relational understanding, Skemp means, "an in-depth and adaptive understanding of a mathematical concept that goes beyond mere application of rules to arrive at answers, whereas instrumental understanding means 'rules without reason'" (Skemp 1979, p. 259; Hobden 2009, p. 20). Both relational understanding and instrumental understanding are critical for progress in learning mathematics.

CHAPTER THREE
RESEARCH METHODOLOGY AND DESIGN

3.1 Introduction

This chapter will introduce detailed discussion of the research methodology adopted. These discussions include the context at which the study was focused; the design within which the research was located; the data collection instruments; data analysis; trustworthiness criteria; ethical considerations, as well as the limitations of the study.

3.2 Context of the Study

The KwaZulu-Natal Department of Education (KZN DoE) in collaboration with the UKZN, embarked on a programme (in 2007) of reskilling teachers in Mathematical Literacy from the whole province. A number of centres under the University of KwaZulu-Natal were identified throughout the province. This study was focused on one of the ten centres - the centre that comprised of teachers from the rural part of KwaZulu-Natal Province of South Africa. Teachers from this centre generally teach in schools that are within and around Ulundi and Nongoma areas in the Vryheid District.

For this study, teachers from this group were classified along the lines of whether they were qualified to teach mathematics or not. For the purpose of this research, a participant was considered as a "mathematics specialist" if s/he studied mathematics up to tertiary level, while a participant was considered as "non-mathematics teacher" if s/he studied mathematics only up to Grade 12 level. The focus of the study was centered on exploring teachers' perceptions with regard to their performances as well as their actual performances in contextualised tasks of ML, based on algebra. The topic of this research project is "An exploration of Mathematical Literacy teachers' perceptions of, and performance in Mathematical Literacy tasks based on algebra ". In trying to address the main research question, it was necessary to develop the following four sub questions:

- Research Question One: What are the perceptions of the teachers in the group concerning the role played by mathematical content knowledge, when solving ML problems?

- Research Question Two(a): Was there a difference in performance between mathematics specialists and non-mathematics teachers, with respect to ML tasks based on algebraic concepts?
- Research Question Two(b): How can this difference in performance of RQ 2(a), be explained?
- Research Question Three: What aspects of mathematisation were experienced as challenging by the whole group of teachers?

Further questions were also identified as a way of directly and indirectly addressing the main research question. These questions appeared on both the questionnaire, as well as in interviews which are dealt with in the later parts of Chapter 3.

3.3 Research Design

Different researchers have a variety of research approaches as is attributed to what Elizabeth Henning (2004, p. 1), describes as the foundations of research traditions. Research traditions are founded on the researchers' beliefs and intra-questions, which include the questions of ontology; epistemology; as well as those of methodology. Engelhard (1991, p. 1) shares similar sentiments as she suggests that:

> "Different research traditions imply different assumptions and different ways of viewing measurement and social science research. The problems selected for study, the statistical models used to analyze the data, the results of the inquiry and the policy implications drawn from the research depend on the measurement models used".

This study consists of an interpretive type of research. Although some quantitative data was gathered in the form of the questionnaires and script analysis, the data was used to complement and supplement the other qualitative data sources (the interviews). "Interpretive researchers start out with assumption that access to reality (given or socially constructed) is only through social constructions such as language, consciousness and shared meanings). This kind of research does not predefine dependent and independent variables, but focuses on the full complexity of human sense making as the situation emerges" (Maree & van der Westhuizen 2007, p. 3). They further point out that an interpretive framework has potential as it requires going into participants' natural setting and experiencing the environment in which these participants create their reality. I found the particular approach of engaging teachers in reflections as being relevant in my study, where my intention was to find meaning within social interactions as the participants were interacting with the context through problem solving.

Within the interpretative paradigm, I opted to utilize a case study approach. According to Nieuwenhuis (2007, p. 75) the term "case study" can be used to describe a unit of analysis (e.g. a case study of a particular organization) or to describe a research method. Yin (2003, p. 13) agrees as he describes a case study as "an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when boundaries between phenomenon and context are not clearly evident". Guba and Lincoln (1988, p. 370) offers an extended definition as she defines the case study as "an intensive or complete examination of a facet, an issue, or perhaps the events of a geographic setting over time". The case in this study is the group of 17 teachers who enrolled at UKZN for the ACEML course. This study sought to explore teachers' perceptions about, and performance in ML tasks based on algebraic concepts. I therefore found the case study methodology being relevant in this study as the theoretical framework stresses the significance of context in problem solving.

For the three data collection methods (reflections; questionnaire; and scripts analysis) to be discussed later, I adopted the convenience sampling method. Maree and Pietersen (2007a, p. 177) point out that this sampling method is only used based on the fact that the elements of the study are easily and conveniently available. I therefore engaged the whole group of teachers as participants of the study, because these were the participants that were available to me. The participants of my study were the original 19 teachers comprising one class of the ACEML students. Initially 19 scripts were used to check the performance of teachers on all 4 modules. During the research process, the number of participants changed - from 19 the number dropped to 14. Two teachers dropped out, so only 17 participants participated in the filling of the questionnaires. Three teachers did not get a DP (Duly performed - meaning permission to write the examination) hence the 14 scripts for the 14 teachers that remained were subjected to the script analysis. My aim was to gather the adequate data to be confirmed through the interviews.

For the process of interviews, I embarked on a purposive sampling using section A of the questionnaire. Section A of the questionnaire required the biographical information of the participants. This information was used as guiding tool towards identifying the participants for the interviews. According to Maree et al., (2007a, p. 178) purposive sampling is the method of sampling used in special situations where the sampling is done with a particular purpose in mind. Purposive sampling was critical in this case, as the group of teachers was divided along the lines of being either in a possession of a mathematics teaching qualification or without. My aim was to engage in detailed interviews with two teachers: one a mathematics specialist; and the other a non-mathematics teacher.

3.4 Data Collection Instruments

The use of multiple methods or a multi-method approach in the social sciences is "an attempt to map out, or explain fully, the richness and complexity of human behaviour by studying it from more than one standpoint" (Cohen, Manion & Morrison, 2007, p. 141). Hence, the study utilized four data collection instruments viz. teachers' reflections; questionnaires; semi-structured interviews; and scripts analysis. The multiple instruments employed in this study locate this study within the qualitative paradigm.

> "qualitative research is a research that attempts to collect rich descriptive data in respect of a particular phenomenon or context with the intention of developing an understanding of what is being observed or studied" Nieuwenhuis (2007, p. 50).

3.4.1 Teachers' Reflections

Firstly, the whole group (17 participants) of in-service teachers on the ACE course were asked to reflect on what was driving their thinking as they engaged on a task taken from the module Shape and Space which required the use of algebra. The task appears in APPENDIX C. This kind of reflection was expected to be in the form writing, with in-service teachers deliberating on what was driving their thinking as they engaged on the tasks. The reflections were analysed qualitatively. The reflective practitioner-the true expert in the field, is described by NVORWO Commission (1995, p. 18) as someone who is both engaged in practice and, at the same time, can articulate exactly what she/he is doing and thinking. Hatton and Smith (1995) describe reflection as a reflection-in-action, which is our 'on the spot experimentation' where teachers think and respond moment-to-moment as needed in the teaching of a lesson. This is where they show an ability to think on their feet in responding to the challenges of the unexpected that the dynamics of the classroom bring at them. Four levels of reflection are described as follows:

- descriptive writing (reports on events with no reason given for events);
- descriptive reflection (providing reasons based on personal judgement);
- dialogic reflection (a form of dialogue 'talking' with oneself and explaining your actions by referring to particular educational theories); and
- critical reflection (where we justify our actions on the basis of broader historical, social, political contexts).

I found the reflections of teachers to the task relevant to this study for one particular reason. The task embraced a real-world problem, the kind of problem envisaged in ML. A real-world problem invites the problem-solver to engage in the process of mathematisation. These reflections enable the researcher to gain a better understanding about how the problem-solver perceives the dynamics of engaging (performing) in the problem. I use the explanation made by North (2008, p. 33), in his 'Mugg and Bean' activity, to explain my task:

- the real-life problem is about tiling the pools (one rectangular; and the other, circular); as well as fencing the pool (circular).
- the mathematics inherent in the problem involves: surface area; conversion of units of measurement from cubic metres to litres; formulation of ratio: in determining the number of tiles; the amount needed for the tiles, as well as that of the fence.
- to help the problem-solver to make sense of the problem, separate rough drawings of each walls of the pools should be drawn.
- to solve the mathematical problem, the problem-solver will calculate the surface area of all the walls of the pools. S/he will then divide the total surface area of the pool by the area of each tile to achieve the number of tiles needed. He will also formulate the ratio to determine the number of boxes of tiles needed.
- because this is a real-world problem, if it happens that the mathematical solution provides a decimal answer, then the problem-solver will need to realise that it is sometimes not

possible to buy a decimal number of goods and that he will have to round up to the nearest number of tiles; or number of boxes.

3.4.2 The Open-Form Questionnaire

The reflecting-on-a-task exercise was followed by the administration of the questionnaire to all members of the class. The questionnaire used appears in APPENDIX E. Prior the teachers' engagement in the questionnaire; the informed consent form was revisited. This visit was done as a way of reminding the whole group (17 participants) of in-service teachers that their participation is still solely on their will. An open-form questionnaire was used. This questionnaire consisted of questions that were aimed at probing the teachers' perceptions on how their mathematical algebraic background knowledge; their mathematics teaching experience; and their use of algebraic knowledge in ML impact on their performance.

Van Dalen (1979, p. 155), is of the idea that rather than forcing respondents to choose between rigidly limited responses, the open-form questionnaire permits them to answer freely and fully in their own words and their own frame of reference. Furthermore, this method of collecting data gives the subjects an opportunity to reveal their motives or attitudes and specify the background or provisional conditions upon which their answers are based. Cohen et al., (2007, p. 158) highlight some advantages of the questionnaire over the interview. They are of the idea that a questionnaire is more reliable; it also encourages greater honesty since it is anonymous; it is more economical in terms of time and money. Maree and Pietersen (2007b, p. 161) further view the use of the open-form questionnaire as being vital in that thematic analysis of responses does yield extremely interesting information, categories and subcategories since complex questions are adequately answered. The notions of validity and reliability are conserved as well (Cohen et al. 2007, p. 133).

However, according to Mouton (2008, p. 103) research has shown that there are common errors in designing the questionnaire. For example, in the case of this study some teachers responded to the questionnaire as if 'adequate' and 'necessary' are synonymous. Furthermore, if subjects are not highly literate and willing to give considerable time and critical thought to questions, they cannot provide useful data (Van Dalen 1979, p. 155; Cohen et al., 2007, p. 158 and; Maree et al. 2007b, p. 161).

The information gathered from section A of the questionnaire revealed that teachers were practicing at the rural schools. This was important information in that, according to norms and standards, a school in an urban area is said to benefit from better resources, as compared to those in rural areas, added to which, the learners and teachers from an urban school are significantly more exposed to technology as compared to those from the rural areas. Section B and section C of the questionnaire, as they appear in APPENDIX G, intended to elicit the responses on the perceptions of teachers about the use of mathematical knowledge in addressing the context-based problems of ML. The information obtained from these sections would be supplemented through the interviews.

3.4.3 Semi-Structured Interviews

Two participants were subjected to semi-structured interviews. The interview questions appear in APPENDIX K. One participant was an educator with a Grade 12 algebraic mathematics background, and the other of post-Grade 12 mathematical backgrounds. The interviews were only semi-structured to allow for open-ended responses. Such an interview is flexible, and allows the interviewer to go into more depth if she desired, or to clear up misunderstandings. It also encourages cooperation and helps establish rapport (Cohen et al., 2007, p. 357). This kind of interview was used in order to gain a better understanding about the teachers' perceptions on how their mathematical algebraic background knowledge; their mathematics teaching experience; and their use of algebraic knowledge influenced their performance in the ACE examination. According to Kurdziel and Liberkin (2002, p. 198), interviews elicit qualitative data. This kind of interview allowed me to achieve the same level of knowledge and understanding as those of participants as Henning (2004, p. 75) suggests. Again, according to Henning (2004, p. 6) interviews "elicit thick data, which is the kind of data that gives an account of the phenomenon that is coherent; giving more than facts and empirical content; as well as interpreting the information in the light of other empirical information in the same study as well as from the basis of a theoretical framework that locates the study".

The interviews were conducted on different days for different participants. Both interviews were tape-recorded with all ethical issues taken into consideration during the course of the interview as per informed consent agreement.

Teacher 1 (non-Mathematics Teacher)

This is the teacher whose biographical details indicate that she has only Grade 12 mathematics experience. The interview with her was held at the Centre I normally used for contact sessions. The place was agreed to by both the participant and myself as being accessible and comfortable. This interview lasted for about forty-five minutes. It was tape-recorded as per agreement in the informed consent documentation.

Teacher 2 (Mathematics Specialist)

This teacher had a tertiary mathematics qualification with experience in teaching algebra at the FET phase. Her interview was held at her home, which was the place that was most comfortable to her. This interview lasted for about forty minutes, enough time to elicit some in-depth data. This interview was tape-recorded as per agreement in the informed consent documentation. The transcribed interviews for both participants appear in APPENDIX L.

3.4.4 Scripts Analysis

Finally, in order to find the possible answers to the questions tabled in section 3.2, the examination scripts for the four modules: Data Handling, Functional Relationships, Numbers and Operations in context, & Shape, Space and Measurement, were analysed. The analysis of scripts appears in APPENDIX I. I categorised the questions from the examination papers according to the above levels. My focus was only on the questions that necessitated the use of algebra. My intention behind analysing the scripts was to identify how the teachers engaged in the ML tasks based on algebra, and how this was related to their performances.

To determine the level of cognitive demand at which assessment tasks are posed, it is useful to use a hierarchy or taxonomy. Effort was made such that these questions were categorised according to the taxonomy levels of SAML school subject. The DoE designed and introduced an assessment taxonomy that could be used to classify the cognitive demand of tasks. The SAML school subject taxonomy was derived from the PISA (Programme for International Student Assessment) Assessment Framework (OECD, 2003) which provides a possible taxonomy for assessment of ML based on what it calls *competency clusters.* Another contribution was derived from the TIMSS (Trends in Mathematics and Science Study) Assessment Framework (IEA, 2001) which provides another taxonomy, based on cognitive domains (DoE 2008b, p. 8). The Mathematical Literacy Subject Assessment Guideline (MLSAG) taxonomy is described below:

- Level One: Knowing
- Level Two: Applying routine procedures in familiar contexts
- Level Three: Applying multi-step procedures in a variety of contexts
- Level Four: Reasoning and reflecting

When I analysed the taxonomy I found that it was not exhaustive enough, in that some of the skills and techniques needed to be applied in answering the ACE ML question paper, were not covered. Consequently I added some of the skills to all the levels in order to meet the needs of ACE ML question paper of the module Numbers and Operations. The revised taxonomy appears in Appendix H. The portions that I added are represented in italics.

3.5 Data Analysis

The data gathered from the reflections, scripts analyses, questionnaires, as well as the interviews were to be analysed in different ways and further discussed with the Supervisor to see if it attempted to answer the identified questions. At first, I had to analyse by identifying if there were any themes derived from the teachers' reflections on the task. This was to be followed by the analysis of the teachers' responses from the questionnaires. I grouped the teachers' responses according to the similarity of items they provided. This was done in order to identify themes that could be derived from the teachers' responses. Thirdly, the detailed analysis was done on the responses from the interviews. Again the intention of the exercise was to identify if there were any themes arising from the teachers' responses. Finally, the a rudimentary quantitative analysis of the teachers' examination scripts was conducted in order to discover whether there might be any supporting information that could supplement the data gathered from the other sources. This exercise was quantitative in nature because I categorised the teachers' responses on the basis of comparisons of their marks when expressed in terms of a percentage. However, this calculation was not intended for generalization, but only for identifying differences in performance in particular items, across the two groups (mathematics specialists and non-mathematics teachers). The data was analysed in the following ways: (i) the average performance of both groups was identified; (ii) these performances were further analysed using the assessment taxonomy levels; (iii) these performances were again viewed in terms of the aspects of mathematisation process; and (iv) these performances were finally viewed in terms of the mathematical demands. The detailed analysis appears in section 4.5 of this thesis. By engaging in this multi-method approach, it was hoped that the adequate data might be elicited to help answer the questions in section 3.2 of this research. Cohen et al., (2007, p. 141) are of the similar idea as they suggest that "the use of multiple methods or multi-method approach in social sciences attempt to map out or explain fully, the richness and complexity of human behavior by studying it from more than one standpoint".

3.6 Trustworthiness Criteria

To ensure the validity and credibility of the findings in this research, "the methods for collecting data will be triangulated in order to determine if there are any discrepancies in the findings" (Maree 2007, p. 297; Maree & Pietersen, 2007a, p. 33; Guba et al., 1988, p. 186 and; Nieuwenhuis 2007, p. 80). Cohen et al. (2007, p. 141) defines triangulation as "the use of two or more methods of data collection in the study of some aspect of human behavior". According to, de Vos (2006, p. 361), the concept of "triangulation is based on the assumption that any bias inherent in a particular data source, investigator and method would be neutralised when used in conjunction with other data sources, investigators and methods". de Vos (2006, p. 360) advocate the use of multiple methods in that the phenomenon investigated in the social sciences are so enmeshed that a single approach can most certainly not succeed in encompassing human beings in their full complexity.

The instruments used were teachers' reflections; questionnaire; semi-structured interviews; and scripts analyses. Cohen et al. (2007, p. 143) are of the opinion that "triangular techniques are suitable when a holistic view of educational outcomes is sought, or where a complex phenomenon requires elucidation". Furthermore, triangulation is useful when an established approach yields a limited and frequently distorted picture. Here one approach will be able to

justify the other approach. Kurdziel et al., (2002, p. 80) agrees, in that the use of multiple data sets can inform the research, yielding insight and methodological changes that improve the study and strengthen findings. Again, this idea is supported Cohen et al. (2007, p. 143) as he points out that "triangulation can be useful technique where a researcher is engaged in a case study".
Furthermore, credibility was ensured through the prolonged engagement by myself at the site of inquiry. Guba and Lincoln (1989, p. 237) are of the view that "substantial involvement at the site of the inquiry, in order to overcome the effects of misinformation, distortion…build the trust necessary to uncover constructions, and to facilitate immersing oneself in and understanding the context's culture". I satisfied this criterion of prolonged engagement through the use of multi-instruments in the research site.

During the research process, the study was continuously submitted to the study Supervisor for cross-examination in order to confirm or clarify issues that arose. Nieuwenhuis (2007, p. 80) is of the similar idea as he suggests that involving several investigators or peer researchers to assist with the interpretation of the data could enhance trustworthiness. Both the confirmability and the reliability of the findings were ensured by the use of verbatim accounts. This means that data can be tracked to its source, and that the logic used to assemble the interpretations into structurally coherent and corroborating wholes is both explicit and implicit. Thus both the "raw products" and the "processes used to compress them" are available to be inspected and confirmed by outside reviewers of the study as suggested by Guba et al., (1989, p. 243).

3.7 Ethical considerations

A letter was forwarded to the UKZN ACEML Programme Coordinator requesting the following regarding the ACE in-service educators: to analyse the examination scripts for the ACE in-service teachers; to engage teachers on an extra tasks for reflections; to engage teachers on a questionnaires; and to interview teachers.

The participating teachers were then made to scrutinise the informed consent documentation, the contents of which were further discussed with me with the aim of bringing to the attention of the participants how vital the exercise was. The use of the informed consent in this research was aimed at sharing openly with participants about the research goals, the process and the outcomes.

Furthermore, "informed consent ensures the full knowledge and cooperation of subjects, while also resolving, or at least relieving, any possible tension, aggression, resistance or insecurity of the subjects" (Strydom 2006, pp. 57-60). In this regard participants become part of the research as they are to perceive its validity.

The research process then progressed by:

- Engaging teachers in the reflective tasks, where they were expected to respond and reflect.
- Discussing the questionnaire and assisting teachers in responding to it.
- Identifying the interviewees and negotiating the interview dates with the interviewees which were audio-taped.
- Engaging in the analysis of the teachers' ACEML examination scripts.

3.8 Limitations of the study

The purpose was to conduct a study that will explore teachers' perceptions with regard to their performances as well as their actual performances in contextualised tasks of ML, based on algebra. This is because it is believed that such developments are going to dramatically impact on the mathematical literacy landscape, yet holding significant implications for the way in which algebra is utilized. The participants of this study are in-service teachers who are enrolled for the ACEML with UKZN.

However, there are various issues that mark the limitations of this research project. This study focused on the 2.3% percent of the in-service teachers who were enrolled in the ACEML qualification for the academic years 2007 and 2008. In fact it focused on one group of 17 in service teachers among 25 groups of a total of 752 teachers, with different tutors, for teachers' reflections; scripts analysis; and questionnaires. Henning (2004, p. 6) asserts that the data gathered using this method only provides the thin description of the phenomenon. This limitation impacted a great deal on the generalization of the data. It would have been of interest if the whole cohort of teachers was made to respond to the questionnaire. Therefore one cannot be certain that all the teachers in the ACEML cohort would have viewed algebra the same way as the ones that were engaged in this study.

Again, the differences observed between the mathematics specialists and non-mathematics teachers may not be applicable to the other students from the group. This claim is based on the fact that participants of this group had a mono-cultural kind of knowledge. Another limitation might have arisen from the fact that the researcher was their tutor. They might have felt compelled to respond to me in a manner they felt would be considered by the researcher to be most appropriate. However I managed to minimize this limitation by always revisiting the informed consent documentation to ensure that they felt as free as possible to respond as they wished. Some of the differences may also be explained by other factors such as difference in schooling, quality of tutor teaching, commitment to their work, increased used of language, etc. however this study has a focus on one particular factor - the use of algebra.

Scripts were analyzed using the modified SAML taxonomy. Romberg (1985, p. 1) speaking from the Washington context, argues that "the existing instruments commonly used to judge student performances in mathematics were not designed to assess mathematical literacy". He goes on to say that "at best these tests measure a student's knowledge of some of the 'design features' associated with mathematical literacy. Also, it is questionable as to whether such instruments measure an understanding of such features. None makes any serious attempt to assess study".

This study adopted the use of a multi-instruments approach. This was done with the aim of identifying whether the different data sources would complement each other. McLaughlin and Mertens (2004, p. 106) strongly oppose this notion of triangulation, pointing out that its use in research implies that it is possible to find consistency across sources, which contradicts the notion of multiple realities.

Another huge limitation is the use of assessment tasks for the research purposes. Examination stress might have affected teachers' responses which would not have been the case if they were responding to the research instrument. Even though the test items are designed for assessment purposes, I used it for research purposes as I found them providing the rich source of data.

3.9 Conclusion

The data collected from the reflections; responses from the questionnaires; interviewing; and analysis of scripts, of the participants, provided a better understanding of the impact the educators' basic mathematical knowledge may have when engaging with contextualized tasks of ML. The findings from this exercise will be dealt with, and discussed in details in the Chapter 4.

CHAPTER FOUR
RESULTS AND ANALYSIS

4.1 Introduction

Presented in this chapter are the findings from the data gathered using the methods mentioned in chapter three of this thesis. The intention was to gain a better understanding of the impact the teachers' understanding of algebraic concepts may have, when dealing with context-based problems of ML. First, the results from the teachers' reflections are presented. This is followed by a discussion of the responses to the questionnaire. Thereafter the analysis of the interviews with the two teachers is presented. Finally, findings from the analysis of the teachers' examination scripts are discussed.

4.2 Results from the teachers' reflections

In this section I consider the various reflections of the teachers. The reflections were made in response to a task based on the Shape and Space module, which required applications of algebra. The teachers were requested to reflect on what was driving their thinking as they engaged with the task given earlier as part of the research process. The task and the details of the teachers' reflections appear in APPENDIX C. Teachers in this research were given the pseudonyms A; B, C, etc. I was initially disappointed to find that the participants did not provide so-called 'thick' descriptions, instead they just provided what Rosenberg (2009, p. 13) regards as descriptive writing (reports on events with no reason given for events). However a deeper analysis of the reflections revealed that teachers do acknowledge the need to draw largely on basic algebra when dealing with context-based problems.

The first theme that emerged from the analysis of the teachers' reflections was that: basic mathematical knowledge, (which was mainly algebra in this case), was necessary when dealing with this task of ML. Teacher **E** said "*but because of the basic knowledge of pure mathematics I have learnt before, I tried to answer some questions. I then strictly say this mathematical literacy needs the understanding of pure mathematics".* This notion was also supported by teacher **D** as she explains "*The task was challenging….but through prior knowledge from other learning areas I was able to attempt".* This notion seems plausible because the problem only required Grade 9 level mathematical knowledge of 'area', which (in this problem) was embedded in the contextual problem of the dimensions of the swimming pool. In contrast, there was also the feeling that the problem required post matric mathematical knowledge, which seems unfounded. This feeling was noted when teacher **Q said,** "*The way the problems were structured, it was very difficult - it required prior knowledge. Therefore if you did not do mathematics after matriculation it was really a problem…".*Teachers who did not study any mathematics after matric, could have experienced problems for two related reasons. Firstly, they missed an opportunity to learn more mathematics, as is expressed above by teachers E and Q. However a second reason is linked to the gap in time between their last experience of studying mathematics in school and picking it up again, after many years of teaching.

The second theme that emerged was that the gap in terms of material interaction seemed to have played a major role. Indeed, most of the teachers did not experience mathematical activities for a long time, since they were not practising mathematics teachers in their areas of work. Teacher **J** had this to say "*one must have background knowledge of calculating area, volume and perimeter. We need to know all those things so it is difficult for a person who did maths in ten years back to do this".* I strongly concur with this feeling in that mathematics is perfected through practice. Therefore a big gap may mean that they struggle to apply the correct procedures in solving the problem at hand because they had not applied such procedures for a long time: It is evident from Appendix C as well, that teachers such as A, B, C, E*, F and N* who did very well in the module, were able to specifically identify the challenges of the problem. They used phrases such as "calculation of the volumes of rectangular prisms" and "…etc." as compared to phrases such as "understanding of perimeter, rectangles, squares …" and "…etc.". This suggests that teachers who performed better, had a more realistic idea of the demands of the ML curriculum while many of those who performed poorly demonstrated a simplistic or even false idea of the demands.

4.3 Responses to the questionnaire

The questionnaire appears in APPENDIX E. Here teachers were requested to respond to various statements related to Mathematical Literacy. When analysing the data from the questionnaire the following notation was used: Letters A to Q represent the seventeen (17) respondents. The results for this section are presented separately for teachers with a mathematical background and those without. A teacher was considered as having a mathematical background, if he/she had trained as a mathematics teacher. A teacher was considered as not having a mathematical background, if his/her highest qualification in mathematics was at Senior Certificate level. The table below shows how the teachers, as they are categorized into mathematics specialists and non-mathematics teachers, responded to the Section B of the questionnaire, where SD; D; N; A; and SA, denote Strongly Disagree; Disagree; Neutral; Agree; and Strongly Agree respectively. Following are the statements from the questionnaire, where S1 stands for Statement1, etc.

Number	Statement
S1	Algebraic teaching experience is fundamental for learning of mathematical literacy
S2	Social background has an impact on learning of mathematical literacy
S3	Technologically rich society learn mathematical literacy better
S4	Grade 12 mathematics is adequate for learning and teaching mathematical literacy
S5	Contexts should be made available to all teachers for the learning of mathematical literacy

Section C of the questionnaire required the participants to give an explanation as to why they responded the way they did in Section B. Further, Section D of the questionnaire required the participants to provide any reasons that they felt were hindering the progress of students in that Mathematical Literacy Course. The results for both Section C and Section D appear in APPENDIX G. Table 2 that follows, provides a summary of the teachers' responses on Section B of the questionnaire.

TABLE 2: Responses from in-service teachers on Section B of the questionnaire

Mathematics Specialists								
	A	**B**	**C**	**D**	**F**	**H**	**L**	**O**
S1	N	A	SA	D	A	A	N	D
S2	D	A	N	SA	N	A	A	A
S3	SD	N	A	SD	N	N	N	A
S4	SA	A	A	A	A	A	D	SA
S5	D	SA	SA	SA	SA	N	D	SA

Non-Mathematics Teachers									
	E	**G**	**I**	**J**	**K**	**M**	**N**	**P**	**Q**
S1	SA	SD	A	A	SA	D	A	D	D
S2	N	D	D	A	A	SA	SA	D	SA
S3	N	A	SA	N	N	D	A	N	SA
S4	A	N	N	A	A	D	N	D	SA
S5	A	SA	SA	A	SA	A	SA	SA	SA

However, the focus of the study was more on S1 and S4 of Section B of the questionnaire.

S1	algebraic teaching experience is fundamental for learning of Mathematical Literacy.
S4	grade 12 mathematical knowledge is adequate for learning and teaching Mathematical Literacy.

Table 3 that follows provides the teachers' responses to statements S1 and S2 of Section B of the questionnaire.

TABLE 3: The analysis of the teachers' levels of agreement/disagreement on S1 and S4 (isolated) of the questionnaire.

Mathematics Specialists									
	A	**B**	**C**	**D**	**F**	**H**	**L**	**O**	
S1	N	A	SA	D	A	A	N	D	
S4	SA	A	A	A	A	A	D	SA	
Non-Mathematics Teachers									
	E	**G**	**I**	**J**	**K**	**M**	**N**	**P**	**Q**
S1	SA	SD	A	A	SA	D	A	D	D
S4	A	N	N	A	A	D	N	D	SA

Table 4 that follows summarizes the teachers' responses to statements S1 and S2 of Section B of the questionnaire where teachers are categorized into mathematics specialists and non-mathematics teachers.

TABLE 4: Responses from teachers on S1 and S4 of the questionnaire with asterisk (*) on non-mathematics teachers.

S1	***Strongly Disagree***	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***
Mathematics Specialists		DO	AL	BFH	C
Non Mathematics Teachers	G	MPQ		IJN	EK
Combined	G*	DM*OP*Q*	AL	BFHI*J*N*	CE*K*
S4	***Strongly Disagree***	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***
Mathematics Specialists		L	C	BDFH	AO
Non-Mathematics Teachers		MP	GIN	EJK	Q
Combined		LM*P*	CG*I*N*	BDE*FHJ*K*	AOQ*

A consideration of Sections B, C and D reveal the following: Firstly that most participants interpreted the word ‘adequate’ in Statement 4 as meaning ‘necessary’. Furthermore 35% of teachers disagreed with S1, while 53% agreed. As a matter of reference I looked at the comments made by participants A, B and L, the people who scored the highest marks. While teacher A remained neutral on the issue, teacher B agreed with S1, with L suggesting that “*maths teaching is advantageous for learning maths lit but not necessarily a key component*”. This response shows that mathematics teaching experience may have been one of a variety of reasons behind the success of certain teachers in ML.

Furthermore, I noted that the questions from the ML Examination Paper were belonging to 4 levels of taxonomy. I therefore attempted to understand a broader picture of teachers' achievement by analyzing their achievement on each level. Table 5 that follows provides a broader analysis of the teachers' achievement where the individual scores are presented in percentage.

TABLE 5: A broader view on teachers' achievement with regard to taxonomy levels in the module Numbers and Operations.

Mathematics Specialists								
Level	**A**	**B**	**C**	**D**	**F**	**H**	**L**	**O**
L1	90	70	50	40	60	30	60	50
L2	89	89	43	75	82	57	100	100
L3	54	71	25	50	55	29	63	46
L4	52	90	21	55	34	38	79	79
Average	71	80	35	55	58	39	76	69
Non-Mathematics Teachers									
Level	**E**	**G**	**I**	**J**	**K**	**M**	**N**	**P**	**Q**
L1	50	70				20	50	40	60
L2	57	86				25	79	46	71
L3	46	41				25	54	25	46
L4	24	66				17	55	07	76
Average	44	66	NoDP	NoDP	NoDP	22	60	30	63

It appeared that there were 5 teachers in total who performed poorly in the examination. From this view it was found that among five teachers who did badly, three agreed with S1, except for P and M. For example, participants C, H, E, I, J and K who did very badly supported Statement 1, which is thereby the evidence for this claim. So both high performing and poor performing teachers agreed with S1. Two teachers who disagreed with S1 were P and M. P on S1 said, "*No, because mathematical literacy had to be known by all educators as it is a new subject in the curriculum*". The very same participants, P and M went on to disagree with S4. M on S4 said "*No matter what knowledge you have, you can be able to learn maths lit*". This statement indicates that these teachers are misinformed about the demands of ML as a learning area. Many teachers, in their response to Section C of the questionnaire demonstrated little or no understanding about the kind of teacher who was expected to take part on the course. Furthermore, I also gained the impression that these educators had no idea of what the pre-requisites of ML were. This was shown by their constant poor performance at all levels of the modules. Table 5 reveals that participants P and M performed very badly, which is an indication that their perceptions are linked to their performance. Most adults come to learning activities for specific reasons, as Wlodkowski (1999, pp. 18-33) suggests. These reasons are based on what they think they need or want. These desires translate into personally relevant goals. These goals may be social interaction, new skills, some type of certification, or simply relief from boredom, advancement in their jobs.

I then decided to establish the relationship between the actual performance of teachers as detailed in Table 5, and their responses on the Section B of the questionnaire. My target was on the two statements which were entirely on algebra and algebraic experience. I then grouped the teachers' responses and categorized them in a percentage form using their total. Table 6 that follows provides the teachers' responses on the Section B of the questionnaire.

TABLE 6: The analysis of the educators' levels of agreement/disagreement on S1 and S4 (combined) of the questionnaire.

Category	Teachers/Participants	Percentage
Agreed on S1 and S4	B, E*, F, H, J* & K*	35%
Disagreed on S1 and S4	M* & P*	12%
Agreed on S1 and neutral on S4	C, I* & N*	18%
Neutral on S1 and agreed on S4	ALG*	6%
Neutral on S1 and disagreed on S4	L	6%
Disagreed on S1 and agreed on S4	D, O & Q*	18%
Disagreed on S1 and neutral on S4	G*	6%

Table 6 reveals that 71% of the participants agreed with both statements S1 and S4. Such a strong level of agreement with the statements (which specify that Algebraic teaching experience is fundamental for learning of mathematical literacy and Grade 12 mathematics is adequate (taken as necessary) for learning and teaching mathematical literacy) together with the outstanding performance shown by Teachers A, B, C, E*, F and N* at almost all levels in the Numbers and Operations module, suggests that they attributed some of their success to the grade 12 algebraic knowledge they had and the mathematics teaching experience they have acquired during their career. Note that Teachers E* and N* have 2 years and 7 years mathematics teaching experience respectively. The abovementioned participants' responses along with their performance suggest that they attribute their success to their strong background knowledge in mathematics, because of the agreement with the statements. On the other hand, the importance of mathematical teaching experience and grade 12 knowledge is also acknowledged by C and H who performed poorly, as well as I*, J* and K* who were denied a DP to write the examination. Their agreement with the statements may indicate that they saw their lack of mathematics teaching experience and knowledge as a hindrance to their success. In confirming this claim, participant I said "*…some of us are not teaching mathematics where they are and they find themselves getting delayed in solving problems*". This feeling was also felt by J, as he said "*…if* *we did mathematics it will be easier to understand maths literacy*". Participants D, O and Q* who performed outstandingly, also shared similar sentiments in that they acknowledged the grade12 algebraic knowledge as the key element to their success. This acknowledgement was also observed in Section D as A is quoted as saying "*Background (mathematical one) is the key element in making learners to pass this course. So lack of this background is not good*". Again, B supports the idea as she points out that, "*Some of the students do not have adequate pre-knowledge background. Sometimes some contexts require the mathematical skills of which some of us don't have because we didn't major with it".*

4.4 Results from the interviews

Two participants (Teacher 1 and Teacher 2) were subjected to semi-structured interviews - the questions appear in Appendix K and in Chapter 3. Teacher 2 (mathematics specialist) was from a rich mathematics background in that she studied mathematics up to tertiary level, while Teacher 1 (non-mathematics teacher) had studied mathematics only up to Grade 12. The transcription of the interviews, appear in APPENDIX L.

The interviews presented an opportunity for the teachers to explain and elaborate on mathematics in general and in particular the role of algebra in the solution of the everyday real-life problems. The aim of the interview was to probe the teachers' understanding of algebra as they apply it in everyday life, in their study and in their teaching. Such interaction made it possible to gain qualitative insights into the various dimensions of their understanding.

The analysis of the interviews revealed the following:

The need to draw on **basic algebraic knowledge** is seen by both teachers (mathematics specialists and non mathematics), as a gateway towards better problem solving in ML, was the first theme that emerged from the analysis of the interviews. Teacher 1 acknowledged the role of prior knowledge when asked about role of the grade 12 algebraic knowledge on the teaching and learning ML. She had this to say: "… *like the prior knowledge that you have got will assist you like in teaching of Mathematical Literacy especially when you are dealing with…if you do not know anything about algebra so it becomes difficult for you…therefore its adequate"*. I believe she was citing this based on her experience and her performance which was outstanding throughout the course. Teacher 2 seemed to support Teacher 1, albeit with some conditions as she is quoted: *"if you have grade12 knowledge only, you struggle…before you reach the solution"*. In fact she did acknowledge the role of prior knowledge but with a feeling that it might seem to be difficult for somebody who only had grade 12 mathematical background.

The second theme emerged when teachers revealed mathematics teaching experience as having a positive role to play towards better problem solving in ML. When teachers were asked about their views on **algebraic teaching experience** in the learning and teaching of ML, they felt that people with mathematics teaching experience find it easier to teach Mathematical literacy for two reasons. Firstly, their additional training experience helps them to solve problems more easily. Teacher1 was quoted as saying*: "… then a person with experience of solving problems finds himself in an advantageous position and is also able to teach better than the one who has not got a chance to teach and has been exposed to problem solving"*. Teacher 2 shares a similar sentiment as she pointed out, "*I think you cannot separate the algebraic experience with Mathematical Literacy because…the one who has been teaching algebra or with the experience in teaching will….with confidence handle the problem"*.

Secondly, the person who has mathematics teaching experience has not had a large break from thinking about mathematics- the work is 'fresh' in their minds. Teacher 1 said, "*Ho…I can say the one who is currently teaching is* fresher *than the one who last did it at grade12 in terms of practicality…so it becomes easier for the person who is teaching to solve problems…you start by struggling but you eventually get there"*.

The third theme emerged when both teachers endorsed the view that the **algebra used in Mathematics as well as in Mathematical Literacy is simila**r. Teacher 1 noted, "*Ya I view the Mathematical class the same way…the difference is in the structuring of questions…like in Mathematical Literacy class the questions are context-based rather than in Maths…so but the algebra is the same"*. Teacher 2 had a different view, as she added, *"No it is not similar, in Mathematical Literacy class they are using simple and simple algebra but in Maths class they are dealing with more complex situations and most of them you cannot relate those problems in a real life situation…"* Here she is referring to pupils who study mathematics rather than ML. It seems a valid point in that simpler mathematics may have more opportunity for applications. The school subject Mathematics is more specialized and therefore more difficult to find authentic situations in which the mathematics can be applied.

She took her point further however, when she was asked about the use of algebra in a culturally diverse class, when she said, *"No, I do not see algebra as being culture driven...so it will be the same…the application or the examples that you are going to use may be culturally biased, but as for algebra, it will be the same".* This seems highly likely, in that most contextual practices do necessitate the use of simpler mathematics than that of advanced mathematics. She took her point further again when asked about the use of algebra in a poorly resourced class, as she said: *"No, for me mathematics will be the same because I mean you can even go to computers but you will need the very same algebraic information that you have…so whether you have resources or no resources…I think resources make work easier but the knowledge that you have is the one that counts".*

The feeling surfaced that similar algebraic skills will be employed at different cultural mathematical problem situations. When Teacher 1 was asked about the use of algebra in a culturally diverse class, she said, "*Eh…because they have got the skills that they are the same, then they will approach the problem the same way, irrespective of the diversity of the class…like if I have got the Ndebeles, then the example that will be relevant to them so they will know how to apply algebra in that and also…and also there will be the one that will concentrate on the Zulu speaking learners… tackling the same problem using different contexts".* Her point is that, the mathematical skills learnt will enable problem solvers to solve any problem situation, regardless of the cultural setting in which is formulated. The ability to apply mathematical knowledge takes learners some way further, when faced with ML problems which may be based in different contextual settings. Teacher 1 said, "*...there will be questions that won't be relevant to them…but using the knowledge that they have acquired throughout the year…it won't be difficult for them to tackle the question even though the problems that are there are not relevant to their culture…but they will be able to tackle the questions…the main point is understanding the context behind…understanding there…then they will be able to answer the questions irrespective of the way the question is framed".*

A fourth theme that emerged from the interview analysis is that **algebraic knowledge is necessary in facing technological demands** as they are facing the society. I strongly believe, these technological demands are in one way or another, the measure of how mathematically literate one is. Although I used the term algebra and the teachers agreed, it is clear that the teachers meant mathematical literacy skills in the way that Steen (1999) describes "Quantitative Literacy". This was when they were asked about the claims that suggest that with the technological demands facing our society, a person without algebraic knowledge will never survive. Teacher 1 responded by saying, *"It does play a role but not that you cannot survive without it…like there are other things you could be able to do using the prior knowledge of algebra, but it does not mean that if you do not apply that knowledge then you won't be able to survive…no"*. Having noted that the interviewee looked at survival in a literal way, I then drew her attention to some societal practices such as paying the bills and; premiums, she then responded by saying, *"Ya, it does need algebra but I was looking at it…eh…like our grandmothers and grandfathers they do not need to do that but they do survive in the community irrespective of the algebraic knowledge that they have got…so they are surviving at the community"*. I then directed the question to her as a literate person, wanting to know whether it was advantageous to have algebraic knowledge, she then said, "*No, it is not right for someone in my position…like a person who is working, a person who needs to look at his water bills and electricity bills and calculate how much water consumption they have used and then the bills that they have to pay whether it corresponds or what…so they do need the knowledge there"*. She also confirmed the point of being algebraically inclined when asked about the upcoming generation and their algebraic knowledge as she responded by saying, *"Ya, looking at the way things are changing…technologically and then our way of life things are changing so all of us we need to be literate in doing mathematics and also to have the algebraic knowledge…that they need to know their accounts…how much do they have…like if they are investing…how much interest are they going to accumulate and things like that so they do need the knowledge of algebra in order for them to survive into this generation"*. Her last comment clarifies that she did not mean "survive' in a literal sense, but in order to make informed decisions. This response gave the impression that the innumerate people versus the numerate people bring our society into a 'societal divide', in that for the interviewee it is accepted that illiterate people are disadvantaged. This feeling was also shared by Teacher 2 as she pointed out, "*…I think that is* *why they introduced Mathematical Literacy…because they have seen that a South African citizen without background in maths or without maths knowledge will be lost because …how are you going to interpret bills if you don't have that? …".*

A fifth theme that emerged is that **context-based problems of ML can be seen as being difficult at first sight**. This is evident from the response of Teacher 1, when asked about the reflection task, "*I think the difficulty was in the understanding of what is it that was wanted from me to do…not actually that I couldn't calculate or what…because after they have showed me how it was done then it became easier…when just looking at it I thought maybe it was gonna be difficult, …".* This feeling was also confirmed by Teacher 2 when she said, "*That was difficult for person with only grade 12 mathematics because there with the experience that you had, you would easily identify the formula to use...".* This I believe was necessitated by the fact that even if one is mathematically inclined, however, it takes one's particular techniques of approaching the problem.

The sixth point that emerged was **the role of practice**. One teacher emphasized that practice and familiarity helped them improve their problem solving skills in ML. Teacher 1 said, "*No, like when I did it for the first time I thought it was very difficult but now when we were doing remedial work in class and then my peers had showed me how to do it, it was not that difficult…but the first time I looked at it I thought no it was going to be difficult and I couldn't do it".* . This notion of familiarity is very important in a problem-solving situation, familiarity which is acquired through experience.

Another significant impediment in teachers' achievement was the **pace at which the course was run**, which emerged as the seventh point. The nature of the course was such that the content was offered in fixed time frames. Each module consisted of 57 hours, with the delivery broken up into 8 days of 6,5 hours per day. This seemed to have an impact on the teachers' achievements as they had diverse mathematical backgrounds. The pace did not help the teachers to cope with the additional demands that were brought on by these context-driven problems. Here are few quotations from the participants, which support my claim:- F: *Students learn a lot in a very limited time.* G: *Is when compiled learning materials are simple and straight forward than tests* *and examinations. Materials should be difficult as tests to prepare us to pass.* I: *A lot of work is given in a short space of time, but what else can be done? Learners need to be taught.* L: *Perhaps if people were allowed to study at their own pace – but this is highly impractical.* M: *I think assessment must be provided in each and every section so that you can be able to face any problem, not doing many aspects because you are getting confused when you are writing the test.* P: *The problem is caused by learning many concepts at a very short period. If you learn one concept and get assessment on it, I hope it will improve the rate to grasp the information. But the course is excellent.*

4.5 Results of Scripts Analysis

In this section, I will present an analysis of the teachers' responses to examination questions which were rich in algebra or algebraic–rich (this is a term I use to describe tasks that require algebraic techniques). The teachers' responses on the examination of four modules were analysed.

The in-service teachers' achievements in the examination of 4 modules were analyzed in terms of the 4 levels of taxonomy of Mathematical Literacy as they appear in APPENDIX H. The modules were Numbers and Operations in context, Data Handling, Functional Relationships, & Shape, Space and Measurement. These scores provided in Table 7 do not represent the teachers' results in the whole papers, since I only targeted the algebraic-rich questions within the four modules, respectively. One of the striking findings is the difference in performance between mathematics specialists and non-mathematics teachers in the various algebraic-rich problems.

Table 7 presents the average marks aggregated per level for the various questions expressed as a percentage for the mathematics specialists and the non-mathematics teachers. That is, individual scores for mathematics specialists per question were added together for each level, and averaged as a percentage for each question, and then averaged per level.

TABLE 7: Comparison between Mathematics Specialists and non-Mathematics Teachers at different levels for four different modules using the average percentages

Numbers and Operations in context							
Level 1		Level 2		Level 3		Level 4	
Math	Non Math	Math	Non Math	Math	Non Math	Math	Non Math
56	48	78	61	49	40	56	41
Difference = 8		Difference = 17		Difference = 9		Difference = 15	

Functional Relationships							
Level 1		Level 2		Level 3		Level 4	
Math	Non Math	Math	Non Math	Math	Non Math	Math	Non Math
66	38	65	45	70	41	52	39
Difference = 28		Difference = 20		Difference = 29		Difference = 13	

Data Handling					
Level 1		Level 2		Level 3	
Math	Non Math	Math	Non Math	Math	Non Math
87	81	85	71	40	26
Difference = 6		Difference = 14		Difference = 14	

Shape, Space and Measurement					
Level 1		Level 2		Level 3	
Math	Non Math	Math	Non Math	Math	Non Math
0	0	65	43	50	26
Difference = 0		Difference = 22		Difference = 24	

The results from Table 7 drawn from APPENDIX I show that, in 4 different modules, and at various levels of taxonomy, the mathematics specialists performed better than the non-mathematics teachers. As a matter of focus, I decided to scrutinize the module Numbers and Operations in context, since it is rich in algebra. It is because of the criteria used that the analysis of the two modules Data Handling; and Shape, Space and Measurement, presented in Table 7 do not contain level 4 questions. In fact, the Numbers and Operations module mainly contained algebraic questions mostly on level 3 and 4.

As pointed out earlier in this report, the focus is more on the module Numbers and Operations in context because of the variety of algebraic questions as compared to the other three modules. For this particular module, all the teachers' responses at all taxonomy of levels of questioning were reviewed. My aim was to identify the differences in the teachers' responses if there were any, and categorize those questions where there were differences in terms of their algebraic mathematical demands. I did this as a way of trying to gain a better understanding of the results, such that the information gathered would assist me in addressing the main research question which was to explore the teachers' perceptions about, and performance in Mathematical Literacy tasks based on algebraic concepts.

An initial analysis as it appears in Appendix B reveals that out of 17 participants, 3 did not get a DP, and were all from the non-mathematics teachers. Furthermore, 4 participants (2 mathematics specialists; and 2 non-mathematics teachers) failed, which makes a total of 5 non-mathematics teachers who did not succeed in the module Numbers and Operations.

One of the complexities of mathematical literacy tasks is the fact that they draw upon different cognitive levels, presenting different challenges within the mathematization aspects (OECD/PISA 2003, p. 26) that lie within different mathematical domains and are embedded within various contexts. The four constructs (cognitive level, mathematics domain, mathematization aspect and context) can be used to characterize the problems presented in Table 8. Firstly, the ML taxonomy (DoE 2008b, p. 8) (revised and extended to the one presented in Appendix H), was used to classify the cognitive level as 1, 2, 3 or 4. Secondly, the aspects of mathematisation (OECD/PISA 2003, pp. 26-28) can be used to identify particular challenges in the mathematization process. The mathematisation process appears in Figure1 on page 25 of this report and discussed in Chapter 2.

In order to analyse the teachers' responses and the challenges they encountered within the aspects of mathematisation, it is necessary to explain the following terms: ***Modeling***: this is the situation where the problem-solver has to translate the problem into mathematical language by using symbols and later progressing to selecting an algorithm such as an algebraic equation to model the given contextual problem. Modeling advocates different mathematical approaches, e.g. direct problems - the problems that necessitate the direct use of mathematical approach to problem solving. The ***Inverse*** approach is where in the formulated mathematical equation, the problem-solver is given the output as a known, and is expected to find the unknown, which is the input. These problems may also necessitate the engagement in a ***Multi-step*** approach to problem-solving, where the problem solver is engaged in a series of sequential steps to meaningfully arrive at a solution. According to Bansilal (2010, p. 10) a problem situation where the input is processed to produce an output and this output is enacted by another process creating another output that leads to a final result, is seen as multi-step problem. ***Contextual reasoning*** refers to a situation where the problem-solver is expected to solve the complex contextual problem using specialized knowledge that is potentially available. Also of interest in the discussion that follows, is the term procedural fluency which, according to Kilpatrick (2001, p. 121) refers to "a knowledge of procedures, when and how to use them appropriately, and skill in performing them flexibly, accurately and efficiently". **Conversion between units** is when the problem is presented in certain units, while the formula requires the use of other units.

After a careful scrutiny of the teachers' responses, I found the questions presented in Table 8 that follows, as bringing the line of distinction between the performances of teachers (mathematics specialists and non-mathematics teachers). In my opinion mathematics specialists should have all scored the highest marks, however the difference in performance among themselves was also noted. The questions marked with an asterisk (*) are the questions where mathematics specialists did better than the non-mathematics teachers. The questions marked (^) indicated those questions where both groups experienced difficulties.

TABLE 8: Certain algebraic questions defining the performance of teachers (mathematics and non-mathematics)

Question	Theme	Nature of mathematisation	Aspect
Level 1			
2.1.1^	Giving the meaning of inflation, given that it was 5% in January 2002	Recall of contextual information	1
3.1*	explain the difference between the terms 'ratio' and 'rate' and provide examples	Recall of mathematical terms	1
Level 2			
1.2.1*	the calculation of the transfer duty	Contextual reasoning	5
6.3.1.2*	given F=1.8C + 32, find F if F=C	Setting up equation, solving equation	3
Level 3			
3.2*	minimizing the buying cost if given the merchandise in different forms of packages	Setting up of model, understanding ratio	3
5.3.1^	given the call rate and the duration of the call, find the cost of the call	Multiplicative calculation, procedural fluency	4
5.3.2^	find the new cost if the initial cost is reduced by 10%	Setting up and solving model of a multi-step problem	3
5.4^	given different call rates and different call durations, find the total cost	Multiplicative calculation, procedural fluency	4
Level 4			
1.2.3*	calculating the cost, given the transfer duty paid	Setting up and solving model using an inverse approach	3
4.3^	given the 10% reduced weight, find the initial weight	Setting up and solving model using an inverse approach	3
5.2^	given the 14% increased cost, find the initial cost	Setting up and solving model, using an inverse approach	3
6.1.4^	Given the table of the current exchange rates, convert R2500 to Botswana Pulas	Knowledge of ratios and rates, contextual reasoning	5

Table 8 reveals that both teachers are experiencing difficulty particularly with aspect three of mathematisation. I now look at common points of difficulty experienced by the non mathematics group by looking at how they responded to questions indicated as (*) from the Table 8. The data presented in the Table 9 that follows reveals the mistakes and the alternate conceptions discovered from the work of the non-mathematics group, which they committed as they wrote the examination of the module Numbers and Operations in context. Table 9 also summarizes the responses from the non-mathematics teachers to particular questions, with respect to levels of

SAML, alluded to in the introduction to section 4.5. The UKZN Numbers and Operations examination paper appears in APPENDIX M.

TABLE 9: Responses from non-mathematics teachers on particular questions of module Numbers and Operations in context.

Non-Mathematics Teachers							
Question	**Level**	**E**	**G**	**M**	**N**	**P**	**Q**
1.2.1 (3)	2	0(found 5%of R495000)+ R995000	3	0(found 5%of R995000)	0(found 5%of R995000)	0 (found 5%ofR100000	3
1.2.3 (6)	4	0 (unable to formulate the statement)	6	0 (no attempt)	0 (unable to formulate the statement)	0 (calculated 5% of R1000 000)	6
3.1(4)	4	2(gave 2examples)	2(gave 2examples)	1(gave 1example)	1(gave 1example)	2(gave examples)	1(gave 1example)
3.2 (4)	3	0 (unable to make ratio)	1 (incomplete)	0 (no attempt)	1 (incomplete)	0 (unable to make ratio)	4
6.3.1.2 (3)	2	0(substituted F=25)	0(substituted c=77)	0 (no attempt)	0(substituted c=25)	0(substituted c=77)	0 (no attempt)

Using the description of the mathematical/contextual demands presented in Figure 2 and the description in Table 8 of the responses (to selected items) of the non-mathematics teachers, I now attempt to identify particular problems of the non-mathematics group.

- For Q1.2.1, it seems that the teachers had problems understanding the representation of the formula/rule presented in the context- which was

For a purchase price of R0-R500 000, the transfer duty is 0%.
For a purchase price of R500 001 to R1 000 000, the transfer duty is 5% on the value above R500 000.
For a purchase price of R 1 000 001 and above, the transfer duty is R25 000 + 8% of the value above R1 000 000.

They needed to find the transfer cost of a house costing R995 000. Teachers G and Q got it correct, with the other teachers correctly identifying the option (from 3 possibilities) but applying the rule inappropriately. This difficulty shows that the teachers experienced difficulty with the first aspect of mathematisation, because they did not fully understand the contextual rule related to transfer duties.

- For Q1.2.3, except for teachers G and Q again, the aspect with which the teachers struggled was the **third aspect,** because they were unable to formulate the appropriate model or rule.
- For Q3.1, the teachers were required to differentiate between the concepts of ratio and rate, and provide examples of each. Here the teachers stumbled with the **first aspect**, situating the concept in a real life context, because they did not provide examples of the concepts appearing in real life.
- For Q3.2, except for teacher Q, the other teachers were unable to perform the **third aspect** of mathematising, which was to identify the relevant process/formula/rule that would enable them to calculate the number of boxes to buy in order to minimize the cost.
- Q6.3.1.2 presented the teachers with a challenge. None of the teachers were able to formulate the equation (linked to **aspect 3** of mathematisation) that was needed. Some used the value of 25º because it appeared in the previous question, with 1 teacher taking it as the value of F and 1 taking it as the value of c. Two other teachers took c= 77, which was the value of F, obtained as the result of the previous question.

Referring to the data from Table 7, it is evident that in the module Numbers and Operations there was a big difference particularly on the SAML level 2 and level 4 questions. However, it must be noted that both groups did well for SAML level 2 questions. Looking at the nature of the questions detailed in Table 8, these questions involve the following concepts:

- Percentage calculation: problems involving the calculation of transfer duty.
- Substitution: in using the compound increase/decrease formula.
- Ratio formulation: mixing quantities using the knowledge of fractions.
- Conversion: from degrees celcius to farhenheit.

Looking at the nature of these questions I can make a conjecture as to why the mathematics specialists performed better in these questions. It would seem that these concepts had been in the mathematics curriculum prior to the introduction of ML, to which the mathematics specialists were exposed. Now, the very same concepts happen to feature in these context-based problems of ML. As a matter of experience and exposure in these types of questions, mathematics specialists found it easier to deal with such problems.

I argue that both groups of teachers had similar problems with the questions. However, in the selected questions discussed above, I have pointed out that the mathematics specialists performed much better than the non-mathematics teachers. Thus the non-mathematics group experienced a higher level of difficulty than their counterparts, particularly to SAML level 4 questions.

I now look at common points of difficulty experienced by the entire group by looking at how they responded to questions from the levels 2 and 4. The data presented in Table 10 reveals the mistakes and the alternate conceptions discovered from the work of both groups (mathematics specialists and the non-mathematics teachers), which they committed as they wrote the examination of the module Numbers and Operations in context.

TABLE 10: Responses of the group to particular questions of module Numbers and Operations in context, as categorized in terms of mathematical demands

Question	Level	Mathematics specialists	Non-mathematics Teachers	Mathematical demand
2.1.1	1	4-goods increased by 5%; 1-decrease by;1-changes by	4-goods increased by 5%	Contextual reasoning, percentage calculations
4.3	4	5-found 10% of 95Kg; 1-incomplete	5-found 10%of 95Kg; 1-no attempt	Modeling using an inverse approach
5.2	4	4-found 14% of (R27, R26, R15); 1-multiplied 14:45 by R1.8; 1-divided R13.5 by 1.14	4-found 14% of R26; 2-rounded 18:39 to 19:00; 1-no attempt	Modeling using an inverse approach
5.3.1	3	3-multiplied 18:39 by R3.3; 2-incomplete	2-rounded 18:39 to 19:00; 1-multiplied 18:39 by R3.3	Conversion between units of time, multi-step computation
5.3.2	3	1-found 10% of R55.17	1-found 10% of R115.86; 1-no attempt	Modeling using a multi step approach
5.4	3	5-no convert sec to min; 2-incomplete; 1-no attempt	4-no convert sec to min; 2-incomplete	Conversion between units of time, computation
6.1.4	4	4-no attempt; 1-divided R6.1625 by R4.5725	2-no attempt; 2-conclusion based on incorrect calculation	Contextual reasoning

The data presented in the Table 9 and Table 10 reveals common trends in responses between the mathematics specialists and the non-mathematics teachers with respect to mistakes committed as they wrote the examination. There was however a bigger percentage of the non-mathematics teachers displaying the errors. Students from both groups had problems with the following common areas:

- For Q2.1.1, teachers were unable to recall the contextual meaning of the inflation rate, which is linked to **aspect 1** of mathematisation.
- For Q5.3.1 and Q5.4 many displayed misconceptions about representations of time. Some rounded off 18:39 (18 minutes 39 seconds) to 19:00 (19 minutes); furthermore, in the problem of cell phone bills, students were also tempted for example, to multiply 13:45 by R1.8 to get R24.21, where they treated 13:45 as 13.45. This is a misconception of decimal notation and understanding of time conversions, linked to **aspect 4** of mathematisation.
- For Q4.3; Q5.2 and Q5.3.2 (linked to **aspect 2** of mathematisation) where there was a domination of the concept of percentages, teachers often did not read what was required of them. They calculated the percentage correctly, without noticing that it was the 'percentage within the problem', not just a straight forward question on percentage. Many failed to formulate the mathematical statement from the given data. These problems were especially serious for the questions requiring a model using an inverse approach, in that a reduced/increased term had to form part of the broader formulated algebraic equation. Most teachers simply calculated the percentage of the term without later embedding it to the formulated a broader equation. I think it is of fundamental importance to address this inability as de Corte et al., (2000, p. xiii) suggest: "in terms of mathematical problem solving in general, there is a broad consensus that successful solution depends on the simultaneous and integrated application of several components such as a well-organized and flexibly accessible knowledge base, heuristic methods, metacognitive processes, and affective aspects".

However, this is very difficult to achieve if learners are found to belong to what Kieran (1992) regards as a procedural form of thinking. People exercising this kind of reasoning fail to apply the algebraic reasoning beyond the use of operations carried out by using numbers and rules of arithmetic. A structural thinker would construct an argument using algebra, and be able to construct her own algebraic argument and would be able to manipulate expressions in different ways to demonstrate different points.

- In various responses including Q6.1.4 the performance of teachers showed a lack of procedural fluency. This is because in some instances they were found dividing or multiplying any values that appeared on the data without in fact understanding exactly what they were doing. In the “distance problem”, instead of multiplying 13.4km/l by 55l, they were dividing 13.4 km/l by 551; in another case instead of first determining the quantity of petrol of 32.09l, they were dividing 430km by R6.7 or dividing R6.7 by 430km. The study by de Corte et al. (2000, p. 6) reveals that this tendency develops at the younger ages as they engage in traditional school mathematics. This study reveals that there is strong evidence that, after a couple of years of experience with traditional mathematics education, students approach word problems in a thoughtless and mechanical way, without paying much attention to the context and without any reference to their common sense. This was evident in their “shepherd problem” thus:- “there are 26 sheep and 10 goats on a ship. How old is the captain?” They found that children were prepared to offer an answer by combining the numbers given in a problem to produce answers. One student when asked how he arrived at the solution, responded; “well, you need to add or subtract or multiply in problems like this, and this one seemed to work the best if I add”. I therefore believe it is likely for any problem-solver if she/he finds no point of departure would definitely manipulate the pieces of data presented, in order to arrive at the solution. Again, students were also in “interest problem”, failing to make decisions based on calculations; in some instances, they used the simple interest formula for both options of which the other was supposed to be the compound formula; making the choices based on incorrect calculations. I do also attest these inabilities to the lack of procedural fluency as well. In confirming these responses, the similar findings (linked to problems in mathematising at **aspect 5**) were also noted in the study of strategies learners select on different representations of the tasks in financial mathematics by da Silva, Mafuya and Pournara (2009, p. 31). They point out that such a response suggests that the learner lacks understanding of the impact of changes in interest rates within a financial context. While rounding of 7.08 to 7 may be appropriate in some contexts, it is highly inappropriate in financial contexts, and it is vital that learners understand the compounded impact of rounding off decimal values in financial calculations, particularly over long periods of time.

Furthermore, even though both groups displayed similarity in committing some mistakes, as they are tabulated in Tables 9 and 10, it was however noted that participant C performed badly as compared to other mathematics specialists. The biographical information indicates that participant C is qualified to teach mathematics at the primary level. It was also noted that participants Q and G were performing outstandingly as compared to other non-mathematics members. If it was not for their inclusion, the average performance of the non-mathematics teachers would have been far lower than what they were. Participant G is currently teaching commercial subjects and financial concepts, as they were part of assessment. Participant Q, when interviewed, advocated thorough practice as the key to her success.

In order to strengthen my findings I further analyzed the teachers' work by looking at Levels 3 and 4 algebraic-rich questions categorized in what I regarded as mathematical demands. I found most of the questions demanding the following insights: reasoning; modeling; inverse; multi-step; and conversion. This I did in order to see how teachers performed at various types of questionings in an examination paper as a whole. Except for teacher M, all participants (mathematics specialists and non-mathematics teachers) performed well in Levels 1 and 2 questions; hence the data would not produce well-founded judgments. The biographical details of M as shown in Appendix F, shows that the teacher is currently teaching IsiZulu, and has never taught ML.

Table 11 that follows shows the analysis of questions as categorized into mathematical demands. From the ACEML Numbers and Operations module, I decided to categorize the algebraic questions into mathematical demands. After numerous discussions with my supervisor, we arrived at the following five algebraic mathematical demands: reasoning; model; inverse; multi-step; and, conversion. For each group, the individual scores were tabulated for each mathematical demand. These scores were then summed to arrive at the group's average percentage. The percentage calculation in this regard is not aimed at statistically differentiating the groups of teachers, but to obtain a global view in terms of their performance.

TABLE 11: Responses from the in-service educators as the Level 3 and Level 4 questions are categorized into mathematical demands

non-Mathematics Teachers										
Question	**E**	**G**	**M**	**N**	**P**	**Q**	**Sub Total**	**Sub %**	**Total**	**Group's %**
Reasoning									120	
1.1 (6)	2	6	2	6	0	6	22/36	61%		
2.1.3 (6)	0	6	4	0	0	3	13/36	36%		
3.4.1(3)	3	3	3	3	0	3	15/18	83%		
6.1.4 (5)	2	0	1	6	5	3	17/30	57%	67	56%
Model									120	
1.2.3 (6)	0	6	0	0	0	6	12/36	33%		
3.2 (4)	0	1	0	1	0	4	6/24	25%		
3.4.3 (2)	0	2	0	0	0	0	2/12	17%		
4.3 (4)	0	0	0	0	0	0	0/24	0%		
5.2 (4)	0	4	0	0	0	0	4/24	17%	24	20%
Inverse									48	
1.3.3 (4)	3	3	0	4	0	3	13/24	54%		
4.2 (4)	4	2	0	4	1	2	13/24	54%	26	54%
Multi-step									84	
3.4.2 (5)	1	5	5	1	0	5	17/30	57%		
5.3.1 (6)	3	0	0	5	2	1	11/36	31%		
5.3.2 (3)	3	3	0	3	0	3	12/18	67%	40	48%
Conversion									114	
4.1 (4)	4	0	0	4	0	0	8/24	33%		
5.1 (4)	2	1	2	2	2	2	11/24	46%		
5.4 (11)	2	0	1	6	5	3	17/66	26%	36	32%

Mathematics Specialists												
Question	**A**	**B**	**C**	**D**	**F**	**H**	**L**	**O**	**Sub Total**	**Sub %**	**Total**	**Group's %**
Reasoning											160	
1.1 (6)	6	6	6	6	2	2	6	6	40/48	83%		
2.1.3 (6)	0	6	5	0	0	0	6	3	20/48	42%		
3.4.1 (3)	3	3	0	3	3	0	3	3	18/24	75%		
6.1.4 (5)	0	5	0	0	0	0	5	2	12/40	30%	90	56%
Model											160	
1.2.3 (6)	6	6	0	6	6	6	6	6	42/48	88%		
3.2 (4)	4	2	4	2	4	0	4	0	20/32	63%		
3.4.3 (2)	0	2	0	2	1	0	2	0	7/16	44%		
4.3 (4)	0	1	0	0	0	0	3	4	8/32	25%		
5.2 (4)	0	4	0	0	2	0	0	2	8/32	25%	85	53%
Inverse											64	
1.3.3 (4)	3	4	0	4	0	3	3	3	20/32	63%		
4.2 (4)	2	4	0	4	4	2	4	0	20/32	63%	40	63%
Multi-step											112	
3.4.2 (5)	5	5	0	5	5	5	5	1	31/40	78%		
5.3.1 (6)	3	6	0	0	3	1	1	3	17/48	35%		
5.3.2 (3)	3	3	0	3	3	3	0	3	18/24	75%	66	59%
Conversion											152	
4.1 (4)	4	4	0	2	4	0	4	4	22/32	69%		
5.1 (4)	2	2	2	2	4	0	0	2	14/32	44%		
5.4 (11)	3	5	0	5	0	1	3	5	22/88	25%	58	38%

Table 11 reveals that the mathematics specialists perform better than the non-mathematics teachers in questions incorporating all mathematical demands. Even though both groups struggled in the conversion type of questions, the non-mathematics teachers struggled significantly in the modeling type of questions.

4.6 Conclusion

Using the information gathered from the teachers' reflections, I was able to gain a better understanding on how the teachers managed to solve the problem that was given to them. This method of data collection was followed by the administration of the questionnaires, where I analyzed the teachers' responses in three categories; section A which was mostly quantitative; section B which was both quantitative and qualitative; and section D which was qualitative. These responses were clustered and categorized based on the general feelings of the educators relating to their responses.

The questionnaires were then followed by the interviews which were predominantly qualitative in that I was getting into a verbal discussion with the participants in order to gain a better understanding of their feelings about the role of basic algebra when dealing with problems in ML. It was in these interviews where it appeared that teachers strongly believe that basic algebraic knowledge is fundamental for ML.

The project was finalized through the script analysis, which was predominantly quantitative in that the scores which the in-service teachers achieved were analyzed statistically. These average scores on different levels of taxonomy were then used to compare the mathematics specialists against the non-mathematics teachers. It was then clear that the mathematics specialists performed better than the non-mathematics teachers, at all four levels, which then supported the idea of fundamentality of prior knowledge acquisition since mathematics specialists were more experienced and exposed. However, both performances were not pleasing taking into account that the other group is specializing in mathematics. A final analysis was also conducted where the questions were now viewed based on their characteristics, against the performance of the participants. Again, these findings revealed a higher performance of the mathematics specialists over the non-mathematics teachers.

The four data sources that have been discussed in the previous sections showed that in-service teachers do need to draw significantly on algebraic knowledge in order to deal with the context-based problems of ML. This is seen through the correlation between them. The results and their implications will be discussed in Chapter 5.

CHAPTER FIVE
DISCUSSIONS AND CONCLUSIONS

5.1 Introduction

This chapter will focus on the discussion of the main research question of the study, namely the exploration of teachers' perceptions about, and performance in Mathematical Literacy tasks based on algebraic concepts. The participants were part of the ACEML programme. This chapter is organized according to the research questions. These questions are answered using the results that have already been presented in Chapter 4. Teachers' reflections; questionnaires; interviews; and scripts analysis were used as a way of exploring teachers' perceptions with regard to their performances as they engaged with contextualised tasks of ML. The answers are discussed with reference to other studies, and implications and suggestions for improvement of the programme are also provided.

5.2 Research Question One:

What are the perceptions of the teachers in the group concerning the role played by mathematical content knowledge, when solving ML problems?

5.2.1The teachers believed basic mathematical knowledge (which in this case was mainly algebra) was adequate for them to deal with ML problems.

The reflections from the task that was given earlier in the study, revealed teachers believed that **foundational mathematical knowledge** was necessary and adequate for them to deal with ML problems**.** The task that was given was used to elicit the teachers' reflections, and only required knowledge of mathematical concepts such as area, perimeter, and ratio, concepts that are covered in the school curriculum prior to Grade 12. Their feelings about solution of the task being driven by their foundational mathematical background were reflected in their responses as they elaborated on how they attempted the task. Furthermore, the analysis of the questionnaire in Chapter 4 confirmed that teachers perceive basic algebra as being necessary in Mathematical Literacy (there were 12 teachers [71%] who agreed with either statements1 or 4 or both). The analysis of the interviews (Teacher 2 noted that "in the ML class they are using simple algebra") also supports this notion that only basic mathematical knowledge was needed to solve ML problems. These teachers' perceptions support the vision of the DoE as stipulated in the ML

Subject Assessment Guideline (2008b, p. 8) to the effect that Mathematical Literacy aims to develop four important abilities:

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

However, teachers experience difficulties when solving contextual problems using the aforementioned strategies. The reflection task in particular was seen in the eyes of many teachers as ‘difficult’. However through various means including practice the use of algebra, they were able to cope in dealing with that problem. Interviewed participants acknowledged that although the mathematical knowledge required to deal with problems of ML was simple, the solution process required a lot of insight. During the interviews a theme that emerged is that context-based problems appear to be more difficult at first sight than they really are. The first educator explained that she was initially taken aback because she could not figure out what was required. However after some guidance and explanations, she was able to cope with such problems. Similar findings were also noted in a problem–solving exercise in a QL-friendly course where the mismatch between the use of the ML mathematical content and the context was revealed, in that, the participants were observed finding the mathematics being used and learned as often elementary, but the contexts and reasoning being sophisticated (Hobden 2009, p. 25). Findell, Kilpatrick and Swafford (2001, p. 118) suggests that it requires ones’ conceptual proficiency to unpack the context by assigning meaningful underlying mathematical relations embedded within that context. It would seem then that even the mathematics specialists do halt momentarily in order to organize such mathematical relations to fit the given context. Further, Christiansen adds on to say “a teacher of ML would have to know enough mathematics…to interpret and critically analyze practical situations using mathematical skills transferred from one context to another” Christiansen (2007, p. 101).

5.2.2 The teachers conveyed different understandings about the ML curriculum.

Responses from the questionnaire also revealed that most teachers who performed badly had **unrealistic expectations/understanding and demands of the ML curriculum.** Teachers who performed better conveyed a more realistic idea and were able to identify specific mathematical terms and demands. Some teachers who performed poorly were vague and general in their descriptions of the mathematics needed when solving ML problems, as is evident in the questionnaire responses as well. This finding suggests that the mathematics teachers have a more realistic idea of the demands and challenges involved in learning and teaching ML. One reason for this misconception about the demands of learning and teaching ML is because the DoE itself recruited teachers with only an average mathematics background to teach ML in schools. This conveys the impression that teaching and learning ML is not mathematically demanding. For many teachers, rather than focusing on personal development, their participation in this teacher development programme could have been driven by financial implications. In fact, salary incentive also attracted teachers who did not qualify to be in the programme. Although the programme was designed for high school teachers, many teachers tried to join the programme by falsely declaring that they teach in a high school. This fabrication was revealed when teachers were required to participate in a reflective practice project. It emerged that teacher C was a primary school teacher, while teacher M taught IsiZulu, neither Mathematics nor Mathematical Literacy.

5.2.3 The teachers believed mathematical teaching experience contributes to improved problem solving in ML.

Mathematical teaching experience was also regarded by many teachers as contributing towards success in ML. The data from the questionnaires revealed that most mathematics specialists who performed well agree with this notion of the benefits of mathematics teaching experience. On the other hand, some non-mathematics teachers who did badly also agreed with this notion. In the latter case, their agreement may indicate that they saw their lack of mathematics teaching experience as a hindrance to their success. For example, Teacher 1 said that those who are not teaching mathematics are "delayed" when finding solutions. It was pointed out in Chapter 4 that, teachers who did not have mathematics teaching experience, would not have studied any mathematics after matric, and therefore could have experienced problems for two related reasons. Firstly, they did not learn any post- matric mathematics. A second reason is linked to the gap in time between their last experience of studying mathematics in school and their enrolment in the ACEML in-service training. It is important to note that that the teachers also saw algebraic teaching experience specifically, as being of an advantage when solving ML problems. This specific reference to algebra emerged in the reflections, questionnaire and the interviews.

This feeling of mathematical teaching experience as advantageous when dealing with ML problems is shared by Christiansen in her claim of the problems likely to be created with the personal identities of both mathematics teachers and retraining teachers as inherent in the NCS. She is quoted as saying, "Teachers of ML have to come from somewhere. While new teachers are in the pipeline, experienced teachers would have to either teach from what they know-it is most likely that existing mathematics and science teachers would feel positioned to do so-or would require retraining" Christiansen (2007, p. 100).

5.2.4 The teachers viewed algebra used in ML as similar to that used in mathematics.

Both the teachers in the interview endorsed the above view. However the one teacher qualified her statement by saying that the algebra used in Mathematical Literacy questions was simpler than what was needed in mathematics questions and it was the contexts which altered the complexity. An important point about cultural contexts also emerged. From the interviews it appeared that there is an agreement that basic algebraic tools learnt are adequate in solving even culturally motivated contextual problems. Questions in a matric Mathematical Literacy paper for an example, includes problems that are derived from all walks of life. This is to speak about problems that range from urban life to rural life; as well as those from western life to African life. I found that the teachers were confident in dealing with such a variety of problems, citing basic algebra skills as adequate tools in solving such problems. Teacher 1 was quoted as saying: "*but using the knowledge that they have acquired throughout the year…it won't be difficult for them to tackle the question even though the problems that are there are not relevant to their culture…but they will be able to tackle the questions…the main point is understanding the context behind…then they will be able to answer the questions irrespective of the way the question is framed*."

Another related point that emerged in the interview is that algebraic knowledge is adequate to survive in our technologically advanced society. Both the participant interviewees emphasized that mathematical literacy is enhanced by algebraic literacy. The latter term (my own) refers to the use of algebra in making sense of everyday situations, such as reading graphs, working out the costs of bills before VAT (value added tax), confirming the accuracy of bills, comparing the costs of articles; which may be quoted in different ways (before tax, after tax, after discount, before discount etc.)

5.2.5 Practice and familiarity helped teachers improve their problem solving skills in ML.

Participants of this study highlighted 'practice' as the cornerstone towards their betterment. The careful consideration that I made in Chapter 4 shows that this practice is two-fold in that the need for thorough practice was driven by the following facts: Firstly, on the one hand, in the previous mathematics curriculum mathematics specialists were not exposed to such complex contextual problems, hence needing what may called 'practice within the broader mathematical world'. Secondly, on the other hand, the non-mathematics teachers experienced the **gap in terms of mathematical interaction** in that they had last seen mathematics while they were still learners, which they feel had a negative impact to their achievement, hence they need the 'practice within the module'. This notion of practice as an aide towards success was also observed in the study conducted by Chase et al., (2002, p. 105) where they compared three different methods of teaching five basic algebra rules involving some kind of practice, they found that cumulative practice of component skills is an effective method of training problem solving. Again, the study conducted by Lovett et al., (2006, p. 4) revealed that the improvements in conceptual knowledge can be enhanced through pure procedural practice.

5.2.6 Teachers believed that the pace of the programme was an impediment to their success

As the point has been discussed in Chapter 4, teachers as learners found it difficult to maintain the pace of the course. It appears that the course content was not fragmented in a way to meet the teachers' needs as learners. One has to consider that in any developmental programme like an ACE course, teachers are doing it for both as learners themselves and as educators. Speaking from the ACE course in Western Cape, Frith et al., (2006, p. 54) point that: "thinking of teacher learning as taking place within a community of practice, throws the focus strongly onto the teacher's sense is of identity and the changes in this identity that the educational programme brings about". They further point out that the educators on such an ACE course are there to develop their own mathematical literacy practices and to learn how to teach the subject "Mathematical Literacy". Here educators are expected to maintain a dual identity as learners and as reflective teachers contemplating implementing a new curriculum. So in one sense they are experiencing in-service teacher education and in another sense also pre-service education since they are in practice already, but not of "Mathematical Literacy"

5.3 Research Question Two(a):

Was there a difference in performance between Mathematics specialists and non-Mathematics teachers with respect to ML tasks based on algebraic concepts?

5.3.1 Mathematics specialists performed better than the non-Mathematics teachers

Results from Appendix B presented in Table 1 of Chapter 1 show that mathematics specialists performed better than the non-mathematics teachers. Five non-mathematics teachers (56% of the non-mathematics teachers) failed the course, and those who passed, obtained marks between 50%-61%. However, for mathematics specialists, 2 teachers (25% of the mathematics specialists) failed and those who passed had marks ranging between 60%-75%. This achievement alone demarcates the non-mathematics teachers from the mathematics specialists. Furthermore, within the 5 non-mathematics teachers who failed, 3(33%) did not get a DP (Duly Performed). Students are not granted the DP if they have achieved less than 40% in the continuous assessment component consisting of tests; assignments; and presentations.

Furthermore, results from Table 7 in Chapter 4, reveal that mathematics specialists performed better than the non-mathematics teachers in all 4 modules at 4 levels of taxonomy, in which algebraic rich questions were categorized. Table 7 was about comparing the mathematics specialists with non-mathematics teachers, using the achievement in algebraic rich questions across the 4 modules. This table also shows that, both groups achieved fewer marks on level 3 and 4 questions of the ML taxonomy presented in Appendix H, as compared to those of level 2. Most of the challenging algebraic-rich questions are on Levels 3 and 4.

A further comparison was made on the module Numbers and Operations, whose results are presented in Table 5. Table 5 was about categorizing teachers' work within the taxonomy of levels in ML. This table reveals that most mathematics specialists (75%) performed better at almost all SAML levels except for teachers C and H (25%). This was a better achievement if compared to non-mathematics teachers as this table indicates that most of them did very poorly at level 3 and 4 questions (56%).

Further evidence of the higher performance by mathematics specialists is provided in Table 12, where the questions were categorized according to mathematical demands. The average performance of the mathematics specialists was higher on questions across all the demands. The highest difference was achieved in questions which required mathematical modeling.

5.3.2 Both groups (mathematics specialists and non-mathematics teachers) struggled with SAML level 4 questions with Mathematics specialists struggling less

Under 5.3.1, I argued that the mathematics specialists performed better than the Non Mathematics teachers. However, there were certain questions that presented challenges to the entire group. The scripts analysis shown in Table 8 of Chapter 4 reveals that, both sets of teachers (mathematics and non-mathematics) struggled with level 4 questions that are algebraic rich. In fact, non-mathematics teachers further struggled with level 3 questions. Again, even though both groups struggled at this level 4, mathematics specialists struggled less than non-mathematics teachers. A further analysis shown in Table 10 shows that both (non-mathematics and mathematics) groups committed mistakes when carrying out procedures, which shows the **lack of procedural fluency**. Procedural fluency is defined by Findell et al. (2001, p. 121) as referring to "knowledge of procedures, knowledge of when and how to use them appropriately, and skill in performing them flexibly, accurately and efficiently". Furthermore they also struggled to identify which procedures to use, which is an indication that the **conceptual understanding** which according to Findell et al. (2001, pp. 118-119) refers to "an integrated and functional grasp of mathematical ideas", was also lacking. According to Kilpatrick (2001) "a significant indicator of conceptual understanding is being able to represent mathematical situations in different ways and knowing how different representations can be useful for different purposes". Teachers made errors (slips), which I believe they struggled with because they did not understand the context(s) that was/were used. The analysis and discussion above has indicated that the students have not developed strongly in two of Kilpatrick's strands of mathematical proficiency.

The inability to express high levels of mathematical proficiency were also noted at an international level as Beckmann and Hofer (2009, p. 224) describe it in the form of two large closely related problem areas they continually come across during the training of mathematical literacy students from the field of functional thinking:

- The problem of a 'too one-sided tuition': here "various representation forms of functions have to be interpreted (e.g. graphs, verbal descriptions, algebraic expressions, and tables) and transformed from one into another. Students should be able to look at them as the classification of points or so-called 'action layer', a dynamic process or 'process layer' or even as an individual object that can be manipulated or 'object layer'".
- The 'Island problem': "this problem occurs when conventional mathematics and reality appear to be disconnected or totally separate fields". For an example, according to Beckmann et al. (2009) "the differences between mathematical and empirical functions seem obvious, as the first defined in algebraic terms and the latter is used to describe everyday situations".

Functional thinking, as it is understood by Beckmann et al., (2009, p. 224), meaning the capacity to apply cognitive knowledge in the field of mathematical functions in a problem-oriented way, is an important part of mathematical literacy. According to Beckmann et al. "the capacity of functional thinking is not only connected with the solution of algebraic equations but also with the capacity to interpret example diagrams - a capacity which is needed in many areas of daily life".

A further point concerns the nature of the teachers' schooling and initial teacher training experiences. Therefore, we need to always consider the fact that these in-service teachers have been grown mathematically, under traditional teaching. Hence, the lack of the strands of mathematical proficiency may have been as a result from such teaching. Beckmann et al., (2009, p. 224) emphasize that if one has to keep to the graph of the house of functional thinking one notes that traditional teaching has put an emphasis on the action layer, resulting in students perceiving conventional mathematics and reality as being disconnected or totally separate fields.

5.4 Research Question Two(b)

How can this difference in performance of 5.3 be explained?

Using the evidence from the data and my insights from carrying out this research, I put forward three reasons for this difference in performance.

5.4.1 Mathematics specialists by virtue of their mathematics teaching experience were exposed to particular concepts

When I analyzed the Numbers and Operations examination paper, I found that among the questions that we identified as algebraic rich questions, there were some that were decontextualised. From my experience as a mathematics teacher, I noted that most financial mathematical problems that appeared in the Numbers and Operations examination paper are those that featured in the previous traditional Standard Grade mathematics paper e.g. Q1.1; Q1.3; and Q2.2. As a result, the mathematics specialists would have had a special advantage of having encountered those problems over non-mathematics teachers, in line with what the participants supposed in Chapter 4.

5.4.2 Non-mathematics teachers have had a long break from thinking about and doing mathematics

While the non-mathematics teachers had a large gap in mathematical content interaction, the mathematics specialists had the mathematical teaching experience and exposure to such kind of problems, which by a variety of means; they (mathematics specialists) might have developed in various strands of mathematical proficiency. This gap has denied the non-mathematics teachers the opportunity to explore and develop various techniques in solving problems. It is again through this teaching experience where mathematics specialists were subjected to some kind of practice. The work by Chase et al., (2002, p. 105) where they compared three different methods of teaching five basic algebra rules involving some kind of practice, reveals that cumulative practice of component skills is an effective method of training problem solving. Again, the study conducted by Lovett et al., (2006, p. 4) revealed that pure procedural practice does lead to improvements in conceptual knowledge.

5.4.3 The weighting of the paper was biased towards level 3 and level 4 question

It was very critical for non-mathematics teachers to get an opportunity to practice. This is because another important point to note is that the distribution of questions in the exam was weighted in favour of level 3 and level 4 in terms of the taxonomy. When analyzing the scripts, I found that the questions were not balanced in terms of ML taxonomy of levels distribution, as advised for the ML at school level. According to the DoE MLSAG (2008b, p. 12) the questioning levels should be distributed as follows:

Level	**1**	**2**	**3**	**4**
Description	Knowing	Applying routine procedures in familiar contexts	Applying multistep procedures in a variety of contexts	Reasoning and reflecting
Marks%	30	30	20	20

In contrast in the Numbers and Operations module the levels were distributed as follows:

Level	**1**	**2**	**3**	**4**
Description	Knowing	Applying routine procedures in familiar contexts	Applying multistep procedures in a variety of contexts	Reasoning and reflecting
Marks%	08	23	46	23

However, the weighting of the paper that favoured Levels 3 and 4 questions could also have inadvertently disadvantaged non-mathematics teachers who struggled with Levels 3 and 4 questions, which required sophisticated mathematical techniques. Again, the pace of the course could not allow the students a further opportunity to explore these problems with understanding, through various means including practice. An opportunity for non-mathematics teachers to explore such problems was denied them by the pace at which the course was offered. The nature of the course was such that the content was offered in fixed time frames, which also meant that, the assessment programme was also within a similar framework. The study conducted in Western Cape reveals that the pace of the programme is critical in student's achievement and engagement. They are quoted as saying:

> "Due to the pressure of time on the programme, it was not possible to include consolidation work that was appropriate for the less skilled teachers, for all the contexts considered. The first objective of providing teachers with the experience of being properly mathematically literate was thus not fully achieved for less skilled teachers. As a consequence, the more reflective parts of the programme became less real to them and were partly memorized rather than evidenced through experience". (Brown et al., 2006, p. 51)

However, in acknowledging such standards on the in-service training of teachers, Lester (1993, p. 2) speaking on professional development of educators, is of the opinion that teachers must be challenged at their level of mathematical competence as a way of deepening their own understanding of the mathematics content; for them to be better prepared to help students become active; engaged mathematical problem solvers. The researchers have argued that a teacher's level of understanding plays a major role in influencing the knowledge that learners construct. This idea is supported by Borko and Brown (1992) as they pointed to the importance of teachers having strong content knowledge as giving them the confidence and resources to engage children at more challenging levels and undertake more adventurous learning tasks.

Furthermore, teachers are struggling with the aspects of mathematisation as a process, in dealing with contextualized problems of ML. The biggest difficulty was in their responses to Level 3 and Level 4 types of questions. These levels are characterized mostly by the modeling type of questions that involves the full cycle of mathematisation. As per categorization defined by OECD/PISA (2003, p. 54) in Chapter 2, I then find mathematics specialists belonging to OECD/PISA level 2, with non mathematics belonging to OECD/PISA level 1. Results from Table 11, which was about identifying the mistakes committed by the non-mathematics teachers, shows that they were only able to carry out single-step processes that involve recognition of familiar contexts and mathematically well-formulated problems; reproducing well-known mathematical facts or processes; as well as applying simple computational skills.

5.5 Research Question Three:

What aspects of mathematisation were experienced as challenging by the whole group of teachers?

The results from Table 10 reveal that non-mathematics teachers found almost all aspects of mathematisation challenging. This analysis came as a result from Table 8 which shows that the problems identified as problematic to non mathematics, were indeed necessitating the engagement of teachers in the mathematisation process. The testimony was also evident in Table 11, which shows that non-mathematics teachers performed almost better in certain mathematical demands except for the mathematical modeling. Mathematical demand of modeling (Table 11) is the only platform where teachers need to engage in a full cycle of mathematisation, which involves in particular the aspect of turning the problem into a mathematical problem. There are only two non-mathematics teachers (G and Q) who performed better than their colleagues. It was also noted that teachers G and Q did well at all levels. One of the reasons could be Teacher Q stressed the notion of practice behind her success. Mathematics specialists found aspects 4 (solving the mathematical problem) and 5 (reinterpreting the mathematical solution to make sense of the real-life problem) of mathematization, as challenging, particularly to Level 3 and 4 types of questions. These levels of taxonomy mostly feature the modeling problems that involve the development of mathematisation skills.

As suggested by the RAND (2001) in the mathematics teaching reforms in USA discussed in Chapter 2, the integrated approach and intensified programme is seen to be required where in-service teachers are exposed to problem solving involving particularly mathematical modeling. This is simply because the results show that even if one is knowledgeable on mathematical modeling, it is the exposure that is playing an important role. In fact, mathematical modeling is an excellent avenue for promoting student understanding of the concept of functions. When students are immersed in the context of modeling real-world data in an applied algebra course, they become more engaged, and thus, they are able to move beyond basic algebra skills to a focus on concepts and applications. Mayes and Zelkowski (2008, p. 50) share similar sentiments when they suggest that, "an applied algebra course can create an environment that gives students the ability to see the practical use of algebra as a tool for modeling their world". Speaking from within the German context, Beckmann et al., (2009, p. 223) are of the similar sentiments as they suggest that "Mathematical literacy implies the capacity to apply mathematical knowledge to various context-related problems in a functional, flexible and practical way. Improving mathematical literacy requires a learning environment that stimulates students cognitively as well as allowing them to collect practical experiences through connections with the real world. In order to achieve this, students should be confronted with many different facets of reality. They should be given the opportunity to participate in carrying out experiments, to be exposed to verbal argumentative discussions and to be involved in model-building activities".

5.6 Implications of the Study

A mathematically literate individual is known to demonstrate what Kilpatrick (2001) regards as strands of proficiency. The platform at which these proficiencies can be demonstrated is when students are challenged with problems that necessitate the engagement into the full cycle of mathematisation. If our teachers are not developed in this combination of abilities, it is likely that no meaningful learning will ever take place in our classrooms. Therefore a failure by the teacher in addressing the context-based problems belonging to SAML levels 3 and 4 means we as an educator community are to a certain extent failing to achieve the aims of ML as explained by the NCS.

However it is pertinent to note that a failure to mathematise did not mean a failure to succeed in the course. As I have pointed out earlier in this chapter, the question paper for the Numbers and Operations featured various types of questions, including the modeling type of questions. Even though some questions were aimed at developing mathematisation skills, others were structured using alternative types of questioning. For example, Q2.2 was broken down into sub-questions Q2.2.1; Q2.2.2 & Q2.2.3; and Q3.4 was also broken down to sub-questions Q3.4.2 & Q3.4.3. This lowered the cognitive demand of the question. This type of questioning is great concern, especially at South African matric ML level. In School ML Paper 1 of 2008, I noted that in all the questions learners were given the formula with which to begin each question e.g.

Q2.2.4 Calculate the area of the circle made by the blades when they rotate [Area = π x $(\text{radius})^2$, using $\pi = 3{,}14$].

Again, in all the questions where learners were supposed to convert between the quantities, they were given the ratio to begin each question e.g.

Q1.3.1 Convert 9oz to grams (1 oz = 30g).

To be explicit, the step-by-step nature of questioning limits the development of mathematisation skills. According to Chitera, Graven, Lampen, Nalube and Venkat (2009, p. 52) the step-by-step nature of the question breakdown serves to direct candidates' attention to particular parts of the text in a sequence. However, I argue, if these skills of mathematisation are not properly cultivated, our society will be deprived of the golden opportunity to interact with real-life problems meaningfully. My argument is driven by the fact that in a real life situation, a person has to identify the problem and decide on the solution. The situation is not accompanied by a set of step by step questions.

The findings of this study suggest that teachers need help in moving from lower thinking levels to higher levels. However, teachers may view this as a threat because teachers like secondary school learners, believe that the tests and assignments should resemble the examination. When this happens, teachers do not have the opportunity to transfer algebraic skills from one context to another context because they only experience familiar contexts. One teacher is quoted as saying, "*Not all the context is dealt with and you encounter problems when you write assignments and writing of examination. The tests do not give a clear reflection on what will be on the exam. The tests are easy and the exam becomes difficult".* One of the strands of mathematical proficiency (conceptual understanding) as described by Findell et al. (2001, p. 121) advocates the ability by students to "know why a mathematical idea is important and kinds of contexts in which it is useful". I think the attitude of the teachers from the above quotation, may limit the development of these proficiencies. Attitude is a personal characteristic, and perhaps the DoE and the Teacher Educators could find ways to address this problem, because otherwise, chances of achieving this important goal (development of mathematical proficiency) are very minimal.

This study has made a contribution to knowledge about learning and teaching ML in the following ways:

- Mathematical demands related to aspects of mathematisation.

- Description of ML tasks in terms of the categories: modeling; contextual reasoning; multi-step; conversion; and inverse.
- Assessment taxonomy

This study has revealed that the mathematics specialist teachers differed from the non-mathematics teachers in the ways that they:

- Responded to the SAML level 3 and level 4 questions of the module Numbers and Operations in context.
- Respond to certain types of algebraic–rich questions that were encountered in the Mathematical Literacy course such as: reasoning; modeling; and multi-step.
- Engaged in the aspects of mathematisation as a process.
- Are ranked at OECD/PISA levels.

Arising from this study, there is a need for further research that can consider the following research questions:

- How can opportunities to mathematical modeling be incorporated in the part-time in-service contact courses like ACEML?
- How can the skills of in-service teachers be improved, such that they are able to use the grade9 mathematical knowledge in solving the problems of ML?
- Can teachers with only grade12 mathematical knowledge, teach ML effectively?
- What knowledge do ML teachers need in order to facilitate the learning of ML with their learners? Is algebraic knowledge the only aspect necessary for ML teaching? What about knowledge of logic, language and spatial sense?
- For those non-mathematics teachers who performed poorly, what are other factors that may have influenced their performance? What role does factors such as a lack of commitment on the part of the students; poor teaching by the lecturers/tutors?
- How can the ZFI of teachers who are on the programme be identified? How can the programme be designed so that it contributes to an extension of the teachers' current ZFI?
- To what extent should programmes designed for ML teachers focus on the development of mathematics content knowledge and skills?

5.7 Way forward

When conducting the course of this nature, Teacher Educators need to recognize that teachers are now learners-it was pointed out that the teachers found the pace difficult. Furthermore, Mathematical Literacy as a learning area should not be regarded as a watered down version of mathematics. Hallendorff (2003) points out that "what is important is to develop mathematical literacy, not as a watered down version of mathematics, but as the application of level 1 mathematics in various contexts, of varying complexity. In this sense, mathematical literacy can progress in complexity from levels 2-4, even though the mathematics remains at level 1".

It is encouraging to note that with time one may anticipate the teachers' personal growth and development as one teacher is quoted as saying:

> "Working with Mathematical Literacy every day slowly forced me to change my views and attitudes. Working through a range of real-life based topics, I found that I was learning a lot from it myself. I do not think I would have had any interest in a national budget speech if it had not been for Mathematical Literacy. I was never interested in my bills before. I used to glance over amounts and pay them, no questions asked, but now I must say that I am much more alert on such issues. I have even queried my bills on occasion and saved myself some money" (Zengela 2008, p. 47)

5.8 Conclusion

This study was conducted with a class from a rural area in KwaZulu-Natal. This was one class among twenty-four which comprised the UKZN ACEML cohort. Research of this kind was conducted for the first time. This study focused on exploring the extent at which in-service teachers draw upon their basic algebraic knowledge as they engage in the context-based problems of ML. My intention was to gain a better understanding of the impact the teachers' understanding of algebraic concepts may have, upon dealing with the context-based problems of ML. This ideal was to be achieved through analysing the teachers' work as they engaged in examination of the module Numbers and Operations in the ACEML course. As the study progressed, it came as a matter of interest to view the teachers' performance along the lines discussed in Chapter 4 (being either mathematics specialists; or non-mathematics teachers).

The analysis of various themes described in this chapter reveals two important findings. Firstly, in an ACEML course, mathematics specialists were found performing better than the non-mathematics teachers. However, most non-mathematics teachers nonetheless passed the course. This can be taken as an encouragement towards the implementation of Mathematical Literacy as a learning area in the South African classrooms. Secondly, all teachers (mathematics specialists and non-mathematics teachers) need help in moving from lower thinking levels to higher thinking levels. This study has revealed that some of the mathematics specialists struggled at certain aspects of mathematisation particularly at level 4 questions.

The discussion from this research is hoped to open opportunities for further research on the use of basic algebra, especially when dealing with context-based problems of ML. Teachers, researchers and other stakeholders may want to scrutinize the suggestions made in this study for improvement in the use of algebra by both in-service teachers, as well as school learners. This is simple because, the exercise of reskilling teachers is an on-going process, therefore the institutions like UKZN which provide this service, may also seek some ways of improving. Further research could be conducted to determine other ways in which the use of algebra can be taught in order to produce better results.

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APPENDICES

APPENDIX A: Student Informed Consent

Title of the Project: Exploring teachers' perceptions about, and performance, in Mathematical Literacy tasks based on algebraic concepts

I am a M Ed (Mathematics) student at the University of KwaZulu-Natal. I am currently conducting research that is aimed at exploring the teachers' understanding of the algebraic concepts in Mathematical Literacy. This study involves analyzing in-service teachers' reflections on the given tasks. It also involves the analysis of examination scripts. This will be followed by the completion of the questionnaire. It also includes interviews with selected students in order to clarify my understanding of the responses in the reflections as well as the questionnaires. These interviews will be tape-recorded. Confidentiality is assured because none of the names will be used in the analysis or the report. If you have any queries or concerns, kindly contact the following persons:

Researcher: Mr A.S. Vilakazi Tel: 032-454 1411 Cell: 082 227 8635	Supervisor: Dr S. Bansilal Tel: 031-260 3451

Declaration:

I………………………………………………………………. (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE OF PARTICIPANT DATE

………………………………………………………………………………………………

APPENDIX B: Mark analysis for modules Data Handling & Numbers and Operations

Student's Name	Numbers & Operations	Data Handling
Left	0 (No DP)	41
G	61	69
I	0 (No DP)	61
A	62	68
N	60	65
K	0 (No DP)	57
B	72	75
D	75	65
Q	63	73
L	72	62
J	0 (No DP)	54
C	38 (Fail)	58
O	61	65
Left	69	71
P	34(Fail)	51
M	35(Fail)	55
H	43(Fail)	62
F	60	65
E	50	52

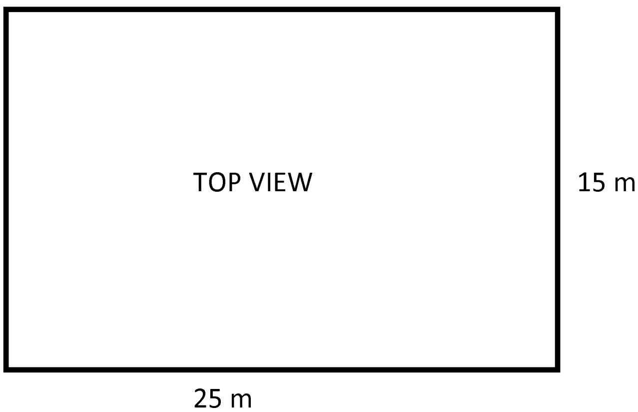
Mathematics Specialists			Non-mathematics Teachers		
Participant	Numbers & operations	Data Handling	Participant	Numbers & Operations	Data Handling
A	62	68	G	61	69
B	72	75	I	0 (No DP)	61
D	75	65	N	60	65
L	72	62	K	0 (No DP)	57
C	38 (Fail)	58	Q	63	73
O	61	65	J	0 (No DP)	54
H	43 (Fail)	62	P	34 (Fail)	51
F	60	65	M	35(Fail)	55
			E	50	52

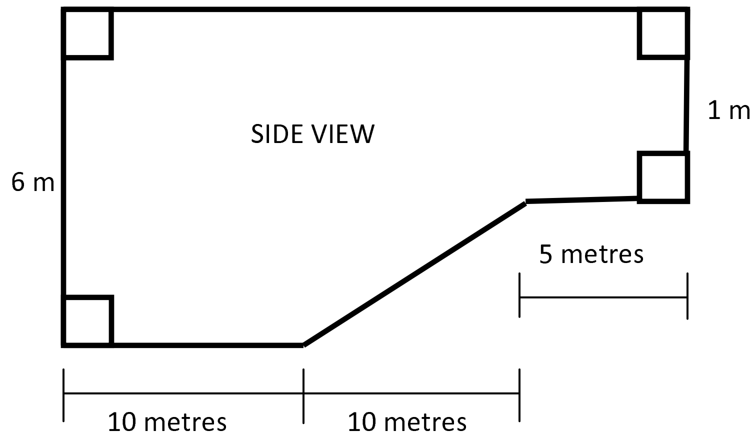
APPENDIX C: The task for teachers to reflect on

Imagine you have decided to build a swimming pool. You have some requirements for the pool, but you need to know how much it is going to cost. You are required to use your mathematical skills to answer the following questions.

SECTION A : Calculating the costs for the design of the pool below:

The design of the pool should be as follows (refer to sketches below – not drawn to scale):





Design considerations:

- The pool should be rectangular in shape, 25 metres long and 15 metres wide.
- The bottom of the first five metres of the pool should be flat and one metre deep.
- In the next 10 metre, the pool gets deeper at a rate of one metre of depth for every one metre of length, so that at 15 metres from the shallow end of the pool, the pool is 6 metres deep.
- The last 10 metres of the pool also has a flat bottom, and is 6 metres deep.

Now answer the following questions:

1.1 Calculate the area of the surface of the pool. (2)

1.2 What is the area of the wall at the shallow end of the pool? (1)

1.3 What is the area of the wall at the deep end of the pool? (1)

1.4 What is the area of one of the sides of the pool? (3)

1.5 What is the area of the bottom of the pool? (2)

1.6 How many cubic metres of water are you going to need to fill up the pool? (5)

1.7 You have picked out blue tiles to cover the bottom and sides of the pool. Each tile is

25 cm^2 . How many tiles will you need to cover a square metre? (2)

1.8 How many tiles will it take to cover the sides and bottom of the pool? (3)

1.9 The tiles come in boxes of 20 each. How many boxes will we need to tile the sides and bottom of the pool? (2)

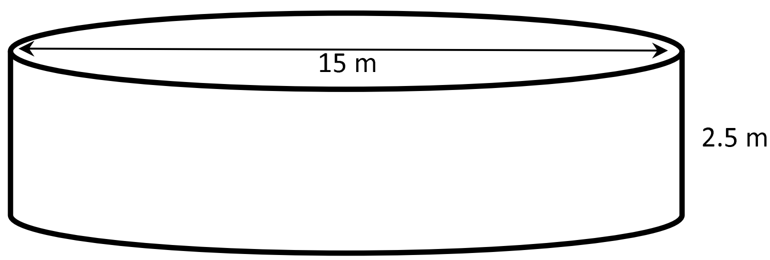
1.10 If each box of tiles cost R185,00, how much will it cost to cover the pool in tiles.? (2)

1.11 The local excavation company charges R700,00 for each cubic metre they dig. How much will it cost to dig the pool? (2)

1.12 How many gallons of water will our pool hold? (Hint: The metric system unit for volume is litres. There are 4 litres in a gallon) (2)

1.13 We finally want to fence this pool. The fence must be 5 metres from the edge of the pool. If fencing costs R15,00 per running metre, how much will it cost to fence the pool? (3)

<u>SECTION B</u>: Calculating the costs incurred in building the circular pool below:



<u>Considerations</u>:

- The pool must have a diameter of 15 metres.
- The depth of the pool must be 2,5 metres.

2.1 Calculate the total cost of tiling the inner walls including the floor of the pool, if tiling costs, including labour, amounts to R85,00 per square metre. (6)

2.2 A local pool company charges R0,45 per litre to fill the pool with water. How much will it cost to fill up this pool with water? (1 litre = 1000 cm^3) (8)

2.3 This pool needs to be fenced about 2,5 metres from the edges of the pool. If it costs R15,75 per running metre to fence, how much will it cost to fence around the pool? (6)

APPENDIX D: Teachers' Reflections on the task given

(Participants are represented by letters A to Q)

I: this assignment was almost all what one has acquired in learning this aspect of mathematics. It became harder where one had to calculate the floor of the swimming pool with different widths as well as calculating the number of tiles to tile the floor of the swimming pool. I wouldn't blame the assignment; we need to be exposed to different situations where one needs to apply this everyday knowledge.

M: this assignment was very difficult to me. Before this assignment there was a need of going back to previous knowledge. My suggestion is that before we go to the assignment more exercises related to that assignment must be given to us, because most of the things in this assignment need to update you about the previous knowledge. The assignment must not be parallel to the work we are doing.

P: the assignment was very difficult, because it new the knowledge about secular volume which we had not learn about it from the module. It is not part of what we had learnt. In future the coordinator for the module must make provision for it from the module, so that the learners would cope with such complicated assignment. Some information was not clear, such that I fail to provide relevant interpretations as required by the questions.

K: on this assignment one need the understanding of perimeters, rectangles, squares on how it is calculated. Also knowledge of the circumference e.g.

circumference of a circle = $2\pi r = \pi d$

H: the pool was not drawn to scale. Volume need to be calculated if you need an amount of water to be filled on a pool. You need to know how many square metres make 10000 cm squared. I tile is equal to 1 m squared. How many litres in a gallon. You also need to know the amount of π.

F: to do this assignment; one must have the knowledge of the following: calculation of the area of a rectangle and a square. Calculation of the volume of a rectangular; prism; and cylinder. One must also be able to make conversions between units of measurement like cm-m; cm cube – l; l – gallons. One must also be able to calculate the perimeter of an object.

B: I believe that in order for a person to be able to complete this assignment without any difficulty, he/she should acquire the knowledge of measurement strategies because they help us connect numbers to space so that we can analyse a model and replicate a shape. The understanding of shapes is also one of the pre-requisite information that is required to solve this assignment without problems. Insight and intuitions about two and three dimensional shapes and their characteristics and formulae of different shapes also plays a major role in solving problems of this assignment.

G: in order for a person to complete this assignment an understanding of single and two dimensional angle/shape/objective is essential. Formulas to calculate area and volume. Be able to calculate different shapes volume, side view and rear view. Be able to draw and read different shapes. Conversions of metres to centimetre also were essential. Cost calculations also. Unit cost etc.

C: this task wasn't easy therefore the cumbersome part of it was when I was supposed to draw a pool. Another crucial point is that there is a huge gap between this task and contact session where we tack this concept. For me it would be better (propose) if we were assessed immediately after the concept (e.g. trigonometry) has been completed.

L: elementary figures: one must be in a position to make a clear distinction between 2D and 3D objects and the familiarity may be shown when problems involving perimeter, area and volume are solved without confusing figures. Drawing/practical construction of elementary figures proves very beneficial for most people though some have a highly developed spatial sense. Being able to read/draw views is indicative of one's understanding of shapes. Conversion of units: the ability to convert bigger units to smaller ones e.g. m cube to l to cm cube is a necessity. Converting metric units (which are still widely used is a requirement e.g. 1 inch = 2.54 cm)

E: *As I was trying to answer all the questions asked in this task, I only found that some questions were not clear and understandable, but because of the basic knowledge of pure mathematics I have learnt before I tried to answer some questions. Although in some questions I failed to use mathematics or mathematical literacy knowledge then I answered them the way I understand. I then strictly say this mathematical literacy needs the understanding of pure mathematics.*

D: When I see the top view and side view of the pool I thought of ways of calculating the area of triangle, rectangle, circle and trapezium. Using formulae for these shapes stated above and using skills taught in class for calculating the area of circle, rectangle, square, triangle and trapezium. Calculating the surface area of a three dimensional surface of a triangle, circle and rectangle. Use of a formula for calculating the circumference to be able to find the cost where I use the knowledge of Mathematics where the cost per metre is multiplied with the size of the circumference. Using the formula for calculating the volume of a rectangle, circle and trapezium. *The task was challenging to use knowledge learnt though some questions were not clear but through prior knowledge from other learning areas I was able to attempt where the conversion of volume in cubic centimetres to litres was the information from the Numbers and Operations and be able to calculate the number of items e.g. tiles.*

Q: *The way the problems were structured, it was very difficult it required prior knowledge. Therefore if you did not do mathematics after matriculation it was really a problem. I think they should have broken down the problems so that they could be easily understandable. Some of the sums were easy to do and make sense. Before we had to embark on the assignment we had to do practice exercise before.*

J: *What I have noticed in this task is that some of the questions were difficult. It was not easy to answer it without thinking so what I did I've tried to draw the whole pool in order to see the deepest part easily. Another thing one must have background knowledge of calculating area, volume and perimeter. We need to know all those things so it is difficult for a person who did maths in ten years back to do this.*

A: when there is a clear picture of this pool (having sketch). Then it was a bit easy to attempt some of the questions. The knowledge of calculation total surface area of rectangles, trapezium, cylinder etc was of help. Knowledge of how to calculate volume was of help also in the attempt of this question.

O: this assignment demanded a lot of background knowledge especially in use and understanding of the formulae on areas of different geometric shapes. The shapes here were involving in particular a circle where formulae to find surface areas and volumes. It further demanded the formulae on the different areas of rectangles and triangles to find their areas. This included dividing the given shape in different geometric figures and then adding all those areas to find the total area of the bigger figure. Thorough understanding of the conversion played a vital role to able to cover the given or calculated areas in real situations. Even the cost of the calculated material if the costs for each unit will be given. This in fact was an assignment demanding real life implications.

N: in doing this assignment the concepts of 3dimensional figures came to mind and also the use of orthographic projection or drawing came to mind as well. It also reminded me with the concept of mensuration whereby different formulae or methods how to be used to find the area and the volumes of a given figures or pools. The concept of multiplication, addition, division were also used to find the sum total of the given sided. The task was although challenging but on the other hand it was interesting in that it brought out critical thinking skills in me and also the creativity of putting orthographical drawings in three dimensional forms. The concept that was more challenging was how to picture the 3dimensional figure from the orthographic point of view. The task would have been much easier if the diagram in section A was drawn in 3dimensional form. Finally, in my perspective I realised that the questions more especially in section A were very lengthy as it does not correspond to the marks allocated for each question

APPENDIX E: The Questionnaire

SECTION A

Biographical Details

Name of Participant :____

Academic Qualification/s :____

____

Major/s :____

Professional Qualification/s :____

Major/s :____

Number of years teaching mathematics:_______________

I am teaching at the (urban, rural, suburban, township) school :______________________

SECTION B

In this section you are presented with a statement to which you should indicate the extent of your agreement/disagreement.

Q1: Algebraic teaching experience is fundamental for learning of mathematical literacy

Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Q2: Social background has an impact on learning of mathematical literacy

Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Q3: Technologically rich society will learn mathematical literacy better

Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Q4: Grade 12 mathematics is adequate for learning and teaching Mathematical Literacy

Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Q5: Contexts should be made available to all teachers for the learning of mathematical literacy

Strongly disagree	Disagree	Neutral	Agree	Strongly agree

SECTION C

This section is based on the responses you provided in SECTION B. Please provide only your opinion if there is any.

*1. Algebraic teaching experience **is/not** fundamental for learning of mathematical literacy*

*2. Social background has **an/no** impact on learning of mathematical literacy*

***3. Technologically rich society/any society** will learn mathematical literacy better*

*4. Grade 12 mathematics is **inadequate /adequate** for teaching mathematical literacy*

*5. Contexts **should/should not** be made available to all teachers for the learning of mathematical literacy*

SECTION D

In this section you are urged to provide any reasons that you feel are hindering the progress of students in this Mathematical Literacy Course.

APPENDIX F: Biographical details of the participants

Category	Participant	Highest qualification/grade passed in Mathematics
Mathematics	A	STD – Mathematics MTE – 14 years
	B	HDE – Mathematics MTE – 2 years
	C	B Paed –Mathematics Primary MTE – 5 years
	D	Diploma in Mechanical Engineering – Mathematics MTE – 2 years
	F	PTD – Mathematics MTE – 11 years
	H	STD – Mathematics MTE – 4 years
	L	ACE – Mathematics MTE – 12 years
	O	STD – Mathematics MTE – 23 years
Non Mathematics	E	Standard 10 MTE – 2 years
	G	Standard 10 MTE – nil Current: Economics & Business Studies
	M	Standard 10 MTE – nil Current: IsiZulu
	N	Standard 10 MTE – 7 years
	P	Standard 10 MTE – 1 year
	Q	Standard 10 MTE – nil Current: Business Studies

APPENDIX G: The responses from Section C and Section D of the questionnaire

A	S1	I have no say
	S4	True
	SecD	Background (mathematical one) is the key element in making learners to pass this course. So lack of this background is not good
B	S1	No, as long as you have that adequate pre-knowledge background you can learn mathematical literacy even if you are not teaching mathematics
	S4	Absolutely, you need to have adequate background because if you don't have it your self-esteem will be affected and you won't feel confident enough to tackle problems.
	SecD	Some of the students do not have adequate pre-knowledge background. Sometimes some contexts require the mathematical skills of which some of us don't have because we didn't major with it.
C	S1	Yes because other concepts seeks somebody to have pre-knowledge on the subjects
	S4	Yes because for students who don't have solid foundation in maths find it difficult to cope with the standard of work
	SecD	Too much work without given students time to reflect, and the information to sink has given students problems. Sometimes facilitators are not equipped/study materials have mistakes/ no memorandum
D	S1	Even if you had not taught mathematics but you can learn Mathematical Literacy if you did MLMMS from grade 1 – grade 9
	S4	No, if you are able to understand a statement and work with numbers you may learn Maths Lit.
	SecD	Some students did not do maths at grade 12 and some are unable to work with numbers but have interest in knowing them so as to be able to work with measurements using instruments
E	S1	Yes because mathematical literacy deals with the basic of mathematics. If you fail to capture the law of maths you fail to understand maths lit.
	S4	True because mathematical literacy has more to do with algebraic knowledge of mathematics

	SecD	No reason
F	S1	Not necessarily so because you can learn mathematical literacy successfully as long as your tutor and yourself are well determined
	S4	Some of the skills and knowledge in grade 12 are applicable in mathematical literacy
	SecD	Students learn a lot in a very limited time
G	S1	You can learn ML even if you are not teaching maths as long as you have background in high school
	S4	Neutral
	SecD	Is when compiled learning materials are simple and straight forward than tests and examinations. Materials should be difficult as tests to prepare us to pass
H	S1	If you learn maths lit you need to know some maths skills like calculating skill and skill of working with numbers and using calculators
	S4	Neutral
	SecD	Language usage Scenario interpretation Calculation skills
I	S1	This is true some of us are not teaching mathematics where they are and they find themselves getting delayed in solving problems
	S4	It is easier for you if you have grade 12 knowledge and at the same time not that you cannot do without
	SecD	A lot of work is given in a short space of time, but what else can be done? Learners need to be taught
J	S1	Yes I agree with this statement because if we did mathematics it will be easier to understand maths literacy
	S4	You must have adequate pre-knowledge in order to get mathematical literacy
	SecD	I think its because it is a new subject but as time goes on learners will be able to pass this subject
K	S1	Not that much, but mathematical background can be of good help

	S4	Yes it can help
	SecD	Language problem
L	S1	Maths teaching is advantageous for learning maths lit but not necessarily a key component
	S4	Not algebra alone, but other branches e.g. stats, geometry, etc
	SecD	Perhaps if people were allowed to study at their own pace – but this is highly impractical
M	S1	You can be able to learn mathematical literacy even if you are not teaching it
	S4	No matter what knowledge you have you can be able to learn maths lit.
	SecD	I think assessment must be provided in each and every section so that you can be able to face any problem, not doing many aspects because you are getting confused when you are writing the test
N	S1	The mathematical knowledge may have a key component in teaching MLit but much still needs to be understood in the context of the realities of MLit.
	S4	Neutral in that mathematical literacy in a whole does not depend on algebraic knowledge only.
	SecD	Inadequate mathematical knowledge due to the unjustified education system of the past. Prejudices thus the pre…..knowledge of many people about calculative subjects
O	S1	No comment
	S4	No comment
	SecD	The understanding of English contexts as well as the basics for mathematics is the crucial one in understanding this course
P	S1	No because mathematical literacy had to be known by all educators as it is a new subject in the curriculum
	S4	Not exactly, because an educator who had not done maths at grade 12 may perform better in maths lit course.
	SecD	The problem is caused by learning many concepts at a very short period. If you learn one concept and get assessment on it, I hope it will improve the rate to grasp the information. But the course is excellent

Q	S1	No, its not, even though you are not teaching it but have done it in your high school years you can learn maths lit.
	S4	Yes, if you do not have pre-knowledge it becomes difficult to master some of the concepts.
	SecD	Not all the context is dealt with and you encounter problems when you assignment and writing of examination. The tests do not give a clear reflection on what will be on the exam. The tests are easy and the exam becomes difficult

APPENDIX H: Taxonomy in Mathematical Literacy

Level 1: Knowing

Tasks at the knowing level of the ML taxonomy require learners to:

- Calculate using the basic operations including:
    - Algorithms for +, −, × and ÷;
    - Appropriate rounding of numbers
    - Estimation
    - Calculating a percentage of a given amount; and
    - Measurement
- Know and use appropriate vocabulary such as equation, formula, bar graph, pie chart, Cartesian plane, table of values, mean, median and mode.
- Know and use formulae such as the area of a rectangle, a triangle and a circle where each of the required dimensions is readily available.
- Read information directly from a table (e.g. the time that bus number 1234 departs from the terminal)
- *Choose the information, then calculate*

Level 2: Applying routine procedures in familiar contexts

Tasks at the *applying routine procedures in familiar contexts* level of the ML taxonomy require learners to:

- Perform well-known procedures in familiar contexts. Learners know what procedure is required from the way the problem is posed. All of the information required to solve the problem is immediately available to the student.
- Solve equations by means of trial and improvement of algebraic processes.
- Draw data graphs for given equations.
- Draw algebraic graphs for given equations.
- Measure dimensions such as length, weight and time using appropriate measuring instruments sensitive to levels of accuracy.
- *Applying or using the formula (derived by themselves) to identify values*
- *Describing the pattern verbally*
- *Carrying out a procedure or operation*
- *Describing a relationship between the variables verbally*
- *Moving from one representation to another (Level Two)*
    - Verbal to symbolic (equation)
    - Symbolic to verbal

- Verbal to table
- Table to verbal
- Table to symbolic
- Symbolic to table
- Graphical to symbolic
- Symbolic to graphical

Level 3: Applying multistep procedures in a variety of contexts.

Tasks at the *applying multistep procedures in a variety of contexts* level of the ML taxonomy require learners to:

- Solve problems using well-know procedures. The required procedure is, however, not immediately obvious from the way the problem is posed. Learners will have to decide on the most appropriate procedure to solve the problem, and may have to perform one or more preliminary calculations before determining a solution.
- Select the most appropriate data from options in a table of values to solve a problem.
- Decide on the best way to represent data to create a particular impression.
- *Describing a pattern/ real situation/ table using an equation or formula*

Level 4: Reasoning and Reflection

Tasks at the *reasoning and reflecting* level of the ML taxonomy require learners to :

- Pose and answer questions about what mathematics they require to solve a problem and then to select and use that mathematical content.
- Interpret the solution they determine to a problem in the context of the problem and where necessary to adjust the mathematical solution to make sense in the context.
- Critique solutions to problems and statements made by others
- Generalizes patterns observed in situations, make predictions based on these patterns and/or the evidence and determine conditions that will lead to desired outcomes.

Reasoning and Reflecting

- *About given data/situation*
- *Where you need to perform a calculation before making a judgment*
- *Where you had to come up with your own solution before making a judgment*

APPENDIX I: Analyzed scripts

NUMBERS AND OPERATIONS

LEVEL ONE

Mathematics Specialists						
Participant	1.2.2 (1)	2.1.1 (3)	3.1 (4)	6.3.1.1 (2)	Total (10)	%
A	1	2	4	2	9	90
B	1	0	4	2	7	70
C	1	0	4	0	5	50
D	1	0	1	2	4	40
F	1	1	2	2	6	60
H	0	0	1	2	3	30
L	1	0	3	2	6	60
O	1	1	1	2	5	50
Total	8	24	32	16	80	
Achieved	7	4	20	14	45	
%	88	17	63	88	**56**	
Non-Mathematics Teachers						
Participant	1.2.2 (1)	2.1.1 (3)	3.1 (4)	6.3.1.1 (2)	Total (10)	%
E	1	0	2	2	5	50
G	1	2	2	2	7	70
I						
J						
K						
M	1	0	1	0	2	20
N	1	1	1	2	5	50
P	0	0	2	2	4	40
Q	1	2	1	2	6	60
Total	6	18	24	12	60	
Achieved	5	5	9	10	29	
%	83	28	38	83	**48**	

LEVEL TWO

Mathematics Specialists								
Participant	1.2.1 (3)	1.3.1 (3)	2.2.1 -3 (7)	3.3+ 3.4.1(8)	6.1.1 -2(4)	6.3.1.2 (3)	Total (28)	%
A	3	3	7	8	4	0	25	89
B	3	3	7	8	4	0	25	89
C	3	0	0	5	4	0	12	43
D	3	3	7	4	4	0	21	75
F	3	3	7	8	2	0	23	82
H	3	3	0	5	2	3	16	57
L	3	3	7	8	4	3	28	100
O	3	3	7	5	4	3	28	100
Total	24	24	56	64	32	24	224	
Achieved	24	21	42	51	28	9	175	
%	100	88	75	80	88	38	78	
Non-Mathematics Teachers								
Participant	1.2.1 (3)	1.3.1 (3)	2.2.1 -3 (7)	3.3+ 3.4.1(8)	6.1.1 -2(4)	6.3.1.2 (3)	Total (28)	%
E	0	3	7	4	2	0	16	57
G	3	3	6	8	4	0	24	86
I								
J								
K								
M	0	0	0	3	4	0	7	25
N	0	3	7	8	4	0	22	79
P	0	3	0	8	2	0	13	46
Q	3	3	7	3	4	0	20	71
Total	18	18	42	48	24	18	168	
Achieved	6	15	27	34	20	0	102	
%	33	83	64	71	83	0	61	

LEVEL THREE

Mathematics Specialists									
Participant	1.3.2 (3)	2.1.3 (6)	3.2 (4)	3.4.2-4.2(15)	5.1 (4)	5.3.1-5.4(20)	6.1.3 (4)	Total (56)	%
A	3	0	4	11	2	9	1	30	54
B	3	6	2	13	2	13	1	40	71
C	3	5	4	0	2	0	0	14	25
D	3	0	2	13	2	8	0	28	50
F	3	0	4	14	4	6	4	31	55
H	3	0	0	7	0	5	1	16	29
L	3	5	4	15	0	4	4	35	63
O	1	3	0	5	2	11	4	26	46
Total	24	48	32	120	32	160	32	448	
Achieved	22	19	20	78	14	56	15	220	
%	92	40	63	65	44	35	47	49	
Non-Mathematics Teachers									
Participant	1.3.2 (3)	2.1.3 (6)	3.2 (4)	3.4.2-4.2(15)	5.1 (4)	5.3.1-5.4(20)	6.1.3 (4)	Total (56)	%
E	3	3	0	9	2	8	1	26	46
G	3	5	1	9	1	4	0	23	41
I									
J									
K									
M	0	4	0	5	2	3	0	14	25
N	3	0	1	9	2	14	1	30	54
P	0	0	0	1	2	7	4	14	25
Q	3	3	4	7	2	3	4	26	46
Total	18	36	24	90	24	120	24	336	
Achieved	12	15	6	40	11	39	10	133	
%	67	42	25	44	46	33	42	40	

LEVEL FOUR

Mathematics Specialists								
Participant	1.1(6)	1.2.3(6)	1.3.3(4)	4.3 (4)	5.2(4)	6.1.4(5)	Total(29)	%
A	6	6	3	0	0	0	15	52
B	6	6	4	1	4	5	26	90
C	6	0	0	0	0	0	6	21
D	6	6	4	0	0	0	16	55
F	2	6	0	0	2	0	10	34
H	2	6	3	0	0	0	11	38
L	6	6	3	3	0	5	23	79
O	6	6	3	4	2	2	23	79
Total	48	48	32	32	32	40	232	
Achieved	40	42	20	8	8	12	130	
%	83	88	63	25	25	30	56	
Non-Mathematics Teachers								
Participant	1.1(6)	1.2.3(6)	1.3.3(4)	4.3(4)	5.2(4)	6.1.4(5)	Total(29)	%
E	2	0	3	0	0	2	7	24
G	6	6	3	0	4	0	19	66
I								
J								
K								
M	2	0	0	0	3	0	5	17
N	6	0	4	0	4	2	16	55
P	0	0	0	0	0	2	2	7
Q	6	6	3	0	3	4	22	76
Total	36	36	24	24	24	30	174	
Achieved	22	12	13	0	14	10	71	
%	61	33	54	0	58	33	41	

SUMMARY

Mathematics Specialists								
	A	**B**	**C**	**D**	**F**	**H**	**L**	**O**
L1	90	70	50	40	60	30	60	50
L2	89	89	43	75	82	57	100	100
L3	54	71	25	50	55	29	63	46
L4	52	90	21	55	34	38	79	79
Average	71	80	35	55	58	39	76	69

Non-Mathematics Teachers									
	E	**G**	**I**	**J**	**K**	**M**	**N**	**P**	**Q**
L1	50	70				20	50	40	60
L2	57	86				25	79	46	71
L3	46	41				25	54	25	46
L4	24	66				17	55	07	76
Average	44	66				22	60	30	63

FUNCTIONAL RELATIONSHIPS

Mathematics Specialists

Level One

Participant	2.2.3(2)	3.5-7(5)	4.1.3(2)	5.1(3)	5.2(2)	6.3(2)	Total(16)	%
A	2	1	0	3	2	2	10	63
B	2	3	2	3	1	1	12	75
C	0	3	0	0	0	1	4	25
D	2	5	0	3	2	1	13	81
F	2	3	2	3	2	0	12	75
H	2	5	0	3	2	0	12	75
L	2	1	1	3	1	2	10	63
O	2	3	1	3	2	0	11	69
Total	16	40	16	24	16	16	128	
Achieved	14	24	6	21	12	6	84	
%	88	60	38	88	75	38	66	

Level Two

Participant	1.2 (3)	1.3 (4)	2.1.1-2 (5)	2.1.3 (2)	2.1.4 (3)	2.1.5 (2)	2.2.1-2 (4)	2.2.4 (4)	3.1-2 (4)
A	0	4	0	0	0	0	4	4	0
B	2	4	0	0	2	0	2	4	4
C	1	4	0	0	2	0	0	0	0
D	3	4	0	0	2	0	4	4	4
F	3	4	5	2	3	0	4	4	2
H	1	0	0	0	2	0	4	4	2
L	3	4	5	2	3	2	4	4	4
O	2	3	5	2	3	2	2	4	4
Total	24	32	40	16	24	16	32	32	32
Achieved	15	27	15	6	17	4	24	28	20
%	63	84	38	38	71	25	75	88	63

Participant	3.3(6)	4.1.2(3)	5.4(3)	6.1(1)	8.1.2(4)	Total(48)	%		
A	1	2.5	3	0	3	21.5	45		
B	4	1	1	1	4	29	60		
C	3	0	3	1	4	18	38		
D	5.5	1	3	1	4	35.5	74		
F	1	1	3	1	3	35	75		
H	4	2	2	1	3	25	52		
L	6	3	2	1	3	46	96		
O	4	3	0	1	4	39	81		
Total	48	24	24	8	32	384			
Achieved	28.5	13.5	17	7	28	249			
%	59	56	71	88	88	65			

Level Three

Participant	1.1 (3)	3.4 (5)	4.1.1 (4)	6.2 (2)	7.1-2 (9)	8.1.1 (3)	8.1.3 (2)	8.1.4 (4)	8.2 (8)	Total (40)	%
A	0	2	4	0	6	3	2	4	8	29	73
B	0	3	4	0	8	3	2	4	8	32	80
C	0	3	0	0	6	0	2	4	0	15	38
D	0	3	4	0	8	2	2	1	8	28	70
F	0	2	2	1	9	3	2	4	8	31	78
H	0	3	4	0	6	2	2	2	0	19	48
L	3	3	4	2	9	3	2	4	8	38	95
O	0	2	4	1	9	3	2	4	8	33	83
Total	24	40	32	16	72	24	16	32	64	320	
Achieved	3	21	26	4	61	19	16	27	48	225	
%	13	53	81	25	85	79	100	84	75	70	

Level Four

Participant	3.8(3)	4.1.4(2)	4.2.1(6)	5.3(3)	6.4a(2)	Total(16)	%
A	1	0	5	1	2	9	56
B	2	2	0	3	2	9	56
C	1	0	0	1	2	4	25
D	2	0	6	0	0	8	50
F	0	2	6	1	2	11	69
H	0	0	3.5	0	0	3.5	22
L	1	2	6	3	2	14	88
O	2	0	2	2	2	8	50
Total	24	16	48	24	16	128	
Achieved	9	6	28.5	11	12	66.5	
%	38	38	59	46	75	52	

Non-Mathematics Teachers

Level One

Participant	2.2.3(2)	3.5-7(5)	4.1.3(2)	5.1(3)	5.2(2)	6.3(2)	Total(16)	%
E	0	4	0	3	1	0	8	50
G	1	1	2	3	2	1	10	63
I	1	2	0	3	1	1	8	50
J	0	1	0	0.5	1	0	2.5	16
K	1	0	0	0.5	0	1	2.5	16
M	0	1	0	0	1	0	2	13
N	2	0	0	3	1	0	6	38
P	0	3	0	1.5	1	0	5.5	34
Q	2	5	0	0.5	1	2	10.5	66
Total	18	45	18	27	18	18	144	
Achieved	7	17	2	15	9	5	55	
%	39	38	11	56	50	28	38	

Level Two

Participant	1.2 (3)	1.3 (4)	2.1.1-2 (5)	2.1.3 (2)	2.1.4 (3)	2.1.5 (2)	2.2.1-2 (4)	2.2.4 (4)	3.1-2 (4)
E	3	0	5	0	3	0	4	1	4
G	2	3	1	0	0	1	0	1	2
I	2	2	0	0	2	0	0	0	2
J	1	2	1	0	2	0	4	4	2
K	0	3	5	0	3	0	0	0	0
M	2	4	0	0	2	0	0	0	0
N	3	4	0	0	2	0	4	4	0
P	0	4	5	2	3	0	2	0	0
Q	2	2	5	0	3	0	3	4	2
Total	27	36	45	18	27	18	36	36	36
Achieved	15	24	22	2	20	1	17	14	12
%	56	67	49	11	74	6	47	39	33

Participant	3.3(6)	4.1.2(3)	5.4(3)	6.1(1)	8.1.2(4)	Total(48)	%		
E	6	0	3	1	4	34	71		
G	6	0	3	1	0	20	42		
I	1	0	1	0	2	12	25		
J	0	0	2	1	0	19	40		
K	0	0	2	1	1	15	31		
M	0	1	2.5	1	1	13.5	28		
N	1	2	2	1	3	26	54		
P	1	0	3	1	2	23	48		
Q	6	1.5	2	1	2	33.5	70		
Total	54	27	27	9	36	432			
Achieved	15	4.5	20.5	8	15	196			
%	28	17	76	89	42	45			

Level Three

Participant	1.1 (3)	3.4 (5)	4.1.1 (4)	6.2 (2)	7.1-2 (9)	8.1.1 (3)	8.1.3 (2)	8.1.4 (4)	8.2 (8)	Total (40)	%
E	3	2	4	0	7	2	2	0	0	20	50
G	0	4	4	0	6	0	0	0	0	14	35
I	0	0	4	0	5	2	2	0	0	13	33
J	0	2	0	0	2	0	0	1	0	5	13
K	0	1	0	0	6	2	0	0	0	9	23
M	0	3	4	0	2	2	0	0	0	11	28
N	0	2	4	0	7	2	0	4	8	27	68
P	0	2	0	0	6	0	2	4	2	16	40
Q	0	3	4	1	9	2	2	2	8	31	78
Total	27	45	36	18	81	27	18	36	72	360	
Achieved	3	19	24	1	50	12	8	11	18	146	
%	11	42	67	6	62	44	44	31	25	41	

Level Four

Participant	3.8(3)	4.1.4(2)	4.2.1(6)	5.3(3)	6.4a(2)	Total(16)	%
E	3	0	6	2	2	13	81
G	1	0	0	3	2	6	38
I	0	0	0	0	1	1	6
J	2	0	0	0	0	2	13
K	1	0	0	0	2	3	19
M	0	2	0	1	1	4	25
N	0	2	6	3	2	13	81
P	3	0	0	0	2	5	31
Q	2	0	5.5	0	2	9.5	59
Total	27	18	54	27	18	144	
Achieved	12	4	17.5	9	14	56.5	
%	44	22	32	33	78	39	

DATA HANDLING

Mathematics Specialists

Level One

Participant	3(17)	4.1a,b,e(4)		5.2(3)	Total(24)	%
A	15	2		3	20	83
B	15	4		3	22	92
C	15	4		3	22	92
D	14	4		3	21	88
F	14	4		3	21	88
H	14	4		3	21	88
L	13	3		3	19	79
O	14	4		3	21	88
Total	136	32		24	192	
Achieved	114	29		24	167	
%	84	91		100	87	

Level Two

Participant	4.1c,d(2)	4.2(7)	5.3(5)	Total (14)	%
A	2	7	4	13	93
B	2	7	5	14	100
C	0	7	1	8	57
D	1	6	5	12	86
F	2	6	4	12	86
H	2	6	2	10	71
L	2	6	5	13	93
O	2	6	5	13	93
Total	16	56	40	112	
Achieved	13	51	31	95	
%	81	91	78	85	

Level Three

Participant	5.4(11)	5.5(5)	Total (16)	%
A	1	5	6	38
B	4	5	9	56
C	0	3	3	19
D	0	5	5	31
F	0	3	3	19
H	0	5	5	31
L	11	4	15	94
O	0	5	5	31
Total	88	40	128	
Achieved	16	35	51	
%	18	88	40	

Non-Mathematics Teachers Level One

Participant	3(17)	4.1a,b,e(4)		5.2(3)	Total(24)	%
E	14	4		3	21	88
G	15	4		3	22	92
I	9	4		3	16	67
J	15	3		3	21	88
K	13	3		3	19	79
M	9	3		3	15	63
N	15	4		3	22	92
P	15	2		3	20	83
Q	13	4		3	20	83
Total	153	36		27	216	
Achieved	118	31		27	176	
%	77	86		100	81	

Level Two

Participant	4.1c,d(2)	4.2(7)	5.3(5)	Total (14)	%
E	0	6	1	7	50
G	2	6	5	13	93
I	1	6	2	9	64
J	1	6	2	9	64
K	1	6	0	7	50
M	1	6	4	11	79
N	2	6	4	12	86
P	1	6	2	9	64
Q	2	6	4	12	86
Total	18	63	45	126	
Achieved	11	54	24	89	
%	61	86	53	71	

Level Three

Participant	5.4(11)	5.5(5)	Total (16)	%
E	0	4	4	25
G	5	5	10	63
I	5	4	9	56
J	1	1	2	13
K	0	2	2	13
M	0	1	1	6
N	2	1	3	19
P	0	1	1	6
Q	2	3	5	31
Total	99	45	144	
Achieved	15	22	37	
%	15	49	26	

SPACE, SHAPE AND MEASUREMENT

Mathematics specialists Level One

Participant	2.5(2)	%	
A	0	0	
B	0	0	
C	0	0	
D	0	0	
F			
H			
L			
O			
Total	8		
Achieved	0		
%	0		

Level Two

Participant	2.3(3)	2.4(7)	2.6(4)	3.7(4)	Total(18)	%
A	3	2	4	4	13	72
B	3	5	4	1	13	72
C	1	5	0	3	9	50
D	1	5	4	2	12	67
F						
H						
L						
O						
Total	12	28	16	16	72	
Achieved	8	17	12	10	47	
%	67	61	75	63	65	

Level Three

Participant	1.2(5)	3.6(4)	Total(9)	%
A	4	2	6	67
B	1	4	5	56
C	0	0	0	0
D	3	4	7	78
F				
H				
L				
O				
Total	20	16	36	
Achieved	8	10	18	
%	40	63	50	

Non-Mathematics Teachers Level One

Participant	2.5(2)	%	
E			
G	0	0	
I	0	0	
J	0	0	
K	0	0	
M	0	0	
N	0	0	
P	0	0	
Q	0	0	
Total	16		
Achieved	0		
%	0		

Level Two

Participant	2.3(3)	2.4(7)	2.6(4)	3.7(4)	Total(18)	%
E						
G	3	3	4	0	10	56
I	3	2	1	3	9	50
J	0	1	4	0	5	28
K	0	2	0	0	2	11
M	0	0	0	1	1	6
N	3	5	4	4	16	89
P	1	0	1	0	2	11
Q	3	6	4	4	17	94
Total	24	56	32	32	144	
Achieved	13	19	18	12	62	
%	54	34	56	38	43	

Level Three

Participant	1.2(5)	3.6(4)	Total(9)	%
E				
G	1	0	1	11
I	0	0	0	0
J	0	4	4	44
K	0	4	4	44
M	1	0	1	11
N	5	0	5	56
P	0	0	0	0
Q	1	3	4	44
Total	40	32	72	
Achieved	8	11	19	
%	20	34	26	

APPENDIX J: Responses from teachers on particular questions of the module Numbers and Operations in context

Mathematics specialists								
	A	B	C	D	F	H	L	O
2.1.1 (6)	2(increase by5% compared to 2001)	0(increase by 5%)	0(increase by 5%)	0(increase by 5%)	1(average increase by5%)	0(changes by5%)	0(increase by 5%)	0(decrease by 5%)
4.3 (4)	0 (10%of95kg)	1 (incomplete)	0 (found 10% of 95kg)	0 (found 10%of 95)	0 (found 10% of 95kg)	0 (found 10% of 95kg)	3	4
5.2 (4)	0 (14%of27)	4	0 (multiplied 14.45 by R1.8)	0 (found 14%of R26)	2 (found 14%ofR 26.55)	0 (found 14% of R15.93)	0 (divided R13.5by1.14)	2 (used R1.80)
5.3.1 (6)	3 (incomplete)	6	0 (multiplied 18:39 by R3.00)	0 (multiplied 18:39 by R5.1)	3 (found R62.70)	1 (18min by 3.30)	1 (3 Feb is a weekend)	3 (incomplete)
5.3.2 (3)	3	3	0 (found 10% of R55.17)	3	3	3	0 (found R52.25)	3
5.4 (11)	3 (convert)	5 (incomplete)	0 (unable to convert seconds into minutes)	5 (incomplete)	0 (no attempt)	1 (unable to convert seconds into minutes)	3 (unable to convert seconds into minutes)	5 (unable to convert seconds into minutes)
6.1.4 (5)	0 (no attempt)	5	0 (no attempt)	0 (divided R6.1625 by R4.5725)	0 (no attempt)	0 (no attempt)	5	2 (wrong conclusion)

Non-Mathematics Teachers						
	E	G	M	N	P	Q
2.1.1 (6)	0(increase by 5%)	2(increase by5% compared to 2001)	0(increase by 5%)	1(average increase by5%)	0(fluctuating by 5%)	2(increase by5% compared to 2001)
4.3 (4)	0 (found 10% of 95)	0 (found 10% of 95kg)	0 (no attempt)	0 (found 10% of 95)	0 (found 10% of 95Kg)	0 (found 10% of 95Kg)
5.2 (4)	0 (14%of R27 +R27)	4	0 (no attempt)	0 (found 14% of R27.0)	0 (found 14% of R26.01)	0 (found 14% of R27.00)
5.3.1 (6)	3 (rounded 18:39 to 19:00)	0 (form ratio)	0 (no attempt)	5	2 (multiplied R3.30 by 18.39)	1 (multiplied 0.98 by 19min)
5.3.2 (3)	3	3	0 (no attempt)	3	0 (found 10% of R115.86)	3
5.4 (11)	2 (unable to convert seconds into minutes)	0 (unable to convert seconds into minutes)	1 (incomplete)	6 (incomplete)	5 (unable to convert seconds into minutes)	3 (unable to convert seconds into minutes)
6.1.4 (5)	2 (conclusion based on incorrect calculation)	0 (no attempt)	0 (no attempt)	2 (concluded from incorrect calculation)	2 (incomplete)	4(incomplete)

APPENDIX K: Interview questions

Here are the interview questions:

- What is your view on the algebraic teaching experience in the teaching of Mathematical Literacy? Do you think algebraic teaching experience has a role to play in the teaching of Mathematical Literacy?

  With this question I was trying to understand the inner feelings of the educator regarding one of the pre-requisites towards being successful in Mathematical Literacy.

- Professional teachers with Grade 12 algebraic knowledge are recruited to teach Mathematical Literacy. Do you think Grade 12 algebraic knowledge is the pre-knowledge that is adequate for the teacher to deal with problems on Mathematical Literacy?

  Here I was trying to get the views of educators as to whether educators themselves are of the idea as that of the Department of Education for the successful implementation of the ML curriculum.

- Mathematical Literacy is characterized by contextual problems which most of them are drawn from different cultural backgrounds. Do you think it is possible for one to solve any culturally related problem using the common algebraic knowledge?

  Do educators view algebraic techniques as applicable to certain cultural contexts or are universal?

- Is there any algebraic knowledge that has been used in this ML ACE Programme which you feel was new to you? i.e. you have been seeing it for the first time?

  To identify whether the algebraic knowledge they were exposed to is not beyond their comprehension

- Do you find algebra playing any role in dealing with problems of Mathematical Literacy?

To what extent is algebra as seen in the eyes of the participants playing a role in ML?

- Is the algebra used in Mathematics (pure) class similar to the one used in Mathematical Literacy class?
- *Are educators still sharing the similar feelings to those they were feeling while in the mathematics classroom?*
- Some claim that with the technological demands facing our society, a person without algebraic knowledge will never survive. What is your view on that?
- *Is there a link between the algebraic knowledge and technology?*
- As an educator, are you comfortable to use algebra?
- *To me comfort ability means success*
- In a culturally diverse class, is the algebra used there the same to cater for different cultural individuals?
- *Do different cultures use the common algebra when solving problem that are emanating from their respective cultures?*
- Looking at the poorly resourced class and the well resourced class, do you think the algebra used there will be the same for both classes?
- *Does the understanding of algebra has something to do with material?*
- With the task on the swimming pool, how did you approach the problem?
- *Confronted by the problem, the vital stage is the first approach*
- Is there anything that you can say about algebra and Mathematical Literacy?
- *If there was any role played by algebra*

APPENDIX L: Transcribed Interviews

Teacher 1: Teacher with only Grade 12 Mathematics background

Me: What is your view on the algebraic teaching experience in the teaching of Mathematical Literacy? Do you think algebraic teaching experience has a role to play in the teaching of Mathematical Literacy?

Teacher *1: Ya I think so, I think so ngoba uthola ukuthi sometimes kunamaproblems osuke unikezwe wona u aplaye iknowledge osuke unayo, so laphoke umuntu vese one experience ekusolveni amaproblems uyakhona ukuthi abe kwiadvantageous position ukuthi akhone ukuthi afundise better kuna lo ongakaze athole ichance yokuthi ayifundise leyonto a encounter amaproblems* (yes I think so, I think so because you find that sometimes there are problems which require the knowledge that you have for you to apply, then a person with experience of solving problems find himself at an advantageous position and is also able to teach better than the one who has not got a chance to teach and being exposed to problem solving)

Me: Professional teachers with Grade 12 algebraic knowledge are recruited to teach Mathematical Literacy. Do you think Grade 12 algebraic knowledge is the preknowledge that is adequate for the teacher to deal with problems on Mathematical Literacy?

Teacher *1: Ya, I think so, I think so so as I have said before like the prior knowledge that you have got will assist you like in teaching of Mathematical Literacy especially when you are dealing with…let me say financial mathematics, calculating things like that, fractions and so forth… so if you do not know anything about algebra so it becomes difficult for you to do..to teach may be in financial mathematics…therefore its adequate.*

Me: Mathematical Literacy is characterized by contextual problems which most of them are drawn from different cultural backgrounds. Do you think it is possible for one to solve any culturally related problem using the common algebraic knowledge?

Teacher *1: Ya it becomes possible if leyongane leyo osuke uyifundisa ine nackground knowledge, ifundile, yaunderstanda ukuthi kukhulunywa ngani…and…then okusizayo futhi kakhulu ukuthi a understande ne context in which the question is phrased… uma e understanda icontext uyakwazi ukuthi a aplaye amaskills asuke ewafundile before irrespective ukuthi* *iquestion is from iculture engasiyona eyakhe* (yes it becomes possible if that learner has the background knowledge, having read and understood the content as well as the context in which the problem is phrased…if you understand the the context you find it easy to apply the skills that you have learnt before irrespective of the culture from which the question is drawn)

Me: Is there any algebraic knowledge that has been used in this ML ACE Programme which you feel was new to you? i.e. you have been seeing it for the first time?

Teacher *1: No, no, it only needed for me to refresh on what I already knew before not that it was altogether new, no*

Me: So does this mean that you were able to use the algebra?

Teacher *1: Ya I was able to use the algebra.*

Me: Regardless of your experience?

Teacher *1: Regardless of the experience.*

Me: But now you have said a person with a rich algebraic experience is of an advantage position?

Teacher *1: Ya I was also at the advantage because I did mathematics up to grade 12…I used the knowledge that I have learnt before…but not in teaching.*

Me: Lets go back to the first question: lets draw a distinction between the algebra that you acquired at school as a learner, and the algebra that you as a teacher has been using throughout the career of teaching mathematics.

Teacher *1: Ya there is the distinction between the two…the other one who is using algebra from his teaching experience is better than the one that is using the algebra that he did at school.*

Me: Any distinction?

Teacher *1: Ho…ngingathi nje lowo oyifundisayo ufresh than lowo okade wayigcina…may be lowo wayigcina esikoleni may be some ten years back wagcina ukwenza lento le and then now bese enza iMathematical Literacy, kanti lo oyenzisayo esikoleni upractical akwenzayo namanje* *is fresh iknowledge yakhe is still fresh ayisekho stale njenge yalowaya owayigcina esikoleni…so it becomes easier for the person who is teaching to solve amaproblems rather than the one who did mathematics at school…you start by struggling but you eventually get there.*

Me: Do you find algebra playing any role in dealing with problems of Mathematical Literacy?

Teacher *1: Hooo….ya it does*

Me: How big or how small is the role?

Teacher *1: It is not small and I can say also it is not that big, but it does because you need to calculate things…like when you are…let say may be in propability you are calculating using the fractions and the things like that so you apply the algebra that you know there and also.. in numbers and operations you use algebra there…its needed…and also…ya it integrate…the algebra will integrate with the Los that you are doing in Mathematical Literacy…so you will find it there always*

Me: Is the algebra used in Mathematics (pure) class similar to the one used in Mathematical Literacy class?

Teacher *1: Ya I view the Mathematical class the same way…the difference is in the structuring of questions…like in Mathematical Literacy class the questions are context-based rather than in Maths…so but the algebra is the same*

Me: Some claim that with the technological demands facing our society, a person without algebraic knowledge will never survive. What is your view on that?

Teacher *1: It does play a role but not that you cannot survive without it…but it does play a role…like there are other things you could be able to do to calculate using the prior knowledge using your prior knowledge of algebra but it does not mean that if you do not apply that work, I mean that knowledge then you wont be able to survive…no.*

Me: If you look at some societal practices: paying the bills; premiums; doesn't that demand the algebraic knowledge?

Teacher *1: Ya, it does need algebra but I was looking at it…eh…like our grandmothers and grandfathers they do not need to do that but they do survive in the community irrespective of the algebraic knowledge that they have got…so they are surviving at the community.*

Me: But now looking at the upcoming citizens, like you, you are a worker; do you think it is wise for someone in your position to be without algebraic knowledge?

Teacher *1: No, it is not right for someone in my position…like a person who is working, a person who needs to look at his water bills and electricity bills and calculate how much water consumption they have used and then the bills that they have to pay whether it corresponds or what…so they do need the knowledge there.*

Me: For the young generation and the algebraic knowledge…what is your view on that?

Teacher *1: Ya, looking at the way things are changing…technologically and then our way of life things are changing so all of us we need to be literate in doing mathematics and also to have the algebraic knowledge…that they need to know their accounts…how much do they have…like if they are investing…how much interest are they going to accumulate and things like that so they do need the knowledge of algebra in order for them to survive into this generation.*

Me: As an educator, are you comfortable to use algebra?

Teacher *1: Ya, I am Iam but sometimes I do encounter problems…as I have said ukuthi eh I did mathematics up to grade 12…I encounter problems…but as I am practicing it becomes easier…and also that I consult with my fellow educators who are teaching mathematics who have been practicing using algebra almost all their lives…then it becomes easier.*

Me: How do you assist the learner that is seen to be lacking in basic algebra?

Teacher *1: Eh…like what I usually do in class…I usually work with groups…so when I am formulating my groups, the groups will consist of mixed ability individuals so that they will assist each other in tackling the problems and then I will be there as a facilitator. If that learner has got a problem, then I give individual assistance to that particular learner or giving him time to teach on his own…but I usually mix them on the groups so that they will learn from each other.*

Me: In a culturally diverse class, is the algebra used there the same to cater for different cultural individuals?

Teacher *1: Eh…because they have got the same skills that they are the same, then they will approach the problem the same way irrespective of the diversity of the class…like may be another one is a muslim, another one is an African or what, but the knowledge that they have got is the same…I don't think what will stop them in solving the problem the same way…however I will start with the example that will be relavant in each and every cultural group in my class…like if I have got the Ndebeles, then the example that will be relevant to them so they will know how to apply algebra in that and also…but it does not mean that it will only be done by the Ndebeles the whole class will participate…and also there will be the one that will concentrate on the Zulu speaking learners and the whole class will be doing that…so I will cater for each and every individual in my class…but tackling the same problem using different contexts.*

Me: Are you aware that these learners are going to write one common paper on Mathematical Literacy?

Teacher *1: Yes*

Me: Do you think the paper is going to be fair in terms of the kinds of the problems that will be asked?

Teacher *1: No it is not going to be fair…its not because some learners will find.. eh..there will be questions that won't be relevant to them…but using the knowledge that they have acquired throughout the year…it won't be difficult for them to tackle the question even though the problems that are there are not relevant to their culture…but they will be able to tackle the questions…the main point is understanding the context behind…understanding there…then they will be able to answer the questions irrespective of the way the question is framed.*

Me: Looking at the poorly resourced class and the well resourced class, do you think the algebra used there will be the same for both classes?

Teacher *1: The approaches will be the same, the only thing is may be lets say the poorly resourced one doesn't have the calculators…then may be I will get one per group one per group and then they will share it which will be time consuming but the approach will be the same.*

Me: With the task on the swimming pool, how did you approach the problem?

Teacher *1: Eh, I was helped by my peers*

Me: What was the difficulty there?

Teacher *1: I think the difficulty was in the understanding of what is it that was wanted from me to do…not actually that I couldn't calculate or what…because after they have showed me how it was done then it became easier…like when we were calculating the price…how much the tiles will cost? And how many tiles are gonna be there? Then it became easier.*

Me: What is it that you feel your learners would have experienced when the similar problem was given to them?

Teacher *1: Some of them won't remember the formulas to use…like may be when they are calculating areas…they will have a problem of remembering the formulas…may be if the formula sheet will be provided then it will be ok because they will know ukuthi this is the formula to calculate the trapezium and so forth and the formulas for volumes and things like that…they will have the problem of remembering the formulas…memorizing them.*

Me: Looking at the level of algebra that was expected on the task, how do you rate it?

Teacher *1: I think it was of a higher standard*

Me: Why do you say so?

Teacher *1: Because I also experienced some difficulty in answering that question…I was able to do it after I got help from other person…like lets say for instance it is in the exam room…there won't be anyone to give you clarity on what is needed there, then you will encounter a problem.*

Me: Is it not that the problem was based on a concept of area? Which I believe is within the Grade 12 scope?

Teacher *1: Ya, may be there I didn't give myself enough time time to do it …when just looking at it I thought may be it was gonna be difficult, that's why I asked my peer to help me.*

Me: If you can come across a problem of that nature, will you experience a similar difficulty?

Teacher *1: No I won't*

Me: Why?

Teacher *1: No, like when I did it for the first time I thought it was very difficult but now when we were doing remedial work in class and then my peers had showed me how to do it, it was not that difficult…but the first time I looked at it I thought no it was going to be difficult and I couldn't do it.*

Me: Is there anything that you can say about algebra and Mathematical Literacy?

Teacher *1: What I can say is ayingabi ningi kakhulu…and also like when bebuza amaquestions, algebra must only be used in level 1,2&3 and not may be in level 4 because may be the questions there will be too difficult for learners to understand using level 4 questioning.*

Me: The name is Mathematical Literacy. How can you separate the algebra from Mathematical Literacy?

Teacher *1: Ya phela khona angeke ukuhlukanise kodwa nje mase zibuzwa izingane…ngoba nje …ngoba nje its not that ngoba zisuke zingazi yini izingane…its not that zisuke zingazi…zisuke zazi zona kuwukuthi bese zifike ziyadideka nje laphaya uma iphepha lisuke seliphambi kwazo…kuthi uma ngabe umuntu usumtshengisa ukuthi bekumele kube kanjani…bese elokhu eqala ethi ohhhhhhhhh kanti bekukanje okuzobenza ukuthi bafeyile vese at the end of the the day.*

Me: What can you say to your colleagues about algebra and Mathematical Literacy?

Teacher *1: They do need to have iknowledge yealgebra to deal with amaproblems amanye akhona kwi Mathematical Literacy, so I cannot say ukuthi algebra must not be there in Mathematical Literacy…it must be there…it must…they will be openminded and be able to calculate things for themselves…and they will also know how to go about solving problems in different situations*

Teacher 2: Educator with both Grade 12 and Post Grade 12 Mathematics backgrounds

Me: What is your view on the algebraic teaching experience in the teaching of Mathematical Literacy? Do you think algebraic teaching experience has a role to play in the teaching of Mathematical Literacy?

Teacher *2: No, I think you cannot separate ialgebraic experience with iMathematical Literacy because…eh…*

Me: Do you think in dealing with Mathematical Literacy there is a difference between the teacher who is using the grade 12 algebraic knowledge and the one who has been teaching algebra for quite sometime?

Teacher *2: Yes, ukhona, ukhona, the one who has been teaching algebra or eneexperience iteaching experience will… I mean…benefit more kunalo because lo wayigcina kwagrade 12 some of the concepts…can't even remember wona ngendlela kanti lo is used kuma concepts asebenzayo and even kwayona imathematics ekhona…so lo kubalula, nanokuthi usuke eneconfidence yokuthi no ngizokwazi ukuthi ngihandlishe iproblem.*

Me: Professional teachers with Grade 12 algebraic knowledge are recruited to teach Mathematical Literacy. Do you think Grade 12 algebraic knowledge is the preknowledge that is adequate for the teacher to deal with problems on Mathematical Literacy?

Teacher *2: Ayi No, ay no because there are some concepts alaphaya kwiMathematical Literacy engiwabone ukuthi they need iknowledge ethe more…like ugrade 12 some of the things like I said you just do it without understanding…you just do that without understanding kanti la uma usunayo iexperience ethe xaxa or imfundo ethe, amanye amaconcepts aba easier for you ukuthi uwasolve…like kumasimultaneous equations there is more mathematics laphaya uma ngibuka…eh…angiboni ukuthi iaplaya kuphi in reallife situation…like sasisho kudala ukuthi iyi tool yebo…ezosebenza kuMathematical Literacy but mawuzoyigcina kwagrade 12 you struggle before you…before you reach the solution.*

Me: If you say there is knowledge above grade 12 needed by the teacher, is it the knowledge to interpret the situation or the knowledge to manipulate algebra?

Teacher *2: Iknowledge yokumanipulata more than iinterpretation…like ko Space, Shape and Measurement konke lokhu kokucalculator amaarea nani nani lowomuntu must be mathematical…I mean he must know more about ama formula ini ini ukuthi how to manipulate this inorder to interpret…uyayibona.*

Me: Is there any algebraic knowledge that has been used in this ML ACE Programme which you feel was new to you? i.e. you have been seeing it for the first time?

Teacher *2: No, algebra, algebra, hayi…yiyo le amasimultaneous, hayi I will note ama simultaneous equations, so mawukwagrade 12 ialgebraic part iright, no angiboni...ukuthi umuntu azi reminder nje ukuthi sasenzenjani, so bese kuyakwazi ukuthi kuyeke phambili...so ialgebra esetshenziswayo ikwilevel efanele.*

Me: Mathematical Literacy is characterized by contextual problems which most of them are drawn from different cultural backgrounds. Do you think it is possible for one to solve any culturally related problem using the common algebraic knowledge?

Teacher *2: As long as uma izohlangana ne culture yami then ngingayisolva but not any cultural bani bani...I don't know whether I got the question very well...but...kunzima ukuthi uzosolva iproblem ebased kwiculture yabanye abantu ongayazi...so ukusebenza kwealgebra kungahluka from different cultures...ngizitshela lana ukuthi uzokwazi ukuyiaplaya leyoknowledge with confidence if you know that culture very well...mina I am more comfortable ukuyi aplaya kwiculture yami.*

Me: Is the algebra used in Mathematics (pure) class similar to the one used in Mathematical Literacy class?

Teacher *2: No it is not similar, in Mathematical Literacy class they are using simple and simple algebra kanti in Maths class they are dealing with more complex situations and most of them you cannot relate…lawo maproblems in a real life situation…so mina I find it easier to work with Mathematical Literacy class because yona ialgebra yayo uyayikhuluma more than ukubhala phansi.*

Me: Is addition and multiplication used in Maths class different from the one used in Mathematical Literacy class?

Teacher *2: Ha, ha, ha…lokho kulula, no iaddition ne multiplication is the same but uyabo ma usuya ko calculus ngiyibuka lapho ukuthi ayi some of the things asuke esedifficult othola ukuthi uyaziaplaya…but the basic things, yes they are the same but kwiMaths class iya ngokuya iba deep deep deep.*

Me: Dou you find algebra playing any role in dealing with problems on Mathematical Literacy?

Teacher *2: Yes, ya ialgebra, ialgebra, ialgebra iyona key, because ngibuka ukuthi uma ungenayo, even yona le yakwagrade 12 mawungenayo hayi you are lost*

Me: Some claim that with the technological demands facing our society, a person without algebraic knowledge will never survive. What is your view on that?

Teacher *2: Ya nami I, I agree with that I think that is they introduced iMathematical Literacy…because babonile ukuthi a South African citizen without background in Maths or without iknowledge kwiMaths will be lost because of the…how are you going to to interprete amabills if you don't have that uyabona?...eh so iMaths ngisho njalo nje angazi ngizothi iyini kodwa nje iyadingeka, iyadingeka kakhulu.*

Me: Are you comfortable to use algebra?

Teacher *2: Yes.*

Me: How do you assist the learner that is seen to be lacking in basic algebra?

Teacher *2: Like if ngimthole kwagrade 11 there is no other way. I used to, I have to go back ezintweni ezazenziwe emuva, eh, sisebenzise ama expanded opportunities, giving him more work nanokuthi sispende nje isikhathi esiningi mina naye ngoba yena usuke esemuva esele kunabanye to catch up yonke lento le esiyenziwe. Ayikho into edlula ukuthi ube naye niqale phansi nisuke le emuva.*

Me: Algebra has been used in mathematics (pure) with high failure rate. Don't you think the same will be experienced with Mathematical Literacy?

Teacher *2: No iMathematical Literacy mina ngibona sengathi indlela eintroduswe ngayo since it is, I mean igxile kakhulu kwi real life situation, I think that is better…compared to Maths so* *ukushintsha nje iattitude yomntwana eh khona ezokwazi ukuyibona lento le I aplaya isebenza, angeke ziyifeyile kakhulu as long as uthisha ezoyi introducer kahle ayi instille nothando lwayo umuntu uzokwazi ukuyibona ayisebenzise. Nokubheka kahle ukuthi sasizondelani iMaths…wawuyizonde ngoba wawenza into ongazi ukuthi izokusizaphi at all.*

Me: Looking at the poorly resourced class and the well resourced class, do you think the algebra used there will be the same for both classes?

Teacher *2: No, mina imathematics will be the same because I mean you can even go to computers but you will need the very same algebraic information that you have…so whether you have resources or no resources…I think amaresources enza umsebenzi ubelula but iknowledge asuke umuntu enayo is the one that count.*

Me: In a culturally diverse class, is the algebra used there the same to cater for different cultural individuals?

Teacher *2: No, ayi ialgebra mina angiyiboni ibased kakhulu kwiculture...so it will be the same…iapplication yakhona or the examples that you are going to use asezoba culturally based but nje as for algebra it will be the same.*

Me: With the task on the swimming pool, how did you approach the problem?

Teacher *2: That was difficult for person with only grade 12 mathematics because there kwakufanele nge experience yakho ubuye ubone ukuthi iyiphi iformula okumele ngiyisebenzise lapho, uyayibona?*

Me: What was the difficulty there?

Teacher *2: No ialgebra. It was amaformula more than ialgebra…into enzima laphaya kwaku wukuqala nje ungazi nokuthi uzoqalaphi…but uma usuqalile hayi ialgebra yayingeyona inkinga wawungazitholi usustacked ungazi ukuthi uzokwenzani…wonke umuntu wayekwazi ukuqhubeka…kwakuba ukuthi umuntu indlela a attacke ngayo isibalo ibibheda.*

Me: How did you approach the problem?

Teacher *2: Very bad. It was difficult for me…it wasn't an easy task I must say it wasn't easy at all because you need to…laphaya kufanele ucabange ubone ukuthi iyiphi iformula okumele uyisebenzise, kambe bafunani uma sekunje…nalamadimensions akhona you have to understand ukuthi this thing is two dimensional so ungayibuki la kuphela ubuke naleli elinye iside…angazi…kuya nange attitude kakhulu.*

Me: Is it not the problem was requiring the use of concept of area – length by breadth which is just substitution and finding the answer?

Teacher *2: Ya, but wawuzobona ngani ukuthi iarea yani? Ungazi?...ma usuyenza wawubona no it was just the area thing, you substitute, you add la kufanele u adde khona but …kwakufanele kube nendlela ecorrect yokusiattempta isibalo.*

Me: Is there anything you can say about algebra and Mathematical Literacy?

Teacher*2: Eh, there is nothing much about iproblem yealgebra eh engike ngakunoter…ngaphandle kokuthi nje izingane kufanele zikwazi zikwazi ukusebenzisa kahle all the basics lawo ebesikhuluma ngawo omultiplication ini ini. Nanokuthi nje iattitude yezingane towards iMaths because when they see ialgebra they think of mathematics kuphela…we need to instill the love of algebra so that it will be easier for them to apply it ngendlela…so there is nothing much about ialgebra…and angiyiboni iyinkinga kangako.*

Me: Are you referring to you as a teacher?

Teacher *2: Yes, to me as a teacher and to my learners…uma sengizo…if mina as a teacher ngiyifundisa phela nezingane zesatshiswa wuwe thisha uma uzoyifundisa…so nawe kuya ngokuthi how do you deliver that algebra kubo, so I think yonke into ilapho ukuthi nje kufanele kumele bazi we are going to deal with numbers there is nothing edifficult la, ukuadda la siadda khona simayinase la simayinasa khona, but akukhonto enzima mina engiyibonayo*

APPENDIX M: UKZN ML(Numbers and Operations) Examination paper

UNIVERSITY OF
KWAZULU-NATAL

SCHOOL OF SCIENCE, MATHEMATICS & TECHNOLOGY EDUCATION
(Edgewood Campus)
ADVANCED CERTIFICATE IN EDUCATION

Mathematical Literacy

EXAMINATIONS – 02 JUNE 2007

Course	**Number and Operations in Mathematical Literacy**	Code	**EDMA140E1**
Duration	**3 hours**	Marks	**140**
Internal Examiners	**Dr S Bansilal;** **Mr T Mkhwanazi**	External Examiner	**Mrs Lynn Webb** **Nelson Mandela Metropolitan University**

Name:_____________________ **Student Number__________________**

Seat Number______________________

Instructions:

- *Answer all questions in the spaces provided on this paper.*
- *If the space is insufficient, use the blank page at the end of the paper and indicate that you have done so.*
- *This question paper consists of six questions and 18 pages including this cover page, two appendices and a blank page for extra work. Please check that you have them all.*

Question One   [26 marks]

1.1 Tiny would like to take a bond of R450 000 to buy the house of his dreams. When he approached the bank for the home loan, he was offered two options which are outlined below.

Options	Interest Rate	Monthly Instalment	Term of the loan
Option 1	12,5 %	R5112,63	20 years
Option 2	12,5 %	R4802,65	30 years

Which option would you advise him to choose? Give detailed calculations to support your advice. (6)

1.2 In 2007, the formula that is used to calculate the transfer duty, payable by a new home owner, is as follows:

- *For a purchase price of R0-R500 000, the transfer duty is 0%.*
- *For a purchase price of R500 001 to R1 000 000, the transfer duty is 5% on the value above R500 000.*
- *For a purchase price of R 1 000 001 and above, the transfer duty is R25 000 + 8% of the value above R1 000 000.*

1.2.1 Calculate the transfer duty payable on a house that is valued at R995 000. (3)

My friend paid transfer duty of R55 000 on the house that she bought in 2007.

1.2.2 Why do you presume that her house cost more than R1000 000? (1)

My friend paid transfer duty of R55 000 on the house that she bought in 2007.

1.2.2 Why do you presume that her house cost more than R1000 000? (1)

1.2.3 How much did her house cost? (6)

1.3 *Formulae that are needed for this question: [$A = P\ (1+ r/100)^n$ and $A = P\ (1 + rt)$]*

Consider an initial amount of R10 000 that was invested for 5 years.

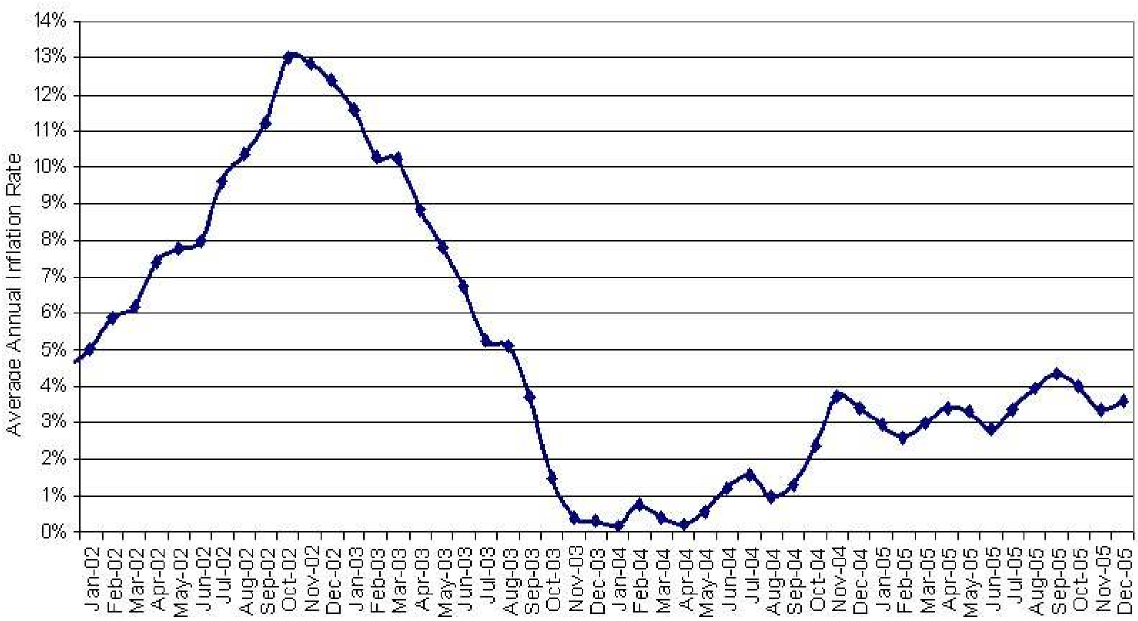
1.3.1 What will the value of the investment be, if it was invested at 13,5 % p.a compounded annually? (3)

1.3.2. What will the value of the investment be, if it was invested at 13,5 % p.a which is compounded monthly? (3)

1.3.3. Suppose the R10 000 was invested using simple interest. How long should it be invested for, in order to achieve the value calculated in Question 1.3.2 above? (4)

Question Two [20 marks]

2.1 Consider the following graph that appears in your notes and which shows the monthly inflation rates over the period January 2002 to December 2005. For example, the monthly inflation rate for January 2002 was 5%, while for February 2002 it was 5,9%. Study the graph and answer the questions that follow.



2.1.1 What does it mean when we say that the monthly inflation rate for January 2002 was 5%? (3)

2.1.2. Your colleague, Mr Right, said to you:

"This graph moves down between October 2002 to October 2003. So this shows that the inflation came down in that period. Yet we know that the price of goods did not come down in that period. So this graph is incorrect."

Do you agree with Mr Right? How would you respond to him? (4)

2.1.3 In March 2003, my new car cost R55 000. What would I have expected to pay for a new car of the same make in March 2005? (6)

2.2. Ayesha is building a house. In order to construct the foundation, she used the following table that she got from the local Builders' supplies which is a guideline for the quantities of cement, sand, stone and water that needed to be mixed.

Quantity of concrete needed (m^3)	No of bags of cement needed	No of wheelbarrows of sand	No of wheelbarrows of stone	No of litres of water
2	10	20	20	400

Ayesha's house needs a volume of 26,5 m^3 of concrete for the foundation.

Calculate how many:

2.2.1 bags of cement she will need for her foundation? (3)

2.2.2 wheelbarrows of sand she will need for her foundation? (2)

2.2.3 litres of water, she will need for her foundation? (2)

Question Three [23 marks]

3.1 Explain the difference between the terms "ratio" and "rate". Use examples that are not appearing in this paper to clarify your answer. (4)

3.2 In the Pick'n Pay store on 28 April 2007, a 500g box of Bran Flakes was R15,99, while a 750 g box of Bran Flakes was priced at R26,59. I need 2 kg of Bran Flakes. How many of each size box should I buy in order to minimise the cost? (4)

3.3 A pharmacist mixes two chemicals (A and B) in the ratio 7:2 to form the "Creamy Skin" face moisturiser. How many ml of chemicals A and B will she use in order to make 450 ml of "Creamy Skin" moisturiser? (5)

3.4 My car uses petrol at a rate of 13,4 km/*l* (kilometres per litre).

3.4.1 How far can the car travel on a full tank of 55 litres? (3)

3.4.2 The distance from Durban to Mbazwana is 430 km. If 1 litre of petrol costs R6,70 calculate the cost of petrol for my car for the trip from Durban to Mbazwana. (5)

3.4.3 What is the estimated petrol cost per km for the trip to Mbazwana? (2)

Question Four [12 marks]

4.1 In order to classify people as under or over-weight, we use the concept: *Body Mass Index (BMI)*. A person's BMI index is defined as a person's weight (in kilograms) divided by the square of the person's height (in metres)

$$\text{i.e. BMI} = \frac{weight}{(height)^2}$$

The BMI is then used to classify someone as follows:

BMI	Classification
Less than 18,5	Underweight
Greater than or equal to18,5 and less than 25	Normal weight
Greater than or equal to 25 and less than 30	Overweight
Greater than 30	Obese

4.1 Calculate the BMI for each of the following people and determine their weight status (i.e. are they underweight, normal, overweight or obese)? (4)

Name	Age (yrs)	Weight (kg)	Height (cm)	BMI	Weight Status
Tanya	19	88	178		
Sipho	11	29,6	143		

4.2 Suppose that I have a BMI of 24 and my weight is 55 kg. What is my approximate height in cm? (4)

4.3 Thina was overweight. The doctor recommended that she bring down her weight by going on a diet for two months. At the end of the two month period Thina's weight was 95 kg. Thina was happy because she calculated that her weight had been reduced by 10%. What was her weight before she went on diet? (4)

Question Five [28 marks]

Refer to the Appendix 2 on page 17 which is a copy of the Cell C rates page that appeared in your guide.

Mr KP has signed up for the **first option** offered in the advert. In the first three days (which are all weekdays) he has made the following calls-appearing in the table below.

Recall that:

- *Weekday Peak times for Cell C rates are 7 a.m to 8 p.m, while Off Peak times are 8 p.m to 7a.m*

No.	DATE	TELEPHONE NUMBER	DURATION	TIME OF CALL
1	1 Feb	088 243 6264 (Cell C)	14:45	14h24
2	2 Feb	(021) 247 8640	32:17	7h31
3	2 Feb	083 545 4600 (Vodacom)	29:52	19h50
4	2 Feb	(041) 204 3613	0:30	15h38
5	3 Feb	**SMS** – 085 121 6268	--------	21h26
6	3 Feb	087 738 2782 (MTN)	13:24	22h07
7	3 Feb	+(44) 0721 8890 4567 (London)	18:39	19h01

5.1. What is the cost of Mr KP's first call? (Note that 14:45 denotes 14 minutes and 45 seconds) (4)

5.2 All prices quoted include VAT which we know is 14% in South Africa. What was the cost of the same call (in 5.1) <u>before</u> the VAT was added? (4)

5.3

5.3.1 Suppose that the Telkom cost of a call to London is R3,30 per minute (peak) and R3,00 per minute (off peak), with Telkom's overseas rates being charged per minute. What would Mr KP's call to London on 3 February have cost? (6)

5.3.2 The advertised 10% discount on International calls means that the Telkom portion of the cost is reduced by 10%. Calculate the cost of the same call, when the discount has been taken into account. (3)

5.4 Calculate the total cost of Mr KP's seven calls as listed in the table. (11)

Question Six [31 marks]

6.1 Task 1

Below is a table, taken from the Sunday Times, 18/03 /2007, showing international currency exchange rates in comparison to the rand. The table shows the values on two dates (**16/03/2007** and the **16/03/2006**). Study the table and then answer the questions that follow:

		R1 EQUALS		**ONE FOREIGN UNIT EQUALS**	
		16/03/2007	**16/03/2006**	**16/03/2007**	**16/03/2006**
US Dollar	USD	0,1345	0,1623	7,4330	6,1625
Australian Dollar	AUD	0,1692	0,2187	5,9098	4,5725
Botswana Pula	BWP	0,8580	0,8826	1,1655	1,1330

6.1.1 How many Botswana Pulas would you have been able to get on 16/03/2007 for R2500? (2)

6.1.2 How many Rands would you have been able to get for 2500 Botswana Pula on 16/03/2007? (2)

6.1.3 Use the information in this table to work out approximately how many AUD you would have obtained for 1 USD on 16/03/2006. (4)

6.1.4 Consider the AUD- USD exchange rate on the 16/03/2006 and 16/03/2007 two dates provided. Would you say that the value of the AUD increased or decreased in comparison to the value of the USD, over the period 16 March 2006 to 16 March 2007? **Explain** using detailed calculations. (5)

6.2 Study Task 1 as it appears in 6.1 above again. Thereafter, **name and explain** which assessment standards from Learning Outcome 1 does the task address? (**Note:** the assessment standards appear on page 16 of this paper). (4)

6.3 Consider Task 2 inside the box given below. (8)

Consider the formula: **F = 1,8 × C + 32**, where
F is the temperature measured in degrees Fahrenheit and
C is the temperature measured in degrees Celcius.

1. Find F if C = 25˚
2. Find the value of F when F = C (Show your working)

6.3.1 Provide solutions to the questions in Task 2.

1.

2.

6.3.2 How many marks would you allocate for each question? How would you distribute the marks?

6.4

6.4.1 What is your understanding of Mathematical Literacy? (2)

6.4.2 Write down two skills that you would like to develop in your Mathematical Literacy learners. Explain why you see these two skills as being important. (4)

Learning Outcome 1: Number and Operations in Context

The learner is able to use knowledge of numbers and their relationships to investigate a range of different contexts which include financial aspects of personal, business and national issues.

Grade 10 We know this when the learner is able to:	Grade 11 We know this when the learner is able to:	Grade 12 We know this when the learner is able to:
10.1.1 Solve problems in various contexts, including financial contexts, by estimating and calculating accurately using mental, written and calculator methods where appropriate, inclusive of: • working with simple formulae • using the relationships between arithmetical operations (including the distributive property) to simplify calculations where possible;. (NOTE: students are not expected to know the distributive property by name) (The range of problem types includes percentage, ratio, rate and proportion).	11.1.1 In a variety of contexts, find ways to explore and analyse situations that are numerically based, by: • estimating efficiently; • working with formulae by hand and with a calculator; • showing awareness of the significance of digits; • checking statements and results by doing relevant calculations. (The range of problem types includes percentage, ratio, rate and proportion).	12.1.1 Correctly apply problem-solving and calculation skills to situations and problems dealt with.
10.1.2 Relate calculated answers correctly and appropriately to the problem situation by: • interpreting answers in terms of the context; • reworking a problem if the first answer is not sensible, or if the initial conditions change; • interpreting calculated answers logically in relation to the problem and communicating processes and results.	11.1.2 Relate calculated answers correctly and appropriately to the problem situation by: • interpreting answers in terms of the context; • reworking a problem if the first answer is not sensible or if the initial conditions change; • interpreting calculated answers logically in relation to the problem, and communicating processes and results.	12.1.2 Relate calculated answers correctly and appropriately to the problem situation by: • interpreting answers in terms of the context; • reworking a problem if the first answer is not sensible or if the initial conditions change; • interpreting calculated answers logically in relation to the problem and communicating processes and results.
10.1.3 Apply mathematical knowledge and skills to plan personal finances, inclusive of: • income and expenditure; • the impact of interest (simple and compound) within personal finance contexts.	11.1.3 Apply mathematical knowledge and skills to plan personal finances and investigate opportunities for entrepreneurship inclusive of: • specifying and calculating the value of income and expenditure items; • estimating and checking profit	12.1.3 Analyse and critically interpret the a variety of financial situations mathematically, inclusive of: • personal and business finances; • the effects of taxation, inflation and changing interest rates • the effects of currency fluctuations; • critical engagement with debates about socially responsible trade.

Appendix 1: for use in Question Six

Appendix 2 Cell Phone Rates (for use with Question Five)

casual**chat** > The deal

Stay in touch without breaking the bank. casual**chat** is an affordable contract range that includes a choice of included off-peak minutes, anytime minutes or anytime SMS. With casual**chat**, you will get:

- Fixed Friends & Family discounted rate on peak calls
- Low Cell C to Cell C call rates
- Per second billing after the first minute
- 10% discount on international calls

connection fee	FREE		FREE		FREE	
Contract length (months)	1,12 or 24		1,12 or 24		1,12 or 24	
monthly fee	R 105		R 105		R 105	
included monthly minutes			100 off-peak		50 anytime	
included sms per month	200 anytime SMS					
Friends & Family	R 1.75		R 1.75		R 1.75	
per second billing	After the first 60 seconds		After the first 60 seconds		After the first 60 seconds	
	Off-peak	**Peak**	**Off-peak**	**Peak**	**Off-peak**	**Peak**
Cell C to Cell C	R 0.90	R 1.80	R 0.90	R 1.80	R 0.90	R 1.80
to other mobile	R 0.98	R 2.45	R 0.98	R 2.45	R 0.98	R 2.45
to Telkom	R 0.90	R 2.30	R 0.90	R 2.30	R 0.90	R 2.30

International calls	R 0.95 + Telkom off-peak	R 1.85 + Telkom peak	R 0.95 + Telkom off-peak	R 1.85 + Telkom peak	R 0.95 + Telkom off-peak	R 1.85 + Telkom peak
sms per message	R 0.36	R 0.80	R 0.36	R 0.80	R 0.36	R 0.80

*+(Telkom - 10%)

Source: http://www.cellcdirect.co.za/contracts/casualchat.asp accessed 19 May 2005